DRAFT FINAL ENGINEERING EVALUATION/COST ANALYSIS

CONTACT AND SONOMA MINES

PINE FLAT MINING DISTRICT RUSSIAN RIVER WATERSHED

Sonoma County, California

Contract Number: GS10F0160J
Order Number: L10PD02567
Requisition Numbers: 0010011546 / 0010022038

June 2010

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List of Abbreviations and Acronyms

Term	Definition
µg/dL	micrograms per deciliter
µg/g	microgram per gram
µg/L	microgram per liter
AF	adherence factor
ARAR	Applicable or Relevant and Appropriate Requirement
AT	averaging time
ATSDR	Agency for Toxic Substances and Disease Registry
bgs	below ground surface
BLM	Department of the Interior Bureau of Land Management
BW	body weight
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COC	Chemical of Concern
COPC	contaminant of potential concern
CSM	conceptual site model
CT	central tendency
cy	cubic yards
E & E	Ecology and Environment, Inc.
EC	exposure concentration
ED	exposure duration
EE/CA	Engineering Evaluation/Cost Analysis
EF	exposure frequency
EFH	Exposure Factors Handbook
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
ERA	Ecological Risk Assessment
ET	exposure time
FSP	Field Sampling Plan
GI	gastrointestinal
HHRA	Human Health Risk Assessment
HI	hazard index
HQ	Hazard Quotient
EUBK	Integrated Exposure Uptake Biokinetic
IR	ingestion rate of receptor
IRIS	Integrated Risk Information System
IRs	soil/sediment ingestion rate of receptor
IUR	inhalation unit risk

List of Abbreviations and Acronyms (cont.)

kg	Kilogram[s]
LADI	lifetime average daily intake
LOAEL	lowest observed adverse effect level
m	meter
MCLs	maximum contaminant levels
mg	milligram
mg/kg	milligrams per kilogram
mg/kg-day	milligrams per kilogram per day
mg/l	milligrams per liter
MMHg	methyl (or monomethyl) mercury
MRLs	Minimal Risk Levels
NCP	National Oil and Hazardous Substance Pollution Contingency Plan
NDs	nondetects
ng/L	nanograms per liter
NOAEL	no observed adverse effect level
PEF	particulate emission factor
ppm	parts per million
PPRTV	Provisional Peer Reviewed Toxicity Values
RA	Risk Assessment
RfCs	reference concentrations
RfDs	reference doses
RG	remediation goals
RMC	Risk Management Criterion
RME	reasonable maximum exposure
ROS	regression on order statistics
RSI	Removal Site Inspection Report
RSLs	Regional Screening Levels
SA	skin surface area
SFs	slope factors
Site	Rathburn-Petray Mercury Mine
STSC	Superfund Health Risk Technical Support Center
SUF	site use factor
TAL	Target Analyte List
UCL	upper confidence limit
USGS	United States Geologic Survey
WOE	weight of evidence
XRF	X-ray Fluorescence

1 Introduction

Ecology and Environment, Inc. (E & E) has been retained under the Department of the Interior Bureau of Land Management (BLM) contract number GS10F0160J, order number L10PD02567 to prepare an Engineering Evaluation/Cost Analysis (EE/CA) for the Contact and Sonoma Mines Site.

This EE/CA has been prepared in accordance with the criteria established under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as well as sections of the National Contingency Plan (NCP) applicable to removal actions (40 Code of Federal Regulations [CFR] § 300.415 [b][4][I]). The EE/CA is also consistent with the U.S. Environmental Protection Agency (EPA) guidance document, *Guidance on Conducting Non-Time Critical Removal Actions Under CERCLA.*

The goals of the EE/CA are to:

- Identify and fill data gaps and document the need for removal actions to address contamination on site;
- Prepare an analysis of available data and verify results of previous Site studies;
- Conduct baseline human health and ecological risk evaluations to determine the potential threats posed by contamination originating at the Site and develop a Site Conceptual Exposure Model; and
- Provide a framework for the evaluation and selection of potential response actions and applicable technologies consistent with the NCP.

2 Site Description and Background

2.1 Site Location

The Contact and Sonoma Mines (Site) are located in the Northeast Quarter of the Northwest Quarter of Section 5, Township 10 North, Range 8 West (UTM: Zone 10N, MDBM 520083 mE / 4289448 mN); in Sonoma County, California (Figure 2-1).

The Site consists of two separate mines, the Contact and Sonoma Mines, which, when combined, are composed of approximately 23 acres of BLM-administered public lands. The Site collectively contains approximately 30,000 cubic yards (cy) of mercury mine wastes. Most of these waste materials include mine waste rock and tailings; however, there also exist physical remains of structures and equipment related to ore extraction and processing at both mine locations.

2.2 Facility Description, Operational Status, and Site History

The Site is located within the rugged Mayacmas Mountains, a geologic range that runs through portions of Mendocino, Sonoma, and Lake Counties. The Contact and Sonoma Mines are both located on patented mining claims in the Pine Flat mining district of northeastern Sonoma County, roughly 11 miles northeast of the town of Healdsburg, California. They are located on public land managed by BLM.

While this EE/CA addresses both the Contact and Sonoma Mines as a combined site, for the purpose of clarity in this section, the facility descriptions, operational statuses, and site histories will be discussed separately, as the two mines were operated as separate entities.

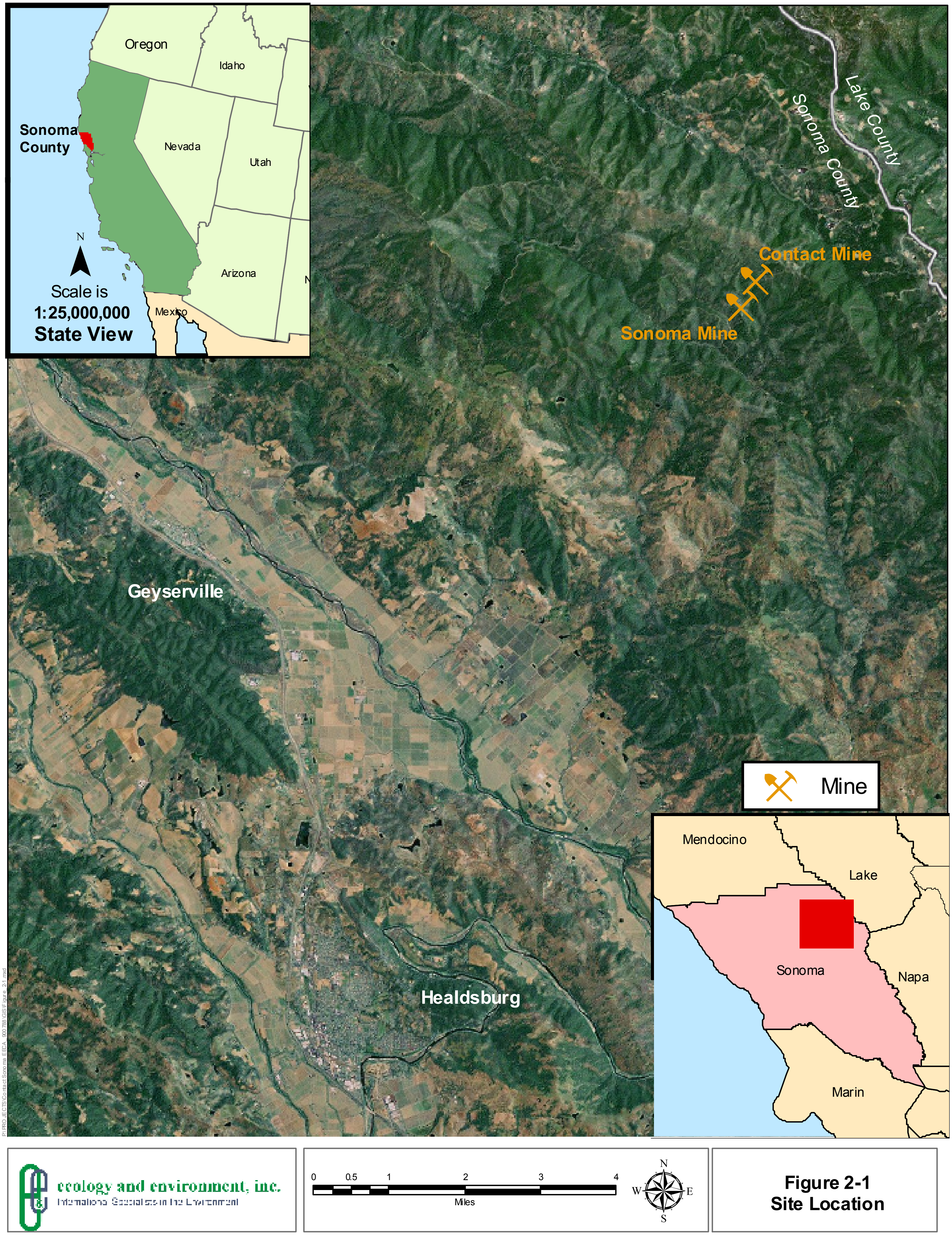

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Figure 2-1
Site Location

2.2.1 Contact Mine Site Setting and Facility Description

The Contact Mine site occupies approximately 11 acres located less than 1/3 mile northeast of the Sonoma Mine. The mine is situated just below a rocky outcrop and has a southwestern aspect. The Contact Mine site currently consists of two adits, a large tailings pile, several smaller tailings piles, and miscellaneous structural debris such as bricks and corrugated sheet metal (Figure 2-2).

The Contact Mine site has three prominent leveled benched areas (flats) connected by several deteriorated dirt road segments. The upper flat is approximately 250 feet by 110 feet and contains mining equipment that was relocated to this location after operations at the mine had ceased. The mining equipment includes a furnace with a concrete pad, corrugated sheet metal, and a boom for hoisting. An adit is located to the northeast of the concrete pad, and an ore cart protrudes from the portal.

The center flat is connected to the upper flat by a 980-foot long access road. There is an approximate one-acre tailings and waste rock pile that continues downward to the lower flat. The lower flat is connected to the center flay by a 1,050-foot access road.

The lower flat is approximately 255 feet by 75 feet. The lower flat contains an adit with a dilapidated portal. A seep runs from the adit and creates a seasonal marshy area. A set of 60-foot-long ore-cart rails are located to the southwest of the adit. Two pipes that may have been used to pump air into the adit are also located on this flat. The remains of a furnace are located to the north of the adit.

To the northeast of the furnace area is a tailings pile with dimensions approximately 350 feet east to west and 75 to 150 feet north to south. The surface of the tailings pile has cemented together to form a continuous hard crust. The tailings are mostly cemented by magnesite. Eighteen vent pipes are located on the lower flat. Additional mine tailings, structures, or equipment may be located below the lower flat; however, the area is heavily vegetated, making the identification of features difficult.

2.2.2 Sonoma Mine Site Setting and Facility Description

The Sonoma Mine site occupies approximately 12 acres located just less than 1/3 mile to the southwest of the Contact Mine. The mine is situated on a slope with a southern aspect. The Sonoma Mine site currently consists of a collapsed mine adit, a large tailings pile, and miscellaneous structural debris such as timber and corrugated sheet metal (Figure 2-3). The remains of a washing plant and retort are also present on-site.

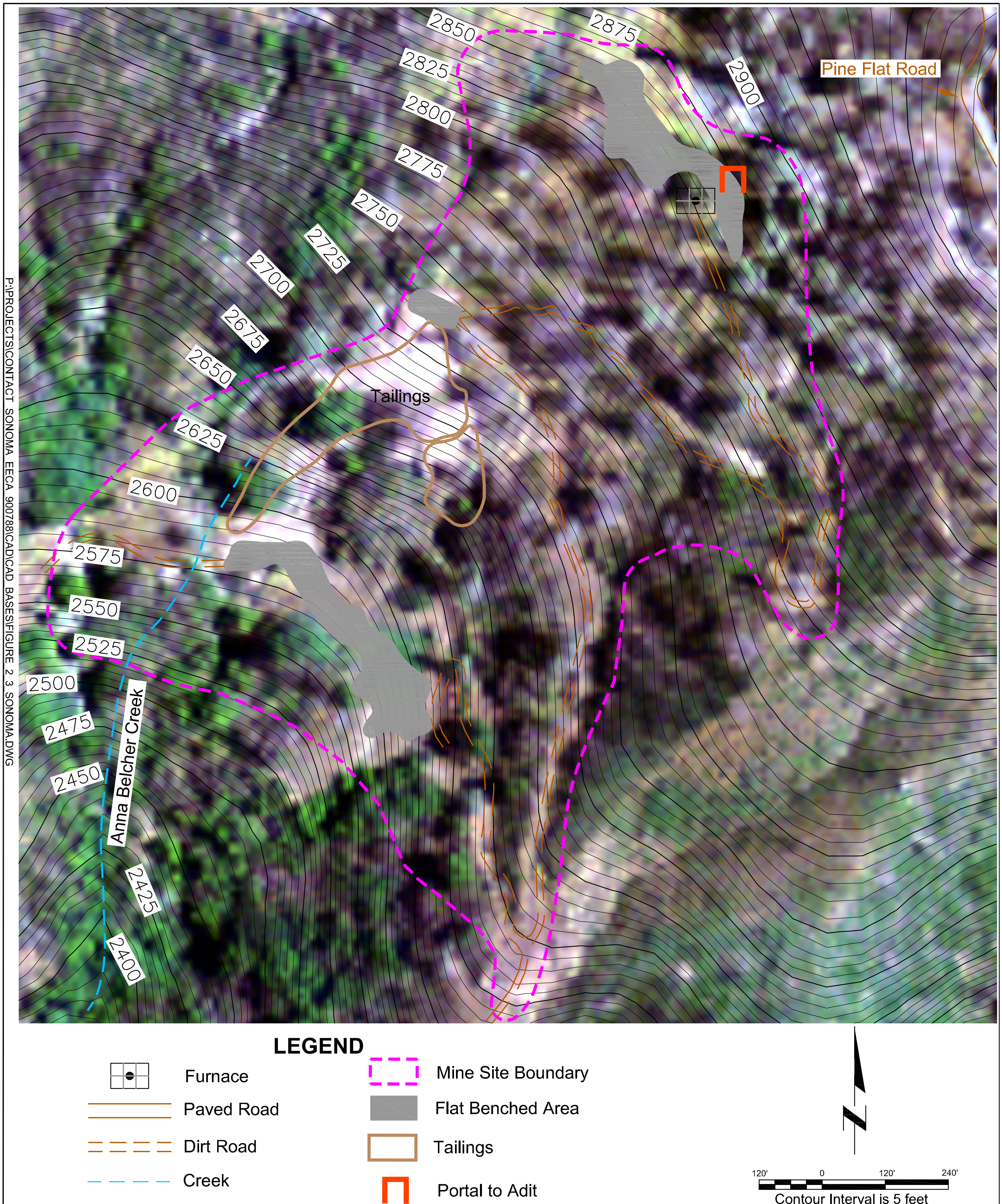
The Sonoma Mine site also has three prominent flats. All three flats contain processing equipment. The uppermost flat is approximately 237 by 64 feet and is located immediately south of a dirt access road that runs towards the east off of Pine

Flat Road. A blower system, screening device to separate cinnabar ore, and a condenser pipe are located on the uppermost flat. The equipment is believed to have been relocated here from a previous location.

The second flat lies to the south and at a lower elevation from the uppermost flat. The flat is approximately 315 by 115 feet in dimensions. The flat contains a 25-foot by 9-foot by 5-foot concrete cinder block furnace in addition to two inlet pipes that enter the furnace and two vertical pipes projecting from the top of the furnace.

The third flat is located to the southeast of the second flat and is approximately 105 feet by 47 feet. There is a large concrete pad, approximately 46 feet by 18 feet, on the third flat. The pad is reinforced with rebar and contains an 8.5-foot by 4.5-foot by 4.5-foot furnace. There are two inlet pipes and two outlet pipes connected to the furnace. The outlet pipes are connected to an 11-foot trough used to collect mercury. The trough is made of sheet metal framed on the sides with wood and is in two pieces. One piece of the trough is on the concrete pad, and the other is located several feet down the slope to the south.

A tailings pile is located directly southeast of the flat. The dimensions of the pile are approximately 100 feet east to west by 70 feet north to south. Part of the tailings pile is re-vegetated, so it is difficult to determine the exact size and volume of the tailings.



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Contact Mine

Sonoma County, California

Figure 2-2
Contact Mine
Site Features

ecology and environment, inc. International Specialists in the Environment	Project Number: 900788.0001.010 June 9, 2010	**Sonoma Mine** Sonoma County, California	**Figure 2-3 Sonoma Mine Site Features**

2.2.3 General Mining History

The Mayacmas Mountains were initially settled in the early 1860s in response to the draw of tourism to their hot springs. While conducting construction activities for road projects through the mountains between the hot springs resort and the town of Calistoga, cinnabar ore was discovered in the Mayacmas. Cinnabar is the ore from which mercury is derived.

Cinnabar is usually refined into mercury on mine premises due to the relatively simple refining process. The ore is heated until the mercury volatizes. The mercury vapor is then collected and cooled until it condenses into a liquid.

Mercury was particularly valuable in nineteenth-century California because it amalgamates with precious metals such as gold and silver. The liquid metal was used to process ore in the gold and silver mines of eastern California and Nevada (Bates and Jackson 1984).

Within a few of years of the initial discovery of cinnabar ore, numerous mine claims had been made in the area. The town of Pine Flat was founded less than a mile south of the Sonoma Mine (Pelanconi 1969).

2.2.4 Contact Mine Operational Status and History

The Contact Mine was discovered in the 1870's; however, no mercury was produced there until 1932. J.E. Grover submitted the first proof of labor document in 1929. Sixteen flasks (approximately 76 pounds per flask) of mercury were produced between 1933 and 1946. The Contact Mercury Mines Company took over operations from J.E. Grover and produced mercury at the mine between 1939 and 1942. The claims were held by numerous individuals and partners for the subsequent years. Approximately 1,000 flasks of mercury were produced from 1932 to1942. Mercury mining ceased from 1942 until 1956, when mining operations were resumed by Calida Mining Co. (U.S. Bureau of Mines 1965).

The mine workings, which are mostly caved, consist of a main inclined shaft, two adits, and a drain tunnel. Other site processes required equipment such as furnaces, separators, and other ore processing tools. The furnace used at the Contact Mine was a Luckhart furnace. Ore was fed into the inclined firebox and heated to drive off the mercury that was released from the other side of the firebox after it had sufficiently cooled to be safely discharged (Rytuba, et al. 2009).

2.2.5 Sonoma Mine Operational Status and History

The Sonoma Mine is a group of seven claims that were originally claimed by brothers Granville and Greenville Thompson in 1872. The brothers sold their claim to the Sonoma Quicksilver Mining Company in 1873 (Pelanconi 1969). It is reported that this company, headed by General George S. Dodge, mined and refined fifty flasks of mercury in 1873 (Raymond 1875). The ore was most likely refined at the Sonoma Mine.

By late 1875, the price of mercury had dropped significantly, and the Mayacmas Cinnabar Mining District had essentially shut down by 1878 (Pelanconi 1969). At the turn of the twentieth century, the price of mercury rose and the mine was reopened as part of the Crown Point Mine. In 1903, the California State Mining Bureau reported that two tunnels and a shaft had been opened in the mine for prospecting work (Aubury 1903).

In 1910, the Sonoma Mine was bought by the Culver-Baer Mine for its surface equipment. It is believed that this equipment may have included some or all of the following: an air compressor, gasoline engine, stoppers, jaw crusher, coarse ore furnace, fine ore furnace, and retort.

By 1918, the Sonoma Mine had been bought by a consortium headed by T. Gale Perkins. Perkins carried out systematic prospecting work that involved excavating nine adits (Bradley 1918).

In the following years, the Sonoma mine was operated by the Crown Point Company; however, there is no indication that mining took place on the property after 1918. The assumption that no further mining took place at the Sonoma Mine is substantiated by a report that the mine was idle as of 1926. At this time, the mine was owned by the New Sonoma Quicksilver Mining Company, although a state mining bulletin noted that there was unresolved litigation over the title to the claims (Root 1926).

2.2.6 Mercury Production Totals

It is estimated that the Contact and Sonoma Mines yielded between 8 and 20 pounds of quicksilver per ton of processed ore. Research from former operators' reports and data obtained from mine inventory reports show that up to 2,000 flasks of mercury were produced. The amount of waste rock produced as a result of cinnabar ore processing is estimated at approximately 30,000 cy.

2.3 Structures and Topography

2.3.1 Structures

As described in Section 2.2, both mines consist of a series of flats or benched levels situated on steep hillsides, and connected by a system of dirt roads. On these flats are remains of mine workings and associated structures, equipment, and debris. Some of the significant items include adits, dilapidated portals, brick furnaces, blowers, screening devices, concrete foundations, sheet metal, hoisting boom, ore carts and rails, piping, bins, and troughs. Refer to Section 2.2 and Figures 2-2 and 2-3 for a detailed description and depiction of the layout and location of these structural remains. There are no other identified structures on either mine site.

2.3.2 Topography

The Contact and Sonoma Mines are located entirely on BLM-administrated lands that are situated on the western slopes of the Mayacamas Mountains. Elevations range from 2,440 feet to 2,840 feet above sea level. The area surrounding the Contact and Sonoma Mines is characterized as containing moderately steep to steep slopes and summits with narrow valleys.

The Contact and Sonoma Mine parcels run in a northeast to southwest direction, and are crossed in several locations by county roads and dirt access roads. The Site is bisected by Pine Flat Road, a paved county road. Near Pine Flat Road, the ground is relatively level. To the east, the topography drops steeply to Anna Belcher Creek. The slopes west of Pine Flat Road are dominated by large outcrops of rock with mining pits and adits.

The Contact and Sonoma Mines are bordered by other mine sites, as well as creeks and tributaries. The Site is bordered by the Socrates Mine to the north, Crystal Mine to the west, Sulphur Creek to the east, and the Anna Belcher Creek to the south. An unnamed tributary of Anna Belcher Creek runs down the eastern boundary of the Sonoma Mine property. Partially washed out dams on this watercourse have created two ponds.

2.4 Geology and Soils

The mines lie within the Mayacmas Mountain range, a geologically active range that runs through portions of Mendocino, Sonoma, and Lake counties. The Contact and Sonoma Mine sites are located in the western part of the later-Pliocene to early Holocene Clear Lake volcanic field. The Clear Lake volcanic field is located within the San Andreas transform fault system. The volcanoes in the Clear Lake volcanic field are largely non-explosive. The latest eruptive activity continued until about 10,000 years ago. This activity formed maars and cinder cones along the shores of Clear Lake. A large silicic magma chamber provides the heat source for the Geysers, the world’s largest producing geothermal field (USGS 2009).

The mercury deposits at the Site are among the youngest mercury deposits in the Coast Range mineral belt. Generally, in both the eastern and western Mayacmas Mountains, the mercury deposits occur along contacts between serpentine and sedimentary rocks of the Franciscan group. The deposits are often pipe-like and occur in either silica-carbonate or sandstone. The ore bodies are associated with minor, northwesterly faults. The mines of the Pine Flat District are located in a silica-carbonate lens and contain native mercury and cinnabar.

The underground workings at the Site explored a north-dipping sheared contact between serpentine and sandstone containing local bodies of silica-carbonate rock. The silica-carbonate ore contains cinnabar. The sandstone ore contained disseminated native mercury in pores of carbonate veins and well-formed cinnabar crystals. Mercury ore was also found in serpentine (USGS 2008).

Soil at the site is primarily Maymen Los Gatos Complex with layers oriented at 30 to 70 percent slopes. The Site is located in a serpentine environment, which means that the soils are generally nutrient poor. Large chunks of green serpentine material are visible on the surface of the Site.

2.5 Hydrology and Hydrogeology

The Site is located in the Russian River watershed in the Big Sulphur Creek Sub-basin. Big Sulphur Creek drains 80 square miles of northeastern Sonoma County (Weston 2009a and 2009b). The sub-basin is bound on the east by the Mayacmas Mountain Range and the west by Alexander Valley. Elevations in the watershed range from up to 4,000 feet mean sea level (msl) along the border between Sonoma and Lake counties to approximately 400 feet msl at the confluence of Big Sulphur Creek and the Russian River. Major streams and tributaries within the sub-basin include Big Sulphur Creek, Little Sulphur Creek, Squaw Creek, Cobb Creek, Alder Creek, and Frasier Creek. Several tributaries to Little Sulphur Creek originate in the pine Flats Mining District. The headwaters of Anna Belcher Creek, which drains to Little Sulphur Creek, are located on the Site. Little Sulphur Creek is part of the Russian River Watershed.

A pond is located on the northern part of the Sonoma Mine site. The pond is present in the winter and spring months during the year. There are no thermal springs on the Sonoma Mine site. Mine tailings on the Sonoma site extend to Anna Belcher Creek, which drains to Little Sulphur Creek (Weston 2009b).

A seep originating from a collapsed adit is located on the southwestern part of the Contact Mine site. The seep sustains a marshy area for approximately 100 feet, and is seasonally connected to Anna Belcher Creek.

This mining region was discovered during development of the nearby hot springs resorts; however, there is no evidence of thermal springs on the Site.

2.6 Surrounding Land Use and Populations

The nearest city to the Site is Healdsburg, approximately 11 miles southwest. Healdsburg has a population of approximately 11,000. There are several thermal spring resorts within 5 to 10 miles northwest of the Site. The Site is bordered by several mines, including the Socrates Mine to the north and Crystal Mine to the west. Neither of these mines is currently in operation. There is no evidence that any mining or processing activities have taken place since the mid 1900s. The primary land use in the immediate vicinity of the Site is recreation. Spent shells, aluminum cans, and makeshift targets located at the Sonoma Mine indicate the area is used for target shooting.

2.7 Ecological Resources

2.7.1 Contact Mine

There are several plant communities surrounding the Contact Mine site. These include mixed chaparral, which contains coffeeberry (*Rhamnus tomentella*) , buckbrush (*Ceanothus cuneatus*), gray pine (*Arceuthobium occidentale*), chamise

(*Adenostoma fasciculatum)*, scrub oak (*Quercus berberidifolia)*, yerba santa (*Eriodictyon spp.)*, and wild oat (*Avena fatua*), as well as a meadow seep community which contains rush (*Juncus spp.)*, thistle (*Cirsium spp.)*, seep spring monkey flower (*Mimulus guttatus*), mint (*Mentha spp.*), ferns, and horsetail (*Equisetum spp.*). Additionally, mixed hardwood trees including black oak (*Quercus kelloggii)* and bay laurel (*Laurus nobilis)* exist on site. Wildlife signs documented at the site include deer (*Odocoileus hemionus*) tracks and scat and coyote (*Canis latrans*) scat (Weston 2009a).

2.7.2 Sonoma Mine Site

The dominant plant community surrounding the Sonoma mine site is mixed chaparral, which contains coffeeberry (*Rhamnus tomentella)*, buckbrush (*Ceanothus cuneatus*), toyon, mountain mahogany (*Cercocarpus spp.*), alder (*Alnus spp.*), gray pine (*Arceuthobium occidentale)*, bay laurel (*Laurus nobilis*), chamise (*Adenostoma fasciculatum*), scrub oak (*Quercus berberidifolia)*, yerba santa (*Eriodictyon spp)*, knobcone pine (*Arceuthobium siskiyouense)*, Manzanita (*Arctostaphylos spp.)*, spicebrush (*Lindera spp.)*, French broom (*Genista monspessulana)*, blackberry (*Rubus spp.)*, fir (*Ephedra spp.)*, poison oak (*Toxicodendron diversilobum)*, yellow starthistle (*Centaurea solstitialis*), native bunchgrass, and various annual grasses. Wildlife signs documented at the site include scat from foxes (*Urocyon cinereoargenteus*), deer (*Odocoileus hemionus)*, and coyotes (*Canis latrans)*, deer tracks and songbird calls (Weston 2009b).

2.8 Sensitive Species and Environments

The California Natural Diversity Database indicates that five sensitive species are located within two miles of the Contact and Sonoma mine sites. These include the endangered plant Geysers Dichanthelium (*Dichanthelium acuminatum)*, the sensitive plants Cobb Mountain Lupine (*Lupinus sericatus*) and Socrates Mine jewelflower (*Streptanthus brachiatus)*, the sensitive species Foothill yellow-legged frog (*Rana boylii)*, and the state sensitive candidate species Purple Martin (*Progne subis*). No sensitive species have been recorded on either the Contact or Sonoma mine sites (Weston 2009a, 2009b).

2.9 Meteorology

The climate in the area of the Site is characterized by moderate temperatures and precipitation. Sonoma County has a great degree of climatic variation and often has very different microclimates. Key factors that contribute to the differences include proximity to the ocean, elevation, and topography. As the nearest town to the Site, Healdsburg climate data is used in this section to describe the general observed temperatures and precipitation.

Average annual precipitation is 41 inches and occurs mainly from November to March each year. The nearby city of Healdsburg receives an average of less than one inch of snow per year; however, the Mayacmas Mountains receive more snow at higher elevations.

Regional weather patterns contribute to high diurnal temperature fluctuations in the area of the Site. In summer, daily high temperatures in Healdsburg are typically in the higher 80s to about 90 degrees Fahrenheit and lows are near 50 degrees Fahrenheit. In the winter, daily high temperatures range from the high 50s to mid 60 degrees Fahrenheit and low temperatures hover around 40 degrees Fahrenheit.

Wind is generally from the south-southwest; however, winds from the north and east are common in the winter and spring months. Wind speeds average 1.3 mph annually. Maximum wind speeds are as high as 18 mph and maximum gusts are recorded up to 31 mph. The higher wind speeds usually occur February through May.

Table 2.1-1 presents the data recorded from the period between 1931 and 2005, including average air temperature, precipitation, and wind speed at a North Healdsburg, California station, approximately -- 11 miles southwest of the Site. The Site is approximately 2,000 feet higher in elevation than the town of Healdsburg. The data in the table was obtained from the Western Regional Climate Center website (WRCC 2010).

Table 2.1-1 Meteorology for the Healdsburg Vicinity

Month	Average air temperature (°F)	Average total precipitation (inches)	Average wind speeds (mph)	Wind direction
Jan	46.5	8.92	0.6	SSW
Feb	47.4	7.40	1.2	S
Mar	51.6	5.55	2.1	SW
Apr	55.9	2.59	2.5	SW
May	62.3	1.11	1.8	SSW
Jun	64.8	0.31	0.8	SSW
Jul	66.7	0.04	1.4	SSW
Aug	67.5	0.13	1.3	SSW
Sep	67.3	0.38	1.2	SSW
Oct	58.7	2.23	1.3	SSW
Nov	50.5	5.33	0.8	SSW
Dec	44.0	8.21	0.4	S

2.10 Previous Investigations

2.10.1 Environmental Impact of the Contact and Sonoma Mercury Mines of Water, Sediment and Biota, of the Anna Belcher and Little Sulfur Creek Watersheds, Sonoma County California - 2001 through 2003

On April 20, 2001, June 19, 2001, July 31, 2002, and April 1, 2003, the United States Geological Survey (USGS) conducted field sampling at the Contact and

Sonoma Mines to assess the concentration of mercury and other inorganic elements in tailings and waste rock piles on-site. Water and sediment samples were collected from mine drainage and iron oxyhydroxide (FeOOH) precipitates at the Contact and Sonoma mines and in the Anna Belcher Creek and Little Sulphur Creek. Sampling was conducted during four separate field events in order to collect samples representative of conditions encountered during both storm events and low flow conditions. Mine tailings and waste rock samples were collected from the waste rock and tailing piles. Sediment samples were collected from mine drainages and creeks and water samples were collected from mine drainage, streams, and the Contact Pond. (Rytuba, et al. 2009).

Sediment samples were collected from the area of Anna Belcher Creek, Contact Mine Pond and Little Sulphur Creek. Samples were also collected from Contact and Sonoma Mine ore and tailings. Samples consisting of 100 to 500 grams of mine tailings and waste rock were collected from waste-rock and tailings piles at the Contact and Sonoma Mine site. Sample results can be found in Section 3.5.2.

2.10.2 National Register Eligibility Evaluation of Selected Features of the Sonoma Mine – August 2001

LSA Associates, Inc. conducted a National Register of Historic Places evaluation of several mining-related features of the Sonoma Mine. The study was prepared for the Santa Rosa Geysers Recharge Project. Research on the Sonoma Mine history was discussed. Ore extraction remains and associated structures and equipment related to mining and ore processing were listed. A possible habitation area was described. The study concluded that only a small portion of archaeological remains of the Sonoma Mine fell within the project area. The remains consisted of various open pits. Study of these pits did not appear to present any historical archaeological information. Therefore, it was LSA Associates, Inc. opinion that the pits did not meet the National Register of Historic Places significance criteria. It is important to note that this evaluation only addressed features found inside the Santa Rosa Geysers Recharge Project. The majority of the remains at the Sonoma Mine lie outside of this area. This study did not determine the eligibility of these features for the National Register of Historic Places.

2.10.3 Cultural Resource Inventory Reports for the Contact and Sonoma Mines – October 2008

In October 2008, the BLM conducted a cultural resources survey of both the Contact Mine and the Sonoma Mine. The purpose of the reports was to determine the presence of any cultural significance the Contact and Sonoma Mines or their components might pose. The report included detailed descriptions of the Site features and layout of the mines. The cultural resources recorded during the 2008 BLM survey were evaluated for their eligibility for inclusion on the National Register of Historic Places. The mining complexes were evaluated using criteria found on the National Historic Preservation Act of 1966 and the Code of Regulations, Title 36, Part 60. According to the BLM, neither the Contact Mine nor the Sonoma Mine meet any of the criteria for inclusion in the National Register of

Historic Places, and therefore, are not eligible for nomination (BLM 2008b, 2008c).

2.10.4 Contact and Sonoma Mercury Mines Removal Site Investigations - March 2009

Removal Site Investigations (RSI) were conducted by Weston Solutions, Inc. in March 2009 for both the Contact Mine and the Sonoma Mine. The RSI reports summarized sample data collected by USGS and Biological/Botanical Resources Inventory Report and Cultural Resources Inventory Report developed by BLM to assess the potential threat to human health and the environment and to determine if there is a need for further action. Conclusions from these investigations determined that removal actions are necessary based on the following factors:

- Actual or potential exposure to nearby human populations, animals, or the food chain from hazardous substances or pollutants or contaminants;
- Actual or potential contamination of drinking water supplies or sensitive ecosystems;
- High levels of hazardous substances or pollutants or contaminants in soils largely at or near the surface that may migrate; and
- Weather conditions that may cause hazardous substances or pollutants to migrate or be released.

Based on these factors, it was determined by Weston Solutions, Inc. that removal actions are necessary at both sites to prevent human and ecological exposure to high levels of mercury, to prevent accumulation of mercury in the food chain and to prevent the continued migration into the Russian River watershed.

2.10.5 E & E Site Characterization Sampling Event 2010

From April 23 – May 16, 2010, the BLM conducted a sampling event at the Contact and Sonoma mines. The objective of this field sampling approach was to address the requirements of the anticipated removal action design. The objectives of the field sampling event were to fill in the following data gaps:

- Presence and concentration of inorganic elements (in addition to mercury, which was previously assessed) in tailings/waste rock, especially arsenic, chromium copper, and nickel, which are known to occur in this region and which have the potential to contribute to human health and ecological risk if present.
- Presence and concentration of inorganic elements near the furnace area; this site has not been previously characterized
- Verify presence and concentration of inorganic elements in the tailings/ waste rock piles; this area was previously sampled, but sample locations are not well documented.
- Volume of tailings/waste rock.
- Presence and concentration of site related contaminants in groundwater.
- Characterization of background soil concentrations of inorganic elements.
- Geotechnical properties of tailings and waste rock for use in evaluating remedial alternatives.
- Detailed topographical mapping.

A summary and results of the E & E site characterization sampling event are presented in Section 3 of this report.

3 Source, Nature, and Extent of Contamination

3.1 Location of Contaminated Materials

Potential sources of mercury contamination at the Site consist of adits, mine tailings piles, and other areas where mining operations occurred such as the furnace areas. The materials contaminated at the site include mine tailings, as well as sediment present within the headwaters of Anna Belcher Creek.

Environmental concerns related to mining and processing of silica-carbonate mercury deposits consist of mercury contamination of soil and water from mine waste rock and tailings, mercury vapors released during ore processing, and acid mine drainage and toxic metal release into watersheds.

Mercury mine wastes include waste rock, low-grade ore, mine tailings, condenser soot, and cyclone dust. In addition to mercury, silica carbonate mercury deposits commonly have elevated concentrations of antimony, arsenic, nickel, cobalt, thallium, and zinc. Copper is usually low, and lead is usually absent in these deposits (Rytuba 2002).

Mercury released into water bodies may become methylated. Methyl-mercury may become highly concentrated throughout biomagnifications in fish and animals that consume fish (Rytuba 1986).

For the purposes of this study, "contaminated materials" are defined as materials with mercury levels above the most conservative criteria established in the site-specific risk assessment. Although other Target Analyte List (TAL) metals were detected at elevated levels in samples collected from the Site, mercury is the driver for the remediation at the Site. Because areas contaminated by other TAL metals are also contaminated by mercury, any alternative that addresses the mercury contamination will also address other metal contamination.

3.2 Volume of Contaminated Materials

The Contact and Sonoma Mines collectively contain approximately 40,000 cubic yards of mercury-bearing waste material. The identified total area of the mine sites is approximately 23 acres.

The data obtained from the 10 meter USGS topographic survey were used in conjunction with other available horizontal or vertical data, such as soil boring and field surface observations, for the calculation of volume of contaminated materials on site. Visual interpretation of aerial photographs and notes from the site visit were used to approximate the horizontal extent of contamination as well. The depth of mercury contamination was approximated using the results of the E & E characterization investigations including soil boring diagrams and site visit observation notes.

Table 3.2-1 presents descriptions of the contaminated areas, their volumes, and the data used to estimate volumes, i.e., surface areas (horizontal extents), depths (vertical extents), and mercury concentrations.

Table 3.2-1 Volumes of Contaminated Material at the Contact and Sonoma Mines

Contaminated Area		Horizontal Extents (square feet)	Vertical Extents (feet)	Volume (cubic yards)	Mercury Concentration Maximum (mg/kg)
Contact Mine	upper flat (main)	8,898	22	7,000	300
	upper flat (south)	3,016	0.5	100	120
	middle flat	12,285	0.5	200	180
	northwest tailings (large)	13,978	5	2,500	90
	southeast tailings (small)	3,977	5	700	89
	lower flat	10,234	21.5	8,000	45
Sonoma Mine	upper flat	10,047	28	10,500	200
	middle flat	15,036	8	4,500	240
	lower flat (including retort areas)	5,111	3.5 – 5	1,000	4,100
	tailings	19,960	5	3,500	140
	cut area/water course	9,906	2.5	900	110
TOTAL		**112,448**	**-**	**38,900**	

An aerial topographic survey has been performed on the Site; however, at the time of this Draft EE/CA, the resulting topography was not available. Once detailed topography is available for the Site, these volume estimates will be refined and presented in the Final EE/CA.

3.3 Physical and Chemical Attributes

The following sections describe the physical and chemical attributes of the Contact and Sonoma Mercury Mine sites. The sections include data from previous studies and from the E & E site characterization sampling event conducted in 2010. While both mine locations are combined under the ultimate remediation goals of the EE/CA, for clarity purposes, environmental media in the Contact and Sonoma Mines are described separately in Sections 3.3.2 and 3.3.3, respectively.

Previous environmental sampling at the Site was performed by USGS in 2001 through 2003 under a study to assess the environmental impact of the Contact and Sonoma Mines to environmental media in the Anna Belcher Creek watershed. USGS personnel collected mine waste, sediment, surface water, and biota samples for mercury, methyl mercury, and metals analyses. Results of USGS field sampling and laboratory analysis are documented in USGS Open File Report 2008-1381 (USGS 2008) and are summarized in the RSI reports for both Contact and Sonoma Mines prepared by Weston Solutions, Inc. (Weston 2009). The RSI reports are available in Appendix A.

In 2010, E & E performed site characterization field studies at both the Contact and Sonoma Mines. During their time on site, field crews collected samples from environmental media including mine waste, surface soils, subsurface soils, and groundwater. These samples were analyzed for an array of metals, but focusing on mercury and methyl mercury. Tables 3.3-1 through 3.3-4 contain summaries of the results; however, complete laboratory results are provided in Appendix B. In addition to the chemical characterization, E & E personnel collected physical characterization data through observations of well and soil borings, measurements of waste material piles, and general visual interpretations of the size and location for sources of contamination on the Site. Refer to Figures 3-1 and 3-2 for the approximate layout of site features and sample locations at Contact Mine and Sonoma Mine, respectively. Complete field notes and boring logs are provided in Appendix C. Photographs taken during the field investigation are provided in Appendix D.

The following sections include a summary discussion of the physical and chemical attributes of media at the Site, compiled from findings of previous studies as well as the investigations performed under tasks in the EE/CA.

3.3.1 Background and Baseline

Background Surface Soil

During the 2010 sampling event, three background surface soil samples were collected from 0 to 6 inches below ground surface (bgs) for the Contact and Sonoma Mine Sites. Background surface soil sample 01CSBG was collected on a former service road that connected the Sonoma and Contact Mine and was located approximately 0.20 miles from the Contact Mine Site and 0.25 miles from the Sonoma Mine. Background surface soil sample 03CSBG was collected approximately 0.020 miles east of the Contact site. Field screening with an X-ray Fluorescence (XRF) indicated a mercury concentration of non-detect. Background surface soil sample 02CSBG was located approximately 50 feet south east of monitoring well 09SMMW. These samples were submitted to TestAmerica Laboratories, Inc. and analyzed for TAL metals (no mercury) and low-level mercury. In total, the three background samples contained nineteen TAL metals. The sample from an abandoned road between the two sites (01CSBG) contained 6 milligram per kilogram (mg/kg) mercury; the sample from east of Contact Mine (03CSBG) contained 0.11 mg/kg mercury; and the sample southeast of monitoring well 09SMMW contained 30.5 mg/kg mercury. See the results for the background samples in Table 3.3-1.

Background Subsurface Soil
No background or baseline subsurface soil samples have been taken for comparison to site characterization findings.

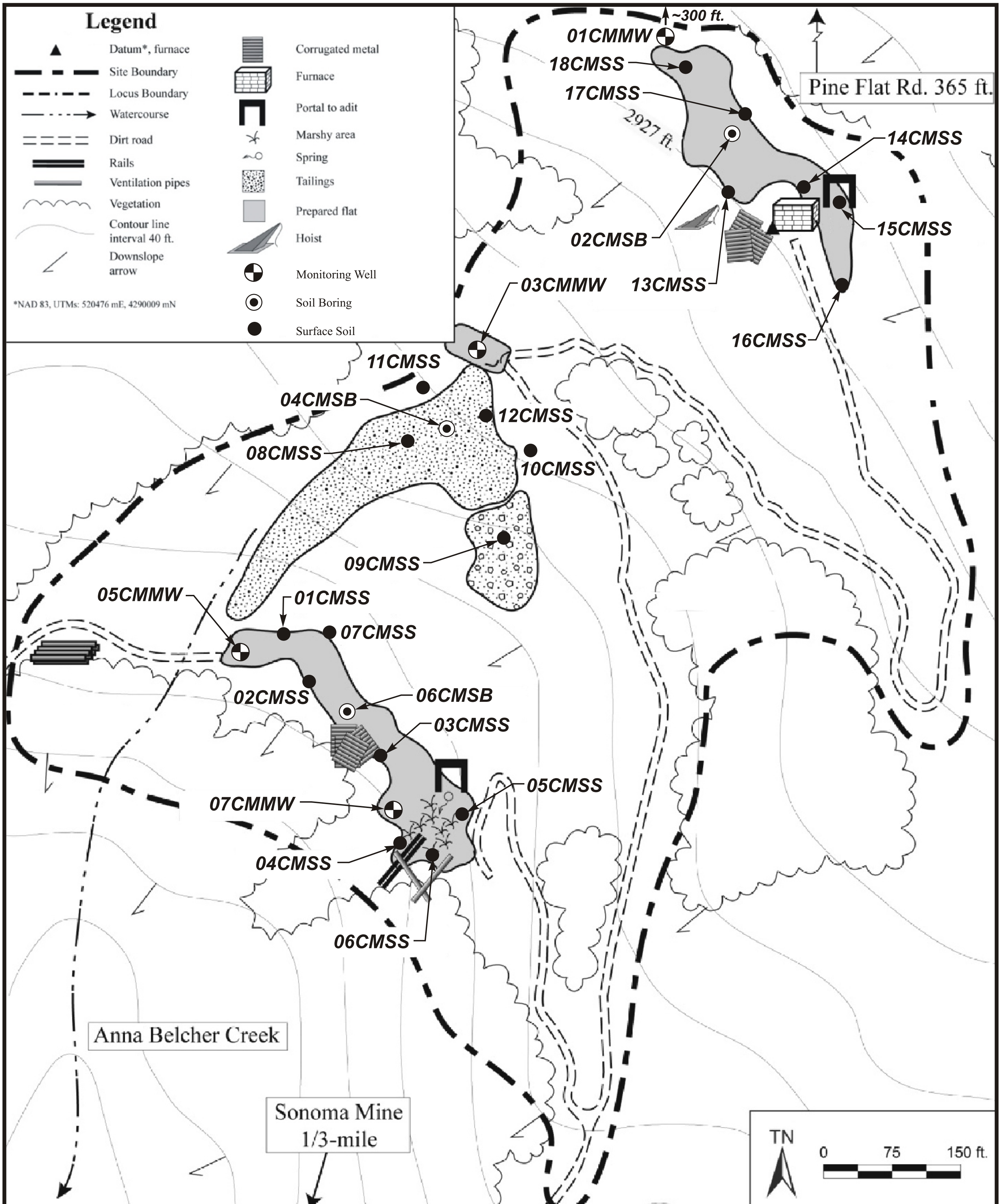
Background Groundwater
No background or baseline groundwater samples have been taken for comparison to site characterization findings.

Background Sediment
Background sediment samples were taken under the USGS 2001 environmental impact assessment. A sediment sample was taken approximately one mile upstream of the confluence of Little Sulphur Creek and Anna Belcher Creek. The mercury concentration in this sample was 0.43 mg/kg. This background sample was used as a baseline comparison to sediment samples taken at both the Contact and Sonoma Mines. A summary of the USGS findings on sediment samples is included in the Contact and Sonoma RSI reports provided in Appendix A.

Background Surface Water
Background surface water samples were taken under the USGS 2001 environmental assessment. The background sample was taken upstream of the Sonoma Mine; however, it was downstream of the lowest tailings at the Contact Mine. While this background surface water sample does not represent true background conditions because it is located inside the Site, results are presented here for reference. The mercury concentration of the surface water sample was 0.104 microgram per liter (µg/L). The headwaters of Anna Belcher Creek originated within the Contact Mine boundary. Therefore, no other background samples were taken upstream of the Contact Mine.

Background Biota
Background biota samples were taken under the USGS 2001 through 2003 environmental assessment. Fish, water strider, and other invertebrate background samples were taken in Bear River at Highway 20 for use in comparing samples taken at or near the Contact and Sonoma Mines. A summary of these samples is included in the Contact and Sonoma RSI reports provided in Appendix A.

Background Air
No background or baseline air samples have been taken for comparison to site characterization findings.



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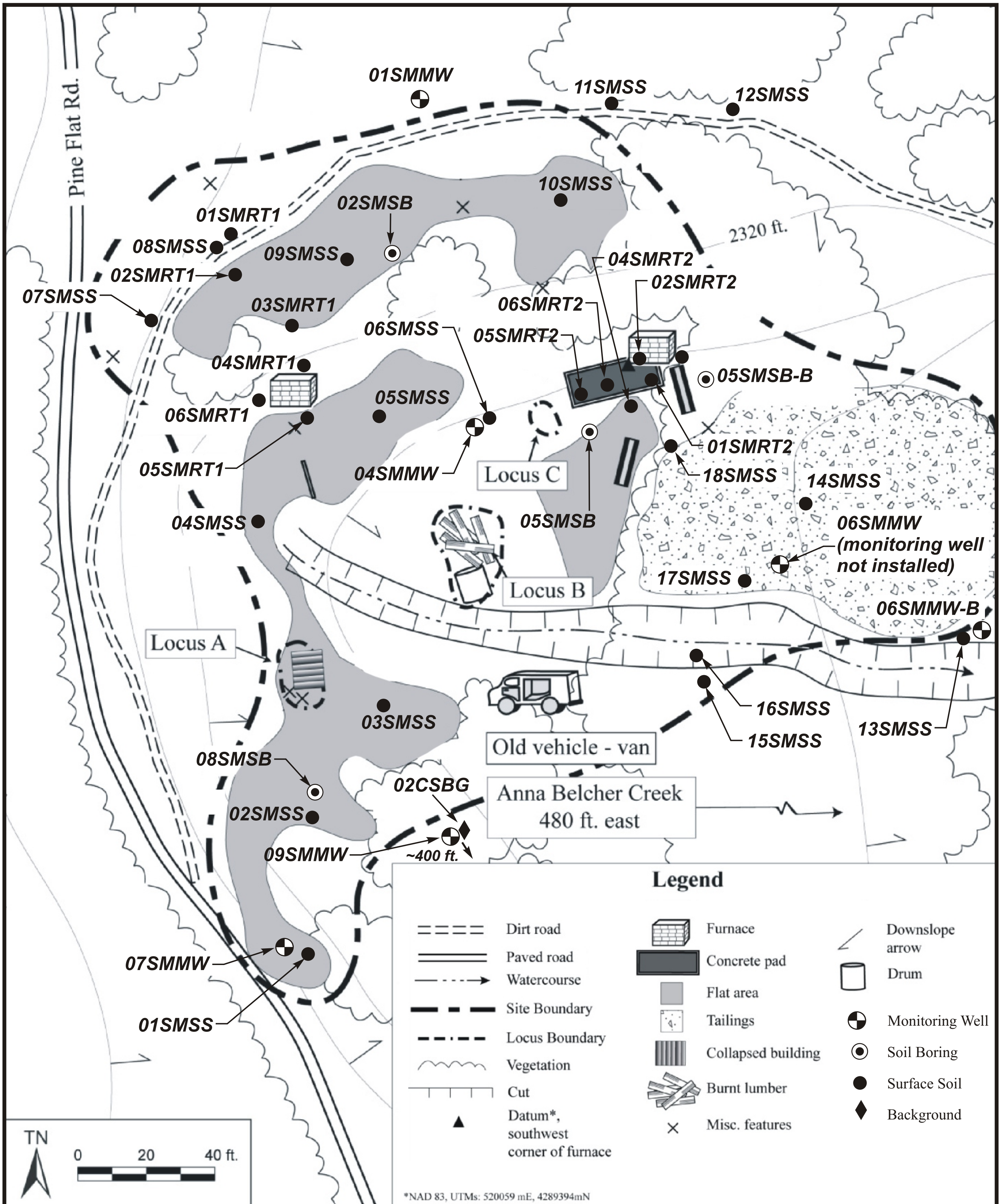
CONTACT MERCURY MINE Sonoma County, California	Figure 3-1 SURFACE SOIL SAMPLE, SOIL BORING, AND MONITORING WELL LOCATIONS		
Source: State of California Department of Parks and Recreation, 2008.	Date: 6-3-10	Drawn by: AES	10:001096OX7501\fig 3-1



ecology and environment, inc. International Specialists in the Environment Seattle, Washington	SONOMA MERCURY MINE Sonoma County, California	Figure 3-2 PROPOSED SOIL BORING/MONITORING WELL LOCATION DIAGRAM		
	Source: State of California Department of Parks and Recreation, 2008.	Date: 6-4-10	Drawn by: AES	10:001096OX7501\fig 3-2

Sample ID	Date	Time	Description	Depth (ft BGS)	Aluminum (mg/kg)	Antimony (mg/kg)	Arsenic (mg/kg)	Barium (mg/kg)	Beryllium (mg/kg)	Cadmium (mg/kg)	Calcium (mg/kg)	Chromium (mg/kg)	Cobalt (mg/kg)	Copper (mg/kg)	Iron (mg/kg)	Lead (mg/kg)	Magnesium (mg/kg)	Manganese (mg/kg)	Mercury (mg/kg)	Nickel (mg/kg)	Potassium (mg/kg)	Selenium (mg/kg)	Silver (mg/kg)	Sodium (mg/kg)	Thallium (mg/kg)	Vanadium (mg/kg)	Zinc (mg/kg)
	Sample				TAL Metals and Mercury in Surface Soils																						
	Ecological Risk Criteria																		30.5								
	Human Health Risk Criteria																		250								
	EPA SL-H				77000	31	0.39	15000	160	70	-	120000	23	3100	55000	400	-	1800	5.6	1500	-	390	390	-	2	390	23000
BACKGROUND SURFACE SOIL SAMPLES																											
01CS-BG	5/8/2010	1700	Surface Soil	0-0.5'	13000	0.51	7.2	180	0.49	0.19 U	2800	44	12	26	27000	9.7	6900	420	6	59	1700	0.53	0.19 U	95 U	0.38 U	38	58
02CS-BG	5/14/2010	1515	Surface Soil	0-0.5'	14000	0.47	6.9	230	0.48	0.19 U	3000	130	25	36	32000	12	17000	640	**30.5**	250	1300	0.74	0.19 U	93 U	0.37 U	45	59
03CS-BG	5/16/2010	1510	Surface Soil	0-0.5'	20000	0.62	8.3	240	0.78	0.21 U	2000	160	26	46	39000	12	19000	860	0.11	240	900	0.51 U	0.21 U	100 U	0.41 U	64	71
FLAT AND TAILINGS SURFACE SOIL SAMPLES																											
CONTACT																											
01CM-SS	5/11/2010	1330	Surface Soil	0-0.5'	18000	0.79	5.4	270	0.47	0.2 U	10000	240	31	27	38000	9.4	44000	640	6.3 J	430	1300	0.51 U	0.2 U	100 U	0.41 U	53	59
02CM-SS	5/11/2010	1340	Surface Soil	0-0.5'	19000	0.88	5.6	240	0.45	0.21 U	14000	340	39	27	42000	9.9	58000	690	10 J	580	1100	0.55	0.21 U	100 U	0.41 U	59	52
03CM-SS	5/11/2010	1350	Surface Soil	0-0.5'	20000	3.9	8.2	1100	1.1	19	16000	170	29	130	46000	600	21000	1100	1.4 J	240	2400	1.6	0.3	330	0.5 U	70	8500
04CM-SS	5/11/2010	1355	Surface Soil	0-0.5'	18000	0.79	6.4	210	0.47	0.22 U	5900	340	42	29	42000	11	45000	740	11 J	620	1200	0.67	0.22 U	110 U	0.44 U	56	72
05CM-SS	5/11/2010	1402	Surface Soil	0-0.5'	14000	0.41	8.4	240	0.45	0.28	6200	110	19	43	32000	8	17000	800	1.2 J	130	880	0.56 U	0.22 U	110 U	0.45 U	64	100
06CM-SS	5/11/2010	1410	Surface Soil	0-0.5'	15000	0.67	9.3	340	0.59	0.35	11000	90	26	50	36000	43	23000	810	24 J	210	1900	0.8 U	0.32 U	160 U	0.64 U	55	100
07CM-SS	5/11/2010	1420	Surface Soil	0-0.5'	19000	1	6.2	330	0.59	1.8	13000	270	35	39	41000	49	48000	710	5.9 J	480	1500	0.62	0.2 U	110	0.4 U	57	970
08CM-SS	5/11/2010	1450	Surface Soil	0-0.5'	7800	0.55	2.5	150	0.23 U	0.23 U	16000	700	73	16	46000	10	110000	800	27 J	1300	400	0.57 U	0.23 U	110 U	0.46 U	38	51
09CM-SS	5/11/2010	1455	Surface Soil	0-0.5'	22000	0.76	6.5	340	0.51	0.21 U	18000	370	43	29	46000	8.6	59000	720	1.9 J	660	1300	1	0.21 U	110 U	0.42 U	67	65
10CM-SS	5/11/2010	1500	Surface Soil	0-0.5'	1500	0.054	0.58	21	0.042	0.022 U	420	17	2.9	2.8	3300	1.2	2000	64	**89 J**	31	140	0.055 U	0.022 U	11 U	0.044 U	4.4	8.2
11CM-SS	5/11/2010	1510	Surface Soil	0-0.5'	1700	0.067	0.7	17	0.044	0.021 U	370	39	5.7	3.4	4300	1.5	5700	79	**90 J**	78	92	0.053 U	0.021 U	11 U	0.043 U	5.3	7
12CM-SS	5/11/2010	1530	Surface Soil	0-0.5'	1200	0.041	0.46	10	0.034	0.021 U	210	34	4.2	2.3	3600	1.1	5500	60	**180 J**	63	76	0.053 U	0.021 U	11 U	0.042 U	3.8	6.7
13CM-SS	5/11/2010	1705	Surface Soil	0-0.5'	7600	0.26	4.5	120	0.32	0.23 U	2000	570	73	20	46000	15	63000	770	**120**	1200	1000	0.56 U	0.23 U	110 U	0.45 U	33	66
14CM-SS	5/11/2010	1710	Surface Soil	0-0.5'	19000	2	6.4	160	0.49	0.77	5400	430	41	37	42000	48	51000	670	**34**	550	1000	0.55 U	0.22 U	110 U	0.44 U	58	480
15CM-SS	5/11/2010	1720	Surface Soil	0-0.5'	19000	0.27	5.3	110	0.39	0.21 U	13000	490	54	35	45000	7.3	98000	700	3.3	870	780	0.52 U	0.21 U	100 U	0.42 U	55	60
16CM-SS	5/11/2010	1730	Surface Soil	0-0.5'	24000	0.27	6.6	120	0.66	0.2 U	5000	310	45	31	44000	10	58000	780	5.1	670	810	0.5 U	0.2 U	99 U	0.4 U	57	69
17CM-SS	5/11/2010	1738	Surface Soil	0-0.5'	21000	0.35	6	180	0.48	0.26 U	6100	400	45	36	42000	11	73000	760	2.2	660	1200	0.66 U	0.26 U	130 U	0.53 U	58	70
18CM-SS	5/11/2010	1745	Surface Soil	0-0.5'	23000	0.57	10	150	0.62	0.21 U	5000	200	27	46	42000	13	31000	660	0.11	270	1400	0.52 U	0.21 U	100 U	0.42 U	59	87
SONOMA																											
01SM-SS	5/9/2010	0751'	Surface Soil	0-0.5'	13000	1.1	16	1800	0.48	0.37	11000	99	30	170	59000	39	14000	7400	11	310	2900	0.82	0.22 U	150	0.45 U	150	200
02SM-SS	5/9/2010	0800'	Surface Soil	0-0.5'	11000	1.4	10	330	0.57	0.24	2900	150	52	58	52000	31	15000	1500	**49**	730	1500	0.63	0.23 U	110 U	0.45 U	59	100
03SM-SS	5/9/2010	0815'	Surface Soil	0-0.5'	9300	1.3	7.5	130	0.45	0.21 U	1300	250	73	32	53000	120	39000	850	14	1300	1200	0.71	0.21 U	100 U	0.42 U	43	70
04SM-SS	5/9/2010	0830'	Surface Soil	0-0.5'	9200	0.72	8.4	170	0.53	0.21	2100	250	67	49	56000	24	33000	940	21	1200	920	0.53 U	0.21 U	110 U	0.43 U	46	110
05SM-SS	5/9/2010	0840'	Surface Soil	0-0.5'	12000	0.34	8	230	0.47	0.22 U	1300	270	58	37	47000	12	57000	840	**42**	950	720	0.55 U	0.22 U	110 U	0.44 U	43	69
06SM-SS	5/9/2010	0846'	Surface Soil	0-0.5'	16000	0.46	7.9	310	0.58	0.2 U	1900	330	69	51	57000	24	39000	1400	**130**	1200	910	0.51 U	0.2 U	100 U	0.41 U	55	90
07SM-SS	5/9/2010	0910'	Surface Soil	0-0.5'	8100	1.2	8.6	130	0.56	0.2 U	960	250	97	38	69000	25	40000	1000	24	1800	820	0.51 U	0.2 U	100 U	0.41 U	41	73
08SM-SS	5/9/2010	0925'	Surface Soil	0-0.5'	12000	0.43	7.2	210	0.43	0.2 U	1700	180	53	33	45000	26	42000	720	28	850	1000	0.51 U	0.2 U	100 U	0.41 U	40	72
09SM-SS	5/9/2010	0935'	Surface Soil	0-0.5'	14000	0.42	7.2	250	0.43	0.31	2400	310	56	37	46000	40	37000	870	**180**	930	750	0.51 U	0.21 U	100 U	0.41 U	54	68
10SM-SS	5/9/2010	1005	Surface Soil	0-0.5'	12000	0.86	7.6	240	0.45	0.17 U	1600	300	62	32	43000	22	37000	1200	**200**	830	950	0.43 U	0.17 U	86 U	0.35 U	45	58
11SM-SS	5/9/2010	1011	Surface Soil	0-0.5'	63 J	0.2 U	0.2 U	13	0.2 U	0.2 U	140	0.53 J	0.32 J	2.2 J	79	1.3	180 J	35 J	**45**	2.8 J	180	0.5 U	0.2 U	100 U	0.4 U	0.2 UJ	2.9 J
12SM-SS	5/9/2010	1025	Surface Soil	0-0.5'	220 J	0.22 U	0.22 U	7.4	0.22 U	0.22 U	110 U	0.56 J	0.31 J	1.5 J	190	0.94	170 J	12 J	**50**	2.3 J	130	0.55 U	0.22 U	110 U	0.44 U	0.45 J	2 J
13SM-SS	5/10/2010	0815'	Surface Soil	0-0.5'	11000 J	0.34	8.8	210	0.51	0.2 U	1100	320 J	82 J	29 J	50000	29	18000 J	980 J	**140**	1100 J	1200	0.5 U	0.2 U	99 U	0.4 U	46 J	57 J
14SM-SS	5/10/2010	0830'	Surface Soil	0-0.5'	12000 J	0.26	5.4	120	0.35	0.23 U	800	470 J	130 J	15 J	65000	5	16000 J	1000 J	**64**	1900 J	1100	0.92	0.23 U	110 U	0.45 U	43 J	44 J
15SM-SS	5/10/2010	0845'	Surface Soil	0-0.5'	16000 J	0.42	14	190	0.59	0.2 U	2200	120 J	27 J	41 J	41000	20	13000 J	610 J	3.4	290 J	1700	0.51 U	0.2 U	100U	0.41 U	54 J	97 J
16SM-SS	5/10/2010	0855'	Surface Soil	0-0.5'	12000 J	0.81	-	130	0.37	0.22 U	630	460	140	13	76000	5.2	20000 J	1000 J	**110**	2200 J	960	0.81	0.22 U	110 U	0.44 U	39	48
17SM-SS	5/10/2010	0905'	Surface Soil	0-0.5'	11000 J	0.79	-	130	0.33	0.21 U	670	540	160	14	76000	7.6	9200 J	1200 J	18	1900 J	1200	0.53 U	0.21 U	110	0.42 U	37	46
18SM-SS	5/10/2010	0915'	Surface Soil	0-0.5'	16000	0.48	10	250	0.6	0.21 U	2500	100	26	48	40000	24	11000	670	21	260	1600	0.53 U	0.21 U	110 U	0.43 U	44	100
RETORT SURFACE SOIL SAMPLES																											
RETORT 1																											
01SM-RT1	5/9/2010	1305	Surface Soil	0-0.5'	12000 J	0.27	7.9	190	0.41	0.21 U	1800	240 J	61 J	28 J	46000	24	44000 J	800 J	**73**	1000 J	1100	0.53 U	0.21 U	110 U	0.43 U	44 J	62 J
02SM-RT1	5/9/2010	1315	Surface Soil	0-0.5'	2300	0.23 U	0.7	47	0.23 U	0.23 U	550	390	110	4.5	47000	3.8	200000	760	2.6	1900	250	0.57 U	0.23 U	110 U	0.46 U	13	26
03SM-RT1	5/9/2010	1330	Surface Soil	0-0.5'	10000	0.51	5.9	200	0.3	0.2 U	4200	280	73	25	58000	15	100000	760	**160**	1300	1100	0.49 U	0.2 U	98 U	0.39 U	35	55
04SM-RT1	5/9/2010	1345	Surface Soil	0-0.5'	12000	0.21	4.1	130	0.36	0.17 U	1200	510	120	15	71000	6.2	100000	690	**36**	2000	470	0.41 U	0.17 U	83 U	0.33 U	37	45
05SM-RT1	5/9/2010	1355	Surface Soil	0-0.5'	12000	0.46	6.1	240	0.43	0.17 U	1200	280	65	30	48000	20	74000	840	**47**	1100	940	0.51	0.17 U	85 U	0.34 U	40	65
06SM-RT1	5/9/2010	1405	Surface Soil	0-0.5'	18000	0.52	9.1	360	0.55	0.17 U	1100	340	74	30	55000	11	45000	1000	**130**	1000	1300	0.43 U	0.17 U	86 U	0.34 U	54	60
RETORT 2																											
01SM-RT2	5/9/2010	1500	Surface Soil	0-0.5'	11000 J	1.9	5	130	0.27	0.43	3700	1500 J	68 J	54 J	150000	620	8000 J	540 J	**4100**	740 J	1200	0.5 U	0.2 U	100 U	0.4 U	61 J	790 J
02SM-RT2	5/9/2010	1510	Surface Soil	0-0.5'	17000 J	0.22	11	220	0.59	0.2 U	1400	170 J	41 J	39 J	43000	18	17000 J	820 J	30	440 J	1100	0.5 U	0.2 U	100 U	0.4 U	50 J	85 J
03SM-RT2	5/9/2010	1515	Surface Soil	0-0.5'	19000 J	0.76	9.9	260	0.59	0.27	2400	130 J	27 J	59 J	42000	140	9800 J	750 J	**920**	220 J	1900	0.56 U	0.22 U	110 U	0.45 U	49 J	120 J
04SM-RT2	5/9/2010	1530	Surface Soil	0-0.5'	14000 J	0.25	7.1	250	0.47	0.18 U	1500	280 J	63 J	32 J	49000	13	58000 J	760 J	**130**	1100 J	1300	0.66	0.18 U	92 U	0.37 U	45 J	89 J
05SM-RT2	5/9/2010	1537	Surface Soil	0-0.5'	18000 J	0.22	9.9	300	0.62	0.19 U	760	200 J	37 J	65 J	42000	16	16000 J	1000 J	**100**	430 J	1200	0.47 U	0.19 U	94 U	0.37 U	47 J	79 J
06SM-RT2	5/9/2010	1547	Surface Soil	0-0.5'	19000 J	0.79	8.7	340	0.63	0.3	2600	230 J	48 J	55 J	48000	78	18000 J	1000 J	**97**	670 J	2000	0.69	0.25 U	120 U	0.49 U	55 J	140 J

BOLD exceeds ecological risk criteria
BOLD and red exceeds human health risk criteria
BLUE exceeds EPA SL-H screening value

J laboratory qualifier
U laboratory qualifier
TAL Target Analyte List
mg/kg miligrams per kilogram

SL-H Screening value from EPA Regional Screening Levels (EPA 2010) unless noted
Note: lead value is obtained from the IEUBK model

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3.3.1 Contact Mine

3.3.2.1 Surface Soils

Samples were collected from the surface materials at the tailings pile and prepared flats to determine the horizontal extent of contamination. Refer to Table 3.3-1 for a complete list of surface soil sample results.

Tailings Pile

Six surface soil samples were collected from the tailings pile, field screened with an XRF, and submitted to TestAmerica Laboratories, Inc. to be analyzed for TAL metals plus mercury. Three of the surface soil samples were collected at the eastern, western, and northern extents of the tailings pile in an effort to determine the lateral extent of metals contamination. The samples from the toe of the pile (10CMSS, 11CMSS, and 12CMSS) contained 18 TAL elements and a range of 89 mg/kg to 180 mg/kg mercury. Three additional surface soil samples were collected from on top of the tailings pile to determine the nature of metals contamination. The three samples from the top of the pile (07CMSS, 08CMSS, and 09CMSS) contained 21 TAL elements and a range of 1.9 mg/kg to 27 mg/kg mercury.

Upper Prepared Flat

Six surface soil samples were collected from the upper prepared flat, field screened with an XRF, and submitted to TestAmerica Laboratories, Inc. to be analyzed for TAL metals plus mercury. All six samples (13CMSS, 14CMSS, 15CMSS, 16CMSS, 17CMSS, and 18CMSS) were collected within the flat to determine the nature of the material in the prepared flat. The samples were found to contain 19 TAL elements. Samples 13CMSS and 14CMSS contained 120 mg/kg mercury and 34 mg/kg, respectively. Samples 15CMSS through 18CMSS contained a range of 0.11 mg/kg to 5.1 mg/kg mercury.

Lower Prepared Flat

Six surface soil samples were collected from the lower prepared flat, field screened with an XRF, and submitted to TestAmerica Laboratories, Inc. to be analyzed for TAL metals plus mercury. All six samples (01CMSS, 02CMSS, 03CMSS, 04CMSS, 05CMSS, and 06CMSS) were collected within the flat to determine the nature of the material in the prepared flat. The samples were found to contain 22 TAL elements. The samples contained a range of 1.2 mg/kg to 24 mg/kg mercury.

Retort Area

Samples were not taken at the retort area near the northern most prepared flat. The retort area characterization was combined with the characterization of the flat area.

3.3.2.2 Subsurface Soils

Soil borings were drilled in areas of known waste material, such as the tailings pile and prepared flats to determine the vertical extent (both visually and by laboratory confirmation) of contamination. Soil borings were also advanced up-gradient and down-gradient of each pile or flat to determine the concentration of inorganic elements of the subsurface soil located up-gradient and down-gradient of the piles. Some soil borings served both as an up-gradient and a down-gradient boring based on their location and site conditions. Refer to Tables 3.3-2 and 3.3-3 for a complete list of subsurface soil sample results.

One soil boring, 04CMSB, was advanced to 21 feet bgs within the tailings pile using a CME-85 equipped with hollow stem auger drilling technology. Subsurface soil samples were collected using a split spoon sampler and field screened with an XRF approximately every 5 feet. All subsurface soil samples collected from within the boring were composited into one soil sample (04CMSB) and submitted to TestAmerica Laboratories, Inc. and analyzed for TAL metals plus mercury and the California Waste Extraction Test (WET). The composite subsurface sample contained 3.6 mg/kg mercury. The California WET resulted in a mercury concentration of 0.002 mg/L.

One soil boring (02CMSB) was advanced to 35 feet bgs within the upper prepared flat using a CME-85 equipped with hollow stem auger drilling technology. Subsurface soil samples were collected using a split spoon sampler and field screened with an XRF approximately every 5 feet. Field screening for mercury indicated a concentration range from 18 to 277 parts per million (ppm). All subsurface soil samples collected from within the boring were composited into one soil sample (02CMSB) and submitted to TestAmerica Laboratories, Inc. to be analyzed for TAL metals plus mercury and the California WET. The composite subsurface sample was found to contain 300 mg/kg mercury. The California WET resulted in a mercury concentration of 0.017 mg/L.

One soil boring (06CMSB) was advanced to 27 feet bgs within the lower prepared flat using a CME-85 equipped with hollow stem auger drilling technology. Subsurface soil samples were collected using a split spoon sampler and field screened with an XRF approximately every 5 feet. Field screening for mercury indicated non-detect at all depths. All subsurface soil samples collected from within the boring were composited into one soil sample (06CMSB) and submitted to TestAmerica Laboratories, Inc. to be analyzed for TAL metals plus mercury and the California WET. The composite subsurface sample was found to contain 2.8 mg/kg mercury. The California WET resulted in a mercury concentration of 0.002 mg/L.

Soil boring (01CMMW), located approximately 300 feet north of the upper flat at the Contact Mine, was advanced to 21.5 feet bgs using a CME-85 equipped with hollow stem auger drilling technology. Subsurface soil samples were collected using a split spoon sampler and field screened with an XRF approximately every 5 feet. Field screening for Mercury indicated non-detects in all samples. All subsurface soil samples collected from within the boring were composited into one soil sample (01CMMW) and submitted to TestAmerica Laboratories, Inc. to be analyzed for TAL metals plus mercury. The composite subsurface sample was found to contain 0.071 mg/kg mercury.

Soil boring (03CMMW), located near the center of the middle prepared flat and above the tailings pile, was advanced to 48 feet bgs using a CME-85 equipped with hollow stem auger drilling technology. Subsurface soil samples were collected using a split spoon sampler and field screened with an XRF approximately every 5 feet. Field screening for mercury indicated a concentration range from non-detect to 33 ppm. All subsurface soil samples collected from within the boring were composited into one soil sample (03CMMW) and submitted to TestAmerica Laboratories, Inc. to be analyzed for TAL metals plus mercury. The composite subsurface sample was found to contain 9.2 mg/kg mercury.

Soil boring (05CMMW), located at the northwest portion of the lower prepared flat, was advanced to 19 feet bgs using a CME-85 equipped with hollow stem auger drilling technology. Subsurface soil samples were collected using a split spoon sampler and field screened with an XRF approximately every 5 feet. Field screening for mercury indicated non-detects in all samples. All subsurface soil samples collected from within the boring were composited into one soil sample (05CMMW) and submitted to TestAmerica Laboratories, Inc. to be analyzed for TAL metals plus mercury. The composite subsurface sample was found to contain 0.13 mg/kg mercury.

Soil boring (07CMMW), located at the southern portion of the lower prepared flat, was advanced to 21.5 feet bgs using a CME-85 equipped with hollow stem auger drilling technology. Subsurface soil samples were collected using a split spoon sampler and field screened with an XRF approximately every 5 feet. Field screening for mercury indicated a concentration of 82 ppm in the 10 feet bgs sample and non-detects in the others. All subsurface soil samples collected from within the boring were composited into one soil sample (07CMMW) and submitted to TestAmerica Laboratories, Inc. to be analyzed for TAL metals plus mercury. The composite subsurface sample was found to contain 45 mg/kg mercury.

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Sample ID	Sample Date	Time	Description	Depth (ft BGS)	TAL Metals and Mercury in Subsurface Soils Aluminum (mg/kg)	Antimony (mg/kg)	Arsenic (mg/kg)	Barium (mg/kg)	Beryllium (mg/kg)	Cadmium (mg/kg)	Calcium (mg/kg)	Chromium (mg/kg)	Cobalt (mg/kg)	Copper (mg/kg)	Iron (mg/kg)	Lead (mg/kg)	Magnesium (mg/kg)	Manganese (mg/kg)	Mercury (mg/kg)	Nickel (mg/kg)	Potassium (mg/kg)	Selenium (mg/kg)	Silver (mg/kg)	Sodium (mg/kg)	Thallium (mg/kg)	Vanadium (mg/kg)	Zinc (mg/kg)
				Ecological Risk Criteria															30.5								
				Human Health Risk Criteria															250								
				EPA SL-H	77000	31	0.39	15000	160	70	-	120000	23	3100	55000	400	-	1800	5.6	1500	-	390	390	-	2	390	23000
CONTACT																											
01CM-MW	5/2/2010	1040	Subsurface Soil	5-21.5'	24000 J	0.73	10	330 J	0.82	0.19 U	12000 J	210 J	25 J	44 J	41000 J	12 J	26000 J	680 J	0.071 J	250 J	1000 J	0.75 J	0.19 U	96 U	0.38 U	72 J	70 J
02CM-SB	4/26/2010	1226	Subsurface Soil	5-35'	7700 J	0.42	8.4	140 J	0.63	0.21 U	3800 J	200 J	27 J	28 J	34000 J	8.8 J	34000 J	480 J	**300 J**	380 J	1300 J	0.0043 UJ	0.21 U	110 U	0.43 U	33 J	59 J
03CM-MW	4/27/2010	0830'	Subsurface Soil	5-48'	23000 J	0.41	6.9	220 J	0.67	0.21 U	13000 J	420 J	36 J	39 J	41000 J	9.1 J	51000 J	680 J	9.2 J	530 J	990 J	0.93 J	0.21 U	110 U	0.43 U	60 J	69 J
04CM-SB	5/2/2010	1325	Subsurface Soil	5-21'	8400 J	0.38	5.6	220 J	0.5	0.19	5400 J	230 J	39 J	64 J	44000 J	6.8 J	41000 J	1700 J	3.6 J	470 J	650 J	0.54 J	0.17 U	85 U	0.34 U	57 J	67 J
05CM-MW	5/3/2010	0930'	Subsurface Soil	5-19'	29000 J	0.6	11	200 J	0.67	0.22	7300 J	310 J	39 J	43 J	46000 J	11 J	51000 J	680 J	0.13 J	470 J	1100 J	0.51 UJ	0.2 U	140	0.41 U	74 J	74 J
06CM-SB	5/3/2010	1300	Subsurface Soil	5-27'	16000 J	0.36	5.6	180 J	0.54	0.22	3000 J	130 J	22 J	29 J	30000 J	9.2 J	21000 J	540 J	2.8 J	240 J	1100 J	0.53 J	0.18 U	88 U	0.35 U	45 J	87 J
07CM-MW	5/2/2010	1614	Subsurface Soil	5-21.5'	13000 J	0.33	5.7	290 J	0.58	0.25	5000 J	150 J	27 J	38 J	33000 J	10 J	33000 J	560 J	**45 J**	360 J	1600 J	0.81 J	0.18 U	91 U	0.36 U	36 J	67 J
SONOMA																											
01SM-MW	4/23/2010	1458	Subsurface Soil	5-28'	23000 J	0.74	12	260 J	0.69	0.21	5300 J	200 J	34 J	47 J	47000 J	12 J	25000 J	920 J	**72 J**	430 J	1100 J	0.77 J	0.18 U	89 U	0.36 U	60 J	75 J
02SM-SB	4/24/2010	1130	Subsurface Soil	5-20.5	14000 J	0.69	9.9	120 J	0.51	0.2 U	2800 J	210 J	46 J	34 J	44000 J	10 J	28000 J	600 J	**380 J**	770 J	1100 J	0.004 UJ	0.2 U	100 U	0.4 U	45 J	63 J
04SM-MW	4/25/2010	0753'	Subsurface Soil	1-12.25'	19000 J	0.4	6.7	180 J	0.5	0.21 U	1700 J	370 J	57 J	32 J	52000 J	9.6 J	48000 J	820 J	**240 J**	1000 J	830 J	0.84 J	0.21 U	110 U	0.43 U	56 J	65 J
05SM-SB-B	4/26/2010	0910'	Subsurface Soil	1-5.6'	19000 J	0.98	12	290 J	0.55	0.26 U	23000 J	490 J	35 J	54 J	58000 J	24 J	12000 J	770 J	**950 J**	320 J	1300 J	1.9 J	0.26 U	130 U	0.51 U	59 J	88 J
06SM-MW-B	4/26/2010	0745'	Subsurface Soil	1-1'	13000 J	0.78	11	140 J	0.62	0.2	6100 J	130 J	36 J	49 J	46000 J	11 J	15000 J	730 J	4.4 J	480 J	1100 J	0.6 J	0.19 U	96 U	0.38 U	46 J	76 J
07SM-MW	5/2/2010	0830'	Subsurface Soil	5-21'	4300 J	0.81	11	140 J	0.56	0.19	17000 J	71 J	28 J	46 J	44000 J	11 J	16000 J	650 J	2.8 J	460 J	950 J	0.63 J	0.19 U	96 U	0.39 U	48 J	80 J
08SM-SB	4/25/2010	1517	Subsurface Soil	1-12'	8000 J	1	13	360 J	0.69	0.22	3300 J	50 J	47 J	42 J	43000 J	16 J	9400 J	2100 J	4.1 J	530 J	1200 J	0.65 J	0.17 U	83 U	0.33 U	31 J	76 J
09SM-MW	4/25/2010	1416	Subsurface Soil	1-6'	16000 J	0.61	7.6	240	0.56	0.25 U	3600 J	170 J	27 J	32 J	34000 J	9.4 J	19000 J	370 J	**33 J**	290 J	1800 J	0.63 UJ	0.25 U	130 U	0.5 U	50 J	58 J

BOLD	exceeds ecological risk criteria
BOLD and red	exceeds human health risk criteria
BLUE	exceeds EPA SL-H screening value
J	laboratory qualifier
U	laboratory qualifier
TAL	Target Analyte List
mg/kg	miligrams per kilogram
SL-H	Screening value from EPA Regional Screening Levels (EPA 2010) unless noted Note: lead value is obtained from the IEUBK model

Sample ID	Sample				WET Metals and Mercury in Subsurface Soils																						
	Date	Time	Description	Depth (ft BGS)	Aluminum (mg/L)	Antimony (mg/L)	Arsenic (mg/L)	Barium (mg/L)	Beryllium (mg/L)	Cadmium (mg/L)	Calcium (mg/L)	Chromium (mg/L)	Cobalt (mg/L)	Copper (mg/L)	Iron (mg/L)	Lead (mg/L)	Magnesium (mg/L)	Manganese (mg/L)	Mercury (mg/L)	Nickel (mg/L)	Potassium (mg/L)	Selenium (mg/L)	Silver (mg/L)	Sodium (mg/L)	Thallium (mg/L)	Vanadium (mg/L)	Zinc (mg/L)
				STLC / TCLP	-	15	5	100	0.75	1	-	5	80	25	-	5	-	-	0.2	20	-	1	5	-	7	24	250
				California WET															0.2								
CONTACT																											
02CM-SB	4/26/2010	1226	Subsurface Soil	5-35'	17	0.2 U	0.2 U	7	0.08 U	0.1 U	94	0.94	1.5	0.22	93	0.1 U	220	24	0.017 J	4.5	18 U	0.2 U	0.2 U	-	0.2 U	0.29	0.3 J
04CM-SB	5/2/2010	1325	Subsurface Soil	5-21'	52	0.2 U	0.2 U	12	0.08 U	0.1 U	140	4.1	1.7	0.56	370	0.11	1800	130	0.002 UJ	16	28 U	0.2 U	0.2 U	-	0.2 U	0.55	0.78
06CM-SB	5/3/2010	1300	Subsurface Soil	5-27'	46	0.2 U	0.2 U	9.6	0.08 U	0.1 U	210	0.41	0.44	0.3	65	0.1	180	9.6	0.002 UJ	1.6	29 U	0.2 U	0.2 U	-	0.2 U	0.23	2.3
SONOMA																											
02SM-SB	4/24/2010	1130	Subsurface Soil	5-20.5	13	0.2 U	0.2 U	4.9	0.08 U	0.1 U	200	0.42	1.1	0.44	65	0.13	210	20	0.0055 J	5.2	22 U	0.2 U	0.2 U	-	0.2 U	0.17	0.16
05SM-SB-B	4/26/2010	0910'	Subsurface Soil	1-5.6'	36	0.2 U	0.2 U	13	0.08 U	0.1 U	1000	0.93	0.51	0.21	53	0.12	100	8.1	0.002 UJ	1.6	24 U	0.2 U	0.2 U	-	0.2 U	0.2	0.37
08SM-SB	4/25/2010	1517	Subsurface Soil	1-12'	9	0.2 U	0.2 U	8.9	0.08 U	0.1 U	160	0.061	1.1	0.45	72	0.16	250	40	0.002 UJ	7.6	19 U	0.2 U	0.2 U	-	0.2 U	0.14	0.89
09SM-MW	4/25/2010	1416	Subsurface Soil	1-6'	29	0.2 U	0.2 U	9.6	0.08 U	0.1 U	120	0.76	0.57	0.42	110	0.14	110	6.2	0.002 UJ	2.3	21 U	0.2 U	0.2 U	-	0.2 U	0.28	0.19

WET Waste Extraction Test (STLC Method)

J laboratory qualifier
U laboratory qualifier
mg/L miligrams per liter
ng/L nanograms per liter

STLC Soluble Threshold Limit Concentrations
TCLP Toxicity Characteristic Leaching Procedure

3.3.2.3 Groundwater

Groundwater Monitoring Wells

Three groundwater monitoring wells were drilled at the Contact Mine site. The locations of monitoring wells 01CMMW, 03CMMW, and 07CMMW are described above. Samples were taken from all three monitoring wells. The samples were found to contain ten TAL elements and a range of 4.2 ng/L to 8.7 ng/L mercury. Methyl-mercury was not detected in 01CMMW or 03CMMW; however, 07CMMW was found to contain 0.015 ng/L methyl-mercury. Refer to Table 3.3-4 for a complete list of groundwater sample results.

3.3.2.4 Sediment

No sediment samples were taken under the E & E characterization effort. Sediment samples were taken under the USGS environmental assessment from 2001 through 2003. Mercury concentrations in two out of the ten sediment samples taken exceeded both the highest background levels and the BLM Human Health (camper) Risk Managed Criterion (RMC) (40 mg/kg) to which they were compared. Concentrations in these samples ranged from 50 to greater than 100 mg/kg mercury.

3.3.2.5 Surface Water

No surface water samples were taken under the E & E characterization effort. Surface water samples were taken under the USGS environmental assessment from 2001 through 2003. A total of six surface water samples were taken under the USGS assessment of the Contact mine. No samples exceeded background or EPA criteria.

3.3.2.6 Biota

No biota samples were taken under the E & E characterization effort. Biota samples were taken under the USGS environmental assessment in 2003. Ten fish biota samples were taken. Mercury concentrations in nine out of the ten fish samples exceeded both background levels and the BLM Human Health (Camper) RMC for fish (0.048 microgram per gram [µg/g]). Concentrations in these samples ranged from 0.145 to 0.221 µg/g. Eight invertebrate samples were taken from the Contact Mine and from Anna Belcher Creek downstream of the Sonoma Mine. Samples were analyzed for mercury and methyl mercury. Concentrations in all samples exceeded background levels for both mercury and methyl mercury. Mercury concentrations ranged from 0.131 to 0.692 µg/g. Methyl mercury concentrations ranged from 0.092 to 0.495 µg/g.

3.3.2.7 Air

No air samples have been taken at the Site.

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Metals, Mercury, and Methyl Mercury in Groundwater

Sample ID	Sample Date	Sample Time	Sample Description	Sample Depth (ft BGS)	Aluminum (mg/L)	Antimony (mg/L)	Arsenic (mg/L)	Barium (mg/L)	Beryllium (mg/L)	Cadmium (mg/L)	Calcium (mg/L)	Chromium (mg/L)	Cobalt (mg/L)	Copper (mg/L)
				Screening Criteria										
CONTACT														
01CM-MW	5/2/2010	1040	Subsurface Soil	5-21.5'	0.4 U	0.002	0.002 U	0.057	0.002 U	0.002 U	50 U	0.002 U	0.002 U	0.002 U
03CM-MW	4/27/2010	0830'	Subsurface Soil	5-48'	0.4 U	0.002 U	0.002 U	0.26	0.002 U	0.002 U	50 U	0.0025	0.002 U	0.005 U
07CM-MW	5/2/2010	1614	Subsurface Soil	5-21.5'	0.4 U	0.002 U	0.0026	0.049	0.002 U	0.002 U	50 U	0.002 U	0.002 U	0.005 U
SONOMA														
01SM-MW	4/23/2010	1458	Subsurface Soil	5-28'	0.4 U	0.0024	0.0032	0.049	0.002 U	0.002 U	73	0.002 U	0.002 U	0.005 U
04SM-MW	4/25/2010	0753'	Subsurface Soil	1-12.25'	0.4 U	0.002 U	0.003	0.0085	0.002 U	0.002 U	50 U	0.002 U	0.002 U	0.005 U
06SM-MW-B	4/26/2010	0745'	Subsurface Soil	1-1'	0.4 U	0.002 U	0.0052	0.014	0.002 U	0.002 U	50 U	0.002 U	0.002 U	0.005 U
07SM-MW	5/2/2010	0830'	Subsurface Soil	5-21'	0.4 U	0.002 U	0.0031	0.035	0.002 U	0.002 U	50 U	0.002 U	0.002 U	0.005 U
09SM-MW	4/25/2010	1416	Subsurface Soil	1-6'	0.4 U	0.002 U	0.002 U	0.18	0.002 U	0.002 U	50 U	0.002 U	0.002 U	0.005 U

Sample ID	Iron (mg/L)	Lead (mg/L)	Magnesium (mg/L)	Manganese (mg/L)	Mercury (ng/L)	Methyl Mercury (ng/L)	Nickel (mg/L)	Potassium (mg/L)	Selenium (mg/L)	Silver (mg/L)	Sodium (mg/L)	Thallium (mg/L)	Vanadium (mg/L)	Zinc (mg/L)
Screening Criteria														
CONTACT														
01CM-MW	0.002 U	0.002 U	14	0.0085	4.2	0.025 U	0.002 U	50 U	0.002 U	0.002 U	50 U	0.004 U	0.0033	0.007 U
03CM-MW	0.2 U	0.002 U	34	0.027	8.7	0.025 U	0.0039	50 U	0.002 U	0.002 U	50 U	0.004 U	0.0045	0.007 U
07CM-MW	0.2 U	0.002 U	38	0.023	8.6	0.015 J	0.002 U	50 U	0.002 U	0.002 U	50 U	0.004 U	0.0077	0.017
SONOMA														
01SM-MW	0.2 U	0.002 U	33	0.097	240	0.14	0.0032	50 U	0.002 U	0.002 U	50 U	0.004 U	0.0054	0.007 U
04SM-MW	0.2 U	0.002 U	65	0.032	75.6	0.063	0.0025	50 U	0.002 U	0.002 U	50 U	0.004 U	0.0084	0.007 U
06SM-MW-B	0.2 U	0.002 U	99	0.01	63.4	0.066	0.0023	50 U	0.002 U	0.002 U	64	0.004 U	0.012	0.0074
07SM-MW	0.2 U	0.002 U	90	0.056	51.8	0.018 J	0.0094	50 U	0.002 U	0.002 U	50 U	0.004 U	0.011	0.007 U
09SM-MW	0.2 U	0.002 U	27	0.1	77.8	0.26	0.0094	50 U	0.002 U	0.002 U	50 U	0.004 U	0.0097	0.007 U

J	laboratory qualifier
U	laboratory qualifier
mg/L	miligrams per liter
ng/L	nanograms per liter

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3.3.3 Sonoma Mine

3.3.3.1 Surface Soils

Samples were collected from the surface materials at the tailings pile, prepared flats, and retort areas to determine the horizontal extent of contamination. Refer to Table 3.3-1 for a complete list of surface soil sample results.

Tailings Pile

Six surface soil samples were collected from the tailings pile, field screened with an XRF, and submitted to TestAmerica Laboratories, Inc. to be analyzed for TAL metals plus mercury. Three of the surface soil samples were collected from the toe of the tailings pile in an effort to determine the lateral extent of metals contamination. The three samples from the toe of the tailings pile (13SMSS, 15SMSS, and 18SMSS) contained 18 TAL. The samples contained 140 mg/kg, 3.4 mg/kg, and 21 mg/kg of mercury, respectively. Three additional surface soil samples were collected from on top of the tailings pile to determine the nature of metals contamination. The three samples from on top of the tailings pile (14SMSS, 16SMSS, and 17SMSS) contained 20 TAL elements and a range of 18 mg/kg to 110 mg/kg mercury.

Upper Prepared Flat

Six surface soil samples were collected from the upper prepared flat, field screened with an XRF, and submitted to TestAmerica Laboratories, Inc. to be analyzed for TAL metals plus mercury. All six samples (07SMSS, 08SMSS, 09SMSS, 10SMSS, 11SMSS, and 12SMSS) were collected within the flat to determine the nature of the material in the prepared flat. Nineteen TAL elements were contained in the samples. The range of mercury concentrations was 24 mg/kg to 200 mg/kg.

Middle Prepared Flat

Six surface soil samples were collected from the middle prepared flat, field screened with an XRF, and submitted to TestAmerica Laboratories, Inc. to be analyzed for TAL metals plus mercury. All six samples (01SMSS, 02SMSS, 03SMSS, 04SMSS, 05SMSS, and 06SMSS) were collected within the flat to determine the nature of the material in the prepared flat. Twenty-one TAL elements were contained in the samples. The range of mercury concentrations was 11 mg/kg to 130 mg/kg.

Retort Areas

The first retort area is located at the northern portion of the middle flat. Six surface soil samples (01SMRT1, 02SMRT1, 03SMRT1, 04SMRT1, 05SMRT1, and 06SMRT1) were collected from the first retort area and submitted to TestAmerica Laboratories, Inc. for TAL metals plus mercury analysis. The six samples were taken such that they surround the current location of the cement pad and the current location of the metal pipe once believe to have been attached to the structure.

The retort samples contained 19 TAL elements and a range of 2.6 mg/kg to 160 mg/kg mercury.

The second retort area is located at the northern end of the lower flat. Six surface soil samples (01SMRT2, 02SMRT2, 03SMRT2, 04SMRT2, 05SMRT2, and 06SMRT2) were collected from the second retort area and submitted to TestAmerica Laboratories, Inc. for TAL metals plus mercury analysis. Samples 01SMRT2, 02SMRT2, 05SMRT2, and 06SMRT2 were all located within the cement pad area. Sample 03SMRT2 was located north of the cement pad below a pipe output. Sample 04SMRT2 was located south-east of the concrete pad. The retort samples contained 20 TAL elements. Sample 01SMRT2, which was taken in reddish soil within the cement pad, was found to contain 4,100 mg/kg mercury. Sample 03SMRT2, which was taken outside of the cement pad roughly below a pipe output, was found to contain 920 mg/kg mercury. The other four samples contained a range of 30 mg/kg to 130 mg/kg mercury.

3.3.3.2 Subsurface Soils

Soil borings were drilled in areas of known waste material, such as the tailings pile and prepared flats to determine the vertical extent (both visually and by laboratory confirmation) of contamination. Soil borings were also advanced up-gradient and down-gradient of each pile or flat to determine the concentration of inorganic elements of the subsurface soil located up-gradient and down-gradient of the piles. Some soil borings served both as an up-gradient and a down-gradient boring based on their location and site conditions. Refer to Tables 3.3-2 and 3.3-3 for a complete list of subsurface soil sample results.

One soil boring (06SMMWA) was advanced to 5.5 feet bgs within the tailings pile using a hand auger. Refusal was encountered due to continual cobble collapse. A surface soil sample (06SMMWA) was collected and field screened with an XRF. Field screening for mercury indicated a concentration of 271 ppm. This sample was not submitted for laboratory analysis, because two samples were not in the scope of soil boring 06SMMW. The sample submitted to the laboratory was from the relocated boring (06SMMWB) at a location where refusal was not met before groundwater was reached. Sample 06SMMWB was found to contain 4.4 mg/kg mercury.

One soil boring (02SMSB) was advanced to 20.5 feet bgs within the upper prepared flat using a CME-85 equipped with hollow stem auger drilling technology. Subsurface soil samples were collected using a split spoon sampler and field screened with an XRF approximately every 5 feet. Field screening for mercury indicated a concentration range from non-detect to 314 ppm. The sample collected from 20.5 feet bgs had a field screening result of non-detect, indicating the bottom of prepared flat where native soils are present. All subsurface soil samples collected from within the boring were composited into one soil sample (02SMSB) and submitted to TestAmerica Laboratories, Inc. to be analyzed for TAL metals plus mercury and the California WET. Sample 02SMSB was found to contain 380 mg/kg mercury. The California WET resulted in a mercury concentration of 0.0055 mg/L.

One soil boring (08SMSB) was advanced to 12 feet bgs within the prepared flat using a hand auger. Subsurface soil samples were collected and field screened with an XRF approximately every 5 feet. Field screening for mercury indicated non detect at all depths. All subsurface soil samples collected from within the boring were composited into one soil sample (08SMSB) and submitted to TestAmerica Laboratories, Inc. to be analyzed for TAL metals plus mercury and the California WET. Sample 08SMSB was found to contain 4.1 mg/kg mercury. The California WET resulted in a mercury concentration of 0.002 mg/L.

Soil boring 06SMMWB, located within the tailings pile, was advanced to 12.5 feet bgs using a hand auger. Subsurface soil samples were collected and field screened with an XRF approximately every 5 feet. Field screening for mercury indicated a concentration range from non-detect to 37 ppm. Mercury was only detected in zero feet bgs sample. All subsurface soil samples collected from within the boring were composited into one soil sample (06SMMWB) and submitted to TestAmerica Laboratories, Inc. to be analyzed for TAL metals plus mercury. Sample 06SMMWB was found to contain 4.4 mg/kg mercury.

Soil boring 04SMMW, located down-gradient of the upper flat, was advanced to 12 feet 3 inches bgs using a hand auger. Subsurface soil samples were collected and field screened with an XRF approximately every 5 feet. Field screening for mercury indicated a concentrations of 156 and 185 ppm. All subsurface soil samples collected from within the boring were composited into one soil sample (04SMMW) and submitted to TestAmerica Laboratories, Inc. to be analyzed for TAL metals plus mercury. Sample 04SMMW was found to contain 240 mg/kg mercury.

Soil boring 09SMMW, located down-gradient of the middle flat, was advanced to 6 feet 6 inches bgs using a hand auger. One subsurface soil sample was collected and field screened with an XRF. Field screening for mercury indicated a concentrations of 26 ppm. The subsurface soil sample collected from within the boring (09SMMW) was submitted to TestAmerica Laboratories, Inc. to be analyzed for TAL metals plus mercury and the California WET. Sample 09SMMW was found to contain 33 mg/kg mercury. The California WET resulted in a mercury concentration of 0.002 mg/L.

Soil boring 01SMMW, located up-gradient of the upper flat, was advanced to 28 feet bgs using a CME-85 equipped with hollow stem auger drilling technology. Subsurface soil samples were collected using a split spoon sampler and field screened with an XRF approximately every 5 feet. Field screening for mercury indicated a concentration range from non-detect to 328 ppm. All subsurface soil samples collected from within the boring were composited into one soil sample (01SMMW) and submitted to TestAmerica Laboratories, Inc. to be analyzed for

TAL metals plus mercury. Sample 01SMMW was found to contain 72 mg/kg mercury.

Soil boring 07SMMW, located near the southern portion of the middle flat, was advanced to 21 feet bgs using a CME-85 equipped with hollow stem auger drilling technology. Subsurface soil samples were collected using a split spoon sampler and field screened with an XRF approximately every 5 feet. Field screening for mercury indicated non-detects at every depth. All subsurface soil samples collected from within the boring were composited into one soil sample (07SMMW) and submitted to TestAmerica Laboratories, Inc. to be analyzed for TAL metals plus mercury. Sample 07SMMW was found to contain 2.8 mg/kg mercury.

Soil boring 03SMMW was cancelled due to the presence of bedrock at the boring location.

Two soil borings (05SMSBA and 05SMSBB) were advanced east of the second retort. Soil boring 05SMSBA was advanced to 12.5 feet bgs using a hand auger. Subsurface soil samples were collected and field screened with an XRF approximately every 5 feet. Field screening for mercury indicated a concentration range from non-detect to 162 ppm. Mercury was only detected in zero feet bgs sample. This sample was not submitted for laboratory analysis, because two samples were not in the scope of soil boring 05SMMW. Soil boring 05SMSBB is located 75 feet east of 05SMSBA and is on top of suspected calcines. The decision to redo 05SMSBA was made to better characterize the area. It was advanced to 5.5 feet bgs where native material found using a hand auger. Two subsurface soil samples were collected and field screened with an XRF. Field screening for mercury indicated concentrations of 101 and 102 ppm. Both subsurface soil samples collected from within the boring were composited into one soil sample (05SMMWB) and submitted to TestAmerica Laboratories, Inc. to be analyzed for TAL metals plus mercury. Sample 05SMSB-B contained 950 mg/kg mercury. Refer to Tables 3.3-2 and 3.3.3 for a complete list of subsurface soil sample results.

3.3.3.3 Groundwater

Groundwater Monitoring Wells

Five monitoring wells were drilled at the Sonoma Mine site. The locations of monitoring wells 01SMMW, 04SMMW, 06SMMW, 07SMMW, and 09SMMW are described above. Groundwater samples were collected from each of the monitoring wells. The samples were found to contain 11 TAL metals. The samples also were all found to contain methyl-mercury in concentrations ranging from 0.018 nanograms per liter (ng/L) to 0.26 ng/L. Sample 01SMMW contained 240 ng/L of mercury. The other four samples contained 51.8 ng/L to 77.8 ng/L mercury. Refer to Table 3.3-4 for a complete list of groundwater sample results.

3.3.3.4 Sediment

No sediment samples were taken under the E & E characterization effort. Sediment samples were taken under the USGS environmental assessment from 2001 through 2003. Mercury concentrations in four out of the ten sediment samples taken exceeded both the highest background levels and the BLM Human Health (camper) RMC (40 mg/kg) to which they were compared. Concentrations in these samples ranged from 50 to 181 mg/kg mercury.

3.3.3.5 Surface Water

No surface water samples were taken under the E & E characterization effort. Surface water samples were taken under the USGS environmental assessment from 2001 through 2003. A mercury concentration of 13.9 µg/L in one surface water sample taken in Anna Belcher Creek below the Sonoma Mine retort remains exceeded both the background sample (0.104 µg/L) and the EPA Ambient Water Quality Criteria Chronic standard (2.5 µg/L). Five other surface water samples were taken under the USGS assessment, with no other exceedances.

3.3.3.6 Biota

Refer to Section 3.3.2.6 for a discussion of the biota samples taken at the Site.

3.3.3.7 Air

No air samples have been taken at the Site.

3.4 Targets Potentially Affected by the Site

3.4.1 Groundwater

3.4.1.1 Municipal Wells

There are no municipal wells within 5 miles of the Site.

3.4.1.2 Private Wells

There are no private drinking water wells currently in the immediate vicinity of the Site. There are a total of three wells within 10 miles of the Site, as documented in the California Department of Water Resources Water Data Library. The closest well is approximately 5.5 miles to the southwest. There is also a well located approximately 6.1 miles west southwest of the Site. The third well is located approximately 6.6 miles south of the Site. Each wells use is listed as domestic, domestic and irrigation, or unused. The Site is not located within a groundwater basin and it is believed that any groundwater at the Site discharges to surface water at Anna Belcher Creek or other drainages and therefore would not affect current groundwater wells in the area.

3.4.2 Surface Water

3.4.2.1 Municipal and Private Users

No known population centers near the Site derive potable water from surface water sources. Surface water flow at the Site is intermittent; however, the headwaters for Anna Belcher Creek originate on the Contact Mine site. There is no record of use of this surface water for drinking water. There are no surface water bodies in the immediate vicinity of the Site.

3.4.2.2 Ecological Targets
Releases to surface water from the contaminated materials would likely pose the most direct risk to ecological receptors in the drainages and tributaries located on site. Various vertebrates and invertebrates could be receptors of releases. Other mammals and birds could also be incidental consumers of water from the drainages when flowing. These mammals may eat the sediments, invertebrates, and vertebrates that live in the area and thus are also potential receptors.

3.4.3 Soil and Air

3.4.3.1 Human Targets
The Site may be accessed by visitors on BLM-administered lands, including hikers, or other recreational users. The majority of the site is surrounded by a large area of BLM-managed lands. There are no known residences in the immediate vicinity of the site. Healdsburg, California, is the nearest populated area.

3.4.3.2 Ecological Targets
The Site may provide suitable habitat for several sensitive plant species. The results from database investigations are included in the discussion in Section 2.8. Windblown dust from the contaminated material could be deposited on the foliar surfaces or other aboveground parts of plants, resulting in direct uptake into plant tissue from aerial deposition. Uptake can also occur through the roots as a result of transport into the soil from deposited windblown dust or by runoff from the ore pile onto the soil. These soil-to-plant pathways can affect the regional fauna as well. Herbivores may be exposed to these contaminants by ingestion.

The Site may provide a suitable habitat for several sensitive species of wildlife. The results from database investigations are included in the discussion in Section 2.7. During site visits limited wildlife was noted, including various species of birds and small burrowing mammals. In addition to direct exposure by ingestion of plant material or surface water, site contaminants may also enter the food web by other means. For example, burrowing animals (including most small mammal species that provide an important prey base for many predators) may uptake contaminants by incidental ingestion of soil, inhalation of particulate-born or gaseous contaminants, or through the skin (dermal) exposure, as well as ingestion of plants or water.

4 Expanded Risk Evaluations

4.1 Human Health Risk Assessment

4.1.1 Introduction

The purpose of a human health risk assessment (HHRA) and ecological risk assessment (ERA) is to determine whether or not residual contamination from previous mining activities at the Contact and Sonoma Mines could pose potentially significant human health or ecological risks. This HHRA and ERA address risks associated with possible exposure to metals in soil, sediment, and surface water. The results of the risk assessment will be used to determine whether remedial measures may be necessary in order to protect public health or the environment and, if so, aid in the selection of appropriate remedial goals.

This Risk Assessment provides methods used to conduct the Human Health Risk Assessment (HHRA) and Ecological Risk Assessment (ERA) for the Contact/Sonoma Mines. It also provides the quantitative estimates of risk to human health and ecological receptors, and uncertainties associated with the risk assessment process.

4.1.1.1 Document Structure

This HHRA consists of the following sections.

- **Section 4.2, Data Evaluation –** Provides the methods for evaluation of site data for usability in risk assessment.

- **Section 4.3, Human Health Risk Assessment –** Presents the human health contaminants of potential concern (COPCs), exposure assessment, toxicity assessment, and risk characterization.

- **Section 4.4, Ecological Risk Assessment –** Presents the methodology and results for the ecological exposure assessment, ecological effects assessment, and risk characterization.

4.1.1.2 Data Evaluation

Preliminary investigations of environmental contamination at the Contact and Sonoma Mine sites have been conducted in the recent past (Weston 2009a and

2009b, Rytuba 2008). These studies, and their results, have been discussed in Section 2.10 of this report. However, because inadequate data from these reports were available to conduct a proper data validation review, use of the data is limited to a qualitative characterization.

4.1.2.1 Data Usability

The rules for data treatment described below have been implemented on the compiled complete project dataset.

4.1.2.2 Data Usability Criteria

The Risk Assessment (RA) highlights chemicals associated with historical operations that are thought or known to have been released to the environment. A review of existing data and a list of target analytes is provided in Section 2.10 of this report.

Relevant data that meet established quality criteria will be considered for use in the RA. Data will also be evaluated according to Guidance for Data Usability for Risk Assessment (EPA 1992b), which provides minimum data requirements to ensure that data will be appropriate for risk assessment use. The guidance addresses the following issues relevant to assessing data quality for risk assessment.

- Data sources – Consider the type of data collected (for example, field screening data and fixed laboratory data) and determine whether data meet QA/QC objectives outlined in the project Field Sampling Plan (FSP).
- Consistency of data collection methods – Review sample collection methods for appropriateness relative to the target analytes, media, and laboratory analytical methods; review field logs to identify sample collection quality issues; and identify differences in sample collection methods, if any, for different field investigations.
- Analytical methods and detection limits – Evaluate methods for appropriateness for the target analytes and media and determine whether detection limits are low enough for risk-based evaluation.
- Data quality indicators – Review data validation reports for data quality issues.

Data Treatment

Data determined to be acceptable for use in the RA may be treated. Treatment may relate to detected or non-detected analytes, data qualifiers, and/or duplicate sample results.

Qualified Data

Problems are sometimes identified in laboratory analytical results. In such cases, detected analytes may be assigned a data qualifier. It is common to identify problems with analytical data associated with the chemical concentration, the chemical identity, interference from other analytes, and/or matrix interferences (EPA 1989).

The analytical results will be validated by an experienced E & E chemist. The data will be validated in accordance with the *National Functional Guidelines for*

Inorganic Data Review (EPA 2002c) and *National Functional Guidelines for Organic Data Review* (EPA 1999) in conjunction with the QA/QC requirements specified in each specific analytical method and any project-specific QC defined in the QAPP.

4.1.3.1 Overview of the HHRA

This chapter outlines the HHRA and consists of methods for determining COPCs and the selected COPCs (Section 4.3.2), the exposure assessment (Section 4.3.3), the toxicity assessment (Section 4.3.4), the risk characterization (Section 4.3.5), and the uncertainty analysis (Section 4.3.6).

COPC determination identifies the compounds that are quantitatively and qualitatively evaluated. The exposure assessment describes how exposures to receptors are quantified for each anticipated exposure pathway, while the toxicity assessment explains how the toxicity of carcinogenic and noncarcinogenic COPCs is estimated. The information from the exposure and toxicity assessments is then combined to generate quantitative estimates of risk. A detailed discussion of uncertainty associated with each step of this HHRA is included as well as an indication of the possible impacts of each source of uncertainty on the overall risk estimates.

This HHRA draws on federal and state guidance, in addition to information presented in peer-reviewed publications, including but not limited to the following documents.

- Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A), Interim Final (EPA 1989)
- Human Health Evaluation Manual, Supplemental Guidance "Standard Default Exposure Factors," Interim Final (OSWER Directive 9285.6-02; EPA 1991a)
- Exposure Factors Handbook (EPA 1997a)
- Child-Specific Exposure Factors Handbook (EPA 2008b)
- Supplemental Guidance to RAGS: Calculating the Concentration Term (OSWER Directive 9285.7-81; EPA 1992a)
- Risk Management Criteria for Metals at BLM Sites (BLM 2004)

Selection of Contaminants of Potential Concern

EPA suggests in their *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part A)* (EPA 1989) that at some sites where a large number of chemicals are present, it can be useful to eliminate from further consideration those chemicals that represent a small contribution to risk. To accomplish this, site concentrations of chemicals are compared to screening values. If the maximum concentration of a chemical is above a screening value, the chemical is considered COPCs and is evaluated quantitatively.

Several metrics are used for screening and selection of COPCs, including:

1. Health-based screening values based on toxicological characteristics of each chemical;
2. Evaluation of essential nutrients; and
3. Comparison to background concentrations.

These parameters are discussed in further detail throughout this section.

As discussed in Sections 3.3 and 3.4,4 both field (EPA Method 6200) and analytical analyses (EPA Method 6020) were conducted at the Contact and Sonoma Mines. Field data analyzed by XRF have not been included in the quantitative risk assessment; only laboratory data are used for the quantitative evaluation of risk. The COPC screening table is provided in Table 4.1-1.

Table 4.1-1 Human Health Screening Level Assessment for Surface Soil, Contact-Sonoma Mines, Sonoma, California

Analyte	Range of Detected Values (mg/kg)		FoD	Health-Based Screening (SL-H)[a] (mg/kg)	FoE RBC	Max Back-ground (mg/kg)	FoE Max Back-ground	COPC?	Rationale
	min	max							
Aluminum	63	24000	48/48	77000	0	20000	4	No	max < SL-H
Antimony	0.041	3.9	45/48	31	0	0.62	19	No	max < SL-H
Arsenic	0.46	16	46/48	0.39	46	8.3	15	**YES**	SL-H
Barium	7.4	1800	48/48	15000	0	240	15	No	max < SL-H
Beryllium	0.034	1.1	44/48	160	0	0.78	1	No	max < SL-H
Cadmium	0.21	19	12/48	70	0	ND	0	No	max < SL-H
Calcium	140	18000	47/48	0	48	3000	17	No	NUT
Chromium	0.53	1500	48/48	120000	0	160	36	No	max < SL-H
Cobalt	0.31	160	48/48	23	42	26	40	**YES**	SL-H
Copper	1.5	170	48/48	3100	0	46	11	No	max < SL-H
Iron	79	150000	48/48	55000	10	39000	40	**YES**	SL-H
Lead[b]	0.94	620	48/48	400	2	12	27	**YES**	SL-H
Magnesium	170	200000	48/48	0	48	19000	30	No	NUT
Manganese	12	7400	48/48	1800	1	860	15	**YES**	SL-H
Mercury	0.11	4100	48/48	5.6	39	30.5	25	**YES**	SL-H
Nickel	2.3	2200	48/48	1500	6	250	39	**YES**	SL-H
Potassium	76	2900	48/48	0	48	1700	5	No	NUT
Selenium	0.51	1.6	13/48	390	0	0.74	5	No	max < SL-H

Table 4.1-1 Human Health Screening Level Assessment for Surface Soil, Contact-Sonoma Mines, Sonoma, California

Analyte	Range of Detected Values (mg/kg)		FoD	Health-Based Screening (SL-H)[a] (mg/kg)	FoE RBC	Max Back-ground (mg/kg)	FoE Max Back-ground	COPC?	Rationale
	min	max							
Silver	0.3	0.3	1/48	390	0	ND	0	No	max < SL-H
Sodium	110	330	4/48	0	48	ND	0	No	NUT
Thallium	ND	ND	0/48	2	0	ND	--	No	ND
Vanadium	0.45	150	47/48	390	0	64	3	No	max < SL-H
Zinc	2	8500	48/48	23000	0	71	21	No	max < SL-H

Key:

COPC = Chemical of Potential Concern.
FoD = number of samples detected above the sample detection limit; denominator is the total samples collected
FoE = number of samples that exceed a screening concentration; denominator is the total samples collected
mg/kg = milligrams per kilogram.
ND =analyte was not detected in any samples

Rationale for COPC selection/deletion:

NUT = nutrient, chemical is not a COPC.
SL-H = Health-based screening level (chemical is a COPC).
max < SL-H = The maximum detected concentration at the site was less then the SL-H, chemical is not a COPC.
Yes = analyte is considered a COPC and will be quantitatively evaluated.
Yes = analyte is considered a COPC but toxicity information is not available.
-- = a value could not be calculated.

[a] Screening value from EPA Regional Screening Levels (EPA 2010) unless noted

[b] Lead value is obtained from the IEUBK model. Soil levels were calculated based on a 5% probability that children exposed to lead not exceed a 10 ug/dL lead concentration.

Screening Values

As noted in the preliminary conceptual site model (CSM), (discussed in Section 4.3.3.1 below), human receptors that may have contact with exposure media at the mine site are primarily recreational visitors. Exposure media include soil, sediment, and surface water. However, surface water and sediments samples were not collected as part of the present assessment Exposure to these media are discussed below in Section 4.3.6 Site screening for the Contact and Sonoma Mine sites focuses on surface soil samples. The maximum site concentrations for each metal were compared to health-based screening concentrations. For exposure assessment, tailings will be treated as soil based on their location and potential for exposure.

EPA does not publish screening levels for a recreational use scenario. While BLM does publish some screening criteria based on recreational use, screening values were not available for all COPCs. For these reasons, EPA Regional Screening Levels for residential soils (EPA 2010) were used for site screening purposes.

Regional Screening Levels are risk-based concentrations derived from standardized equations that combine default exposure assumptions with EPA toxicity data. These screening levels are considered to be protective for humans (including sensitive groups) over a lifetime. If the maximum site concentration does not exceed the Regional Screening Levels, the compound was eliminated as a COPC. If the site concentration exceeds the screening level, the compound was retained for further evaluation and carried through the quantitative risk assessment.

Essential Nutrients

EPA (1989) recommends removing chemicals from further consideration if they are considered “essential nutrients,” that is, naturally occurring chemicals essential to human life. These chemicals are toxic only at very high doses, and are present at concentrations that would not be due to chemical sources at the mine site. The essential nutrients eliminated from the list of COPCs include magnesium, calcium, sodium, and potassium.

Background Comparisons

Three background surface soil samples were collected and analyzed for TAL metals for the Contact and Sonoma Mines. Background concentrations were not used as a screening tool but are included to provide additional information for characterization of the site. In the case of mercury, the background concentrations ranged from 0.11 mg/kg to 30.5 mg/kg, while site concentrations ranged from 0.11 mg/kg to a maximum detected concentration of 4,100 mg/kg. Likewise, the maximum nickel background concentration was 250 mg/kg while the maximum site concentration was 2.200. For manganese, the maximum background concentration was 860 mg/kg wile the maximum site concentration was 7400 mg/kg.

Table 4.1-1 provides a comparison of the maximum detected background concentrations and site levels for all TAL metals.

Results of COPC Screening

Table 4.1-1 summarizes the COPC selection process for the Contact and Sonoma Mine sites. Maximum site soil concentrations were compared to residential screening criteria. Background concentrations are also included to provide additional information. Analytes that are essential nutrients (such as calcium, magnesium, potassium, and sodium) were eliminated from further consideration. Screening results indicate that arsenic, cobalt, iron, lead, manganese, mercury, and nickel may be of potential concern. Thus, these chemical are quantitatively evaluated in the risk assessment process.

4.1.3.2 Exposure Assessment

The purpose of the exposure assessment will be to quantify potential exposures of human populations that could result from contact with COPCs from the mine site. Each complete exposure pathway contains four necessary components:

- A contaminant source and a mechanism of COPC release;
- An environmental medium and mechanism of COPC transport within the medium;
- A potential point of human contact with the affected environmental medium, also called the exposure point; and
- An exposure route.

The exposure assessment characterizes the exposure setting; identifies receptors that may be exposed; identifies direct and indirect pathways by which exposures could occur (i.e., pathways for direct ingestion of COPCs from soil and indirect uptake from ingestion of suspended particulates); and describe how the rate, frequency, and duration of these exposures will be estimated. The exposure assessment includes the following subsection components:

- Preliminary conceptual site model
- Exposure Scenarios

Preliminary Conceptual Site Model

The CSM for the Contact and Sonoma Mines is presented in Figure 4-1 and discussed in this section. A CSM is a schematic representation of site conditions as they relate to the HHRA. The CSM:

- Identifies the primary source of contamination in the environment (e.g., waste rock, washes, etc).
- Shows how chemicals at the original point of release might move in the environment (e.g., wind-blown particulate).
- Identifies the different types of human populations (e.g., resident, recreational visitors) who might come into contact with contaminated media.
- Lists the potential exposure pathways (e.g., ingestion of contaminated soil, inhalation of particulate, dermal contact with contaminated soil) that may occur for each population.

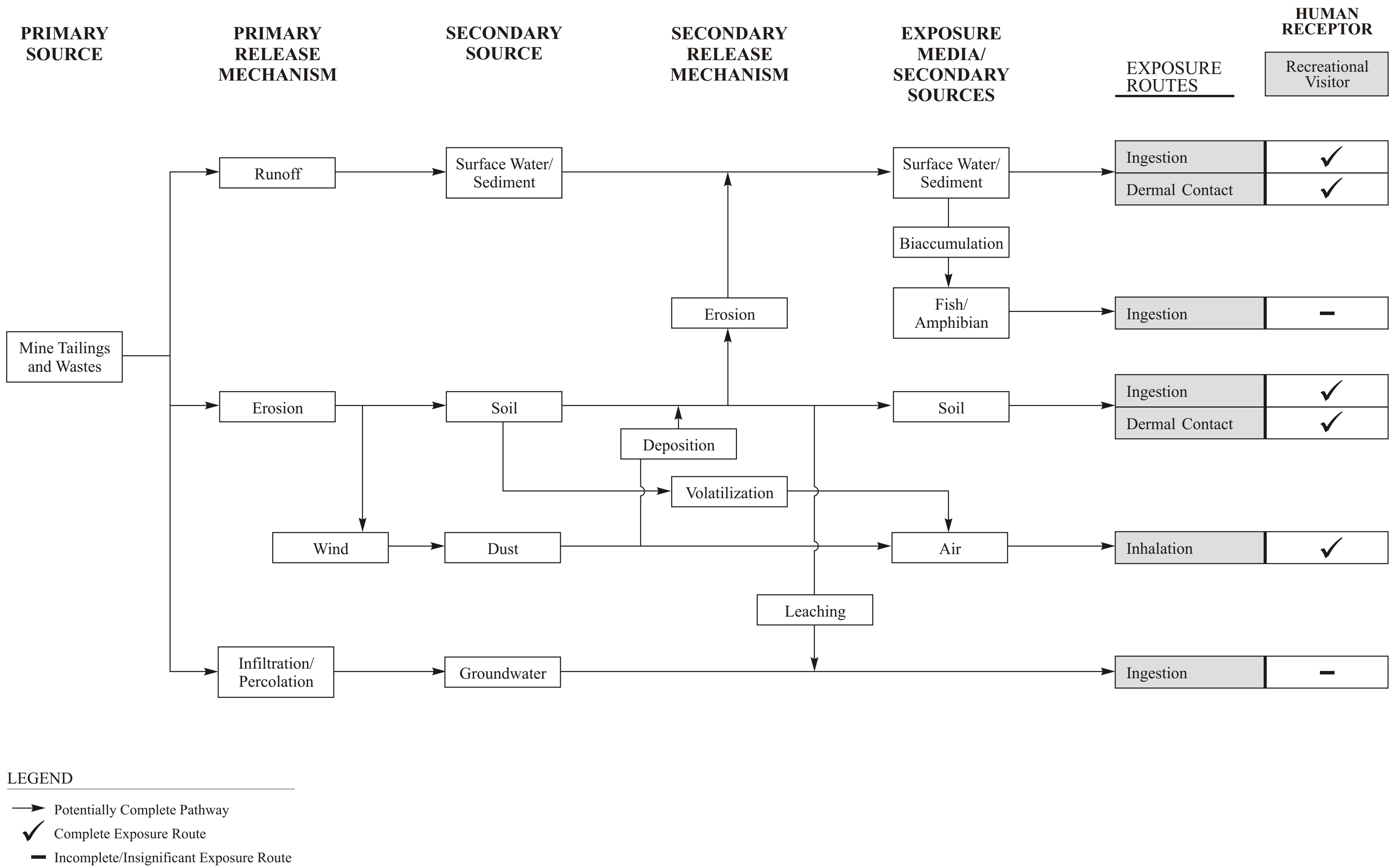
A complete exposure pathway must exist for exposure and subsequent risks to occur. A complete pathway must include the following elements (EPA 1989):

- A source and mechanism for release of constituents.
- A transport or retention medium.
- A point of potential human contact (exposure point) with the affected medium.
- An exposure route.

If one of the above elements is missing, the exposure pathway is not considered complete and is not evaluated in the risk assessment.

Contaminants from mine waste, groundwater, or air emissions may enter the surface water or sediment through surface water runoff, erosion from soils, or direct placement of mine waste in surface water bodies. Contaminants may enter groundwater through infiltration or leaching from source areas. Contaminants may also be directly released to soils, erode from sources, or be deposited from air emissions during previous mine operations. Volatile chemicals in soil (i.e., mercury) may volatilize into air; other contaminants may be entrained in fugitive dust. Contaminants may bioaccumulate from soils, surface water, or sediment into plants, animals, and fish.

Healdsburg is approximately 11 miles southwest of the Contact Mine. The primary land use is recreational. Spent shells, aluminum cans, and makeshift targets were located at the Sonoma Mine. Currently, no one lives permanently or temporarily at the site. Future use of the Site is unknown but most likely the Site will remain as an occasional recreational use area. Typical current activities include target shooting, nature study, and seasonal deer hunting. Bike riders train on the road located above the mines. Recreational visitors used the Sonoma mine for four-wheeled off-road vehicles, but the BLM has recently erected barriers to prevent this activity. No fishing is known to occur on site (Sharpe 2010). Typical activities include target shooting and overnight camping. Based on the known and anticipated activities at the Contact and Sonoma Mine sites, the following recreational visitor scenarios for adults, adolescents and children were selected to represent current or potential future use of the Site.



ecology and environment, inc.
International Specialists in the Environment
Portland, Oregon

CONTACT AND SONOMA MERCURY MINES
Sonoma County, California

Figure 4-1
HUMAN HEALTH CONCEPTUAL SITE MODEL FOR CONTACT/SONOMA MINES

Date:	Drawn by:	
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Recreational Visitors

As discussed previously, the only current and anticipated use of the Site is for recreational purpose. The district is a popular destination for target shooting and nature study. Recreational users may be exposed to mining-related contamination via incidental ingestion of contaminated soil, inhalation of air-borne soil particles, and dermal contact with soils.

In addition, there are small streams located on the Site. Recreational users may come in contact with surface water and sediments. Recreational visitors are likely to bring their own beverages to the site, rather than drinking from the on-site streams. Bicyclists and people engaged in nature study would more than likely bring their own water. If people were to drink from streams, there are much better nearby water sources than at the mine sites. No fishing is known to occur at the mines (Sharpe 2010). . There are no potable water wells at the site; therefore, groundwater exposure is not evaluated. Adults, adolescent (aged 10 to 15-years), and children (aged 4 to 10 years) campers are considered. It has been assumed that no plants on-site would be consumed by people. Although seasonal deer hunting occurs, it is unlikely that deer feed often from the site because a typical mule deer's home range is over 700 acres and the site is only 23 acres (Sample et al. 1997). Therefore, ingestion of deer meat was not considered.

Although camping does not occur on-site, a camping scenario was selected because it would be more conservative than the existing known recreational uses and would cover the possible future recreational uses.

Quantification of Exposure

The magnitude, frequency, and duration of exposure for each complete pathway are estimated based on EPA recommended methods. Quantification of exposure involves two sequential tasks. First, an exposure point concentration (EPC) was calculated. An EPC is defined as an upper-bound concentration of COPC in a media that receptors may contact. Next, the EPC is combined with standard exposure parameters (body weight [BW], duration of contact, etc.) to estimate receptor intake or the amount of the COPC taken into the body. The methodology, intake equations, and exposure parameters used to quantify exposure are provided below.

Estimation of Exposure Concentration

The concentrations of COPCs to which human receptors will be exposed over time will be estimated according to EPA guidance (EPA 1992b). The EPA indicates that a 95% upper confidence limit (UCL) on the mean of COPC concentrations should be used as the EPC. Inherent in this approach is the assumption that receptors that contact an environmental medium containing a COPC do so randomly. Thus, an estimate of average concentration (or in this case the upper bound on the average) is the concentration to which a receptor might be exposed.

To determine the 95% UCL, the EPA's ProUCL program, version 4.00.2 (EPA 2007f) was used. ProUCL 4.0 includes goodness-of-fit tests (e.g., normal, log-normal, and gamma) for data sets with and without non-detects (ND). For data sets with NDs, ProUCL 4.0 can create additional columns to store extrapolated values for NDs obtained using regression on order statistics (ROS) methods, including normal ROS, gamma ROS, and lognormal ROS (robust ROS) methods. ProUCL 4.0 also has parametric (e.g., maximum likelihood estimate, t-statistic, gamma distribution), nonparametric (e.g., skewness-adjusted CLT, Kaplan-Meier), and computer intensive bootstrap (e.g., percentile, BCA) methods to compute UCLs for uncensored data sets and also for data sets with ND observations. In cases where the 95% UCL value is greater than the maximum detected value in the data set, the maximum detected value will be used as the EPC.

EPC values used in the risk assessment are summarized in Table 4.1-2.

COPC Concentrations in Air

To estimate the concentration of particulates in dust at the Contact and Sonoma Mine sites, EPC for particulates was calculated using a particulate emission factor (PEF). The PEF relates the concentration of contaminant in soil to the concentration of dust particles in air generated from a "fugitive" or open source. For this assessment, EPA's default PEF of 1.32E+9 was used. This PEF was calculated based on the equations and parameters identified in the *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites* (EPA 2002b)

Calculation of Intake

Potential exposures to the receptors described in the above scenarios are quantified using intakes, which are expressed with units of milligrams of a chemical per unit BW per unit time. Estimated intakes, then, are provided in units of milligrams of COPCs per kilogram of BW per day (mg/kg-day). When evaluating carcinogenic COPCs, the intake is referred to as the lifetime average daily intake (LADI), because the intake is averaged over a lifetime.

The generic equation and variables for calculating chemical intakes are described below (EPA 1989).

$$I = \frac{C \times CR \times EF \times ED}{BW \times AT} \qquad \text{Equation 1}$$

Where:

I	=	intake; the amount of chemical at the exchange boundary (mg/kg body weight/day)
C	=	EPC in specific media (e.g., milligrams per liter of water)
CR	=	contact rate, which is the amount of contaminated medium contacted per unit time or event (e.g., liters/day)
EF	=	exposure frequency, which describes how often exposure occurs (days/year)

ED = exposure duration, which describes how long exposure occurs (years)
BW = body weight, which is the average body weight over the exposure period (kilogram [kg])
AT = averaging time, which is the period over which exposure is averaged (days)

This generic equation was modified to account for scenario-specific exposures to COPCs. For the inhalation route of exposure, the intake is depicted as an exposure concentration (EC), and for the dermal route (water contact only) the intake is depicted as the dermally absorbed dose. Additional variables were added to account for unit conversions or factors specific to one pathway, such as skin surface area and exposure time. Intake equations and values for exposure parameters are presented in Tables 4.1-2 through 4.1-4and discussed in this section.

The intakes calculated for each scenario are intended to represent reasonable maximum exposure (RME) conditions. An RME scenario is a combination of high-end and average exposure values and is used to represent the highest exposure that is reasonably expected to occur. The RME scenario is a conservative exposure scenario that is plausible yet well above the average exposure level. Intake rates are discussed in the following section.

Identification of Exposure Scenarios

The overview of the exposure assessment in Section 4.3.3.1 and 4.3.3.2 provides the foundation for how intake estimates are calculated for each exposure scenario. The following section provides a discussion of the exposure parameters used to quantify intakes. Two scenarios are evaluated - a RME scenario and a central tendency (CT) scenario for each receptor population.

The RME and CT scenarios are defined by EPA (1989). As stated above, the RME scenario is a combination of high-end and average exposure values and is used to represent the highest reasonable exposure that could occur. The CT scenario is based on average exposure conditions but at upper bound contaminant concentrations. The RME scenario provides a health-protective estimate of exposure that is reasonable but is still well above the average exposure level, while the CT scenario provides an estimate of exposure for most individuals within a population.

The following complete exposure scenarios are quantitatively evaluated in the HHRA using the equations provided below (Tables 4.1-3 – 4.1-5).

- Current/future Camper – Adult (ingestion, dermal, and inhalation)
- Current/future Camper – Adolescent (ingestion, dermal, and inhalation)
- Current/future Camper – Child (ingestion, dermal, and inhalation)

Descriptions of the exposure routes for all receptors, including exposure factors relevant to each scenario, are described and defined in the following sections.

Exposure parameters for the RME and CT are presented for the each scenario. Tables 4.1-3 to 4.1-5 present the values used for each exposure parameter along with the source of the value. Exposure parameters were drawn primarily from EPA's Exposure Factors Handbook (EFH) (EPA 1997a) and from BLM's Risk Management Criteria document (BLM 2004). The EFH presents a compilation of data for many of the exposure factors and thus, is a primary resource for the selection of appropriate exposure factors. For BLM's Risk Management Criteria, scenario-specific exposure variables were supplied by Dr. Karl Ford (Ford 2010).

Adult Camper

A U.S EPA default value of 70 kg is assumed for the BW for the adult camper. Based on the recommendation for the adult residents, it is assumed the adult camper exposure duration (ED_A) is 9 and 30-year for the CT and RME cases, respectively. For assessment of oral and dermal non carcinogens, an averaging time (AT_{nc}) of 10,950 days and 3,285 days (ED x 365 day/year) is used. For inhalation, an AT_{nc} of 262,800 hours and 78,840 hours is used (CT and RME; ED x 365 day/year x 24 hours/day). For carcinogens, the EPA default oral and dermal AT_c of 25,550 years and inhalation AT_c of 613,200 hours is used. For inhalation exposure, an ED of 24 hours/day is assumed, based on professional judgment.

Soil ingestion rates are not available specifically for campers. The CT ingestion rate for adult campers (IR_A; 50 mg/day) is based on EPA's Exposure Factor Handbook (EPA 1997a) recommendations for resident adults. The RME value of 480 mg/kg for this receptor is based on a recommendation by Hawley (1985), as presented EPA 1997a, and represents soil ingestion by adults engaged in outdoor activities.

Surface area (SA) assumptions were based on recommendations from EPA's Dermal Assessment Guidance (EPA 2004). Adult campers are assumed to wear short sleeve shirts, long pants, and shoes leaving the head, hands, and forearms available for contact. The adult camper surface area (SA_A) for dermal contact with soil for the RME and CT case is assumed to be 3,300 cm^2. This value is the average of the 50th percentile for males and females greater than 18 years of age.

Soil-to-skin adherence factors (AF) assumptions are based on values presented in EPA's Dermal Assessment Guidance (EPA 2004). There are not specific AF recommendations for camping. The adult camper AF (AF_A) for the RME and CT case (0.08 and 0.01, respectively) is based on the 50^{th} and 95^{th} percentile values for adult soccer players. Data characterizing exposure time (ET) and exposure frequency (EF) for the camper in the area is not available. Based on the BLM Risk Management Criteria (BLM 2004), it is assumed that campers visit the site 14 days a year for the RME and CT cases (Ford 2010). An ET of 24 hours per day is assumed, also based on professional judgment.

Adolescent Camper

The adolescent camper exposure duration (ED_{AD}) is assumed to be the entire adolescent period (age 10 to 15-years) for the CT and RME cases. Therefore, ATnc for oral and dermal routes is calculated to be 2,190 days and for inhalation exposure, 52,560 hours. For carcinogens, the EPA default oral and dermal AT_c of 25,550 years and inhalation AT_c of 613,200 hours is used. The adolescent body weight is assumed to be 48 kg for both the CT and RME cases. This value is based on data presented in the EHF (EPA 1997a) and represents the averaged 50^{th} percentile (CT) body weights for boys and girls aged 10 to 15-years. Adolescent campers are assumed to wear short sleeve shirts, long pants, and shoes leaving the head, hands, and forearms available for contact. The CT and RME cases SA is assumed to be 3250 cm^2 for dermal exposures, which represents the average SA for adolescent boys and girls (EPA 1997a, 2004). As recommended in EPA 2004, all SA estimates use 50th percentile values (for RME and CT cases) to correlate with average body weights to prevent inconsistent parameter combinations as body weight and SA are dependent variables. The adolescent adherence factor ($AF_{,AD}$) for the RME and CT (0.4 and 0.04 mg/cm^2-event), respectively, are based on the 50^{th} and 95^{th} percentile values for children (aged 8 to 12) playing in dry soil (EPA 2004). The adolescent soil intake rates (IR_{AD}) of 100 mg/day and 400 mg/day (CT and RME cases, respectively) represent the EFH recommended values for soil ingestion for children. The EFH recommendations are based on several studies involving young children (<6-years). However, there is currently no data available characterizing the soil ingestion rates for children by age group. Data characterizing ET and exposure frequency (EF) for the camper in the area are not available. Based on BLM estimates (Ford 2010), exposure frequency for RME and CT campers will be 14 days per year. An ET of 24 hours per day is assumed, also based on professional judgment.

Recreational Child Camper

The child camper is assumed to be a 4 to 10 year old child. Thus, the exposure duration is 6 years and averaging time for oral and dermal exposures to noncarcinogens is 2,190 days. For carcinogens, the default averaging time for oral and dermal exposures is 25,550 days. The averaging times for inhalation exposures to noncarcinogens and carcinogens are 52,560 hours and 613,200 hours, respectively. The average BW for the child is 24 kg (EPA 1997a). Exposure frequency for the child camper will be assumed to be 14 days per year for both RME and CT cases (BLM 2004) The EPA recommended CT ingestion rate (IRc) of 100 mg/day and the high-end or RME ingestion rate of 400 mg/day are used to estimate incidental ingestion of soil (EPA 2002c). The child camper is assumed to wear a short-sleeved shirt and shorts, leaving the feet, lower legs, forearms, hands, and head exposed to soil, resulting in an exposed skin surface area of 2400 cm2 (EPA 1997a, 2004). This value is used for both the CT and RME cases. Soil-to-skin adherence factors of 0.2 mg/cm2 and 0.4 mg/cm2 was used for the CT and RME cases, respectively. The CT value is EPA's (2004) recommendation based on a study of kids playing at a day care and in wet soil. The RME is based on a study of children playing in dry soil (EPA 2002).

Table 4.1-2 Exposure Point Concentrations for Surface Soil, Human Health Assessment, Contact-Sonoma Mines, Sonoma, California

COPC	n	Range of Detected Values (mg/kg)	Mean (mg/kg)	Median (mg/kg)	Standard Deviation (mg/kg)	95% UCL for EPC (mg/kg)[a]	ProUCL Recommended 95% UCL
Arsenic	48	0.46 - 16	7.001	nc	3.125	7.581	95% KM (Percentile Bootstrap) UCL
Cobalt	48	0.31 - 160	54.26	50	35.39	105.1	99% Chebyshev (Mean, Sd) UCL
Iron	48	79 - 150000	46156	46000	23070	79287	99% Chebyshev (Mean, Sd) UCL
Lead	48	0.94 - 620	47.46	15	121.6	222.1	99% Chebyshev (Mean, Sd) UCL
Manganese	48	12 - 7400	906.3	775	1007	2352	99% Chebyshev (Mean, Sd) UCL
Mercury	48	0.11 - 4100	158.1	35	596.9	395.2	95% Chebyshev (MVUE) UCL
Nickel	48	2.3 - 2200	806.2	700	580.4	1030	95% Approximate Gamma UCL

Key:

COPC = Chemical of Potential Concern.
mg/kg = milligrams per kilogram.
na = no value available; the ProUCL program does not calculate a medium value for censored data sets.
n = number of samples collected.
UCL = upper confidence limit. The 95% UCL defines a value that equals or exceeds the true mean 95% of the time.

[a] EPA ProUCL version 4.00.02 was used to generate 95% UCL concentrations.

Table 4.1-3 Calculation of COPC Intake from Soil/Sediment Ingestion

A. Intake Equation:

$$Dosage\,(mg\,/\,kg\,/\,day) = \frac{C_s\ x\,IR\,x\,CF\ x\,EF\ x\,ED}{BW\ x\,AT}$$

B: Variables and Assumptions:

Variables	Exposure Case CT	RME	Units	Description	Citation
C_s	Chemical-specific concentration in soil		mg/kg	Concentration of COC in soil; 95% UCL	–
IR_A	50	480	mg/day	Adult soil ingestion rate	EPA 1997a
IR_{AD}	100	400	mg/day	Adolescent soil ingestion rate	EPA 2002c
IR_C	100	400	mg/day	Child soil ingestion rate	EPA 2002c
CF	$1x10^{-6}$		kg/mg	Unit correction factor	–
EF_A EF_{AD} EF_C	14	14	day/year	Adult, adolescent, and child exposure frequency	Ford 2010
ED_A	9	30	year	Adult exposure duration	EPA 1991
ED_{AD}	6	6	year	Adolescent exposure duration	Adolescent period (age 10 to 15)
ED_C	6	6	year	Child exposure duration	Child period (age 4 to 10)
BW_A	70	70	kg	Adult body weight	EPA 1989
BW_{AD}	48	48	kg	Adolescent body weight	EPA 1997a
BW_C	24	24	kg	Child resident body weight	EPA 1997a
ATc	25,550		days	Averaging time – carcinogens	EPA 1989
ATnc	ED x 365		days	Averaging time - noncarcino-gens	EPA 1989

Key:
COPC = contaminant of potential concern
EPA = U.S. Environmental Protection Agency
kg = kilogram
mg = milligram
CT = average or central tendency
RME = reasonable maximal exposure
TBD = to be determined
UCL = upper confidence limit

Table 4.1-4 Calculation of COPC Intake From Dermal Soil/Sediment Contact

A. Intake Equation:

$$Dosage(mg/kg/day) = \frac{C_s \; x \; SA \; x \; AF \; x \; ABS \; x \; CF \; x \; EF \; x \; ED}{BW \; x \; AT}$$

B. Variables and Assumptions:

Variable	Exposure Case CT	Exposure Case RME	Units	Description	Citation
C_s	Chemical specific concentration in soil		mg/kg	Concentration of COC in soil; 95% UCL	–
SA_A	3300	3300	cm^2/day	Adult exposed body surface area	EPA 1997a
SA_{AD}	3250	3250	cm^2/day	Adolescent exposed body surface area	EPA 1997a; EPA 2004
SA_C	2400	2400	cm^2/day	Child exposed body surface area	EPA 1997a; EPA 2004
CF	$1x10^{-6}$		kg/mg	Unit correction factor	–
AF_A	0.01	0.08	mg/cm^2	Adult skin adherence factor	EPA 2004
AF_{AD}	0.04	0.4	mg/cm^2	Adolescent skin adherence factor	EPA 2004
AF_C	0.2	0.4	mg/cm^2	Child skin adherence factor	EPA 2004
ABS	Chemical Specific		unitless	Skin absorption	EPA 2004
EF_A EF_{AD} EF_C	14	14	day/year	Adult ,adolescent, and child exposure frequency	Ford 2010
ED_A	9	30	year	Adult exposure duration	EPA 1991
ED_{AD}	6	6	year	Adolescent exposure duration	Adolescent period (age 10 to 15)
ED_C	6	6	year	Child exposure duration	Child period (age 4 to 10)
BW_A	70	70	kg	Adult body weight	EPA 1989
BW_{AD}	48	48	kg	Adolescent body weight	EPA 1997a
BW_C	24	24	kg	Child body weight	EPA 1997a
ATc	25,550		days	Averaging time - carcinogens	EPA 1989
ATnc	ED x 365		days	Averaging time - noncarcinogens	EPA 1989

Key:
cm = centimeter
COPC = contaminant of potential concern
CT = average or central tendency case
EPA = U.S. Environmental Protection Agency
kg = kilogram
mg = milligram
RME = reasonable maximal exposure case
TBD = to be determined
UCL = upper confidence limit

Table 4.1-5 Calculation of COPC Intake from Soil Inhalation Exposure

A. Intake Equation:

$$Dosage(mg/m^3) = \frac{C_a \, x \, ET \, x \, EF \, x \, ED}{AT}$$

B. Variables and Assumptions:

Variable	Exposure Case CT	Exposure Case RME	Units	Description	Citation
C_a	Chemical specific concentration in air		mg/m^3	Concentration of COC in air; 95% UCL or modeled concentration	–
ET_A ET_{AD} ET_C	24	24	hr/day	Adult, adolescent , and child exposure time	Site-Specific; Professional Judgment
EF_A EF_{AD} EF_C	14	14	day/year	Adult , adolescent, and child exposure frequency	Ford 2010
ED_A	9	30	year	Adult exposure duration	EPA 1991 (based on adult resident)
ED_{AD}	6	6	year	Adolescent exposure duration	Adolescent period (age 10 to 15)
ED_C	6	6	year	Child exposure duration	EPA 1991
ATc (all receptors)	613,200		hours	Averaging time - carcinogens	EPA 2009d
ATnc (all receptors)	ED x 365 days/year x 24 hour/day		hours	Averaging time - noncarcinogens	EPA 2009d

Key:
cm = centimeter
COPC = contaminant of potential concern
CT = average or central tendency case
EPA = U.S. Environmental Protection Agency
kg = kilogram
mg = milligram
RME = reasonable maximal exposure case
TBD = to be determined
UCL = upper confidence limit

4.1.3.3 Toxicity Assessment

The objectives of the toxicity assessment are to compile information on the nature of the adverse health effects of COPCs and to provide an estimate of the dose-response relationship for each COPC selected (i.e., determine the relationship between the extent of exposure and the likelihood and/or severity of adverse effects).

For the risk assessment, COPCs will be divided into two groups: agents known or suspected to be human carcinogens (carcinogens) and those thought to pose no carcinogenic risks (noncarcinogens). As used here, the term “carcinogen” denotes any chemical for which there is sufficient evidence that exposure may result in continuing uncontrolled cell division (cancer) in humans and/or laboratory animals. The risks posed by these two groups are assessed differently because noncarcinogenic chemicals generally exhibit a threshold dose below which no adverse effects occur, whereas for carcinogens the simplifying assumption has been made that carcinogenic responses are linearly related to dosage even in the unobservable area of the dose-response curve. That is, it is assumed for carcinogens that each incremental increase in dosage produces an incremental increase in the risk for cancer.

Quantitative Indices of Toxicity

Toxicity values were chosen according to the following hierarchy recommended in EPA’s *Human Health Toxicity Values in Superfund Risk Evaluations* (EPA 2003a.:

1. Integrated Risk Information System (IRIS) Computer Database (EPA 2010a). IRIS is the preferred source of information because this database contains the most recent toxicity values that have been reviewed extensively by EPA.

2. EPA’s Provisional Peer Reviewed Toxicity Values (PPRTVs). The Office of Research and Development/National Center for Environmental Assessment/Superfund Health Risk Technical Support Center (STSC) develops PPRTVs on a chemical-specific basis (EPA 2010b)

3. Other Values. In the absence of established values from IRIS or PPRTVs, toxicity values from several sources (California EPA toxicity values, EPA regional toxicologists, Agency for Toxic Substances and Disease Registry (ATSDR) toxicological profiles, or National Center for Environmental Assessment may be used.

It is acknowledged that multiple Tier 3 sources for toxicity values exist. For the toxicity values used in this assessment, the following hierarchy is used for the Tier 3 values.

1. ATSDR minimal risk levels (MRLs) (ATSDR 2010a).

2. California EPA toxicity values.(CalEPA 2010)

3. EPA Superfund program's Health Effects Assessment Summary Tables as obtained from EPA (EPA 1997b).

This hierarchy is consistent with the hierarchy used by EPA in development of the Regional Screening Tables (EPA 2010d. Therefore, if no IRIS values are obtained from Tier 2 and Tier 3 sources, toxicity values were obtained from the Regional Screening Tables.

Noncarcinogenic and carcinogenic indices are tabulated separately. For noncarcinogenic effects, tabulations include chemical route-specific reference doses RfD (oral and dermal), reference concentrations (RfC; inhalation), critical effects, RfD/RfC basis/source, and uncertainty/modifying factors. Tables include the information by chemical and exposure, for carcinogenic effects; the values in the tables will include SFs (oral and dermal), inhalation unit risk (IUR) (inhalation), mutagen potential, weight or evidence or cancer guideline description, and SF basis/source.

Toxicological summaries for all COPCs that contributed substantially to overall risk or hazard are included in Appendix E. These summaries qualitatively discuss toxicokinetics and key adverse effects that could result from exposure to site contaminants.

Route-to-Route Extrapolation of Reference Doses and Slope Factors

Once a substance has been absorbed via the oral or dermal routes, its distribution, metabolism, and elimination patterns (biokinetics) are usually similar regardless of the exposure route. For this reason, and because dermal route RfDs and SFs are usually not available, oral route RfDs and SFs are commonly used to evaluate exposures to substances by both the oral and dermal routes. In such cases, the dermal intake has to be adjusted to account for differences in a chemical's absorption between the oral and dermal routes of exposure.

Although inhalation route biokinetics differ more from oral route kinetics than do the dermal route kinetics, oral RfDs and SFs may also be used to evaluate inhalation exposures if inhalation route RfCs and IURs are not available, and *vice versa*. Toxicological indices will not be extrapolated from one route to another if the critical effect for either route is at the point of contact.

Assessment of Lead

Lead has previously been identified as a COPC at the Contact/Sonoma Mine site. Although the toxic effects from lead exposure are well known, there are no verified or consensus toxicity values available for lead in IRIS, Health Effects Assessment Summary Tables, or other sources. The absence of authoritative toxicity values reflects the scientific community's inability to agree on a threshold dose for lead's noncarcinogenic effects or to satisfactorily estimate its carcinogenic potency, despite a large body of scientific literature on its toxicological effects.

Due to the lack of toxicity values, exposure to lead will be assessed using physiologically based toxicokinetic models for children and adults. The exposure estimates derived using these models will then be compared with acceptable exposure limits.

Models have been adopted to assess blood lead dose-response relationships in adults and children in lead-contaminated areas. Young children are the segment of the population at greatest risk from lead exposure because in comparison to adults their intake of lead from the gastrointestinal tract is greater (50% for children versus 5% for adults) and their developing organ systems are more sensitive to the toxic effects of lead. The lead Integrated Exposure Uptake Biokinetic (IEUBK) model is recommended (EPA 2007g) to assess potential impacts to children from exposure to lead.

The IEUBK model predicts blood lead levels in young children resulting from multiple pathways of exposure, including intake via air, soil, drinking water, and diet. Default parameters exist in the model for intake of lead via the listed pathways. Site-specific data can also be input into the model to derive site-specific results. The IEUBK dietary intake parameter does include consumption of fish or other locally harvested food as a default parameter; therefore, if lead is identified as a COPC and can be taken up into locally harvested food, this consumption will be included as an "alternative" dietary source of lead.

4.1.3.4 Risk Characterization

Risk characterization, the final component of the risk assessment process, integrates the findings of the first two components (exposure and toxicity) by quantitative estimation of human health risks. For each scenario evaluated, incremental lifetime cancer probabilities will be estimated for an RME exposure scenario.

Assessment of Carcinogens

EPA (EPA 2005k) uses a weight-of-evidence (WOE) approach to evaluate the likelihood that a substance is a carcinogen. EPA uses standard descriptors as part of the hazard narrative to express the conclusion regarding the WOE for carcinogenic hazard potential. EPA recommends five standard hazard descriptors: "Carcinogenic to Humans," "Likely to Be Carcinogenic to Humans," "Suggestive Evidence of Carcinogenic Potential," "Inadequate Information to Assess Carcinogenic Potential," and "Not Likely to Be Carcinogenic to Humans." Under EPA's 1986 guidelines for carcinogen risk assessment, the WOE was described by categories A through E. These categories are (A) human carcinogen, (B1 or B2) probable human carcinogen, (C) possible human carcinogen, and (D) not classifiable as a human carcinogen, and (E) not a carcinogen to humans (EPA 1986).

When adequate data exist, EPA publishes a cancer slope factor (SF) for known and probably human carcinogens. The SF represents the carcinogenic potency of the substance and is expressed as risk per milligram per kilogram per day [$(mg/kg\text{-}day)^{-1}$]. SFs are used along with calculated intake to estimate the potential for excess cancer risk (see Section 4.3.5.3).

EPA (EPA 2004) has not developed SFs for dermal exposure to all chemicals, but has provided a method for extrapolating dermal SFs from oral SFs. This route-to-route extrapolation has a scientific basis because an absorbed chemical's distribution, metabolism, and elimination patterns are usually similar regardless of exposure route. However, dermal toxicity values are typically based on absorbed dose, whereas oral exposures are usually expressed in terms of administered dose. Consequently, if adequate data on the gastrointestinal (GI) absorption of a COPC is available, then dermal SFs may be derived by applying a GI absorbance factor to the oral toxicity value (EPA 2004). For chemicals lacking a GI absorbance value, absorbance is assumed to be 100% and the oral SF is used to estimate toxicity via dermal absorption.

As discussed above, carcinogenic potency for inhalation is represented by an IUR, which is expressed in as $[(ug/m3)^{-1}]$. Similar to oral and dermal assessment, IURs are combined with calculated intakes to estimate the potential for excess cancer risk

Oral and dermal SF and IURs, GI absorption factors, and WOE classification are presented in Table 4.1-6.

Table 4.1-6 Toxicity Factors

Compound	Oral Reference Dose (mg/kg)	Dermal Reference Dose (mg/kg)	Reference Concentration (mg/m^3)	Dermal Absorbance (unitless)	Oral Slope factor $(mg/kg\text{-}day)^{-1}$	Dermal Slope factor $(mg/kg\text{-}day)^{-1}$	Unit Inhalation Risk $(mg/m^3)^{-1}$	GI Absorbance (unitless)
Arsenic	0.0003	0.0003	0.000015	1	1.5	1.5	0.0043	0.03
Cadmium	0.001	0.000025	0.00001	0.025	nv	nv	0.0018	0.001
Chromium	1.5	0.0195	nv	0.013	nv	nv	nv	0.001
Cobalt	0.0003	0.0003	0.000006	1	nv	nv	0.009	0.001
Iron	0.7	0.7	nv	1	nv	nv	nv	0.001
lead	nv	nv	nv	nv	nv	nv	nv	0.001
Manganese	0.14	0.14	0.00005	1	nv	nv	nv	0.001
Mercury	0.00016	0.00016	0.0003	1	nv	nv	nv	0.001
Nickel	0.02	0.0008	0.00009	0.04	nv	nv	0.00026	0.001
Thallium	6.5E-05	0.000065	nv	1	nv	nv	nv	0.001
Vanadium	0.00504	0.00504	nv	1	nv	nv	nv	0.001

Sources: EPA 2010a, RAIS 2010

Noye: nv = no value

Any exposure to a carcinogen theoretically entails some finite risk of cancer. However, depending on the potency of a specific carcinogen and the level of exposure, such a risk could be practically negligible.

Scientists have developed several mathematical models to estimate low-dose carcinogenic risks from observed high-dose risks. Consistent with current theories of carcinogenesis, EPA has selected the linearized multistage model based on prudent public health policy (EPA 1986, 2005k). As a further conservatism, the EPA uses the upper 95% UCL on the dose-response relationship from animal studies to estimate a low-dose SF. By employing these procedures, the regulatory agencies are likely to overestimate the actual SF for humans.

Using the SF (oral and dermal), lifetime excess cancer risks can be estimated by:

$$Risk = \sum LADI_i \times SF_i \qquad \text{Equation 2}$$

Where:

$LADI_i$ = Exposure route-specific lifetime average daily intake (mg/kg-day)

SF_i = Route-specific (oral and dermal) slope factor $(mg/kg\text{-}day)^{-1}$

Using the IUR (inhalation), the risk is determined by multiplying the EC by the IUR as shown below:

$$Risk = \sum EC_i \times IUR_i \qquad \text{Equation 3}$$

Where:

EC_i = Exposure concentration (micrograms per cubic meter [$\mu g/m^3$])

IUR_i = Inhalation unit risk $(\mu g/m^3)^{-1}$

Assuming risk additivity, the carcinogenic risks for the oral, dermal, and inhalation routes of exposure are summed.

Carcinogenic risk estimates represent increased lifetime cancer risk (ILCR) and are expressed as the number of excess cancer cases that could occur in an exposed population. The results are expressed as cases per population exposed which can be expressed, for example as 1 excess case per million people exposed or as a fraction such as $1x10^{-6}$. Regulatory bodies set their own acceptable cancer risk levels (or *de minimus* risk) and generally they are $1x10^{-6}$ or $1x10^{-5}$. BLM's Risk Management Criteria for Metals at BLM Mining Sites uses a $1x10^{-5}$ criteria; therefore, this will be used to evaluate human health cancer risks in this document.

Assessment of Noncarcinogens

To evaluate noncarcinogenic effects, EPA (EPA 1989) defines acceptable exposure levels as those to which the human population, including sensitive subgroups, may be exposed without adverse effects during a lifetime or part of a lifetime, incorporating an adequate margin of safety. The potential for adverse health effects associated with noncarcinogens (for example, organ damage, immunological effects, birth defects, and skin irritation) usually is assessed by comparing the estimated average daily intake (that is, exposure dose) to a RfD.

RfDs are expressed in units of mg/kg-day. The RfD is an estimate (with uncertainty possibly spanning an order of magnitude) of the daily intake to humans (including sensitive subgroups) that should not result in an appreciable risk of deleterious effects. EPA assigns a qualitative level of confidence (low, medium, or high) to the study used to derive the toxicity value, database, and RfD. The relative degree of uncertainty associated with the RfDs and the level of confidence EPA assigns to the data and the toxicity value are considered when evaluating the quantitative results of the risk assessment.

EPA (EPA 2004) has not developed reference doses for dermal exposure to all chemicals, but has provided a method for extrapolating dermal RfDs from oral RfDs. If adequate data regarding the GI absorption of a COPC are available, then dermal RfDs may be derived by applying a GI absorbance factor to the oral toxicity value (EPA 2004). For chemicals lacking a GI absorbance value, absorbance is assumed to be 100%, and the oral RfDs are used to estimate toxicity via dermal absorption.

Oral and dermal toxicity data, including oral and dermal RfDs, inhalations RfCs, GI absorption factor, critical effect, and target organ are presented in Table 4.1-6. Target organ data were obtained from EPA's IRIS database (EPA 2010a) and ATSDR's MRL list (ATSDR 2010a).

In accordance with EPA guidelines (EPA 1989), a hazard quotient (HQ) for noncarcinogenic risks is derived for each chemical and exposure route and, based on the assumption of dose additivity, the individual HQs are summed over all contaminants to determine the hazard index (HI).

Risks associated with non-cancer effects (e.g., organ damage, immunological effects, birth defects, and skin irritation) are usually assessed by comparing the estimated average exposure to the acceptable daily dose, RfD or RfC. The RfD is selected by identifying the lowest reliable no observed adverse effect level (NOAEL) or lowest observed adverse effect level (LOAEL) in the scientific literature, then applying a suitable uncertainty factor (usually ranging from 10 to 1,000) to allow for differences between the study conditions and the human exposure situation to which the RfD is to be applied. NOAELs and LOAELs can be derived from either human epidemiological studies or animal studies; however, they are usually based on laboratory experiments on animals in which relatively high doses are used. Consequently, uncertainty or safety factors are applied when deriving RfDs to compensate for data limitations inherent in the underlying experiments and for the lack of precision created by extrapolating from high doses in animals to lower doses in humans.

Non-cancer hazards are usually assessed by calculating an HQ, which is the ratio of the estimated exposure to the RfD (oral and dermal), as follows:

$$HQ = \sum \frac{CDIi}{RfDi} \qquad \text{Equation 4}$$

Where:

CDI_i = Chronic Daily Intake (mg/kg-day)
RfD_i = Reference Dose (mg/kg-day)

Likewise, inhalation hazard is assessed by comparing the EC to the inhalation RfC:

$$HQ = \sum \frac{ECi}{RfCi} \qquad \text{Equation 5}$$

Where:

EC_i = Exposure concentration (µg/m^3)
RfC_i = Reference concentration (µg/m^3)

The HI calculated for a single mode of action is a measure of how close the estimated exposure comes to the RfD. If the HI is less than 1, adverse effects would not be expected. If the HI is greater than 1, adverse effects are possible, but not necessarily certain. If the HI exceeds 1, toxicology staff will review and segregate major chemical-specific effects identified in the derivation of the RfD by mechanisms of action and target organ. Upon segregation, HIs will be recalculated for specific effects or target organs in to further define potential risks.

Cancer Risk

Table 4.1-7 summarizes cancer risk for the camper scenarios evaluated in this risk assessment. The possible carcinogens evaluated include arsenic from ingestion and dermal exposure, and arsenic, cadmium, cobalt, and nickel from inhalation exposure. Total risk (i.e. the sum of ingestion and dermal and inhalation) for all RME case campers was below $1x10^{-5}$ with the highest cancer risk of 1.3×10^{-6} being associated with the adult and child campers. For all campers, ingestion exposure to arsenic provided greater than 90% of the total risk. Risk from the ingestion pathway was about 10-fold greater than dermal risk, and six to eight orders of magnitude greater than inhalation risk.

Because all RME cancer risks were found to be within *de minimus* risk levels, cleanup criteria (see Section 4.3.5.6) were not calculated based on a cancer endpoint.

Details for cancer risk calculations are shown in Appendix F.

Table 4.1-7 Summary of Excess Cancer Risk, Contact-Sonoma Mining Site

	COPC	Adult Camper CT	Adult Camper RME	Adolescent Camper CT	Adolescent Camper RME	Child Camper CT	Child Camper RME
Ingestion	Arsenic	4.0E-08	1.3E-06	7.8E-08	3.1E-07	1.6E-07	1.2E-06
	Cobalt	--	--	--	--	--	--
	Iron	--	--	--	--	--	--
	Lead	--	--	--	--	--	--
	Manganese	--	--	--	--	--	--
	Mercury	--	--	--	--	--	--
	Nickel	--	--	--	--	--	--
	Total	4.0E-08	1.3E-06	7.8E-08	3.1E-07	1.6E-07	1.2E-06
Dermal	Arsenic	7.9E-10	2.1E-08	3.0E-09	3.0E-08	2.2E-08	9.0E-08
	Cobalt	--	--	--	--	--	--
	Iron	--	--	--	--	--	--
	Lead	--	--	--	--	--	--
	Manganese	--	--	--	--	--	--
	Mercury	--	--	--	--	--	--
	Nickel	--	--	--	--	--	--
	Total	7.9E-10	2.1E-08	3.0E-09	3.0E-08	2.2E-08	9.0E-08
Inhalation	Arsenic	1.2E-16	4.1E-16	8.1E-17	8.1E-17	8.1E-17	8.1E-17
	Cobalt	3.5E-15	1.2E-14	2.4E-15	2.4E-15	2.4E-15	2.4E-15
	Iron	--	--	--	--	--	--
	Lead	--	--	--	--	--	--
	Manganese	--	--	--	--	--	--
	Mercury	--	--	--	--	--	--
	Nickel	1.0E-15	3.3E-15	6.7E-16	6.7E-16	6.7E-16	6.7E-16
	Total	4.7E-15	1.6E-14	3.1E-15	3.1E-15	3.1E-15	3.1E-15
	Total all pathways	4.1E-08	1.3E-06	8.1E-08	3.4E-07	1.8E-07	1.3E-06

Noncancer Risk

Noncancer hazard for the child camper scenarios was greater than 1.0 for the RME cases (Table 4.1-8). Noncancer hazard was greatest for the child RME case (HI = 2.0). The ingestion route was the major contributor to noncancer risk and ingestion exposure to mercury contributed approximately two-thirds of the risk. Cobalt and iron were other major contributors to noncancer risk. Mercury exposure contributed the greatest to overall noncancer risk and, thus, will be used to calculate a cleanup criterion (see Section 4.3.5.6).

Details for the noncancer risk calculations are shown in Appendix F.

Table 4.1-8 Summary of Noncancer Hazard, Contact-Sonoma Mining Site

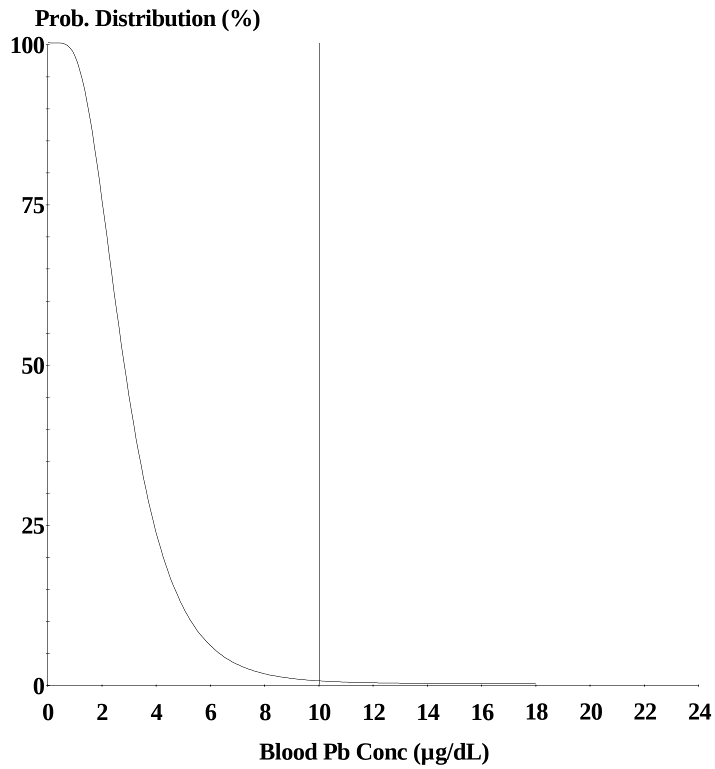
	COPC	Adult Camper CT	Adult Camper RME	Adolescent Camper CT	Adolescent Camper RME	Child Camper CT	Child Camper RME
Ingestion	Arsenic	6.923E-04	6.646E-03	2.E-03	8.E-03	4.E-03	2.E-02
	Cobalt	9.598E-03	9.214E-02	3.E-02	1.E-01	6.E-02	2.E-01
	Iron	3.103E-03	2.979E-02	9.E-03	4.E-02	2.E-02	7.E-02
	Lead	--	--	--	--	--	--
	Manganese	4.603E-04	4.419E-03	1.E-03	5.E-03	3.E-03	1.E-02
	Mercury	6.767E-02	6.496E-01	2.E-01	8.E-01	4.E-01	2.E+00
	Nickel	1.411E-03	1.355E-02	4.E-03	2.E-02	8.E-03	3.E-02
	Total	8.294E-02	7.962E-01	2.E-01	1.E+00	5.E-01	2.E+00
Dermal	Arsenic	1.E-05	1.E-04	8.E-05	8.E-04	6.E-04	1.E-03
	Cobalt	6.E-06	5.E-05	4.E-05	4.E-04	3.E-04	5.E-04
	Iron	2.E-06	2.E-05	1.E-05	1.E-04	9.E-05	2.E-04
	Lead	--	--	--	--	--	--
	Manganese	3.E-07	2.E-06	2.E-06	2.E-05	1.E-05	3.E-05
	Mercury	4.E-05	4.E-04	3.E-04	3.E-03	2.E-03	4.E-03
	Nickel	2.E-05	2.E-04	1.E-04	1.E-03	1.E-03	2.E-03
	Total	9.E-05	7.E-04	5.E-04	5.E-03	4.E-03	8.E-03
Inhalation	Arsenic	1.E-05	1.E-05	1.E-05	1.E-05	1.E-05	1.E-05
	Cobalt	5.E-04	5.E-04	5.E-04	5.E-04	5.E-04	5.E-04
	Iron	--	--	--	--	--	--
	Lead	--	--	--	--	--	--
	Manganese	1.E-03	1.E-03	1.E-03	1.E-03	1.E-03	1.E-03
	Mercury	4.E-05	4.E-05	4.E-05	4.E-05	4.E-05	4.E-05
	Nickel	3.E-04	3.E-04	3.E-04	3.E-04	3.E-04	3.E-04
	Total	2.E-03	2.E-03	2.E-03	2.E-03	2.E-03	2.E-03
	Total all pathways	9.E-02	8.E-01	2.E-01	1.E+00	5.E-01	2.E+00

Risk from Lead Exposure

The IEUBK model was run using default parameters except for site-specific soil. The IEUBK model predicts risk for child residents not the intermittent exposures assumed for the campers in this risk assessment. In that case, risk predictions from the IEUBK model likely overpredict risk attendant to lead exposure at Contact/Sonoma.

Model output is provided in the form of a probability density curve that shows the probability of blood lead concentrations occurring in a hypothetical population of children. This curve shows a plausible distribution of blood lead concentrations centered on the geometric mean blood lead concentration predicted by the model from available information about children's exposure to lead. From this distribution, the model calculates the probability that children's blood lead concentrations will exceed a level of concern (EPA 1994).

The EPA and the Centers for Disease Control and Prevention have determined that childhood blood lead concentrations at or above 10 micrograms of lead per deciliter (µg Pb/dL) present risks to children's health (CDC 1991). Therefore, a value of 10 µg/dL is generally used as the blood lead level of concern and is the threshold used in this assessment. The probability density curves designate the percentage of children predicted to have blood lead levels that exceed the threshold. Probability density curve was generated for this site and are provided as Figure 4-2. The EPA's risk reduction goal for contaminated sites is that no more than 5% of the population exposed to lead will have blood lead levels greater than 10 µg/dL (EPA 2003d). The IEUBK model gives potential percentages of children with blood lead levels above 10 µg/dL for the resident scenario of 0.222%. This result is well below the 5% EPA threshold.



Cutoff = 10.000 µg/dl
Geo Mean = 2.937
GSD = 1.600
% Above = 0.457

Age Range = 0 to 84 months

Run Mode = Research

Figure 4-2 Distribution Probablility Percent

Site-Specific Cleanup Criteria

Intake equations, such as those shown above for the camper scenarios evaluated in this RA, use exposure point concentrations, assumptions about the intake and frequency of contact, and toxicity values to estimate risk attendant to these hypothetical exposures. Conversely, those equations can be solved for the EPC value utilizing a resumed target risk that would reflect acceptable exposure conditions. Generally for carcinogenic risk calculations a target risk of $1x10^{-5}$ or $1x10^{-6}$ is assumed; for noncancer assessments the target risk is usually set to 1.0 that is where the dosage calculated is equivalent to the dose that the regulatory entity has determined to be safe.

As discussed above, caner risk for the camper scenarios yielded Increased Lifetime Cancer Risk values below $1x10^{-5}$, which for the purposes of this risk assessment will be considered a *de minimus* risk. On the other hand, noncancer hazard quotients for RME case adolescent and child campers were significantly above 1.0. Thus, remediation goals (RG) were calculated for noncancer hazard and the lowest RG for any scenario will be selected as the health-based RG for the site. Noncancer risk was driven by mercury exposure; thus, a remediation goal for mercury was calculated.

Mathematically, the relationship shown in Equations 4 or 5 can be rearranged to solve for the intake of the receptor as shown below.

$$CDIi = HQ \times RfD \quad \text{or} \quad ECi = HQ \times RfC \qquad \text{Equation 6}$$

The camper scenarios evaluated in this risk assessment considered soil exposure via ingestion, dermal, and inhalation routes. The RG calculated for the site should likewise include ingestion, dermal, and inhalation exposures. Using Equation 6 and the equations shown in Tables 4.1-3 through 4.1-5, the equation below was used to determine RG values for the site.

$$RG = \frac{TR}{EF \times ED} \times \left(BW \times \left(\frac{RfDo \times AT}{IR \times CF} + \frac{RfDd \times AT}{SA \times AF \times CF} + \frac{RfC \times AT}{PEF \times ET}\right)\right)$$

Where:

RG = Remediation goal (mg/kg)
TR = Target risk (HI = 1.0)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
RfDo= Oral reference dose (mg/kg-day)
AT = Averaging time (days)
IR = Soil ingestion rate (mg/day)
CF = Unit conversion factor (kg/mg)
RfDd = Dermal reference dose (mg/kg-day)
SA = Exposed body surface area (cm^2)

AF = Soil adherence factor (mg/cm^2)
RfC = Reference concentration (mg/m^3)
PEF = Particulate emission factor (m^3/kg)
ET = Exposure time (hours/day)

For the three camper scenarios evaluated in this risk assessment, soil mercury RG values were 1,700 mg/kg (adult), 655 mg/kg (adolescent), and 355 mg/kg (child). The RG for the child is recommended as a health-based criterion for the site.

4.1.3.5 Uncertainty Analysis

Uncertainty is inherent in every step of the risk assessment process. Understanding uncertainty is crucial for the interpretation of risk assessment results. The following sections briefly describe some uncertainties associated with each step of the process and the way they likely affect the overall risk estimates.

Environmental Sampling and Analysis and EPC Uncertainties

Samples collected during the investigations were intended to characterize the nature and extent of contamination at the site. While this sampling approach is sound for site characterization, it can result in uncertainties in estimating the average concentration, or EPC, that people may contact over time.

For example, although many sampling locations were selected in a random or systematic fashion using a grid system, some sampling locations were selected in a purposeful or directed manner to focus on particular areas where contamination was known or suspected to be present. Samples collected in this manner provide considerable information about the site but are not statistically representative of contamination that may be present on the site and may overestimate the average concentration that people may be exposed to.

Because of the variability and uncertainty inherent in the sampling and analysis processes, the chemical concentrations reported may differ from the actual chemical concentrations. Uncertainty is introduced by the use of estimated, or J-qualified, results, which may not have the same precision and accuracy as data meeting all standard quality control criteria. These uncertainties may overestimate or underestimate the true concentrations present.

Exposure Assessment Uncertainties

All exposure calculations assume that the chemical concentrations in soils will remain constant over the duration of exposure. Actual concentrations could remain the same or decrease, depending on both site-specific and chemical-specific factors.

Selection of appropriate exposure parameters is typically a challenging exercise in conducting human health risk assessment as it is difficult to make generalizations about potentially impacted populations and site-specific exposure studies are very rare. Nevertheless, the risk assessor must make the best assumptions possible based on available information.

The individual exposure parameter values used in the RME calculations were selected to represent a high-end estimate of exposure for an individual that is a conservative, or protective, estimate of actual exposures. The exposure values selected were either standard default values consistent with the EPA regulation or were conservatively protective estimates selected based on best professional judgment. Estimated risks based on CT, or mean or median, exposure values may be considerably lower than the estimates based on RME assumptions presented in this assessment, but may still have a tendency to overestimate the true risk at the site.

Contact with surface water and sediment represents a complete exposure pathway. However, there was insufficient data available to characterize the nature of surface water and sediment contamination. Previous investigations at the site indicate that contamination in sediment, surface water, and biota may be of concern. The USGS collected limited sediment, surface water, biological, and soil samples at the Contact and Sonoma mines in 2008. Mercury was detected in the two sediment samples collected onsite from the Sonoma mines above BLM's Human Health RMC for camper of 40 mg/kg as well as in two of the eight sediment samples collected downstream of the mines (Weston 2009a, 2009b). Trout samples collected downstream of the mines contained mercury at or above the BLM Human Health RMC of 0.048 ug/g in the ten samples collected (Weston 2009a, 2009b). While these data were not of sufficient quality for inclusion in a quantitative risk assessment, results report by the USGS indicates that contamination of these media may be of concern. Omission of the surface water and sediment pathway from the quantitative risk assessment most likely results in an underestimation of the total risk and hazard, particularly if recreational users frequently contact and/or ingest surface water and sediments.

Toxicity Assessment Uncertainties

The basic uncertainties associated with the derivation of toxicity values in the toxicity assessment include:

- Uncertainties arising from the design, execution, or relevance of the scientific studies that form the basis of the assessment; and
- Uncertainties involved in extrapolation from the underlying scientific studies to the exposure situation being evaluated, including variable responses to chemical exposure within human and animal populations, between species, and between routes of exposure.

These uncertainties could result in a toxicity estimate based directly on the underlying studies that either underestimates or overestimates the true toxicity of a chemical. The toxicity assessment process compensates for these basic uncertainties through: the use of uncertainty factors and modifying factors in the derivation of RfDs and RfCs for assessing noncarcinogenic effects; and the method of calculating the 95% UCL value from the linearized multistage model to derive low-dose SFs and IUR for assessing cancer risks. This approach ensures that the potential toxicity of a chemical to humans is unlikely to be underestimated; however, actual toxicity may be substantially overestimated as a result.

The use of adjusted oral toxicity values to evaluate dermal risks is an additional source of uncertainty to the dermal risk estimates, because the biokinetics (uptake, distribution, metabolism, and elimination) from dermal exposure may be different from ingestion.

In the absence of information to the contrary, EPA guidelines indicate that carcinogenic risks should be treated as additive and that HIs for similar noncarcinogenic effects should also be treated as additive. The assumption of risk additivity ignores possible synergisms or antagonisms among different chemicals, which would increase or decrease their toxic effects and could tend to underestimate or overestimate total site risks.

EPA has recently withdrawn the thallium RfD (for soluble salts) based on data quality issues. EPA states that the principal study (MRI 1988) suffers from certain critical limitations (e.g., high background incidence of alopecia, lack of histopathological examination of skin tissue in low- and mid-dose groups, and inadequate examination of objective measures of neurotoxicity), and there are particular difficulties in the selection of appropriate endpoints.

If toxicity information is not available, a chemical can not be evaluated quantitatively. Instead of eliminated thallium from quantitative assessment, the withdrawn thallium RfD was used for assessment. This conservative approach is preferable to eliminated quantitative assessment of this COPC. Use of the withdrawn value most likely overestimates site risks.

4.2 Ecological Risk Assessment

4.2.1 Introduction

This section presents the expanded ERA for the Contact and Sonoma Mines. The purpose of the ERA is to determine whether or not residual contamination from previous mining activities poses risks to ecological receptors at the site. The results of the ERA will be used to determine whether or not remedial measures may be necessary to protect the natural environment and, if so, aid in the selection of appropriate remedial goals.

The methodology used in the ERA was consistent with EPA, BLM, and California State guidance, including, but not limited to:

- *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (EPA 1997c);
- *Guidelines for Ecological Risk Assessment* (EPA 1998);
- *Wildlife Exposure Factors Handbook* (EPA 1993);
- *Guidance for Developing Ecological Soil Screening Levels* (EPA 2005i);
- *Risk Management Criteria for Metals at BLM Sites* (BLM 2004); and
- *Depth of Soil Samples Used to Set Exposure Point Concentrations for*

Burrowing Mammals and Burrow-Dwelling Birds in Ecological Risk Assessments (California EPA 1998).

In addition to the above mentioned state and federal guidance documents, E & E also used publications from Oak Ridge National Laboratory and articles from the peer-reviewed literature, as appropriate.

The remainder of this section is organized as follows:

- Section 4.2.2 briefly describes the ecological characteristics of the site;
- Section 4.2.3 presents a problem formulation;
- Sections 4.2.4 and 4.2.5 present risk evaluations for terrestrial plants and soil invertebrates, respectively;
- Sections 4.2.6.6 present a risk evaluations for wildlife;
- Section 4.2.7 identifies and discusses sources of uncertainty; and
- Section 4.2.8 presents a summary.

4.2.2 Site Ecological Characteristics

As discussed in Section 2.8, plant communities surrounding the Contact Mine site include mixed chaparral, which contains coffeeberry, buckbrush, gray pine, chamise, scrub oak, yerba santa, and wild oat, as well as a meadow seep community which contains rush, thistle, seep spring monkey flower, mint, ferns, and horsetail. Additionally, mixed hardwood trees including black oak*)* and bay laurel exist on site. Wildlife signs documented at the site include deer tracks and scat and coyote scat (Weston 2009a).

The dominant plant community surrounding the Sonoma mine site is mixed chaparral, which contains coffeeberry, buckbrush, toyon, mountain mahogany, alder, gray pine, bay laurel, chamise, scrub oak, yerba santa, knobcone pine, Manzanita, spicebrush, French broom, blackberry, fir, poison oak, yellow starthistle, native bunchgrass, and various annual grasses. Wildlife signs documented at the site include scat from foxes, deer, and coyotes , deer tracks, and songbird calls (Weston 2009b).

The California Natural Diversity Database indicates that five sensitive species are located within two miles of the Contact and Sonoma mine sites. These include the endangered plant Geysers Dichanthelium, the sensitive plants Cobb Mountain lupine and Socrates Mine jewelflower, the sensitive species Foothill yellow-legged frog, and the state sensitive candidate species Purple Martin. No sensitive species have been recorded on either the Contact or Sonoma mine sites (Weston 2009a, 2009b).

4.2.3 Problem Formulation

Problem formulation is the first step in the ERA process and identifies the goals, breadth, and focus of the assessment (EPA 1997c, 1998). The problem-formulation step identifies ecosystems and receptors of concern; chemicals of potential concern (i.e., stressors); contaminated media; and exposure pathways. A conceptual model is then developed to summarize the relationship between stressors and receptors. Lastly, assessment endpoints and measures (previously called measurement endpoints) are developed to guide the remaining steps of the risk assessment process. The problem formulation step is presented below.

4.2.3.1 Contaminant Sources an Migration Pathways

The Contact and Sonoma Mines are located in southeastern Sonoma County, California. The mines are located near one another in the headwaters of Anna Belcher Creek, which flows into Big Sulfur Creek and eventually into the Russian River. Both mines are located in a serpentine environment. Consequently, chromium, cobalt, and nickel are naturally enriched in site soils and bedrock. Cinnabar is the principal mercury-containing mineral at the site. Mercury was mined at both sites beginning in the 1870s through the 1940s. Contaminated soil, crushed ore, tailings, and other mine wastes have been exposed at the surface for decades. Mercury and other metals in these wastes have been subject to transport by water and wind to Anna Belcher Creek, groundwater beneath the site, and surrounding terrestrial areas.

4.2.3.2 Principal Site-Related Chemicals

Based on work conducted by USGS (2008) and Weston (2009a, 2009b), the principal site-related contaminants are mercury and methyl-mercury. In addition, arsenic, chromium, nickel, and cobalt are elevated in site soils because the local bedrock and soils are serpentine in nature.

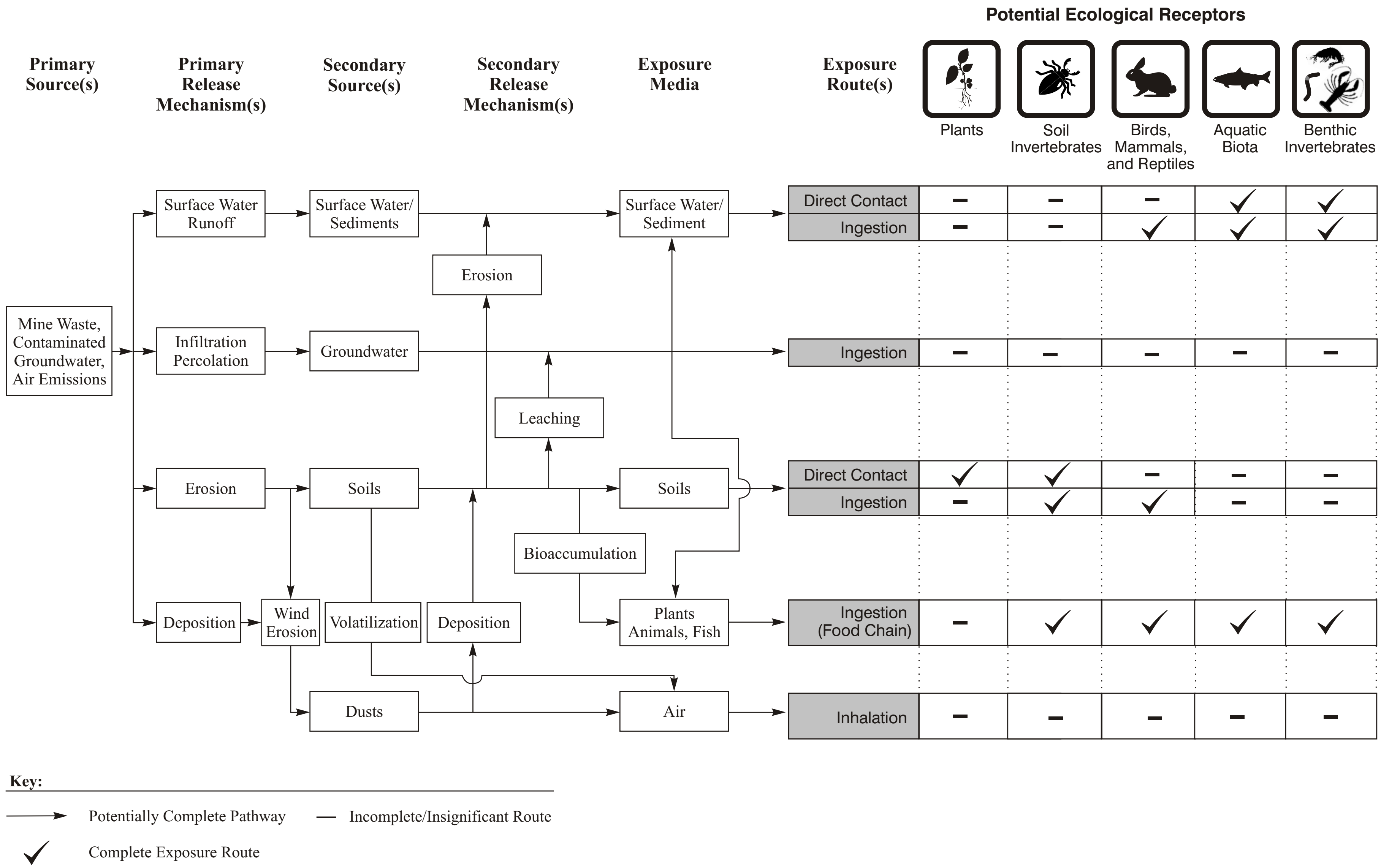
4.2.3.3 Ecological Receptors

The following ecological receptor groups have the potential be affected by site-related contaminants at the Contact and Sonoma Mines.

- Terrestrial plants and soil invertebrates;
- Mammals, birds, and reptiles and use the mine site, Anna Belcher Creek, and downstream areas to satisfy their food and habitat needs.
- Aquatic biota (e.g., benthos, fish, etc.) in Anna Belcher Creek and downstream areas.

4.2.3.4 Preliminary CSM

Figure 4-3 provides a preliminary ecological CSM for the site featuring the ecological receptor groups identified in the previous section. Terrestrial plants may be exposed to site-related chemicals by direct contact with contaminated soil. Soil invertebrates may be exposed to site-related contaminants by direct contact with contaminated soil, ingestion of contaminated soil, and through the food chain. Birds, mammals, and reptiles may be exposed to site-related chemicals through incidental ingestion of soil and/or sediment, consumption of food, and through drinking. Dermal exposure of wildlife to site-related chemicals is expected to be negligible compared with other exposure routes due to the protection provided by their external coverings (fur, feathers, and scales). Aquatic biota in Anna Belcher Creek and downstream areas may be exposed to site-related chemicals through direct contact with and ingestion of contaminated sediment and surface water and through the food chain.



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CONTACT AND SONOMA MERCURY MINES
Sonoma County, California

Figure 4-3
PRELIMINARY ECOLOGICAL CONCEPTUAL SITE MODEL FOR CONTACT/SONOMA MINES

Date: 6/9/10
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4.2.3.5 Assessment Endpoints and Measures

Assessment endpoints are expressions of the ecological resources that are to be protected (EPA 1997c). An assessment endpoint consists of an ecological entity and a characteristic of the entity that is important to protect. According to EPA (1998), assessment endpoints do not represent a desired achievement or goal, and should not contain words such as protect or restore, or indicate a direction for change such as loss or increase. Assessment endpoints are distinguished from management goals by their neutrality (EPA 1998).

Measurements used to evaluate risks to the assessment endpoints are termed "measures" and may include measures of effect (e.g., results of toxicity tests), measures of exposure (e.g., chemical concentrations in soil) and/or measures of ecosystem and receptor characteristics (e.g., habitat characteristics) (EPA 1998). Based on the site ecology, site-related chemicals, and ecological CSM, the ecological resources potentially at risk at the Contact andSonoma Mines include terrestrial vegetation; soil invertebrates; mammals; birds; reptiles; and aquatic organisms (fish, benthos, and other aquatic organisms) in Anna Belcher Creek and downstream areas.

Table 4.2-1 lists the assessment endpoints and measures selected for the Contact and Sonoma Mine sites. Although aquatic organisms and wildlife that prey on aquatic organisms are a valued resource that may be impacted by the Site, they are not directly evaluated in this ERA. Instead, this ERA refers to work done by the USGS (2008) and Weston (2009a, 2009b) regarding possible adverse impacts to aquatic ecological receptors near the site. Also, although predatory terrestrial wildlife species (e.g., hawk, coyote, etc.) are likely to occur at the Site, these groups were not selected as assessment endpoints for the following reasons.

- Predatory wildlife species typically have large home ranges. Hence, predators are likely to forage in other areas besides the site, which would reduce their exposure to site-related chemicals. Also, because of their large home-range requirements, only a few individual predators would be expected to utilize the site. Hence, a population-level impact seems unlikely.
- Incidental soil ingestion by predatory wildlife species tends to be zero or very small (Sample et al. 1996, 1997). Hence, the exposure of predators to site-related chemicals is expected to be less than for herbivores and invertivores, which often ingest considerable amounts of soil while foraging.

Table 4.2-1 Ecological Assessment Endpoints and Measures, Contact/Sonoma Mines, Sonoma County, California

Assessment Endpoint[a]	Representative Species	Measure
Terrestrial Plants	Annual grasses, Manzanita, scrub oak, gray pine	Chemical concentrations in soil compared with soil-screening benchmarks for effects on plants.
Soil invertebrates	Beetles, ants, earthworms	Chemical concentrations in soil compared with soil-screening benchmarks for effects on soil fauna.
Herbivorous birds	California quail	HQ method based on measured chemical concentrations in soil and modeled concentrations in vegetation compared with avian TRVs from the available literature.
Herbivorous mammals	Long-tailed vole	HQ method based on measured chemical concentrations in soil and modeled concentrations in vegetation compared with mammalian TRVs from the available literature.
Invertivorous birds	American robin	HQ method based on measured chemical concentrations in soil and modeled concentrations in soil invertebrates compared with avian TRVs from the available literature.
Invertivorous mammal	Vagrant Shrew	HQ method based on measured chemical concentrations in soil and modeled concentrations in soil invertebrates compared with avian TRVs from the available literature.
Reptiles	Lizards and snakes	None. Quantitative methods for assessing risks to reptiles from chemicals in the environment are poorly developed.

Note
a = Sustainability (growth, survival, and reproduction) of the listed communities and wildlife populations in the site vicinity)

Key:
HQ = Hazard quotient
TRV = Toxicity reference value

4.2.3.6 Available Data

The ERA is based on 51 samples of soil, tailings, and waste rock collected from the Contact and Sonoma Mines by E & E in May 2010. Surface samples (0 to 0.5 feet bgs) and subsurface samples with a lower depth of 6 feet or less were used for the ERA. Sediment and aquatic biota data from USGS (2008) were reviewed and are discussed below as appropriate.

4.2.4 Risk Evaluation for Terrestrial Plants

As indicated in Table 4.2-1, potential risks to terrestrial vegetation were evaluated by comparing chemical concentrations in soil with phytotoxicity screening benchmarks. The benchmarks and screening results are shown in Table 4.2-2. Arsenic, chromium, cobalt, copper, lead, manganese, mercury, nickel, vanadium, and zinc exceeded the available phytotoxicity screening benchmarks. The frequency of exceedance was high for chromium, cobalt, manganese, mercury, nickel, and vanadium, suggesting that potential risks to plants from these chemicals may be widespread at the site. However, it should be noted that comparing site samples with literature-based phytotoxicity benchmarks is a conservative method for evaluating potential risks to plants and may overestimate risk. The following caveats should be kept in mind when interpreting the phytotoxicity screening results presented in Table 4.2-2:

- Most of the available soil phytotoxicity benchmarks were developed from laboratory studies in which chemical solutions were added to clean soil to arrive at a range of test concentrations. In such studies, the added chemicals are highly bioavailable. Comparing total chemical concentrations in soil to solution-based benchmarks is likely to result in an overestimation of risk because only a small fraction of the total chemical concentration is bioavailable in most soils.
- The available soil phytotoxicity benchmarks are largely based on studies with crop plants or other temperate-zone plant species. Benchmarks for the specific plants found in the mixed Chapparal/hardwood environment at the site are not available. These plants may be hardier than crop species given their ability to withstand drought conditions and occasional wildfires. If so, then comparison of site soil samples with literature-based phytotoxicity benchmarks is inherently conservative.

Table 4.2-2 Soil Ecological Screening Results, Contact and Sonoma Mines Site, Sonoma County, California

Analyte	n	Maximum Detected Concentration (mg/kg)	FoD	FoD (%)	Background[a] (mg/kg)	FoE Background	FoE Background (%)	ECO-SSL Plant[b] Value	ECO-SSL Plant[b] FoE	ORNL Plant[c] Value	ORNL Plant[c] FoE	Alloway Plant[d] Value	Alloway Plant[d] FoE	ECO-SSL Soil Invert[b] Value	ECO-SSL Soil Invert[b] FoE	ECO-SSL Birds[b] Value	ECO-SSL Birds[b] FoE	ECO-SSL Mammal[b] Value	ECO-SSL Mammal[b] FoE	BLM Deer Mouse[e] Value	BLM Deer Mouse[e] FoE	COPC?	Rationale[f]
Aluminum	51	24000	51	100%	20000	4	8%	na	--	50	51	na	--	na	--	na	--	na	--	na	--	No	MSC
Antimony	51	3.9	48	94%	0.62	21	41%	na	--	5	0	na	--	78	0	na	--	0.27	36	na	--	Yes	>Bkg, SL-W
Arsenic	51	16	49	96%	8.3	17	33%	18	0	10	5	na	--	na	--	43	0	46	0	230	0	Yes	>Bkg, SL-P
Barium	51	1800	51	100%	240	16	31%	na	--	500	2	na	--	330	6	na	--	2000	0	na	--	Yes	>Bkg, SL-I, TRV
Beryllium	51	1.1	47	92%	0.78	1	2%	na	--	10	0	na	--	40	0	na	--	21	0	na	--	No	FoE Bkg < 5%
Cadmium	51	19	13	25%	ND	0	0%	32	0	4	1	na	--	140	0	0.77	2	0.36	5	7	1	No	FoE Bkg < 5%
Calcium	51	23000	50	98%	3000	20	39%	na	--	na	--	na	--	na	--	na	--	na	--	na	--	No	MSC
Chromium	51	1500	51	100%	160	38	75%	na	--	na	--	75	46	na	--	26	48	34	47	na	--	Yes	>Bkg, SL-P, SL-W
Cobalt	51	160	51	100%	26	43	84%	13	46	20	45	na	--	na	--	120	3	230	0	na	--	Yes	>Bkg, SL-P, SL-W
Copper	51	170	51	100%	46	13	25%	70	2	100	2	60	3	80	2	28	35	49	10	640	0	Yes	>Bkg, SL-P, SL-W
Iron	51	150000	51	100%	39000	42	82%	na	--	na	--	na	--	na	--	na	--	na	--	na	--	No	MSC
Lead	51	620	51	100%	12	28	55%	120	3	50	5	na	--	1700	0	11	29	56	5	142	2	Yes	>Bkg, SL-P, SL-W
Magnesium	51	200000	51	100%	19000	30	59%	na	--	na	--	na	--	na	--	na	--	na	--	na	--	No	MSC
Manganese	51	7400	51	100%	860	15	29%	220	46	500	45	1500	1	450	45	4300	1	4000	1	na	--	Yes	>Bkg, SL-P
Mercury	51	4100	51	100%	30.5	27	53%	na	--	0.3	50	0.3	50	na	--	na	--	na	--	2	47	Yes	>Bkg, SL-P, SL-W
Nickel	51	2200	51	100%	250	42	82%	38	48	30	49	100	46	280	40	210	44	130	45	na	--	Yes	>Bkg, SL-P, SL-W
Potassium	51	2900	51	100%	1700	6	12%	na	--	na	--	na	--	na	--	na	--	na	--	na	--	No	MSC
Selenium	51	1.9	15	29%	0.74	6	12%	0.52	14	1	2	na	--	4.1	0	1.2	2	0.63	10	na	--	Yes	>Bkg, SL-W
Silver	51	0.3	1	2%	ND	--	--	560	0	2	0	na	--	na	--	4.2	0	14	0	na	--	No	FoD < 5%
Sodium	51	330	4	8%	ND	--	--	na	--	na	--	na	--	na	--	na	--	na	--	na	--	No	MSC
Thallium	51	ND	ND	ND	ND	--	--	na	--	1	--	na	--	na	--	na	--	na	--	na	--	No	ND
Vanadium	51	150	50	98%	64	3	6%	na	--	2	49	50	22	na	--	7.8	46	280	0	na	--	Yes	>Bkg, SL-P, SL-W
Zinc	51	8500	51	100%	71	23	45%	160	5	50	41	na	--	120	6	46	42	79	18	419	4	Yes	>Bkg, SL-P, SL-W

Note: Columns from ECO-SSL Plant through BLM Deer Mouse are grouped under "Ecological Risk-Based Benchmark for Soil (mg/kg) and Frequency of Exceedence (FoE)".

Table 4.2-2 Soil Ecological Screening Results, Contact and Sonoma Mines Site, Sonoma County, California

Key:

--)	= not relevant
COPC	= Chemical of Potential Concern
Eco-SSL	= Ecological Soil Screening Level
FoE	= frequency of exceedence (number of samples)
mg/kg	= milligrams per kilogram
n	= number of samples collected
na	= not available or not applicable
ND	= analyte was not detected in any sample
No	= chemical is not a COPC
#	= FoE of background or benchmark > 5%
Yes	= chemical is a COPC and will be quantitatively evaluated in the ERA.
ORNL	Oak Ridge National Laboratory

Notes:

[a] Based on three site-specific background soil sample (0 to 6 inches below ground surface) taken 500 to 1000 feet from the site.
[b] EPA Ecological Screening Levels. Available at http://www.epa.gov/ecotox/ecossl/.
[c] Efroymson et al. 1997.
[d] Alloway 1990.
[e] BLM 2004.
[f] Rationale codes. See text for discussion of screening results.

- For Yes:	> Bkg = Background exceeded by more than 5% of site samples.
	SL-I = Invertebrate screening level exceeded by more than 5% of site samples.
	SL-P = Plant screening level exceeded by more than 5% of site samples.
	SL-W = Wildlife screening level exceeded by more than 5% of site samples.
	TRV = toxicity reference value (for wildlife) available.
- For No:	FoE Bkg < 5% = frequency of exceedance of background less than 5 %.
	FoD < 5% = frequency of detection less than 5 %.
	MSC = Major soil constituent (of low toxicity; Gough et al. 1979).
	NUT = Nutrient.
- Other:	Bkg na = Background not available
	NTD = No toxicity data (quantitative evaluation not possible).

4.2.5 Risk Evaluation for Terrestrial Invertebrates

As described in Table 4.2-1, potential risks to soil invertebrates were evaluated by comparing chemical concentrations in soil with screening benchmarks for protection of earthworms and other soil fauna. The benchmarks and screening results are shown in Table 4-2-1. Barium, manganese, nickel, and zinc exceeded their respective soil-fauna screening benchmark. . The frequency of exceedance was high for manganese (45 of 51) and nickel (40 of 51), but low for barium (6 of 51) and zinc (2 of 26), suggesting that manganese and nickel are the principal chemicals of concern for soil fauna.

4.2.6 Wildlife Risk Evaluation

This section presents an evaluation of potential risks to wildlife at the Site. The evaluation was conducted in accordance with available guidance for ecological risk assessment, as described in Section 4.2. The wildlife risk evaluation consists of three parts: (1) exposure assessment, (2) ecological effects assessment, and (3) risk characterization. The exposure assessment estimates wildlife exposure to Site-related chemicals using measured concentrations of chemicals in environmental media and exposure parameters for the chosen receptor species. The ecological effects assessment summarizes potential toxic effects of Site-related chemicals on wildlife by establishing a toxicity reference value (TRV) for each chemical for each receptor. The exposure assessment and ecological effects assessment comprise the analysis phase in the EPA (1998) ERA paradigm. The risk characterization combines the results of the exposure and ecological effects assessments to provide an estimate of risk to wildlife at the Site.

Chemicals to be included in the wildlife risk evaluation were selected by comparing chemical concentrations in soil with background and conservative soil screening benchmarks for wildlife protection. The screening values were taken from BLM (2004) and EPA (2005a,b,d–i, 2006, 2007a–e, 2008). Based on these comparisons, antimony, barium, chromium, cobalt, copper, lead, mercury, nickel, selenium, vanadium, and zinc were determined to be chemicals of potential concern for wildlife. These chemicals exceeded background and a wildlife soil screening benchmark in greater than 5% of site samples or, if no benchmark was available, exceeded background in greater than 5% of site samples and a TRV (in mg/kg-day) was available for that chemical.

4.2.6.1 Wildlife Exposure Scenarios and Pathways

This section identifies specific wildlife exposure scenarios that will be evaluated in the assessment, estimates levels of chemicals in exposure media, and quantifies exposure.

Wildlife Exposure Scenarios and Pathways

As indicated in Table 4.2-1, two herbivorous wildlife species, the California quail (*Callipepla californica*) and Long-tailed vole (*Microtus longicaudus*) and two invertivorous wildlife species, the American robin (*Turdus migratorius*) and Vagrant shrew (*Sorex vagrans*), were selected for evaluation. These species have a high potential to be exposed to contaminants in soil and food at the site given their foraging habits and small home ranges. For these four species, exposure from incidental ingestion of contaminated soil and consumption of contaminated food were evaluated. Exposure through drinking was not quantitatively evaluated because consumption of surface water accounts for only a small faction of total chemical exposure for wildlife. This is due to the fact that chemicals occur at much greater concentrations in soil and biota compared with surface water. Direct contact with contaminated media is a minor route of exposure for wildlife due to the protection provided by their external coverings (fur, feathers, and scales) and therefore was not quantitatively evaluated.

Wildlife Exposure Calculations

Wildlife exposure to chemicals of potential concern was calculated as the sum of exposures from diet and incidental soil ingestion. Dietary exposure was calculated by multiplying the chemical concentration in each food item by its fraction of the total diet and summing the contribution from each item. This sum was then multiplied by the receptor's SUF, ED, and ingestion rate (IR), and divided by the receptor's BW, as shown in the following equation:

$$EE_{diet} = ([(C_1 \times F_1) + (C_2 \times F_2) + \ldots (C_n \times F_n)] \times SUF \times ED \times IR)/BW$$

where:

EE_{diet} = Estimated exposure from diet (mg/kg-day);
C_n = Chemical concentration in food item *n* (mg/kg dry weight);
F_n = Fraction of diet represented by food item *n*;
SUF = Site use factor (unitless);
ED = Exposure duration (unitless);
IR = Ingestion rate of receptor (kg/day dry weight); and
BW = Body weight of receptor (kg).

The SUF indicates the portion of an animal's home range represented by the site. If the home range is larger than the site, the SUF equals the site area divided by the home range area. If the site area is greater than or equal to the home range, the SUF is set equal to 1. ED is the percentage of the year spent in the site area by the receptor species. Home-range size, IR, diet composition, and BW for the California quail, log-tailed vole, American robin, and vagrant shrew were taken from Dunning (1993), Sample and Suter (1994), and other reliable sources. The values are provided in Table 4.2-3. The SUF was set equal to 1 for the four wildlife species being evaluated given their small some range size compared with the site.

Wildlife exposure to chemicals through incidental soil ingestion was estimated in a manner similar to dietary exposure. Specifically, the soil chemical concentration was multiplied by the soil IR and then multiplied by the SUF and ED and divided by BW. Soil ingestion rates for the receptors being evaluated were taken from Sample and Suter (1994), Beyer et al. (1994), Tetra Tech (2005), and other reliable sources. The values are provided in Table 4.2-3.

The total exposure for a receptor was calculated as the sum of exposure from diet and soil ingestion, as represented by the following equation:

$$EE_{total} = EE_{diet} + EE_{soil}$$

where:

EE_{total} = total exposure (mg/kg-day);
EE_{diet} = estimated exposure from diet (mg/kg-day); and
EE_{soil} = estimated exposure from soil ingestion (mg/kg-day).

Table 4.2-3 Exposure Parameters for Wildlife Species

Species	Dietary Composition		Soil Ingestion (kg/day) dry	Home Range (ha)	Fraction Soil in Dry Diet	Food Ingestion Rate (kg/day) dry	Exposure Duration	Body Weight (kg)
	Soil Invertebrates	Terrestrial Vegetation						
Terrestrial Invertivores								
American Robin[a]	100%		0.00019	0.42	0.104	0.0186	0.5	0.077
Vagrant Shrew[b]	100%		0.00023	0.39	0.13	0.0018	1	0.015
Terrestrial Herbivores								
California Quail[c]		100%	0.00167	3.3	0.09	0.0186	1	0.173
Long-tailed Vole[d]		100%	0.00012	0.06	0.024	0.0006	1	0.044

Notes:

a - Home range size, food ingestion rate, and body mass taken from Sample and Suter (1994). Percent soil in diet of 10.4% (dry weight basis) assumed based on data from Beyer et al. (1994) for American woodcock.
b - Home-range size, food ingestion (wet), body mass, and percent soil in diet (13%) from Sample and Sutter (1994) for short-tailed shrew.
c - Body weight from Dunning (1993). Food ingestion rate (dry) calculated using allometric equation for birds from Sample et al. 1996; soil ingestion rate of 9% of dry food ingested rate based on Tetra Tech (2005).

d - Home-range size, food and soil ingestion rates, and body mass from Sample and Suter (1994) for meadow vole.

Exposure Point Concentrations

EPCs were calculated for soil, tailings, and waste rock combined with ProUCL version 4 software (Singh, et al. 2007) using samples collected between 0 and 6 feet bgs. The values are provided in Table 4.2-4. The EPCs were used to estimate wildlife exposure from incidental soil ingestion and to model chemical concentrations in plants and soil invertebrates. Chemical concentrations in terrestrial plants were modeled using soil-to-plant uptake factors and equations from EPA (2005c), Bechtel-Jacobs (1998), and Baes, et al. (1984). Chemical concentrations in soil invertebrates (i.e., earthworms) were modeled using soil-to-invertebrate uptake factors and equations from EPA (2005c) and Sample et al. (1998). The earthworm and plant EPCs are provided in Tables 4.2-5 and 4.2-6, respectively.

Table 4.2-4 Exposure Point Concentrations for Surface Soil, Ecological Assessment, Contact-Sonoma Mines, Sonoma, California

COPC	Range of Detected Values (mg/kg)	Minimum Detected Value (mg/kg)	Maximum Detected Value (mg/kg)	Number of Samples	Mean (mg/kg)	Median (mg/kg)	Standard Deviation (mg/kg)	95% UCL for EPC (mg/kg)[a]	ProUCL Recommended 95% UCL
Antimony	0.041 - 3.9	0.041	3.9	51	0.697	na	0.636	1.048	95% KM (Chebyshev) UCL
Barium	7.4 - 1800	7.4	1800	51	241.1	210	272.9	479.7	97.5% Chebyshev (Mean, Sd) UCL
Chromium	0.53 - 1500	0.53	1500	51	291.4	270	233.4	495.4	97.5% Chebyshev (Mean, Sd) UCL
Cobalt	0.31 - 160	0.31	160	51	52.99	45	34.71	83.34	97.5% Chebyshev (Mean, Sd) UCL
Copper	1.5 - 170	1.5	170	51	36.78	32	28.48	54.16	95% Chebyshev (Mean, Sd) UCL
Lead	0.94 - 620	0.94	620	51	45.54	15	118.2	61.41	95% H-UCL
Mercury	0.11 - 4100	0.11	4100	51	168.2	34	590.1	437.7	95% H-UCL
Nickel	2.3 - 2200	2.3	2200	51	780.1	670	572.9	914.6	95% Student's-t UCL
Selenium	0.51 - 1.9	0.51	1.9	51	0.846	na	0.394	0.704	95% KM (% Bootstrap) UCL
Vanadium	0.45 - 150	0.45	150	51	47.54	na	21.76	60.37	95% KM (Chebyshev) UCL
Zinc	2 - 8500	2	8500	51	273.9	69	1187	1312	97.5% Chebyshev (Mean, Sd) UCL

Key:

COPC = Chemical of Potential Concern.
mg/kg = milligrams per kilogram.
na = no value available; the ProUCL program does not calculate a medium value for censored data sets.
n = number of samples collected.
UCL = upper confidence limit. The 95% UCL defines a value that equals or exceeds the true mean 95% of the time

Notes:

[a] EPA ProUCL version 4.00.02 was used to generate 95% UCL concentrations.

Table 4.2-5 Exposure Point Concentration Summary for American Robin and Vagrant Shrew

Analyte	Minimum detected value	Maximum Detected value	Number of Samples	Exposure Point Concentration Soil	BAF Earthworm	EPC Earthworm
Antimony	0.041	3.9	51	1.048	1.00	1.05
Barium	42.2	42.2	42.2	479.7	0.091	43.65
Chromium	0.53	1500	51	495.4	0.306	151.59
Cobalt	0.31	160	51	83.34	0.122	10.17
Copper	1.5	170	51	54.16	0.515	27.89
Lead	0.94	620	51	61.41	see note 1	22.31
Mercury	0.11	4100	51	437.7	see note 1	1.03
Nickel	2.3	2200	51	914.6	1.059	968.56
Selenium	0.51	1.9	51	0.70	see note 1	0.72
Vanadium	0.45	150	51	60.37	0.042	2.54
Zinc	2	8500	51	1312	see note 1	901.3

Key:
BAF = Bioaccumulation factor
EPC = Exposure Point Concentration
mg/kg = milligrams per kilogram

Notes:
1. Soil-to-earthworm regression equation used to calculate earthworm EPC. See text for references used.

Table 4.2-6 Exposure Point Concentration Summary for California Quail and Long-tailed Vole

Analyte	Minimum Detected value	Maxiu-mum De-tected value	Number of Sam-ples	Exposure Point Con-centration Soil	Soil to Plant Up-take Fac-tor	EPC Plant
Antimony	0.041	3.9	51	1.048	see note	0.04
Barium	42.2	42.2	42.2	479.7	0.156	74.833
Chromium	0.53	1500	51	495.4	0.041	20.31
Cobalt	0.31	160	51	83.34	0.0075	0.63
Copper	1.5	170	51	54.16	see note	9.4
Lead	0.94	620	51	61.41	see note	2.67
Mercury	0.11	4100	51	437.7	see note	10.10
Nickel	2.3	2200	51	914.6	see note	17.76
Selenium	0.51	1.9	51	0.70	see note	0.34
Vanadium	0.45	150	51	60.37	0.00485	0.293
Zinc	2	8500	51	1312	see note	257.8

Key:
BAF = Bio-accumulation factor
EPC = Exposure Point Concentration
mg/kg = milligrams per kilogram

Note: Soil-to-plant regression equation used to calculate the plant EPC. See text for references used.

4.2.6.2 Ecological Effects Assessment

Mammalian and avian NOAELs and LOAELs for chronic effects on reproduction, growth, or survival were taken from EPA (2005a, 2005b, 2005d, 2005e, 2005f, 2008), Sample *et al.* (1996), and/or the scientific literature. The values are listed in Table 4.2-7.

Table 4.2-7 Toxicity Reference Values for Wildlife

Analyte	Wildlife Class	NOAEL TRV (mg/kg-day)	Critical Effect	LOAEL TRV (mg/kg-day)	Critical Effect	Reference and Comments
Antimony	Birds	NA	NA	NA	NA	NA
	Mammals	0.059	Reproduction	0.59	Reproduction	EPA (2005d). Highest bounded NOAEL (0.059 mg/kg-d) for growth or reproduction below lowest bounded LOAEL (0.59 mg/kg-d) for growth or reproduction from 20 laboratory toxicity studies.
Barium	Birds	20.8	Survival	41.7	Survival	Sample et al. 1996.
	Mammals	51.8	Reproduction, growth, and survival	121	Growth and survival	EPA (2005f). Geometric mean NOAEL for growth, reproduction, and survival from 12 laboratory toxicity studies. Lowest bounded LOAEL for reproduction, growth, or survival greater than geometric mean NOAEL.
Chromium	Birds	2.66	Reproduction, growth, and survival	2.78	Survival	EPA (2008). Geometric mean NOAEL for growth, reproduction, and survival from 17 laboratory toxicity studies. Lowest bounded LOAEL for reproduction, growth, or survival greater than geometric mean NOAEL.
	Mammals	2.4	Reproduction and growth	NA	NA	EPA (2008). Geometric mean of NOAELs for reproduction and growth from 14 laboratory studies with trivalent chromium.
Cobalt	Birds	7.61	Growth	7.8	Growth	EPA (2005i). Geometric mean NOAEL for growth from 10 laboratory toxicity studies. Lowest bounded LOAEL for growth or reproduction greater than geometric mean NOAEL.
	Mammals	7.33	Reproduction and Growth	10.9	Reproduction	EPA (2005i). Geometric mean NOAEL for reproduction and growth based on 21 laboratory toxicity studies. Lowest bounded LOAEL for growth or reproduction greater than geometric mean NOAEL.
Copper	Birds	47	Growth	61.7	Growth	Sample et al. (1996).
	Mammals	11.7	Survival	15.14	Survival	Sample et al. (1996).
Lead	Birds	1.63	Reproduction	1.94	Reproduction	EPA (2005b). Highest bounded NOAEL (1.63 mg/kg-d) for growth, reproduction, or survival lower than the lowest bounded LOAEL (1.94 mg/kg-d) for growth, reproduction, or survival based on 57 laboratory toxicity studies.

Table 4.2-7 Toxicity Reference Values for Wildlife

Analyte	Wildlife Class	NOAEL TRV (mg/kg-day)	Critical Effect	LOAEL TRV (mg/kg-day)	Critical Effect	Reference and Comments
	Mammals	4.7	Growth	5	Growth	EPA (2005b). Highest bounded NOAEL (4.7 mg/kg-d) for growth, reproduction, or survival lower than the lowest bounded LOAEL (5 mg/kg-d) for growth, reproduction, or survival based on 220 laboratory toxicity studies.
Mercury	Birds	0.45	Reproduction	0.9	Reproduction	Sample et al. (1996).
	Mammals	13.2	Reproduction and survival	NA	NA	Sample et al. (1996).
Nickel	Birds	77.4	Growth and survival	107	Growth and survival	Sample et al. (1996).
	Mammals	40	Reproduction	80	Reproduction	Sample et al. (1996).
Selenium	Birds	0.5	Reproduction	1	Reproduction	Sample et al. (1996).
	Mammals	0.2	Reproduction	0.33	Reproduction	Sample et al. (1996).
Vanadium	Birds	0.344	Growth	0.413	Reproduction	EPA (2005a). Highest bounded NOAEL (0.344 mg/kg-d) for growth, reproduction, or survival less than lowest bounded LOAEL (0.413 mg/kg-d) for reproduction, growth, or survival based on 94 laboratory toxicity studies.
	Mammals	4.16	Reproduction and growth	5.11	Growth	EPA (2005a). Highest bounded NOAEL (4.16 mg/kg-d) for growth or reproduction less than lowest bounded LOAEL (5.11 mg/kg-d) for growth, reproduction, or survival based on 94 laboratory toxicity studies.
Zinc	Birds	70	Reproduction	124	Reproduction	Jackson et al. (1986)
	Mammals	160	Reproduction	320	Reproduction	Sample et al. (1996).

Table 4.2-7 Toxicity Reference Values for Wildlife

Analyte	Wildlife Class	NOAEL TRV (mg/kg-day)	Critical Effect	LOAEL TRV (mg/kg-day)	Critical Effect	Reference and Comments

Key:
TRV = Toxicity reference value
mg/kg/day = milligrams per kilogram per day
NA = no value available
LOAEL = lowest observed adverse effect level
NOAEL = no observed adverse effect level

4.2.6.3 Wildlife Risk Characterization

Potential risks posed by site-related contaminants were estimated by calculating a hazard quotient (HQ) for each contaminant for each endpoint species. The HQ was determined by dividing the total estimated exposure (EE_{total}) by the appropriate TRV, as shown in the following equation.

$$HQ = EE_{total}/TRV$$

HQs for each receptor were calculated based on both the NOAEL and LOAEL and are abbreviated as HQ-NOAEL and HQ-LOAEL, respectively. For a given receptor and chemical, a HQ-NOAEL greater than 1 indicates that the estimated exposure exceeds the highest dose at which no adverse effect was observed. Such a result does not necessarily imply that the receptor is at risk, especially if the HQ-NOAEL is only marginally above 1. A HQ-LOAEL greater than 1 suggests that a chronic adverse affect if possible to an individual receptor, assuming that the estimated exposure for that receptor is accurate.

The American robin and Vagrant shrew were evaluated as representative invertivorous wildlife species. Chromium, lead, mercury, nickel, vanadium, and zinc may pose a potential risk to the robin (see Table 4.2-8). Antimony, chromium, and nickel may pose a potential risk to the shrew (see Table 4.2-9). For both receptors, the greatest risks appear to be due to chromium.

The California quail and Long-tailed vole were evaluated as representative herbivorous wildlife species. Chromium, mercury, and vanadium were found to pose a potential risk to the quail, with mercury posing the greatest potential risk (see Table 4.2-10). No risks were found for the vole (see Table 4.2-11).

Table 4.2-8 American Robin Exposure Estimates and Hazard Quotients

	American robin							
Analyte	**EPC soil**	**EE-soil** (mg/kg/d)	**EE-diet** (mg/kg/d)	**EE-total** (mg/kg/d)	**NOAEL** (mg/kg/d)	**LOAEL** (mg/kg/d)	**HQ-NOAEL**	**HQ-LOAEL**
Antimony	1.048	0.001	0.13	0.13	NA	NA	NA	NA
Barium	479.7	1.184	10.54	11.73	20.8	41.7	0.564	0.281
Chromium	495.4	0.611	18.31	18.92	2.66	2.78	7.113	6.806
Cobalt	83.34	0.103	1.23	1.33	7.61	7.8	0.175	0.171
Copper	54.16	0.067	3.37	3.44	47	61.7	0.073	0.056
Lead	61.41	0.076	2.69	2.77	1.63	1.94	1.699	1.428
Mercury	437.7	0.540	0.12	0.66	0.45	0.9	1.478	0.739
Nickel	914.6	1.128	116.98	118.11	77.4	107	1.526	1.104
Selenium	0.70	0.001	0.09	0.09	0.5	1	0.175	0.088
Vanadium	60.37	0.074	0.31	0.38	0.344	0.413	1.107	0.922
Zinc	1312	1.619	108.86	110.47	70	124	1.578	0.891

Key:

EE-diet = estimated chemical exposure from diet

EE-soil = estimated chemical exposure from incidental soil ingestion

EE-total = total chemical exposure

EPC = exposure point concentration

HQ = hazard quotient

LOAEL = lowest observed adverse effect level

NOAEL = no observed adverse effect level

mg/kg = Milligrams per kilogram

mg/kg/day = Milligrams per kilogram per day

NA = Not available

Grey shading = HQ exceeds 1.0

Table 4.2-9 Vagrant Shrew Exposure Estimates and Hazard Quotients.

Vagrant Shrew								
Analyte	EPC soil	EE-soil (mg/kg/d)	EE-diet (mg/kg/d)	EE-total (mg/kg/d)	NOAEL (mg/kg/d)	LOAEL (mg/kg/d)	HQ-NOAEL	HQ-LOAEL
Antimony	1.048	0.016	0.13	0.14	0.059	0.59	2.404	0.240
Barium	479.7	7.355	5.24	12.59	51.8	121	0.243	0.104
Chromium	495.4	7.596	18.19	25.79	2.4	NA	10.745	NA
Cobalt	83.34	1.278	1.22	2.50	7.33	10.9	0.341	0.229
Copper	54.16	0.830	3.35	4.18	11.7	15.14	0.357	0.276
Lead	61.41	0.942	2.68	3.62	4.7	5	0.770	0.724
Mercury	437.7	6.711	0.12	6.84	13.2	NA	0.518	NA
Nickel	914.6	14.024	116.23	130.25	40	80	3.256	1.628
Selenium	0.70	0.011	0.09	0.10	0.2	0.33	0.484	0.294
Vanadium	60.37	0.926	0.30	1.23	4.16	5.11	0.296	0.241
Zinc	1312	20.117	108.15	128.27	160	320	0.802	0.401

Key:
EE-diet = estimated chemical exposure from diet
EE-soil = estimated chemical exposure from incidental soil ingestion
EE-total = total chemical exposure
EPC = exposure point concentration

HQ = hazard quotient
LOAEL = lowest observed adverse effect level
NOAEL = no observed adverse effect level
mg/kg = Milligrams per kilogram
mg/kg/day = Milligrams per kilogram per day
NA = Not available
Grey shading = HQ exceeds 1.0

Table 4.2-10 California Quail Exposure Estimates and Hazard Quotients

California Quail								
Analyte	EPC soil	EE-soil (mg/kg/d)	EE-diet (mg/kg/d)	EE-total (mg/kg/d)	NOAEL (mg/kg/d)	LOAEL (mg/kg/d)	HQ-NOAEL	HQ-LOAEL
Antimony	1.048	0.0101	0.0044	0.0145	NA	NA	NA	NA
Barium	479.7	4.6314	8.0277	12.6591	20.8	41.7	0.609	0.304
Chromium	495.4	4.7829	2.1789	6.9618	2.66	2.78	2.617	2.504
Cobalt	83.34	0.8046	0.0671	0.8717	7.61	7.8	0.115	0.112
Copper	54.16	0.5229	1.0085	1.5314	47	61.7	0.033	0.025
Lead	61.41	0.5929	0.2864	0.8793	1.63	1.94	0.539	0.453
Mercury	437.7	4.2259	1.0833	5.3091	0.45	0.9	11.798	5.899
Nickel	914.6	8.8302	1.9057	10.7359	77.4	107	0.139	0.100
Selenium	0.70	0.0068	0.0370	0.0438	0.5	1	0.088	0.044
Vanadium	60.37	0.5829	0.0314	0.6143	0.344	0.413	1.786	1.487
Zinc	1312	12.6670	27.6596	40.3266	70	124	0.576	0.325

Key:

EE-diet = estimated chemical exposure from diet

EE-soil = estimated chemical exposure from incidental soil ingestion

EE-total = total chemical exposure

EPC = exposure point concentration

HQ = hazard quotient

LOAEL = lowest observed adverse effect level

NOAEL = no observed adverse effect level

mg/kg = Milligrams per kilogram

mg/kg/day = Milligrams per kilogram per day

NA = Not available

Grey shading = HQ exceeds 1.0

Table 4.2-11 Long-tailed Vole Exposure Estimates and Hazard Quotients

Long-Tailed Vole								
Analyte	EPC soil	EE-soil (mg/kg/d)	EE-diet (mg/kg/d)	EE-total (mg/kg/d)	NOAEL (mg/kg/d)	LOAEL (mg/kg/d)	HQ-NOAEL	HQ-LOAEL
Antimony	1.048	0.0029	0.0006	0.0034	0.059	0.59	0.058	0.006
Barium	479.7	1.3083	8.5038	9.8120	51.8	121	0.189	0.081
Chromium	495.4	1.3511	0.2770	1.6281	2.4	NA	0.678	NA
Cobalt	83.34	0.2273	0.0085	0.2358	7.33	10.9	0.032	0.022
Copper	54.16	0.1477	0.1282	0.2759	11.7	15.14	0.024	0.018
Lead	61.41	0.1675	0.0364	0.2039	4.7	5	0.043	0.041
Mercury	437.7	1.1937	0.1377	1.3314	13.2	NA	0.101	NA
Nickel	914.6	2.4944	0.2422	2.7366	40	80	0.068	0.034
Selenium	0.70	0.0019	0.0047	0.0066	0.2	0.33	0.033	0.020
Vanadium	60.37	0.1646	0.0040	0.1686	4.16	5.11	0.041	0.033
Zinc	1312	3.5782	3.5160	7.0942	160	320	0.044	0.022

Key:
EE-diet = estimated chemical exposure from diet
EE-soil = estimated chemical exposure from incidental soil ingestion
EE-total = total chemical exposure
EPC = exposure point concentration

HQ = hazard quotient
LOAEL = lowest observed adverse effect level
NOAEL = no observed adverse effect level
mg/kg = Milligrams per kilogram
mg/kg/day = Milligrams per kilogram per day
NA = Not available
Grey shading = HQ exceeds 1.0

4.2.7 Uncertainties

Significant sources of uncertainty in this assessment include the following:

- **Bioavailability:** The bioavailability of chemicals in soil, tailings, and waste rock at the site is poorly understood. To be conservative, it was assumed that 100% of all chemicals in these media were bioavailable. If bioavailability is less than 100%, which seems likely, then the potential risks to all categories of ecological receptors would be correspondingly lower.

- **Reliability of Phytotoxicity Benchmarks:** Many of the available soil screening benchmarks for plants were developed from laboratory studies in which chemical solutions were added to clean soil to arrive at a range of test concentrations. In such studies, the added chemicals are highly bioavailable. Comparing total chemical concentrations in soil to solution-based benchmarks is conservative and likely results in an overestimation of potential risk. Other uncertainties associated with using literature-based phytotoxicity benchmarks to evaluate potential risks to vegetation at the site are described in Section 4.2.4. These other uncertainties also are expected to result in an overestimation of potential risk.

- **Lack of Toxicity Data for Reptiles:** Reptiles are an important component of many ecosystems in the western United States. Unfortunately, reptiles have been understudied compared with other animal groups. Consequently, there is a lack of reliable toxicity data for reptiles and potential risks to reptiles from chemicals in the environment cannot be quantitatively assessed.
- **Chemicals in Wildlife Foods:** Food-chain transfer of chemicals at the site is poorly understood. The potential risks to wildlife at the site are largely driven by estimated concentrations of chemicals in their food. For this assessment, food concentrations were estimated from measured soil concentrations using uptake factors from the literature. The uncertainty associated with this approach often is high because a number of site-specific factors affect food-chain transfer of chemicals. In general, the uptake factors used in this assessment are intended to provide a conservative estimate of chemicals in wildlife foods and are likely to result in an overestimation of risk.
- **Wildlife Diet:** Uncertainty may result from assumptions made about the diets of the wildlife receptors evaluated in this assessment. For the shrew and robin, the assumption of a diet consisting entirely of earthworms is conservative. In addition to earthworms, shrews consume other invertebrates (i.e. slugs, snails, centipedes, and various insects), fungi, plant materials, and small mammals (EPA 1993). Similarly, robins also consume other invertebrates (i.e., sowbugs, spiders, and various insects) and plant materials (EPA 1993). These foods are less intimately associated with the soil matrix than earthworms, and thus accumulate lesser amounts of soil contamination. The diet assumed for the shrew and robin in this ERA likely overestimates exposure and risks from chemicals in soil.
- **Aquatic Ecological Risks:** This ERA did not quantitatively evaluate risks to fish, benthic invertebrates, and semi-aquatic wildlife species (e.g., mink, water ouzel, etc). However, the aquatic environment of Anna Belcher Creek and downstream areas was evaluated by the USGS (2008) and Weston (2009a, 2009b). These authors found that inorganic mercury was being mobilized to aquatic habitats near the site, methylated, and accumulated by aquatic biota. Hence, at least for mercury and methylmercury, a rudimentary understanding of potential aquatic ecological exposure and risk exist. Therefore, the lack of evaluation of aquatic habitats in this ERA is not considered to be a major source of uncertainty in understanding the overall impact of the Contact and Sonoma Mines on the environment.

4.2.8 Summary and Recommendations

The assessment endpoints for this ecological risk assessment included terrestrial plants, soil invertebrates, and herbivorous and invertivorous birds and mammals (see Table 4.2-1). The results of this ERA suggest that current levels of soil contamination at the site are great enough to pose a potential risk to all of these assessment endpoints, except perhaps for soil invertebrates (see Table 4.2-12). The greatest number of chemicals of concern (10) was identified for terrestrial plants. In addition, for many metals, the magnitude and frequency of exceedance of the available soil screening benchmarks for plants were high (see Table 4.2-1). This result suggests that potential risks to terrestrial plants may be widespread at the site. A fewer number of chemicals were found to pose risks to wildlife and the resulting HQs were typically less than 10, and often less than 5 (see Tables 4.2-8 to 4.2-11).

The results of this ERA suggest that terrestrial plants are the receptor group at greatest risk at the Contact and Sonoma Mine sites. Of the ten chemicals that exceed soil screening benchmarks for plants, the benchmark for mercury is routinely exceeded in site samples by the greatest amount, often by several orders of magnitude. Hence, if the results of this ERA are used to establish a remedial goal for the site, E & E recommends that it be based on protection of plants from mercury. Because the soil screening benchmark for plants for mercury (0.3 mg/kg) is less than local background mercury levels in soil, E & E recommends that the maximum, site-specific, background soil mercury concentrations (30.5 mg/kg) for the site be used at the remedial goal. Other reasons to focus remedial actions on mercury as opposed to other metals include: (1) the site was a mercury mine; (2) mercury becomes methylated and biomagnifies in aquatic food webs, and this has been shown to be occurring at the site by the USGS (2008); (3) cleaning-up mercury in site soils would be protective all terrestrial ecological receptors (except perhaps for some plants) and aquatic biota in Anna Belcher Creek and downstream areas, by reducing transport of mercury to the creek; and (4) other metals in soil at the site likely are correlated with mercury so a cleanup goal based on mercury would address the other metals.

Table 4.2-12 Summary of Chemicals Exceeding Screening Benchmarks or Toxicity Reference Values

	Environmental Medium and Receptor Group			
	Soil			
			Wildlife[C]	
Analyte	Plants[A]	Soil Fauna[B]	NOAEL	LOAEL
Antimony			X	
Arsenic	X			
Barium		X		
Chromium	X		X	X
Cobalt	X			
Copper	X			
Lead	X		X	X
Manganese	X	X		
Mercury	X		X	
Nickel	X	X	X	X
Selenium				
Vanadium	X		X	X
Zinc	X	X	X	

Key:

LOAEL = Lowest observed adverse effect level

NOAEL = No observed adverse effect level

Shading = primary COPC based on considerations described in text.

TRV = toxicity reference value

X = benchmark or TRV exceeded

Notes:

A - Based on comparing soil chemical concentrations to phytotoxicity benchmarks.

B - Based on comparing soil chemical concentrations to soil fauna screening benchmarks.

C - Based on modeled exposure estimates for the robin, shrew, quail, and vole.

5 Applicable or Relevant and Appropriate Requirements

The lead Federal agency (BLM) is responsible for the identification of Applicable or Relevant and Appropriate Requirement (ARARs) of all environmental laws that pertain to any CERCLA removal actions. This analysis of ARARs is provided to ensure the proposed removal actions themselves are consistent with existing environmental standards. As defined in the Guidance on Consideration of ARARs During Removal Actions (EPA 1991):

> *"Applicable requirements are cleanup standards, standards of control, and other substantive requirements, criteria or limitations promulgated under Federal environmental or State environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location or other circumstances found at a CERCLA site.*
>
> *Relevant and appropriate requirements are cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under Federal environmental or State environmental or facility siting laws that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location or other circumstances at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site and are well-suited to the particular site.*
>
> *Other information To Be Considered (TBC) generally falls within three categories: health effects information with a high degree of credibility; technical information on how to perform or evaluate site investigations or response actions; and policy."*

Table 5.1-1 presents the federal and State of California ARARs for the Contact Sonoma Mine. The table is organized by the three categories of ARARs; chemical-, location- and action-specific. Chemical-specific ARARs are generally health- or risk-based numerical values or methodologies applied to site-specific conditions that result in the establishment of a cleanup level. Chemical-specific ARARs are further evaluated based on the media of concern; at the Contact and Sonoma Mines Site the media of concern are: surface water, sediment, and tailings and waste rock piles. Groundwater is not a media of concern, as samples taken from groundwater monitoring wells do not show evidence of mercury concentrations elevated above criteria identified in the site-specific risk assessment.

Table 5.1-1 Applicable or Relevant and Appropriate Requirements

Standards, Requirement, Criteria, or Limitation	Citation	Description	Applicable or Relevant and Appropriate
Chemical-Specific			
Clean Water Act Water Quality Standards	33 USC 1251-1387, Section 303(c)(2)(B), 40 CFR Section 440.40-440.45 40 CFR Part 131, Quality Criteria for Water 1976, 1980, 1986	Chapter 26, Water Pollution Prevention and Control, sets criteria for water quality based on toxicity to aquatic organisms and human health	Relevant to surface water quality standards at the site
Porter-Cologne Water Quality Act	California Water Code, Division 7: Water Quality, Water Code Section 13000-13002	Mandates that the quality of all the waters of the state shall be protected for use and enjoyment by the people of the state. Also mandates each Regional Board to formulate and adopt basin plans for all areas within the region.	Relevant
Regional Basin Plan for Central Valley	RWQCB Basin Plan water quality objectives	The Basin Plan for the Central Valley was prepared and implemented by the Central Valley RWQCB to protect and enhance the quality of waters in the region. The Basin Plan established location-specific beneficial uses and water quality objectives for surface water and groundwater of the region.	Relevant
State of California Water Resources Control Board	SWRCB Resolution 68-18, Statement of Policy with Respect to Maintaining High Quality Waters in California	Resolution 68-16 establishes the policy that high quality waters of the state "shall be maintained to the maximum extent possible" consistent with the "maximum benefit to the people of the state."	Relevant
State of California Water Resources Control Board	SWRCB Resolution 92-49, Policies and Procedures for Investigation and Cleanup and Abatement of Discharges under California Water Code Section 13304	Resolution 92-49 contains policies and procedures that the regional boards apply to all investigations and cleanup and abatement activities for all types of discharges subject to California Water Code Section 13304. Section III.G of the Resolution requires attainment of background water quality, or if background cannot be restored, the best water quality that is reasonable.	Relevant
State of California Drinking Water Policy	State Water Resources Control Board (SWRCB) No. 88-63	Provides direction indicating that surface water and groundwater is considered a potential drinking water source if the TDS levels are below 3,000 mg/L (specific conductance of 5,000 µS/cm) and the yield is more than 200 gallons per day.	Relevant to drinking water quality at the site

Table 5.1-1 Applicable or Relevant and Appropriate Requirements

Standards, Requirement, Criteria, or Limitation	Citation	Description	Applicable or Relevant and Appropriate
Safe Drinking Water Act National Primary Drinking Water Regulations and Maximum Contamination Goals National Secondary Drinking Water Regulations	40 USC 300 40 CFR Part 141, Subpart B pursuant to 42 USC 300(g)(1) and 300(j)(9) and 40 CFR Part 141, Subpart F, pursuant to 42 USC 300(g)(1) 40 CFR Part 143, Subpart B pursuant to 42 USC 300(g)(1) and 300(j)(9)	Establishes health-based standards for public water systems (maximum contaminant levels) and sets goals for contaminants Establishes welfare-based (non-enforceable) standards for public water systems (secondary maximum contaminant levels) CERCLA Section 1211(d)(2)(B) provides that CERCLA response actions "shall require a level of standard or control which at least attains MCLGs established under the Safe Drinking Water Act." Section 300.430(f)(5) of the NCP provides that remedial actions must generally attain MCLs or non-zero MCLGs if water is a current or potential source of drinking water. The MCL for mercury is 0.002 mg/L.	Relevant to drinking water quality at the site
California Water Plan	Water Code §10004(a)	Provides for the orderly and coordinated control, protection, conservation, development, and utilization of the water resources of the state (Water Code §10004(a))	Relevant
California Safe Drinking Water Act	Title 22 California Code of Regulations (CCR) Sections 64431 and 64449(a)	Primary and secondary MCLs for public drinking water under the California SDWA of 1976.	Relevant
Risk management Criteria for Metals at BLM Mining Sites	Ford, K.L., 1996, *Risk Management Criteria for metals at BLM Mining Sites* (Technical note 390) and BLM, 1998, *Interim Revision of Wildlife Management Criteria.*	BLM risk management criteria for metals at mining sites used to evaluate the potential risk posed by these metals; criteria have been developed for human, livestock, and wildlife receptors.	Applicable
EPA Region IX Preliminary Remedial Goals, Residential Soils	EPA Region IX PRG Table (10/01/2002)	Combine current EPA toxicity values with "standard" exposure factors to estimate acceptable contaminant concentrations in different environmental media (soil, air, and water) that are protective of human health.	To be considered
EPA Region IX Preliminary Remedial Goals, Industrial Soils	EPA Region IX PRG Table (10/01/2002)	Combine current EPA toxicity values with "standard" exposure factors to estimate acceptable contaminant concentrations in different environmental media (soil, air, and water) that are protective of human health.	To be considered

Table 5.1-1 Applicable or Relevant and Appropriate Requirements

Standards, Requirement, Criteria, or Limitation	Citation	Description	Applicable or Relevant and Appropriate
California Human Health Screening Levels (CHHSLs)	http://www.calepa.ca.gov/Brownfields/documents/2005/CHHSLsGuide.pdf	Used in evaluation of contaminated properties to calculate health based cleanup levels.	To be considered
DTSC 1999 Preliminary Endangerment Assessment Manual	http://www.dtsc.ca.gov/PublicationsForms/prog_pubs.cfm?prog=Site%20Cleanup	The human health screening evaluation process discussed in the manual can be used to assess risk associated with existing conditions or calculate health based cleanup levels for unrestricted land use.	To be considered
CalTOX	http://eetd.lbl.gov/led/ERA/caltox/	A spreadsheet risk assessment model for multimedia exposure.	To be considered
Supplemental Guidance for Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities	http://www.dtsc.ca.gov/AssessingRisk/index.cfm	Provides State methods and default parameters for conducting risk assessment.	To be considered
Surface soil risk-based screening levels, Residential (May 2008)	California Regional Water Control Board, San Francisco Bay Region – "Screening for Environmental Concerns at Sites with Contaminated Soil & Groundwater"	Guidance for the application of risk-based screening levels and decision making to sites with impacted soil and groundwater	To be considered
Surface soil risk-based screening levels, Industrial (May 2008)	California Regional Water Control Board, San Francisco Bay Region – "Screening for Environmental Concerns at Sites with Contaminated Soil & Groundwater"	Guidance for the application of risk-based screening levels and decision making to sites with impacted soil and groundwater	To be considered
Location-Specific			
National Environmental Policy Act	7 CFR 799 (1969)	http://ceq.eh.doe.gov/nepa/regs/nepa/nepaeqia.htm	Substantive requirements are applicable.
Section 10 of the Rivers and Harbors Act	Section 10 of the Rivers and Harbors Act, 33 USC Section 403	Prohibits unauthorized obstruction or alteration of any navigable water of the United States.	Appropriate.
Protection of Wetlands Order, Executive Order 11990	40 CFR Part 6	Requires minimizing and avoiding adverse impacts to wetlands	Relevant.
Fish and Wildlife Coordination Act	16 USC 1251 661 et seq.; 40 CFR 6.302(g)	Requires coordination of Federal and State agencies to protect fish and wildlife	Substantive requirements are applicable

Table 5.1-1 Applicable or Relevant and Appropriate Requirements

Standards, Requirement, Criteria, or Limitation	Citation	Description	Applicable or Relevant and Appropriate
California Fish and Game Code	Section 2080 Section 3005 Section 5650	California natural resource law for threatened or endangered species.	Substantive requirements are applicable
Migratory Bird Treaty Act	16 USC 703	Establishes federal responsibility for the protection of international migratory bird resources	Relevant.
California Wildlife Conservation Act	Fish and Game Code Section 2050-2068, Section 2080, Section 3005, and Section 5650.	California Department of Fish and Game Habitat Conservation Planning Branch	Substantive requirements are applicable.
Endangered Species Act	316 USC § 1531 (h) through 1543 40 CFR Part 6.302 50 CFR Part 402	Requires action to conserve endangered species and critical habitat.	Substantive requirements are applicable.
Historic Sites, Buildings, and Antiques Act and Executive Order 11593	16 USC 461 et seq. 40 CFR Part 6.301(a)	Requires federal agencies to consider the existence and location of landmarks on the National Registry of Natural Landmarks to avoid undesirable impacts on such landmarks.	Relevant.
The Historic and Archeological Data Preservation Act of 1974	16 USC 469 40 CFR 6.301	Establishes procedures to provide for preservation of historical and archeological data that might be destroyed through alteration of terrain as a result of a federal construction project or a federally licensed activity or program.	Relevant.
California Preservation Laws	Administrative Code, Title 14, Section 4307	No person shall remove, injure, deface or destroy any object of paleontological, archaeological, or historical interest or value	Relevant.
California Cultural and Paleontological Resources	Document 33.4	State-level cultural resource protection is regulated through the provisions of Appendix K of the California Environmental Quality Act (CEQA). Paleontological resource protection is regulated through the 1906 Antiquities Act.	Relevant.
Action-Specific			
Clean Water Act National Pollutant Discharge Elimination System Effluent Limitations	33 USC 1342 Section 404 40 CFR Parts 122, 125 33 USC 131140 CFR Part 440	Requires permits for the discharge of pollutants from any point source into waters of the United States Sets standards for discharge of treated effluent to waters of the United States	Substantive requirements applicable.

Table 5.1-1 Applicable or Relevant and Appropriate Requirements

Standards, Requirement, Criteria, or Limitation	Citation	Description	Applicable or Relevant and Appropriate
General Permits for Industrial/Construction Storm Water Discharges requirements	http://www.waterboards.ca.gov/centralvalley/water_issues/storm_water/index.html	The regulations require that storm water associated with industrial/construction activity (storm water) that discharges either directly to surface waters or indirectly through municipal separate storm sewers must be regulated by an NPDES permit The regulations require facility operators to: 1. Eliminate unauthorized non-storm water discharges; 2. Develop and implement a storm water pollution prevention plan (SWPPP); and 3. Perform monitoring of storm water discharges and authorized non-storm water discharges.	Substantive requirement applicable
Clean Air Act National Primary and Secondary Ambient Air Quality Standards National Emission Standards for Hazardous Air Pollutants	42 USC 7409 40 CFR Part 50 40 CFR Part 61, Subparts N, O, P, pursuant to 42 USC 7412	Establish air quality levels that protect public health, sets standards for air emissions Regulates emissions of hazardous chemicals to the atmosphere	Relevant pertaining to disturbance of waste material during consolidation, removal, or treatment.
California Air Quality Control Act	California Air Resources Board	www.arb.ca.gov	Relevant pertaining to disturbance of waste material during consolidation, removal, or treatment
Northern Sonoma County Air Pollution Control District (ACPD) Regulations	Chapter 4 – Prohibitions (specifically Rules 400, 410, 420, 430, 492)	Rules and regulations enacted to achieve and maintain local, state, and federal ambient air quality standards within Northern Sonoma County. Air Quality standards include ambient air quality standards adopted by the state board pursuant to section 39606 of the Health and Safety Code and which have been established pursuant to Sections 108 and 109 of the federal Clean Air Act pertaining to criteria pollutants and section 169A of the federal Clean Air Act pertaining to visibility.	Relevant pertaining to disturbance of waste material during consolidation, removal, or treatment.

Table 5.1-1 Applicable or Relevant and Appropriate Requirements

Standards, Requirement, Criteria, or Limitation	Citation	Description	Applicable or Relevant and Appropriate
California Hazardous Waste Disposal and Transportation Program	Title 26 CCR, Division 4 - Cal/OSHA, Division 21.5 - Health and Welfare (Prop 65), and Division 22 - Department of Health Services, and 49 CFR - Parts 100-177 and 350-399 - Department of Transportation (DOT).	Regulates transportation and disposal of hazardous waste.	Applicable if waste is transported offsite.
Hazardous Materials Transportation Act: Standards Applicable to Transport of Hazardous Materials	49 USC § 1801-1813 49 CFR Parts 10, 171-173 and 177	Requires placing, packaging, documentation for the movement of hazardous materials on public roadways.	Potentially applicable
Closure Criteria for Municipal Solid Waste landfills	40 CFR Part 258.60 (a)(1-3)	Establishes design for caps.	Applicable to potential capping alternative
Resource Conservation and Recovery Act	40 CFR Part 261, Subpart D	Defines wastes which are subject to regulation as hazardous wastes under 40 CFR Parts 262-265 and Parts 124, 270, and 271	Relevant pertaining to the potential disposal of the waste material.
California Solid Waste Management Regulations	TITLE 27. Environmental Protection, Division 2. Solid Waste, Subdivision 1. Consolidated Regulations for Treatment, Storage, Processing or Disposal of Solid Waste	Applies to all disposal sites meaning active, inactive closed or abandoned, as defined in §40122 of the Public Resources Code including facilities or equipment used at the disposal sites	Potentially applicable if solid waste is transported away from site or relevant and appropriate if a disposal facility is constructed as part of final action

Table 5.1-1 Applicable or Relevant and Appropriate Requirements

Standards, Requirement, Criteria, or Limitation	Citation	Description	Applicable or Relevant and Appropriate
Solid Waste Disposal Act as amended by the Resource Conservation and Recovery Act	42 USC 6901, et seq.		
Standards Applicable to Transporters of Hazardous Waste	40 CFR Part 263, pursuant to 42 USC 6923	Establishes standards for persons transporting hazardous waste within the US if the transportation requires a manifest under 40 CFR Part 262	Applicable if hazardous wastes are transported off-site
Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities	40 CFR Part 264, pursuant to 42 USC 6924, 6925	Defines acceptable management standards for owners and operators of facilities that treat, store, or dispose of hazardous waste	Substantive requirements possibly applicable
Bevill Amendment	RCRA Section 3001 (a)(3)(A)(ii) 42 USC 6921 (a)(3)(A)(ii) 40 CFR Section 261.4(b)(7)	Exempts most mining wastes from regulation as hazardous waste. Exempted waste includes waste from the extraction and beneficiation of minerals, and some mineral processing waste.	Applicable
California Health and Safety Code Definition of Hazardous Waste §25117 Hazardous Waste Criteria §25141	http://www.ciwmb.ca.gov/leatraining/wasteclass/yep.htm	Recognizes the Bevill exclusion; mining wastes are subject to requirement of Chapter 6.8 with respect to "hazardous substances".	Applicable

Table 5.1-1 Applicable or Relevant and Appropriate Requirements

Standards, Requirement, Criteria, or Limitation	Citation	Description	Applicable or Relevant and Appropriate
California Mining Waste Regulations	27 CCR 22470-22510	Establish three groups of mining waste: • Group A – mining waste that must be managed as hazardous waste provided the RWQCB finds that such mining wastes pose a significant threat to water quality • Group B – mining wastes that consist of or contain hazardous wastes that qualify for a variance, provided that the RWQCB finds that such mining wastes pose a low risk to water quality, or mining wastes that consist of or contain non-hazardous soluble pollutants of concentrations which exceed water quality objectives for, or cold cause, degradation of waters of the state • Group C – wastes from which any discharge would be in compliance with the applicable water quality control plan, include water quality objectives other than turbidity	Applicable
Design and Siting under California Water Code	Section 13172	State regulations governing the design of mining waste disposal units, the RWQCB imposes specific requirements on siting, construction, monitoring, and closure and post-closure maintenance of existing and new units. Restrictions depend upon whether the wastes are Group A, B, or C and whether the units are existing or new.	Applicable
California Surface Mining and Reclamation Act of 1975	Office of Mine Reclamation Article 9 Title 14 14CCR 3703 14CCR 3704 14CCR 3705 14CCR 3706 14CCR 3710 14CCR 3713	Protection standards for wildlife habitat Performance standard for backfilling, re-grading, slope stability, and recontouring Performance standards for revegetation Performance standards for drainage, diversion structures, waterways, and erosion control Performance standards for stream protection Performance standards for closure of surface openings	Potentially Applicable
Comprehensive Environmental Response, Compensation, and Liability Act	(CERCLA), Section 121	This section requires that all remedial actions which result in any hazardous substance, pollutants, or contaminants remaining on the Site be subject to Five-Year Review to evaluate the performance of the remedy.	Applicable

6 Identification of Removal Action Objectives

Removal action objectives (RAOs) have been developed based on analysis of the sources of contamination, the nature and extent of contamination, results of the human health and ecological risk evaluations, and the ARARs that have been identified. The RAOs have been developed to control the contamination sources, and eliminate the potential for exposure of human and ecological receptors to Site contamination.

6.1 Removal Scope

The general evaluation criteria for the analysis of potential removal actions, as defined in the EPA document *Guidance on Conducting Non-Time-Critical Removal Actions Under CERCLA* (1993), are effectiveness, implementability, and cost. These criteria are discussed in detail in Section 7.0. To define the RAOs for the Contact and Sonoma Mines site, results of the site characterization activities and baseline risk evaluation were evaluated in an effort to develop removal goals that comply with the ARARs and are protective of human health and the environment. The RAOs are to:

- Prevent or reduce human exposure (through inhalation, ingestion, and dermal contact) to mercury in waste materials at the Site;
- Prevent or reduce ecological exposure (through inhalation, ingestion, and dermal contact) to mercury in waste materials at the Site;
- Prevent or reduce potential migration of mercury in waste materials at the Site via surface runoff, erosion, and wind dispersion; and
- Prevent or reduce potential migration of mercury in waste materials at the Site to groundwater and eventual potential recharge to surface water.
- Groundwater remediation alternatives are not included in the removal action objectives as preliminary data appears to indicate that groundwater is not affected by the sources of contamination at the site. Instead, the alternatives posed will address the reduction of migration of contamination to groundwater through surface media remedies and will incorporate long term monitoring of groundwater.

For the Site, not only must the proposed removal action address the RAOs, but it must also address any planned future use of the property to ensure consistency with these objectives. As a result, both the proposed removal action alternative and any potential further land use will be evaluated in subsequent sections to determine the extent to which they meet these RAOs. Although immediate and 100% attainment of the RAOs is not required for a removal action, it is considered to be a goal that is desirable pending availability of effective technologies and funding.

6.2 Removal Schedule

The BLM has determined that a non-time-critical removal action is appropriate at the Site. The removal could commence within 6 to 12 months following approval of this EE/CA. Based on past experience with the implementation of removal action technologies similar to those proposed in this EE/CA, it is estimated that any removal action undertaken can be completed within one year, assuming funding is available.

7 Identification and Analysis of Management and Treatment Technologies and Removal Action Alternatives

According to 40 CFR 300.415, the purpose of an EE/CA is to analyze potential removal action alternatives based on current site conditions to address contamination present at a site. The alternatives are evaluated and developed through the criteria suggested in the EPA document, *Guidance on Conducting Non-Time-Critical Removal Actions Under CERCLA* (1993). Specifically, the removal action alternatives have been developed and analyzed against the RAOs and evaluation criteria separately.

The development and analysis of removal action alternatives involves four steps. In Section 7.2, the general categories of potential response actions are identified and described. The broad array of technologies that may apply to each category are then identified and screened in Section 7.3. This preliminary screening procedure has been conducted to identify those technologies considered applicable to the Site, and which may be potentially effective in meeting the RAOs. Although many of the technologies discussed in Section 7.3 are not applicable to the Contact Sonoma site, they are presented to document that they were identified and considered. In Section 7.4, the potential response actions and technologies retained from the screening process in Section 7.3 have been assembled into removal action alternatives. Finally, the alternatives were analyzed against the criteria of effectiveness, implementability, and cost. A detailed description of this analysis is presented in Section 8.0.

7.1 Overview of Evaluation Criteria

The criteria used to evaluate removal action alternatives in an EE/CA are defined by EPA (1993). The three general criteria are effectiveness, implementability, and cost. The specific components of each criterion are defined as follows:

Effectiveness

- Overall protectiveness of human health and the environment
- Ability to achieve RAOs/ARARs
- Short- and long-term effectiveness

Implementability
- Technical feasibility
- Administrative feasibility
- Availability of materials and sources
- Community acceptance

Cost
- Capital cost
- Post-removal control cost
- Present worth cost
- Maintenance and monitoring costs

7.2 Description of Broad Categories of Potential Removal Actions

The broad categories of potential removal response actions include:
- No action;
- Institutional controls;
- Surface water controls;
- Management and/or treatment of ore and tailings materials; and
- Site reclamation.

7.2.1 No Action

The No Action Alternative leaves contaminated materials at the Site in their current condition and assumes no further intervention will occur. Although the No Action Alternative will not actively meet the RAOs for the Site (they may be eventually achieved through natural attenuation), its consideration and evaluation is required. Other potential response actions will be compared to the baseline provided by the No Action Alternative. Under the No Action Alternative, no response activities or monitoring would occur at the Site.

7.2.2 Institutional Controls

Institutional controls include administrative land use restrictions, site access restrictions (such as fencing), and/or relocation of potential receptors in an attempt to minimize the potential for exposure to site contamination. In general, administrative controls do not actively address site contamination, but attempt to meet the RAOs by reducing the potential for human and ecological exposure to the contaminants. However, these controls do not address the mobility of the contamination, the direct exposure of contaminants to human or ecological targets, or the off-site transport of contaminated materials via other exposure pathways. Used in conjunction with a removal action, administrative controls can be an effective deterrent to deterioration of a remedy such as an engineered cap, by providing controls for natural processes such as erosion, as well as human intrusion such as trespassing or vandalism. Administrative controls may also include long-term maintenance activities such as monitoring.

7.2.3 Surface Water Controls

Surface water run-on and runoff controls or stormwater management structures include drainage channels, berms, swales, or other structures designed to prevent surface water from coming into contact with contaminated materials. By doing so, erosion of contaminated surfaces and subsequent off-site transport of contaminants via the surface water pathway are reduced. However, these controls do not address direct exposure of contaminants to human or ecological targets, or the off-site transport via other exposure pathways, particularly the air pathways. Surface water controls may be used in conjunction with other technologies to help the technologies perform optimally.

7.2.4 Management and/or Treatment of Waste Rock and Tailings Materials

Management or treatment of ore and tailings materials includes options that can be conducted in-situ or ex-situ. While it is typical to include treatment methods that do not require movement or handling of mining waste material (such as capping) in EE/CA reports, all in-situ treatment methods for the Site will require moderate handling of the mining waste. Stabilization of the contamination in place, restricting potential exposure by capping, or using innovative technologies to remove the contaminants without physically removing the ore or tailings piles have been identified and potential options are presented in Section 7.3. In addition, treatment methods that involve removal of the material to either on-site or off-site locations have been reviewed and are also presented in Section 7.3. In general, options that involve excavation of contaminated materials will meet the RAOs by either completely removing the contaminants from the property or providing a barrier between potential receptors and the contaminated materials; however, a higher initial cost is typically associated with these actions. Removal actions that involve leaving material in place are likely less expensive in the short term but may not always be effective in meeting the RAOs.

7.2.5 Site Reclamation

Site reclamation measures typically follow removal to stabilize the Site and bring natural processes such as erosion and deposition back into equilibrium. Site reclamation includes measures for amending and improving the soil to support vegetation, and revegetating the Site to stabilize the soil and support wildlife.

7.3 Identification and Screening of Management and Treatment Technologies

7.3.1 No Action

The No Action Alternative does not require the use of any management or treatment technologies.

Site-Specific Evaluation: Although the No Action Alternative will not meet the RAOs, it is used as a baseline against which other alternatives are measured. For this reason, and because a No Action Alternative is required according to EPA guidance, it is retained for further evaluation.

7.3.2 Institutional Controls

Institutional controls are used to restrict access or control use of a site. They include construction of barriers, installation of fences and gates, moats, warning signs, hostile vegetation, and designating the Site on lands records as a repository with ground water use restrictions. Site patrols and enforcement actions may be practical depending upon the remoteness of a site.

Site-Specific Evaluation: Institutional controls at the Site would not be expected to be effective in meeting the RAOs. Currently access is not limited. There is evidence at the Site of illegal trash dumping, shooting, and off-road vehicle use. BLM has installed gates and barriers to abate the off-road vehicle use, but other illicit activities have continued at the site. While additional fencing may offer added human trespass prevention, it will likely not limit ecological exposure, nor does it address the potential for off-site migration of the contamination. Because of these issues, institutional controls by themselves, although retained for further analysis as a component of other identified alternatives in Section 7.4, are not expected to sufficiently address the RAOs.

Options such as installation of fences, gates, and warning signs are most appropriate for the Site because they are less expensive and easier to implement and maintain than barriers consisting of moats or earthen structures. However, due to past problems at the site, institutional controls may be vandalized and damaged, requiring maintenance and/or more robust controls. Site patrols were deemed impractical due to the remoteness of the Site location and were therefore screened out.

7.3.3 Surface Water Controls

Surface water diversion measures are implemented to reduce contaminant mobility by limiting water erosion processes. Drainage channel improvements are utilized for many purposes, including relocation or diversion of a stream around potentially contaminated areas. One approach is to use surface water management systems that divert stormwater away from contaminated areas, and possibly use vegetation or riprap to limit the potential for erosion. This option can be effective in reducing the potential for migration of contaminants; however, it will not reduce the potential for direct human and/or ecological exposures on site.

Site-Specific Evaluation: Surface water controls at the Site would be expected to contribute to remedial actions effective in meeting the RAOs. Surface water controls may prevent potential off-site migration from erosion of contaminated surfaces into the drainage channels present on Site. While surface water at the Site is very minimal if present at all, runoff from the site features flows into tributaries, and subsequently into Anna Belcher Creek. Therefore, controlling surface water flow through and over the contaminated materials on site may limit a significant exposure pathway. It is noted that surface water controls by themselves, are not expected to sufficiently address the RAOs. However, they are retained for further analysis as a component of other identified alternatives in Section 7.4.

7.3.4 Management and/or Treatment of Waste Rock and Tailings/Materials

This section provides a brief description of the management and treatment alternatives for waste rock and tailings materials at the Site. The management and treatment alternatives are:

- Stabilization/containment;
- Solidification/fixing technologies;
- Excavation and removal to an on-site consolidation location; and
- Excavation and removal to an off-site commercial landfill facility.

7.3.4.1 Stabilization/Containment

Stabilization/containment technologies for application at contaminated sites include landfill covers (caps), vertical barriers, and horizontal barriers. Stabilization/containment is most likely applicable for (1) wastes that are low-hazard or immobile, (2) wastes that have been treated to produce low-hazard to low-mobility waste for on-site disposal, and (3) wastes whose mobility must be reduced as a temporary measure to mitigate risk until a permanent remedy can be tested and implemented (EPA 1997). Stabilization/containment is considered an established technology at sites where moderate volumes of metal contaminants (which are largely immobile) are the primary concern.

Capping systems reduce surface water infiltration, improve runoff control, control fugitive dust emissions, improve aesthetics, and provide a stable surface over the waste. Capping prevents or reduces direct contact exposure from ingestion and inhalation. Consolidation and capping-in-place is an appropriate alternative when contaminated materials are left on site. This type of containment is an option where excavation and disposal or treatment actions are cost prohibitive. Consolidation and capping-in-place is a standard construction practice for addressing mine and mill waste; it uses standard equipment and employs demonstrated design methods. Cap construction costs depend on the number of components in the final cap system. In-situ vertical barriers, such as slurry walls, constitute an impermeable barrier situated perpendicular to the ground surface and groundwater flow to minimize the movement of contaminated groundwater off site and/or limit the flow of uncontaminated groundwater on site (EPA 1997).

The most important advantages of stabilization/containment are (1) surface caps and vertical barriers are relatively simple and rapid to implement at low cost and can be more economical than excavation and removal of waste, (2) caps and vertical barriers can be applied to large areas or volumes of waste, (3) engineering control is achieved and may be a final action if metals are well immobilized and potential receptors are distant, and (4) in some cases it may be possible to create a land surface that can support vegetation and/or be applicable for other purposes (EPA 1997).

Disadvantages of stabilization/containment include (1) design life is uncertain, (2) contamination remains on site and is available to migrate should containment fail, (3) long-term inspection, maintenance, and monitoring is required, and (4) the site must be amenable to effective monitoring (EPA 1997).

Site-Specific Evaluation: Consolidation and capping-in-place would be an appropriate action for the Site if excavation and disposal or treatment actions are cost prohibitive, for lower levels of contamination where environmental impacts outweigh the benefit, or if alternative actions are deemed too difficult to implement. Consolidation and capping-in-place is a standard construction practice for addressing mine and mill waste; it uses standard equipment and employs demonstrated design methods. Slope stabilization activities could include the partial excavation and re-compaction of the existing waste piles and re-contouring of the existing pile slopes.

Capping would involve placing covers over the waste material piles to limit the potential for human and ecological exposure to the contaminants, and limit the potential for off-site migration. The capping configuration would be graded so that drainage would follow the natural contours of the area. Surface water and erosion controls would limit the potential for degradation of the cover. Although capping would not reduce the toxicity or volume of contamination, it would reduce direct exposure, risk, and mobility by making the contamination inaccessible to human receptors. Capping would also limit stormwater flow and infiltration and promote runoff away from the contaminated areas, thereby reducing the potential for leaching of contaminants to groundwater. For these reasons, this technology is retained for evaluation.

7.3.4.2 Solidification/Fixing Technologies

Solidification or fixing technologies are treatment processes that change the physical characteristics of the contaminated material to reduce the mobility of the contaminants by creating a physical barrier to leaching. Specifically, these technologies improve the physical characteristics of the waste by producing a solid from liquid (or semi-liquid) wastes, reduce the contaminant solubility by formation of sorbed species or insoluble precipitates, decrease the exposed surface area across which mass transfer loss of contaminants may occur, and limit the contact between transport fluids and contaminants by reducing the material’s permeability (EPA 1997).

Physical treatment methods involve the separation of particles based on differences in physical properties. Studies have shown that typical mobility of contaminants is an inverse function of particle size: the most mobile contaminants are usually found to be the smaller particle size classes (EPA 1997). Therefore, by physically separating the fines, or smaller particles, from the larger materials in the waste matrix, it may be possible to limit the volume of waste materials requiring treatment or storage. On the whole, this provides project cost savings by volume reduction; however, most physical separation techniques decrease in efficiency as particle sizes decrease. Physical treatment methods include particle size classification, gravity separation, and froth floatation, which utilizes a material's hydrophobic properties for separation. Other physical treatment methods include electrokinetic treatment and deep tilling.

Solidification technology is usually applied by mixing contaminated soil or treatment residuals with a physical binding agent to form a crystalline, glassy, or polymeric framework surrounding the waste particle. The applicability of this technology depends on the chemistry of the site-specific contaminants and the binders being used (EPA 1997). The soil-contaminant-binder equilibrium and kinetics are influenced by several factors and the cost of implementation can be relatively high.

Chemical treatment methods focus on using chemical reactions such as coagulation, ion exchange, and adsorption to either remove metals or neutralize the acid forming potential. These treatment processes include metals flocculation, precipitation, co-precipitation processes, soil washing, leaching processes, hydrometallurgical processing, fixation/stabilization processes, and various forms of in-situ treatment. Soil washing is a chemical process that extracts contaminants, such as metals, from sludge or soil using a liquid medium such as water as the washing solution. Acid extraction processes involve applying an acidic solution to the contaminated materials causing metals to be dissolved. Alkaline leaching is similar to acid extraction in that leaching solutions, such as ammonia, lime, or caustic soda, are applied to the contaminated media. Soil flushing is another innovative process that injects acidic or basic reagents or chelating agents into the contaminated media to solubilize metals (EPA 1997). Hydrometallurgical reprocessing involves excavating the waste materials and transporting the waste to an existing operating mill or smelter facility for processing, metals recovery, and subsequent disposal of the processed materials.

In-situ geotechnical fixation is a cost-effective method of remediating metals-contaminated soil and groundwater. In-situ fixation involves mixing chemical reagents with a small volume of pumped groundwater, and subsequent reinjection of the treated water around the upgradient perimeter of the contaminated plume. Fixation is a process of chemically altering the wastes to reduce the mobility and/or toxicity of the constituents. In-situ treatment involves direct mixing of precipitating and neutralizing chemicals or stabilization agents with the contaminated media in place. Chemical bond processes use in-situ mixing of proprietary powder or liquid reagents with soil to effect a chemical reaction forming an insoluble bond. For inorganic- and organic-based encapsulation methods, the contaminants are bound or enclosed within a stabilized mass, or a chemical reaction is induced between the stabilizing agent and the contaminant to reduce its mobility. Thermal desorption and distillation, a thermal rather than chemical method, can be used to remove mercury from waste material using a rotary kiln, or by distillation processes; however, these processes do not address the other metals in the waste material and are fairly costly.

Site-Specific Evaluation: While physical and chemical treatment of contaminated waste and soils has been effective on most metals; effectiveness in reducing the leaching potential of mercury in the waste materials is not well established. There is insufficient data to determine if leaching is occurring. No known treatment technologies applied directly to the solid mine waste materials are expected to sufficiently address the RAOs. For these reasons, physical and chemical treatment technologies are not retained for further analysis.

Excavation and Removal to an On-Site Consolidation Cell

This action involves excavation, relocation, and placement of the waste rock and tailings materials in an on-site consolidation cell or repository. Under this alternative, the on-site consolidation cell would be selected based on available surface area, natural lithology, groundwater table elevation, surface drainage area, and other relevant factors. The area of consolidation would be specifically designed and constructed to contain the waste and mining materials.

Excavated waste rock and tailings materials would be transferred to the on-site consolidation cell and placed in the densest volume practicable (by compaction). The consolidation cell design could include appropriate controls such as a barrier layer, leachate collection system, surface water controls, and site security and/or fencing as needed. In addition, programs could be developed for the consolidation cell to address waste characterization, operating protocols, daily cover, groundwater monitoring, and explosive gas monitoring, as applicable. Notification and closure plans would be prepared for the location.

Upon completion of waste rock and tailings placement, final grading would be completed and final cover layers would be placed, leaving the consolidation location in a condition of orderliness and good aesthetic appearance. Final grading would promote surface water runoff and protect against excessive erosion. Final cover layers would likely include a low-permeability layer, as well as rooting and seed bed layers to support native plant growth. Establishment of a vegetative cover over the consolidation cell would further reduce infiltration and erosion due to transpiration and interception processes. Removal and placement of the waste materials into the on-site consolidation cell would substantially reduce the potential exposure to human and ecological receptors.

Site-Specific Evaluation: Relocation of the waste rock and tailings materials to a controlled environment would eliminate the unchecked migration of contaminants. The on-site consolidation cell's final cover system would reduce the potential for contaminant transportation via surface water and air pathways. By reducing the potential for water to contact the waste, transport by groundwater would also be reduced. Removal and placement of the waste rock and tailings materials into an on-site consolidation cell would substantially reduce the potential exposure to human and ecological receptors. This alternative provides a high potential for RAO and ARAR achievement and is retained for further evaluation.

7.3.4.3 Excavation and Removal to an On-Site Consolidation Cell

This alternative involves excavation, relocation, and placement of the waste materials in an off-site commercial landfill facility. Under this alternative, the location of the off-site facility would be selected based on availability of landfill space, haul distance, and cost. The facility would be permitted for solid waste and would be able to accept the waste rock and tailings materials without substantial facility modifications.

Excavated waste rock and tailings materials would be transferred to the off-site landfill and placed in open cells in a manner determined by the facility operator. The facility would be responsible for being in compliance with all applicable regulations governing solid waste disposal which may include site security, fencing, daily cover, groundwater monitoring, explosive gas generation, leachate collection, and hazardous waste characterization.

Site-Specific Evaluation: Relocation of the waste rock and tailings materials to a controlled environment would eliminate the unchecked migration of contaminants. The off-site commercial facility would be responsible for installation of a cover system to reduce the potential for contaminant transportation via the surface water, groundwater, and air pathways. Material from the Site with analytical results exceeding the EPA TCLP or California WET levels would require additional treatment prior to delivery to a solid waste landfill, or would require placement in a regulated hazardous waste landfill. Additional samples may need to be collected to further characterize the contamination areas to determine final disposal locations (hazardous or nonhazardous). Removal and placement of the waste rock and tailings materials into an off-site commercial facility would substantially reduce the potential exposure to human and ecological receptors. This alternative provides a high potential for RAO and ARAR achievement and is retained for further evaluation.

7.3.4.4 Excavation and Removal to an Off-Site Commercial Landfill Facility

This alternative involves excavation, relocation, and placement of the waste materials in an off-site commercial landfill facility. Under this alternative, the location of the off-site facility would be selected based on availability of landfill space, haul distance, and cost. The facility would be permitted for solid waste and would be able to accept the waste rock and tailings materials without substantial facility modifications.

Excavated waste rock and tailings materials would be transferred to the off-site landfill and placed in open cells in a manner determined by the facility operator.

The facility would be responsible for being in compliance with all applicable regulations governing solid waste disposal which may include site security, fencing, daily cover, groundwater monitoring, explosive gas generation, leachate collection, and hazardous waste characterization.

Site-Specific Evaluation: Relocation of the waste rock and tailings materials to a controlled environment would eliminate the unchecked migration of contaminants. The off-site commercial facility would be responsible for installation of a cover system to reduce the potential for contaminant transportation via the surface water, groundwater, and air pathways. Material from the Site with analytical results exceeding the EPA TCLP or California Wet levels would require additional treatment prior to delivery to a solid waste landfill, or would require placement in a regulated hazardous waste landfill. Additional samples may need to be collected to further characterize the contamination areas to determine final disposal locations (hazardous or nonhazardous). Removal and placement of the waste rock and tailings materials into an off-site commercial facility would substantially reduce the potential exposure to human and ecological receptors. This alternative provides a high potential for RAO and ARAR achievement and is retained for further evaluation.

7.3.5 Site Reclamation

Site reclamation measures typically follow removal to stabilize a site and bring natural processes such as erosion and deposition back into equilibrium. In addition to the surface water control measures and treatment measures included in this discussion, site reclamation includes measures for amending and improving the soils to support vegetation, and revegetating the Site to stabilize the soil and support wildlife.

7.3.5.1 Soils

Amending the soils in the disturbed areas of the Site can be accomplished by augmenting them with new soils from other areas, by soil replacement and rebuilding the soil horizons. Organic matter, water polymers, micronutrients, macronutrients, and nitrogen fixers can be added and tilled in as necessary to help the soils sustain vegetation (Claussen 1998, Munshower 1994, Groff 1994). These activities can stimulate plant growth, and enhance microbial processes, nitrogen utilization, and nutrient cycling rates. Organic matter can be introduced by adding composted plant litter or composts, or by planting fast-growing grasses that distribute a large amount of root biomass through the upper horizons of the soil (Munshower 1994, Claussen 1998). Bacterial and mycorrhizael (fungal) inoculants are often used to enhance the soil matrix to promote recovery (Claussen 1998). Use of these inoculants is determined through a survey of the mycorrhizae and ectorrhizae present in the native vegetation on site (Claussen 1998, Groff 1994).

Mulching provides moisture retention, limits the impacts from erosion, and helps prevent seed loss from wind dispersion. An extensive mulching effort using native hay with litter detritus, seed, and root materials can also provide organic material and propagules (Munshower 1994). Other traditional mulch materials include straw, wood fiber (cellulose), netting, mats, paper, gravel, jute, bark chips, rice hills, and coconut fiber (Goldman, et al. 1986). For most areas, pea-sized gravel mulch at 25 percent by volume in the growth media is used with surface roughening to prevent rill erosion from forming (Munshower 1994).

7.3.5.2 Revegetation

The reintroduction of native species to an area should be utilized to achieve a desired ecosystem mix and provide a more self-sustaining population. Revegetation can be accomplished through various seeding and planting methods. Seeding should be accomplished in the fall, and could be performed by traditional methods such as broadcast seeding, seed drills, and hydromulch, or by innovative methods such as seed balls, which mimic cattle's role in seed distribution (SER 1999).

Site-Specific Evaluation: Site reclamation will be used in combination with other alternatives and is retained for evaluation. All revegetation alternatives incorporate the highest quality classes of specified materials and amendments. These include Class I commercial compost (Biocomp), agricultural grade lime, Biosol™, Humate™, weed-free straw mulch, double-net erosion control fabric, and exclusively native species in the seed mix. Previous experience has shown that the somewhat higher cost of these products is greatly outweighed by the benefit they contribute to enhanced revegetation success. Soil amendments are recommended based upon soils analysis results and site conditions.

7.4 Assembly of Removal Action Alternatives

The general potential response actions and technologies described in the preceding sections have been assembled into five Removal Action Alternatives which have been analyzed with respect to the evaluation criteria. These alternatives have been developed based on the known nature and extent of soil contamination and results of the human and ecological risk evaluations.

The five alternatives are as follows:

- Alternative 1: No Action
- Alternative 2: Limited Action – Erosion and Institutional Controls
- Alternative 3: Onsite Consolidation, Stabilization, and Capping
- Alternative 4: Onsite Lined Repository
- Alternative 5: Offsite Disposal

7.4.1 Alternative 1: No Action

The No Action Alternative leaves contaminated materials at the Site in their current condition and assumes no further intervention will occur. This Alternative does not require the employment of any management or treatment technologies. This Alternative will not meet RAOs; however, it is used as a baseline against which other alternatives are measured, and is included for comparison purposes. Under this alternative, no response activities or monitoring would occur at the Site.

7.4.1.1 Effectiveness

The No Action Alternative would not be effective in protecting human health or the environment, would not attain ARARs, and would not meet RAOs. As presented in Section 3.3 and 3.4, laboratory results indicate concentrations of mercury throughout the site exceed EPA, California, and BLM screening criteria. The majority of material sampled was taken from the surface of the piles, indicating a high probability of off-site migration and exposure of contact pathways. The highest measured mercury concentration that would remain in surface materials is 200 mg/kg, at the upper flat of the Sonoma Mine; however, it is possible that higher concentrations of mercury exist on the surface at the site.

Stormwater drainage flows over the exposed soil and waste rock piles in the form of run-on or sheet flow. These flows will continue to erode waste rock and exposed surfaces, and will transport mercury-laden materials off-site. The soils and waste rock in their current condition pose short- and long-term risks to environmental resources and, potentially, human health; these risks would continue to exist if no action is taken. The No Action Alternative does not reduce the risk to human health through ingestion, inhalation, and dermal contact pathways. The toxicity, mobility and volume of contaminants would not be reduced under this alternative.

7.4.1.2 Implementability

The No Action Alternative is technically implementable; however, this alternative would likely not be acceptable to regulatory agencies or BLM personnel given that the risk evaluation concluded that several waste rock and tailings piles pose an unacceptable risk to human health and the environment based on the elevated concentrations of mercury. Technical and administrative feasibility criteria do not apply to the No Action Alternative.

7.4.1.3 Cost

There are no direct capital and/or operating costs associated with implementing this alternative.

7.4.2 Alternative 2: Limited Action – Erosion and Institutional Controls

Alternative 2 is presented as an implementable, lower-cost alternative to other alternatives that propose comprehensive, site-wide remediation. The goal of Alternative 2 is to reduce the ongoing release of mercury contamination via wind, gravity, and surface water erosion transport.

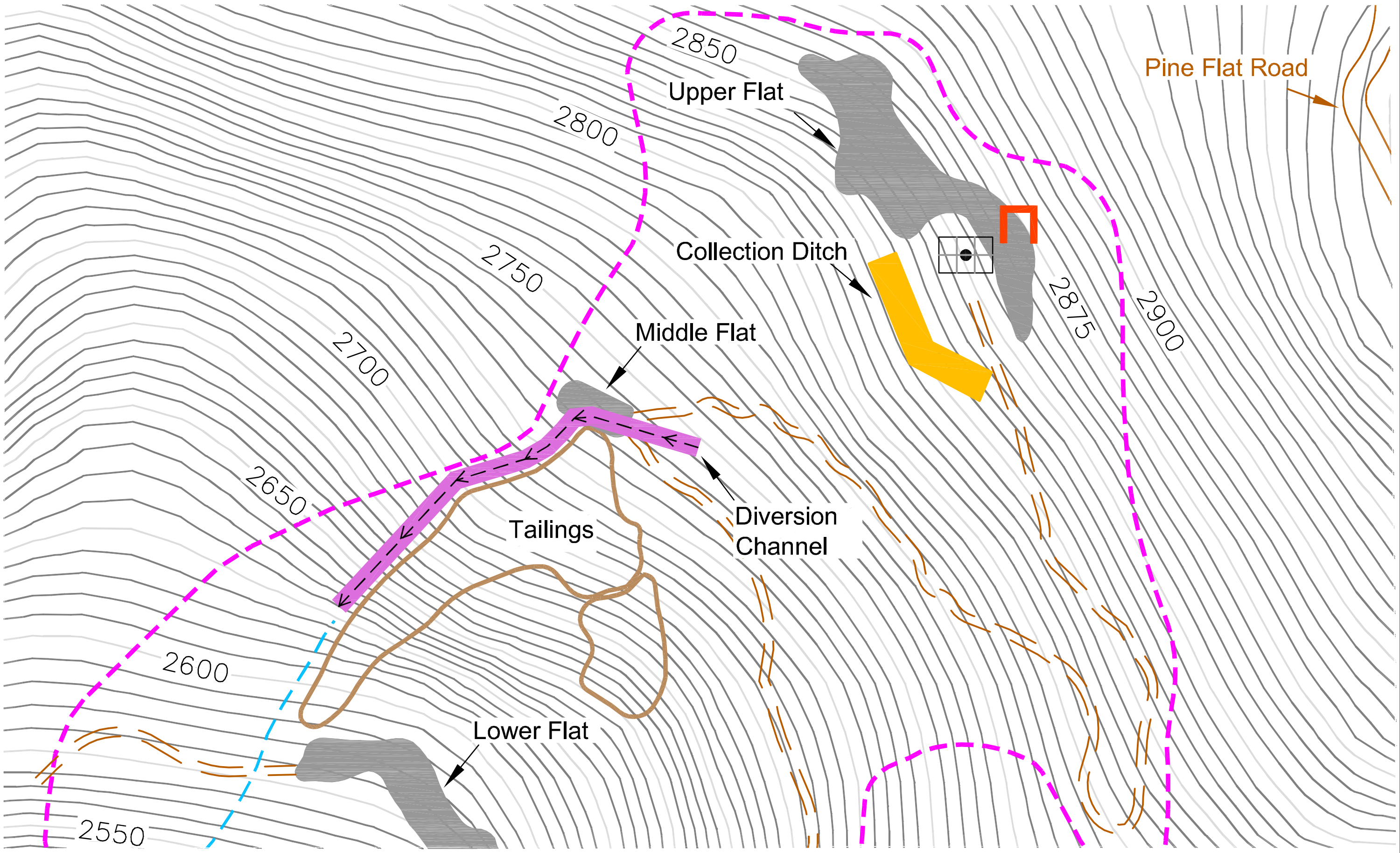
Under Alternative 2, no activities will be undertaken to significantly disturb or relocate the waste rock and tailings piles. Instead, erosion control measures such as surface water diversion structures, minor re-contouring of waste pile toes, and revegetation measures will be constructed in the areas surrounding the contamination source areas with the greatest potential for erosion transport. In addition to erosion control measures, Alternative 2 will implement institutional controls to restrict access and control use of contaminated areas of the Site. Fencing, signage, and administrative closures will be used to prohibit public access to the remaining exposed contamination.

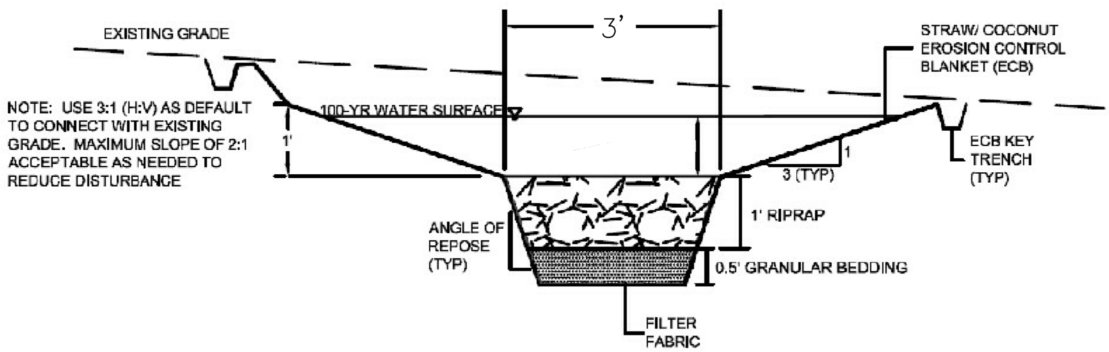
Mercury contamination has been detected in surface soils at both the Contact and Sonoma Mines. At the Contact Mine, there are five surface soil samples with mercury levels elevated above the site specific ecological risk criteria of 30.5 mg/kg. While there are two outlying surface samples near the furnace at the bottom edge of the upper flat that contain elevated mercury levels, the majority of elevated mercury levels in surface soils have been identified in the upper reaches of the tailings pile located near the middle flat of the Contact Mine. At the Sonoma Mine there are significantly more surface soil samples with elevated mercury levels; and the samples are more widely dispersed over the area of the site. There are a total of 19 surface samples with mercury concentrations elevated above the site specific ecological risk criteria; ranging from 36 to 200 mg/kg. The elevated samples were taken at the Sonoma Mine from areas north of Pine Flat Road, the upper flat, the middle flat, the retort furnace areas, the tailings pile, and the cut area just south of the tailings pile. A localized hot spot has been identified at the furnace located north of the lower flat. Two samples taken from the surface of the retort area just north of the lower flat were found to have concentrations of mercury exceeding the human health criteria of 250 mg/kg. These samples contained 920 and 4100 mg/kg of mercury.

Surface Water Diversion

Surface water controls will be installed around the existing flat bench and tailings areas to divert run-on and control run-off. At the Contact Mine, this would likely involve a diversion berm and channel system surrounding the middle flat and tailings pile, diverting stormwater flow around the areas. The diversion channel would run from the northeast end of the tailings pile, around the north edge, and then southwest to the southern end of the pile, a course of approximately 500 linear feet. The surface water diversion structure would connect back into natural drainage paths that eventually become the headwaters for Anna Belcher Creek. A ditch down-gradient of the upper flat area would trap sediment from run-off over the contaminated surface materials near the adit and furnace structures. This trapped material would be removed, as necessary during ongoing maintenance activities, and could be placed on the existing tailings piles in a stable location not prone to surface water flow. Refer to Figure 7-1 for a conceptual layout of the surface water diversion systems for the Contact Mine.

Similar structures could be built at the Sonoma Mine. Because the areas of contamination are dispersed over the majority of the flat benched features, a series of interconnected diversion structures would be required to redirect run-on around all of the areas of surface contamination. One diversion channel (Channel 1) would collect run-on above the upper flat and along the southern edge of the dirt access road. The channel would run east for approximately 200 linear feet to join the natural drainage paths to the east side of the Sonoma Mine boundary. At the middle flat, two berm structures (Berm 1 and Berm 2) would be constructed to redirect run-on around the northern and southern edges, respectively, of the middle flat. It is estimated that these berms would be located along the uphill edges of the middle flat and would run approximately 80 to 100 feet in length. The diverted flow would then join natural drainage paths and/or other constructed diversion structures (see following discussion). The next diversion channel (Channel 2) system would collect run-on at the top (north) of the lower flat and tailings pile, run west-southwest along the upper edge of the lower flat, and then south to join the existing cut and west to east watercourse located south of the lower flat (see following discussion), eventually joining Anna Belcher Creek approximately 480 feet to the east of the Sonoma Mine site boundary. The length of Channel 2, not including the existing water course, would be approximately 170 linear feet. A collection structure, similar to the one describe above for the Contact Mine, would trap sediment below (south-southeast of) the tailings pile. The material removed during ongoing maintenance activities would be placed on the existing tailings pile in a stable location not prone to surface water flow. There is evidence that the above mentioned cut and water course located south of the lower flat and tailings pile currently contain mercury contaminated materials. For this reason, portions of the water course will be excavated, and a new channel (Channel 3) will be created and lined with clean material. It is estimated that a length of approximately 200 feet of the existing water course will be removed and rebuilt. The contaminated material removed during excavation of the existing water course would be placed on the existing tailings pile in a stable location not prone to surface water flow. Refer to Figure 7-2 for a conceptual layout of the surface water diversion systems for the Sonoma Mine





TYPICAL SECTION

DIVERSION CHANNEL
NTS

LEGEND

- Furnace
- Paved Road
- Dirt Road
- Creek
- Portal to Adit
- Mine Site Boundary
- Flat Benched Area
- Tailings
- Diversion Channel
- Collection Ditch

Notes:
1) Contour data reflected here on was generated using USGS 10 meter DEM data. Date of data is unknown.

2) The Collection Ditch and Diversion Channel shown hereon do not presently exist on the ground and are shown here on as a visual aid for the Alternatives described in the EECA.

60' 0 60' 120'
Contour Interval is 10 feet

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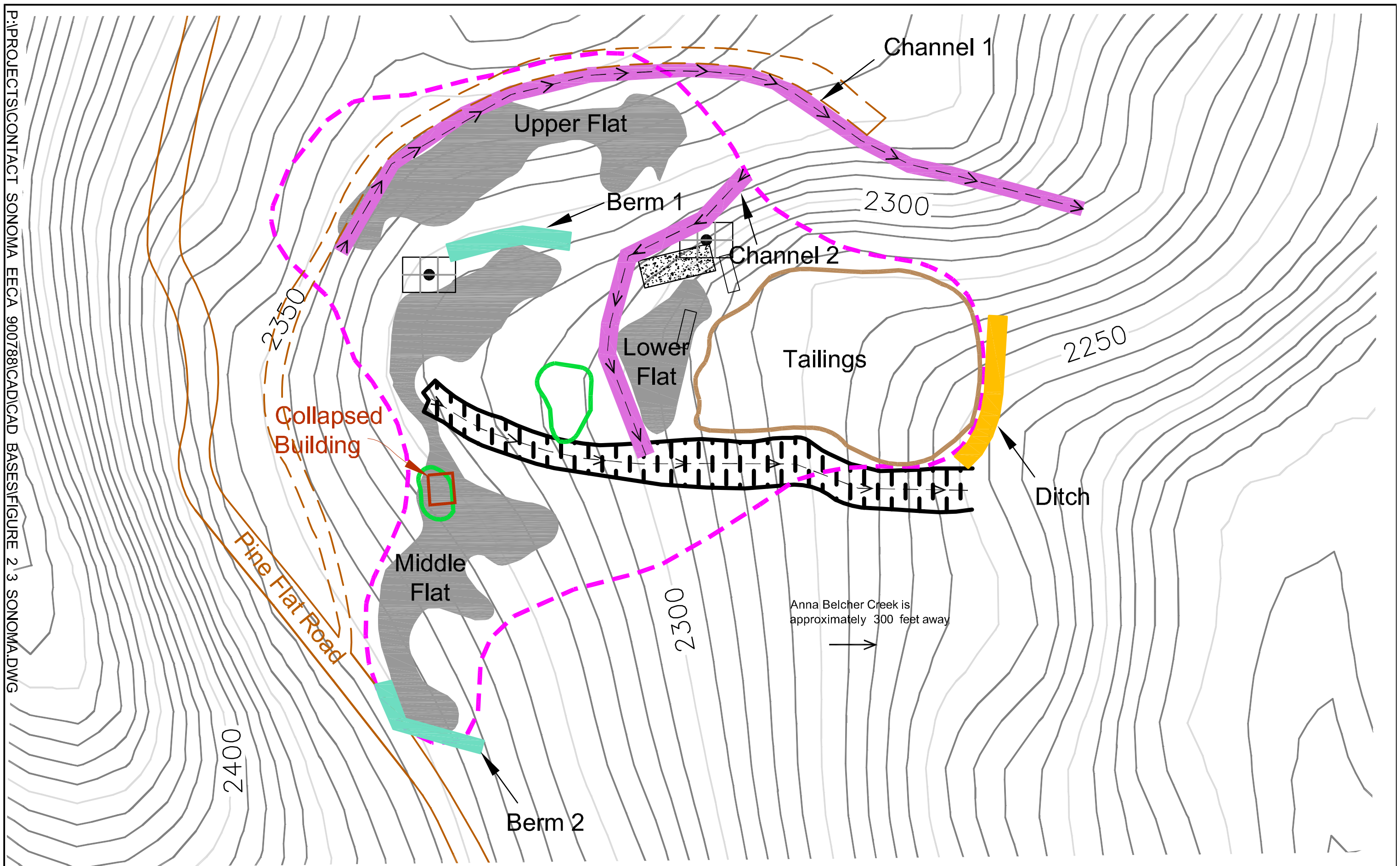
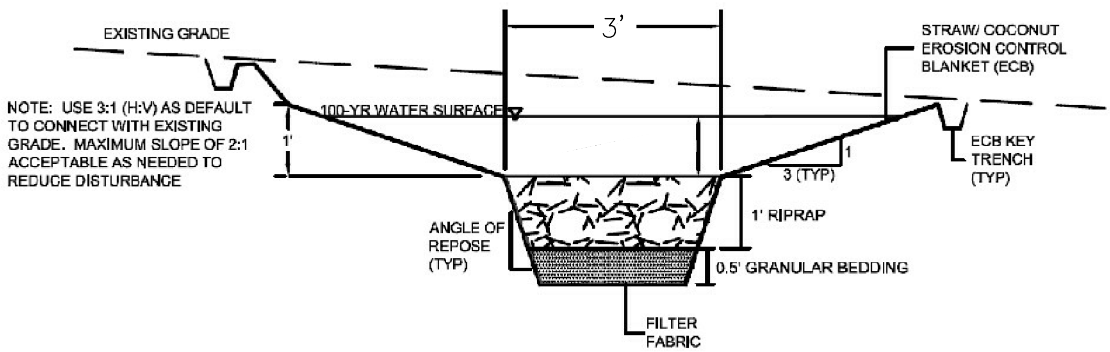
Contact Mine

Sonoma County, California

Figure 7-1
Contact Mine
Alternative 2





TYPICAL SECTION

DIVERSION CHANNEL
NTS

LEGEND

- Furnace
- Paved Road
- Dirt Road
- Mine Site Boundary
- Flat Benched Area
- Tailings
- Boundary of miscellaneous debris and/or structure
- Concrete
- Cut
- Diversion Channel
- Collection Ditch
- Berm

Notes:
1) Contour data reflected here on was generated using USGS 10 meter DEM data. Date of data is unknown.

2) The Collection Ditches, Diversion Channels and berms shown hereon do not presently exist on the ground and are shown here on as a visual aid for the Alternatives described in the EECA.

60' 0 60' 100'
Contour Interval is 10 feet

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June 9, 2010

Sonoma Mine

Sonoma County, California

Figure 7-2
Sonoma Mine
Alternative 2

Minor Re-Contouring

Alternative 2 proposes to re-contour and stabilize areas around the base, or toe of slope, of the tailings piles that pose a threat of release of contaminated materials via air, gravity, or surface water erosion. The areas which lie directly in the drainage flow paths of Anna Belcher Creek or its tributaries are of greatest priority. Steep slopes will be graded to reduce the potential for erosion via gravity. Great care will be taken to minimize unnecessary disturbance to stable areas.

Anna Belcher Creek runs generally north to south along the north-northwest edge of the Contact Mine tailings pile. An area of approximately 150 feet in length exists where the tailings pile toe reaches the banks of the creek to sufficiently stabilize the contaminated material in this area, a set-back of approximately 30 feet will be used. For the purposes of volume calculations, a conservative average tailings depth of 5 feet will be used. Therefore, it is estimated that approximately 830 cubic yards of material will be disturbed or regraded at the Contact Mine tailings pile.

The material that is disturbed will be regraded to a more uniform slope, tying into the natural topography of the adjacent areas where possible. Where limited space restricts the regrading efforts, tailings material will be excavated and placed on another location of the tailings pile.

Sediment that has been transported away from the tailings piles in a general southwest direction down the flow path of Anna Belcher Creek will be excavated and returned to a stable location on the tailings pile. During construction, if it is found, through screening efforts, that additional sediment media located within the Anna Belcher Creek drainage exhibits mercury concentrations in exceedence of the established human health and ecological risk criteria, these materials may also be excavated and relocated to the tailings pile.

Alternative 2 proposes to excavate sediment to 18 inches deep for an approximate length of 100 feet along Anna Belcher Creek. The width of the creek varies; however, for the purposes of volume calculations, an average width of 6 feet will be used. Excavation will be performed using a track mounted excavator positioned along the bank of the drainage so as not to contribute to the sloughing off of waste material, soil, or sediment into the watercourse. The excavated material will be dumped in the relatively level area of the tailings pile. It is estimated that approximately 33 cubic yards of material will be excavated from the creek and moved to the tailings pile at the Contact Mine.

Areas where sediment is excavated will be stabilized with rip-rap, appropriately sized to the expected velocities of storm event runoff. This will reduce erosion on the slope. It is assumed for cost estimation purposes that an adequate amount of low-mercury-bearing rip-rap material is available within the Site. It is estimated that 25 cubic yards of granular bedding, and 15 cubic yards of Class I or II riprap, will be required in the areas of excavation within Anna Belcher Creek.

Revegetation

No cap will be installed on top of the re-contoured areas. Field observations show that some areas of the Contact Mine tailings pile have already begun to revegetate naturally. For these reasons, Alternative 2 proposes to encourage natural revegetation as well as apply revegetation technologies to the areas where re-contouring or other disturbance takes place. These technologies will include seeding, mulching, and geo-fabrics where appropriate and implementable. In addition, every reasonable effort will be made to encourage existing growth on the tailings pile and precautions will be made to avoid further damage to the naturally revegetated areas.

Fencing and Signage

Because Alternative 2 involves leaving the majority of the contaminated materials in place and uncovered, it is important for the success of reclamation that access to the exposed contaminated material areas be completely restricted. It does not appear that the mine areas or interconnected access roads currently receive much ATV or foot traffic. Institutional controls, such as permanent access fencing and signage, will be installed across the access points to discourage all recreational activities.

A dirt access road currently connects the upper, middle, and lower flat features at the Contact Mine. This road also accesses the toe of the tailings pile near the location of the proposed re-contouring activities. To limit access both during construction and as a long-term deterrent to trespassing, a fence with locking gates should be installed around the tailings pile. Locking gates would allow access for BLM and construction personnel while denying access for recreational uses. It is estimated that this fence will be 1,000 feet long. The locking gates would be located at the dirt road access points to the lower flat and middle flat. As many as four locking gates would be required.

While the features at the Sonoma Mine are somewhat less accessible, because contaminated surface materials will remain exposed, it is recommended that the entire Sonoma Mine be fenced, including the upper, middle, and lower flats, as well as the tailings pile. Approximately 1,000 feet of fencing will be required to enclose the entire mine. The fence line would approximately follow the mine site boundary, where possible. There is currently an access road that follows the west and north boundaries of the mine. As access may be necessary for BLM and construction personnel, several access gates with locking mechanisms will be installed for both western and northern access points to the Sonoma Mine. In addition, a locking gate will be installed on the downhill side (southeast) of the tailings pile.

Signs prohibiting trespassing will be posted at all gate access points and along the length of the fences at 100 foot intervals. Signs warning of the potential human health threats will also be posted at the gate access points.

Administrative Closure
It is recommended that the areas addressed in Alternative 2 remain under administrative closure. Alternative 2 does not address all of the potential human exposure pathways. For this reason, access to the tailings piles and other contaminated media must be prevented administratively. A record closure of the Site to future uses such as recreation or residential should be made.

7.4.2.1 Effectiveness

Alternative 2 provides a limited reduction in exposure of mercury to humans and the environment. This alternative may meet some, but not all, ARARs and RAOs.

This alternative addresses transport of contaminated materials most prone to erosion via air, gravity, and surface water as well as human exposure to contaminated materials. A small amount of stability is provided for waste in the lower reaches of the waste rock and tailings piles. Surface water run-on and run-off are minimized through diversion structures, thus preventing surface water from coming in contact with the waste material. It would also be effective in decreasing direct human contact with the solid materials in the waste rock and tailings piles through institutional controls. Permanent fencing, signage, and area closure will protect the exposed areas and improve the chances of revegetation.

Sediment, with high levels of mercury, is removed from Anna Belcher Creek. This is a temporary solution, as mercury-laden waste material will continue to be transported from waste piles at both mine sites into the drainages. Surface water will be prevented from contacting exposed waste material through diversion; however, incidental precipitation directly on the surface of the piles will continue to erode the steep slopes and waste piles. Mercury will continue to be transported away from the site and into the drainage which is a tributary to Anna Belcher Creek.

Alternative 2 addresses mercury exposure at the Site in a very limited way. Fencing and signage are used to discourage human contact with mercury-bearing waste material; however, fences and signs will not last forever and are not completely preventative. It is foreseeable that fences and signs may be ignored by recreational users. Such controls also do nothing to address mercury transport by wind, gravity, or surface water, and will not prevent ecological contact with the piles.

It is anticipated that there may be several short-term mitigable impacts to the environment during implementation of this alternative. Impacts could include wildlife disturbance through noise and human activity during construction. Because all operations would be conducted on site, potential risks to the public related to the transport of waste would be limited.

7.4.2.2 Implementability

Alternative 2 is implementable and feasible. Material and labor resources and site access required for implementation of this alternative are expected to be available for the anticipated performance period.

The majority of the physical work to be performed under this alternative involves only minor earth moving and limited site access requirements. Exposed waste that is difficult to access (e.g., waste dumps on steep slopes) will be left in-place; this improves the implementability of Alternative 2. The sediment to be extracted is located in a sensitive drainage, which is also a difficult location to access. Minor improvements to access roads or trails may be necessary; however, excavation work and re-contouring work occurring in close proximity to flowing water will be done with techniques that minimize disturbance, or by hand, where possible.

The actions required for remediation at the Site are technically feasible using standard methods and procedures. The necessary equipment, personnel, and services are readily available to support implementation of this alternative. It is assumed light to moderate excavation equipment and limited hand work would be necessary at the Site.

Construction materials such as drainage bedding, gravel, select fill, and vegetative media for this alternative will have to be located and obtained, whether from an offsite source or a location within the Contact and Sonoma Mines. Potential borrow areas will have to be evaluated during the design phase of this project for adequate volume and appropriate agronomic and geotechnical properties. A potential borrow area may be located on the Sonoma Mine site. During sampling activities for this EE/CA, two soil boring locations were determined to have no evidence of tailings material. Laboratory analyses confirming that these materials contain no or low levels of mercury may allow material from these areas to be used as borrow material. Geotechnical and revegetative properties should be evaluated before use. The first area is located in the northeast portion of the Sonoma Mine near the furnace that is situated on a concrete pad. The second potential borrow area is located in the southern portion of the middle flat feature. This material would be relatively accessible as it is located on a level area where excavated material could be stockpiled. Borrow areas will require regrading and revegetation after excavation of material.

During excavation and earthwork activities, best management practices (BMPs) must be employed to minimize erosion and transport of contaminated materials. Such BMPs that could be used include silt fences, temporary berms, dust control, sediment traps, truck washing, and other structures or activities as deemed necessary.

Site Access

Minor access road improvements under this alternative may be necessary because vehicle traffic on-site and off-site would be required for transport of construction equipment and earthen fill and vegetative materials. .

7.4.2.3 Cost

The estimate for implementing this alternative is $541,000 in year 2010 dollars. Annual operating and maintenance costs, as well as estimated indirect capital costs associated with administration, testing, and engineering, have been included. The costs have been included in the total under a present worth analysis over a 30-year design life using a discount rate of 7%. A detailed cost estimate is included in Appendix D.

7.4.3 Alternative 3: Onsite Consolidation, Stabilization, and Capping

At the Contact and Sonoma Mine sites, mercury-bearing waste material is exposed in several tailings piles and surface soils spread over approximately 23 acres. Alternative 3 proposes to consolidate all safely accessible waste material from the mines into two consolidation cells, one at the Contact Mine and one at the Sonoma Mine.

The mercury content of waste material in the tailings piles, flats, and other areas where mining processes took place varies greatly from location to location. Concentrations exceed both human health and ecological risk criteria. Alternative 3 proposes to consolidate all contaminated material exposed on the surface of the Site as well as contaminated material at depth expected to be uncovered during excavation activities under this alternative. Contaminated material, defined as material exceeding 30.5 mg/kg mercury, will be removed from its current location and consolidated within a designated consolidation cell in either the Contact Mine area or the Sonoma Mine areas, as appropriate.

Physical and institutional controls would be required under this alternative to ensure that the integrity of the consolidation cells is not compromised by damage from natural or human-made disturbance. These controls may include surface water diversion structures, fencing and signing measures, and administrative closures. The support these features provide to this remedy is a key component to the long-term success of the alternative.

Consolidation Cells

Locations have been proposed for consolidation cells at both the Contact Mine and the Sonoma Mine. The locations were chosen based on the topography, geotechnical properties, proximity to potential environmental targets, and accessibility. The consolidation cells would be sized to contain all exposed material exceeding the human health risk criteria for mercury. The material will be stabilized or placed and compacted to maximize volume availability. The cells will not be lined; however, they will be capped with a soil and vegetative layer. The finished consolidation cell would blend in with the natural topography, as practicable.

The footprint chosen for the Contact Mine consolidation cell is located at the site of the tailings pile, as the majority of the contaminated materials from this site are already located there. The cell dimensions will be approximately 100 feet (west to east) by 50 feet (north to south) and approximately 20 feet in height. Materials that are currently situated within the proposed consolidation cell footprint will be stabilized and left in-place. Any materials that have been placed or migrated down slope of the level area of the tailings pile will be brought back up to the footprint. Contaminated materials excavated from other areas of the site will be placed and compacted in the designated cell footprint. It is estimated that a total of 3,500 cubic yards of contaminated material will be placed within the consolidation cell at the Contact Mine. Refer to Figure 7-3 for a conceptual layout of the consolidation cell.

The footprint chosen for the Sonoma Mine consolidation cell is located at the site of the upper flat. This location was selected because the flat provides a relatively level base and it is situated central to the majority of the locations from which contaminated materials will be collected. In addition, the upper flat is easily accessible by the dirt access road, which will provide for hauling and construction access. The cell dimensions will be approximately 75 feet (north to south) by 200 feet (east to west) and approximately 20 feet in height. Materials that are currently situated within the proposed consolidation cell footprint will be stabilized and left in-place. Any materials that have been placed or migrated down slope of the level area of the upper flat will be brought back up to the footprint. Contaminated materials excavated from other areas of the site will be placed and compacted in the designated cell footprint. It is estimated that a total of 11,000 cubic yards of contaminated material will be placed within the consolidation cell at the Sonoma Mine. Refer to Figure 7-4 for a conceptual layout of the consolidation cell.

Cover System and Revegetation

The consolidation cells at both the Contact and Sonoma mines will require a physical barrier between the contaminated material and potential human receptors. Therefore, a simple cap system will be installed. The total capped area of the Contact Mine consolidation cell is estimated at 5,000 square feet. The total capped area of the Sonoma Mine consolidation cell is estimated at 15,000 square feet. Each of the consolidation cells will be capped with 18 inches of select fill and 6 inches of topsoil, and will then be revegetated. More specifically, the cap layers will consist of the following.

- 6-inch vegetative layer consisting of growth media; soil amendments with the micro-and macro nutrients necessary to sustain growth; and native vegetation and mulch, erosion mats, or other sufficient cover to reduce surface erosion, encourage transpiration, and reduce infiltration through the repository.

- 18-inch select fill layer consisting of common soil sufficient for development of good root support for vegetation, and for moisture storage.

For both caps, it is estimated that 2,200 cubic yards of select fill, and 1,100 cubic yards of topsoil, will be required.

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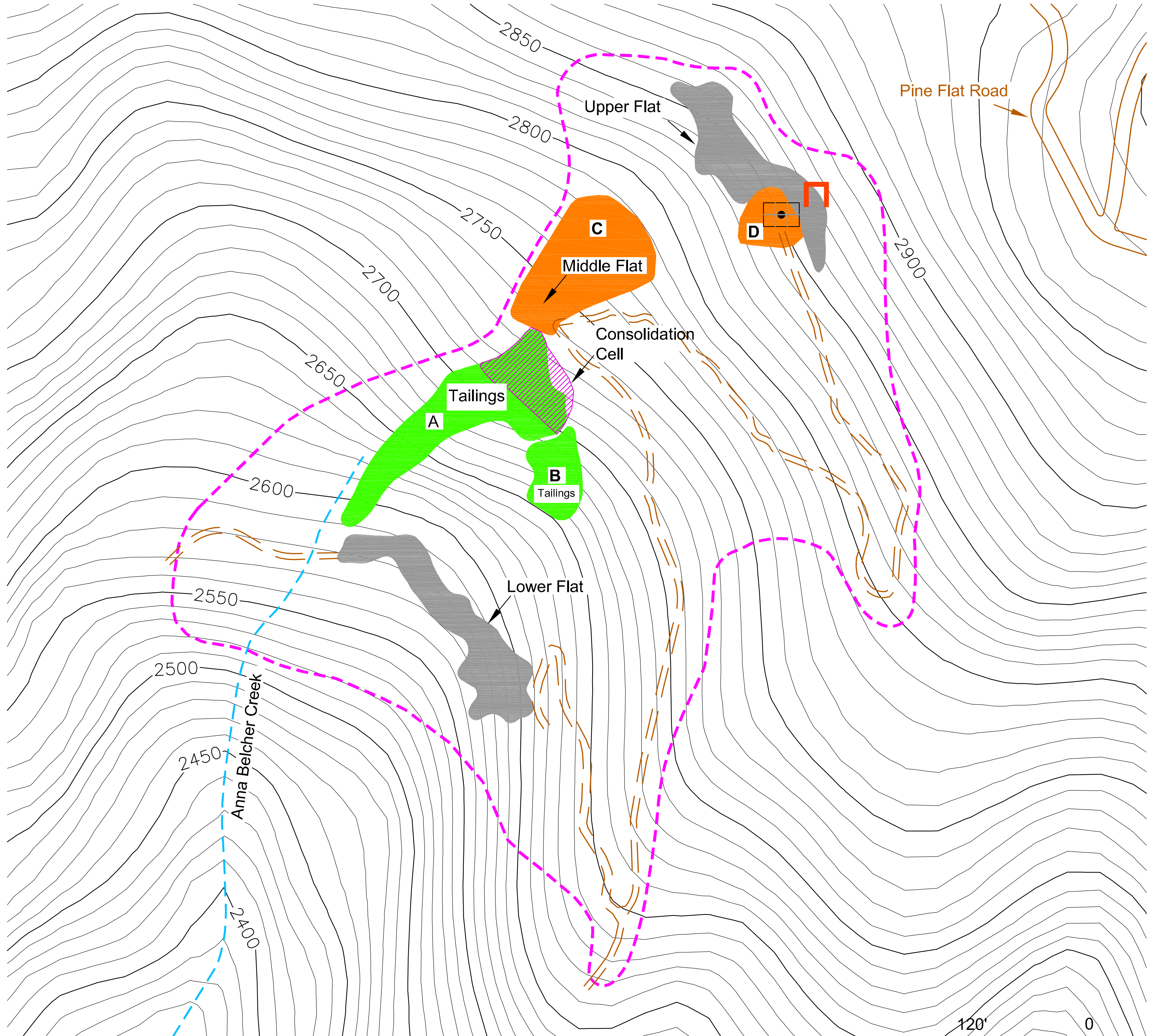

Notes:
1) Contour data reflected here on was generated using USGS 10 meter DEM data. Date of data is unknown.

2) Contaminated Material = Mercury concentrations exceeding 30.5mg/kg.

Excavation Calculations

Location	Description	Area in Sq. Ft.	Volume (Cubic Yards)
Area A	Large Tailing	13,978	2,500
Area B	Small Tailing	3,977	700
Area C	Middle Flat	12,285	200
Area D	Small Upper Flat	3,016	100

LEGEND

- Contact Mine Consolidation Cell
- Excavate Contaminated Material to 5' depth
- Excavate Contaminated Material to 0.5' depth

Consolidation Cell Calculations

Area in Sq. Ft.	Volumes (Cubic Yards)
5,024	3,500

120' 0 120' 240'

120' 0 120' 240'

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Contact Mine
Sonoma County, California

Figure 7-3
Alternative 3

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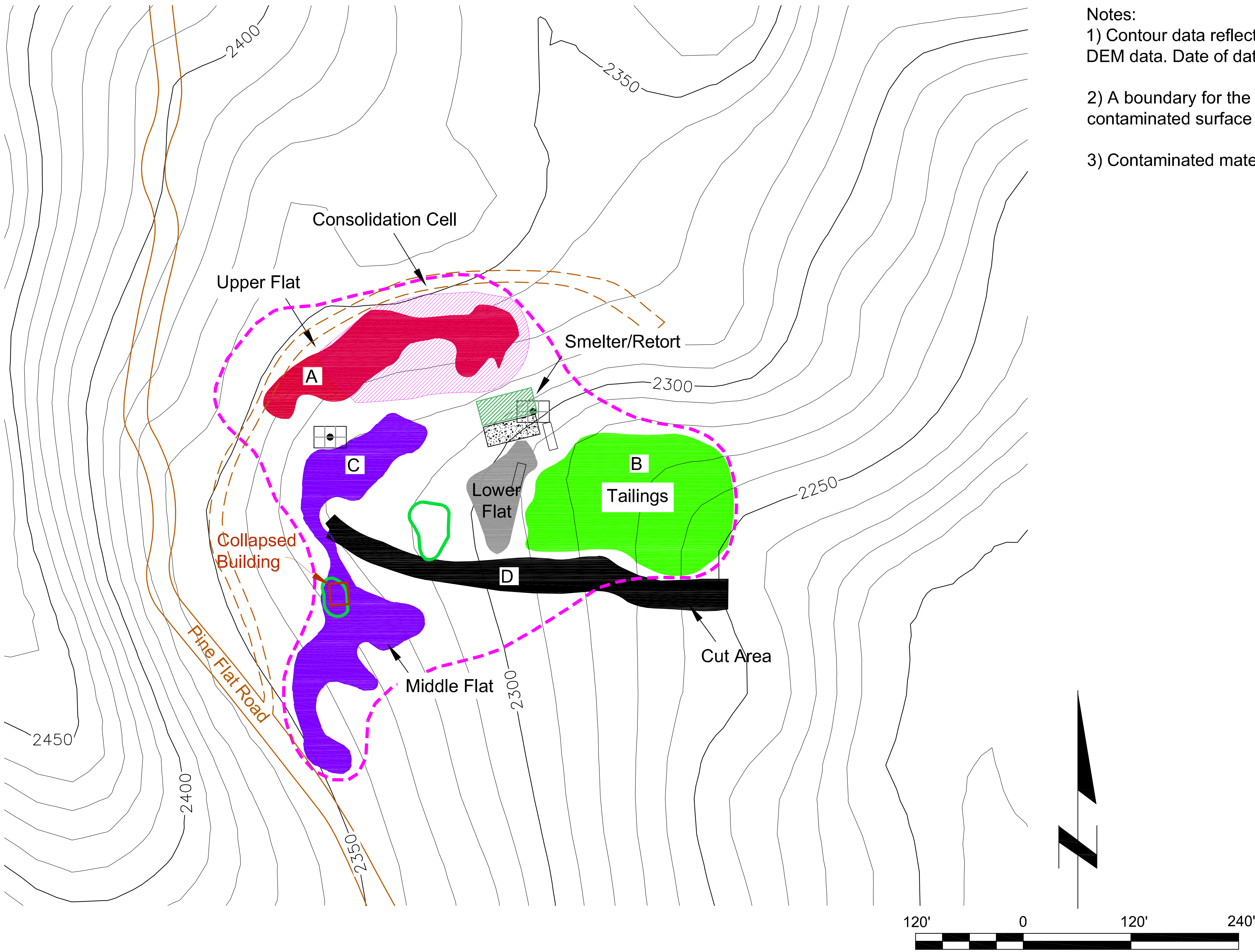

Notes:
1) Contour data reflected here on was generated using USGS 10 meter DEM data. Date of data is unknown.

2) A boundary for the smelter/retort area has been approximated. Extent of contaminated surface materials should be field and laboratory verified.

3) Contaminated material = Mercury concentrations exceeding 30.5 mg/kg

LEGEND

- Mine Site Boundary
- Flat Benched Area
- Contact Mine Consolidation Cell
- Excavate Contaminated Material to 2.5' depth
- Excavate Contaminated Material to 5' depth
- Excavate Contaminated Material to 8' depth
- Excavate Contaminated Material to 28' depth

Excavation Calculations			
Location	Description	Area in Sq. Ft.	Volume (Cubic Yards)
Area A	Upper Flat	2,025	2,100
Area B	Tailing	19,960	3500
Area C	Middle Flat	15,036	4500
Area D	Cut Area	9,906	900

Consolidation Cell Calculations	
Area in Sq. Ft.	Volumes (Cubic Yards)
15,193	11,000

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Sonoma Mine
Sonoma County, California

Figure 7-4
Alternative 3

This configuration would provide physical protection of the waste material from weathering elements and would reduce the infiltration of precipitation and subsequent development of leachate from the contaminated materials.

The cap would be sloped from the center of the containment outward at a minimum 2% slope to allow for good lateral drainage over the cover, and to limit erosive velocities of local runoff on the cap. If erosion matting is not used, then the slope should be roughened to prevent rill erosion from forming (Munshower 1994, Goldman, et al 1986).

Surface Water Controls

Locations Surface water controls will be installed around the consolidation area to avoid run-on and control run-off. At the Contact Mine, this would likely involve a diversion berm and ditch system surrounding the consolidation area, diverting stormwater flow around the area. A ditch downgradient of the area would trap sediment, which could then be replaced on the consolidated material during maintenance activities.

A cut and water course which runs west to east through the middle of the Sonoma Mine site contains mercury concentrations above the human health risk criteria. The material within this feature will be excavated to a depth of 2.5 feet and moved to the consolidation cell at Sonoma Mine. It is estimated that approximately 919 cubic yards of material will be excavated from the water course and placed in the consolidation cell. Areas where contaminated material is excavated from this water course will be lined with granular bedding and stabilized with riprap, appropriately sized to the expected velocities of storm event runoff. This will reduce further erosion into downstream drainages. It is assumed for cost estimation purposes that an adequate amount of low-mercury-bearing rip-rap material is available within the Site. It is estimated that 300 cubic yards of granular bedding, and 600 cubic yards of Class I or II riprap, will be required in the areas of excavation within the water course feature.

Site Access Controls

It is important for the success of reclamation that access to the consolidation area be completely restricted. While access to the cells will need to be maintained for long-term monitoring and maintenance activities, Alternative 3 proposes that the road which follows the west edge of the pit be gated and signed. A permanent fence shall be installed which completely encompasses each consolidation area. It is estimated that the length of fence required will be 500 feet at the Contact Mine cell and 750 feet at the Sonoma Mine cell.

The Contact and Sonoma Mines are also characterized by many smaller features, such as prospecting disturbances, furnace and retort foundations, and road cuts. Many of these features are not directly accessible from the existing roads. Excavation of contaminated materials in these locations will likely require some new road construction to provide access to these features; however, it is important that, upon completion of excavation, such new roads be completely restored to a natural state.

7.4.3.1 Effectiveness

The design concepts comprising this Alternative 3 provide a high level of environmental protection considering the chemical and physical characteristics of the contamination. This alternative would be effective in significantly limiting the potential for off-site migration. The alternative would provide stability and containment for much of the waste material on site. It would also prevent surface water from coming in contact with much of the waste material. It would be effective in reducing direct ecological and human contact with the piles. Because all operations would be conducted on-site, potential risks to the public related to the transport of hazardous waste would be limited.

In this alternative, administrative controls would be implemented, such as fencing and signage. Fencing and signage would reduce human contact with contamination that remains exposed at the Site.

Surface water erosion problems and the associated sediment transport mechanisms associated with the contaminated materials will be corrected through the proposed cap and channel design measures. By rerouting the path of uncontaminated stormwater, infiltration through the waste sources and resulting migration of contaminants into surface water is limited, and transport of mercury offsite will be greatly reduced.

The revegetation effort will become more effective over the long-term. The run-on control system is expected to maintain long-term effectiveness with some maintenance required. Long-term risk will be further decreased as additional vegetation takes hold on the consolidation cap surfaces, and a wider range of vegetative species develop.

It is anticipated that there may be several short-term mitigable impacts to the environment during implementation of this alternative. Impacts could include wildlife disturbance through noise and human activity during construction.

7.4.3.2 Implementability

The actions required for construction of this alternative are technically feasible using standard methods and procedures. The necessary equipment, personnel, and services are readily available to support implementation of this alternative. For Alternative 3, it is assumed moderate to heavy excavation equipment and limited hand work would be necessary.

Minor road improvements under this alternative will be necessary because vehicle traffic on and off site would be required for transport of construction equipment and earthen fill and vegetative materials.

Select fill for the consolidation cell caps will have to be located and obtained, whether from an offsite source or a location within the Site. Potential borrow areas will have to be evaluated during the design phase of this project for adequate volume and appropriate agronomic and geotechnical properties. A potential borrow area may be located on the Sonoma Mine site. During sampling activities for this EE/CA, two soil boring locations were determined to have no evidence of tailings material. Laboratory analyses confirming that these materials contain no or low levels of mercury may allow material from these areas to be used as borrow material. The first area is located in the northeast portion of the Sonoma Mine near the furnace that is situated on a concrete pad. The second potential borrow area is located in the southern portion of the middle flat feature. This material would be relatively accessible as it is located on a level area where excavated material could be stockpiled. Borrow areas will require regrading and revegetation after excavation of material.

During excavation and earthwork activities, BMPs must be employed to minimize erosion and transport of contaminated materials. BMPs that could be used include silt fences, temporary berms, dust control, sediment traps, truck washing, and other structures or activities as deemed necessary.

7.4.3.3 Cost

The estimate for implementing this alternative is $1,264,000 in year 2010 dollars. Annual operating and maintenance costs, as well as estimated indirect capital costs associated with administration, testing, and engineering, have been included. The costs have been included in the total under a present worth analysis over a 30-year design life using a discount rate of 7%. A detailed cost estimate is included in Appendix G.

7.4.4 Alternative 4: On-Site Lined Repository

The on-site repository alternative is a comprehensive effort that is potentially effective in meeting the response goals and ARARs for all of the identified contaminated solid media (soil, sediment, waste rock, tailings) at the Site. The action of removal, consolidation, capping, and subsequent revegetation of the contaminated surface materials will essentially eliminate the amount of waste being transported off-site by surface water and air pathways. In addition, the repository cap will serve as a barrier between site contamination and potential human and ecological receptors. Revegetation of select native material used as a growth media should support sufficient vegetation of the resulting disturbed areas. Implementation of this alternative will take place in one specific location of the Site. The waste rock and tailings from both the Contact Mine and the Sonoma Mine, surrounding soils and sediments, and all auxiliary waste piles will be removed and consolidated at an engineered repository at the Sonoma Mine.

This alternative will involve the excavation of all identified mercury-contaminated solid materials from the surface and subsurface of the Site and relocation into an area at the Sonoma Mine. Following placement of the relocated materials, the surface of the consolidated materials will be compacted and graded in preparation for cap placement and revegetation. Consolidation of the waste prior to capping is beneficial in that the surface area of the contaminated materials is reduced, thereby reducing the volume of cap materials required and reducing the surface area requiring revegetation.

The primary elements of removal of all contaminated solid material to an on-site repository at the Sonoma Mine include the following.

- Construction of a lined repository with a leachate collection system within the north central portion of the Sonoma Mine where the upper flat is currently situated to provide containment for approximately 39,000 cy of contaminated material;
- Excavation of approximately 19,000 cy of material from the Contact Mine and approximately 20,000 cy of material from the Sonoma Mine; and placement into the constructed repository;
- Diversion of surface water run-on around the repository and runoff away from the repository by utilizing a system of diversion berms and channels;
- Regrading of the surface of the area from which the contaminated material was removed; and
- Implementation of access controls such as fencing and signage to preclude or minimize access to the Site prior to, during, and after construction of the repository by humans or wildlife.

Repository Construction

This action includes an on-site repository located within the boundaries of contamination in the Sonoma Mine. The repository would be located near the current site of the upper flat in the north central portion of the Sonoma Mine. The footprint of the proposed repository would be oriented on the benched portion of the flat and backed against the existing steep grade to the north and northwest of the upper flat to form an elliptical-shaped area with sides measuring approximately 150 feet north to south by 200 feet east to west, filled to 20 vertical feet. The edges of the repository will be contoured to match existing (natural) grade of the hillside where possible. A lined repository with a soil-fill-clay cap system provides the level of protection necessary to reduce the threat of release of the contaminants. By locating the repository within Sonoma Mine, hauling distance from the surrounding contaminated material in the entire Site will be minimal. Refer to Figure 7-5 for a conceptual layout of the onsite repository.

The repository side slopes are proposed at a 3 horizontal to 1 vertical slope, based upon available space and maintenance considerations. However, this configuration may be revised during design based upon geotechnical analyses concerning slope stability, foundation settlement, and the compaction rate of placed waste material. The engineered cover system that has been designed to deflect runoff will greatly reduce the risk of release of the primary COPC, mercury, from the contaminated material through dissolution processes.

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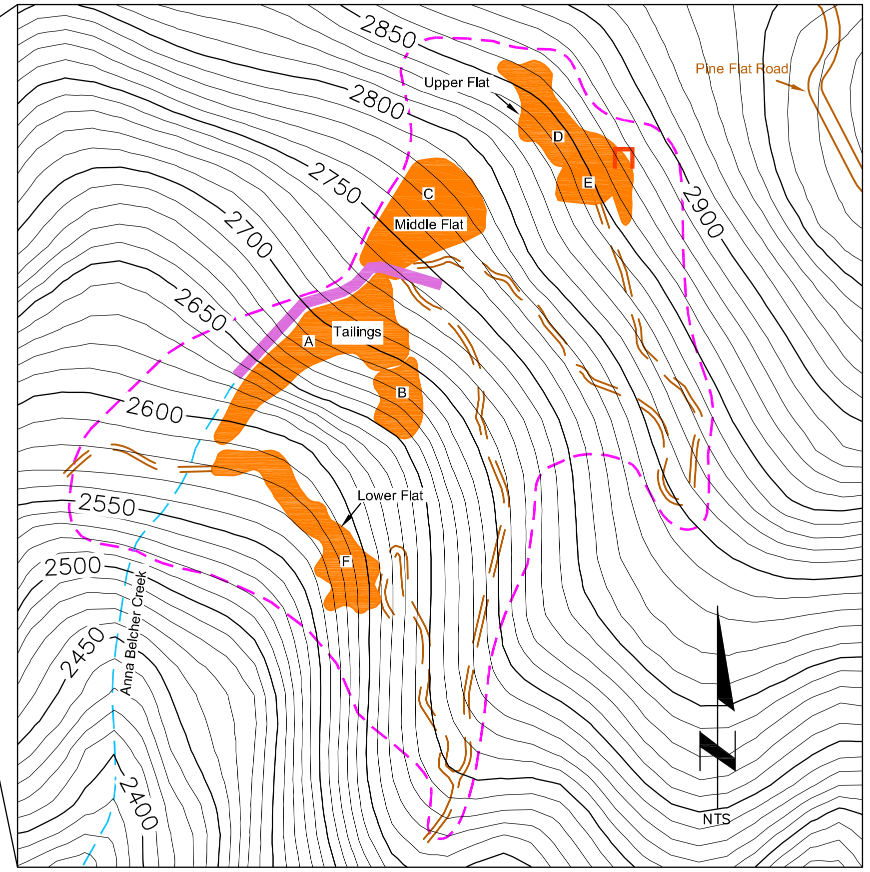
P:\PROJECTS\CONTACT_SONOMA_EECA_900788\CAD\CAD_LAYOUTS\FIGURE_7-5.DWG

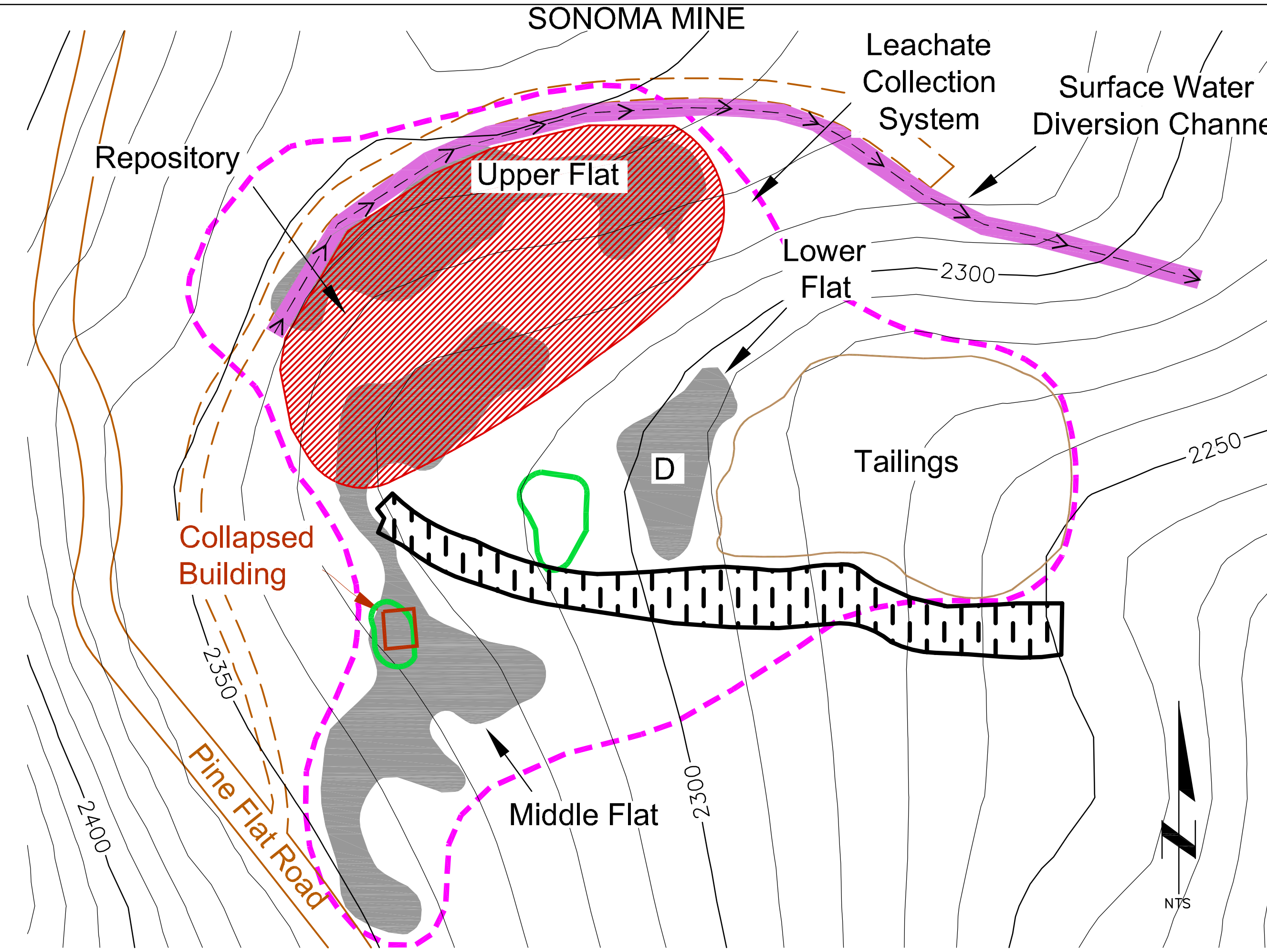
Contact Excavation Calculations

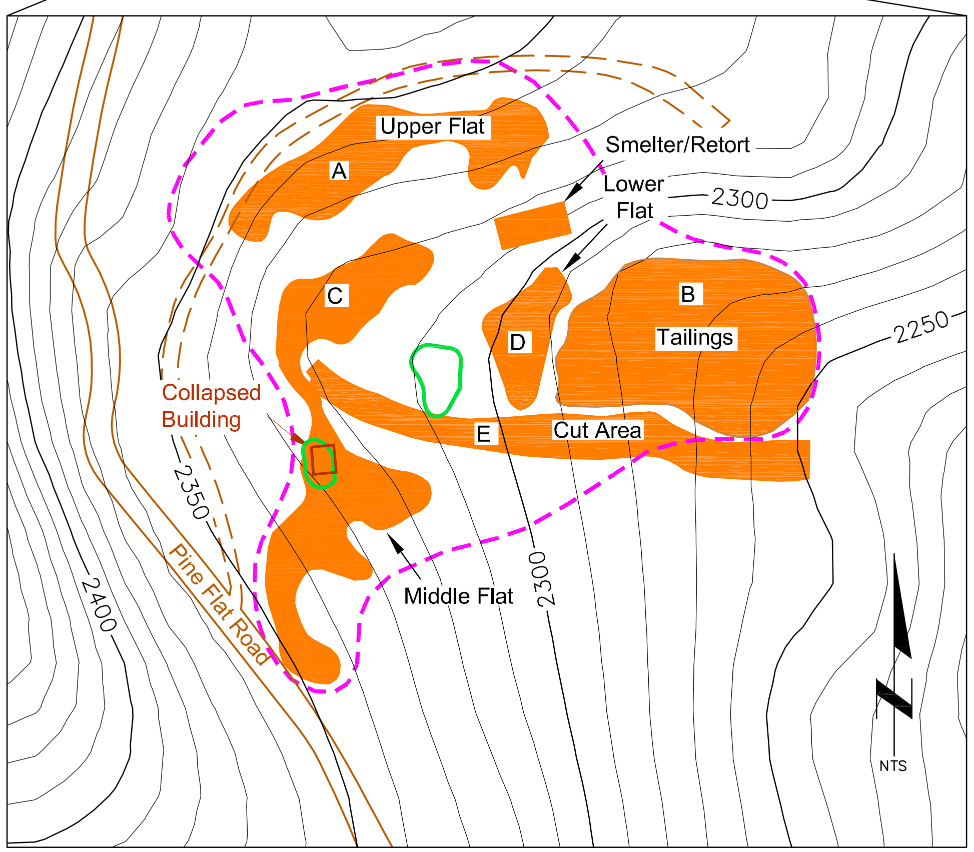
Location	Description	Area in Sq. Ft.	Volume (Cubic Yards)
Area A	Large Tailing	13,978	2,500
Area B	Small Tailing	3,977	700
Area C	Middle Flat	12,285	200
Area D	Large Upper Flat	8,898	7,000
Area E	Small Upper Flat	3,016	100
Area F	Lower Flat	10,234	8,000

Sonoma Excavation Calculations

Location	Description	Area in Sq. Ft.	Volume (Cubic Yards)
Area A	Upper Flat	10,047	10,500
Area B	Tailing	19,960	3,500
Area C	Middle Flat	15,036	4,500
Area D	Lower Flat and Retort	4,830	1,000
Area E	Cut Area	9,906	900







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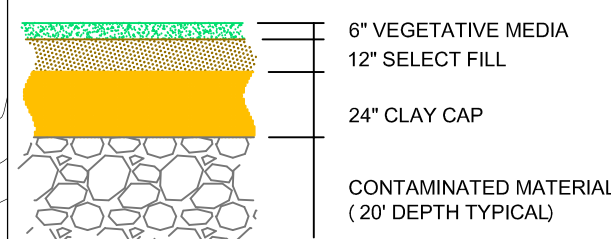
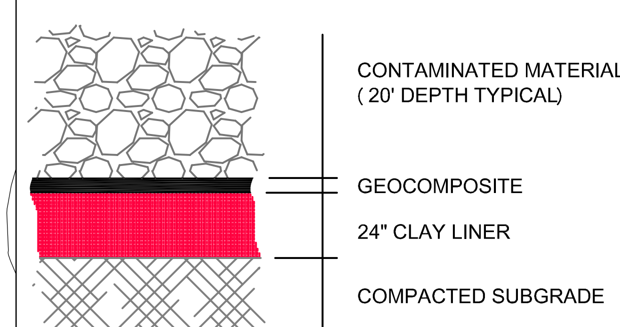
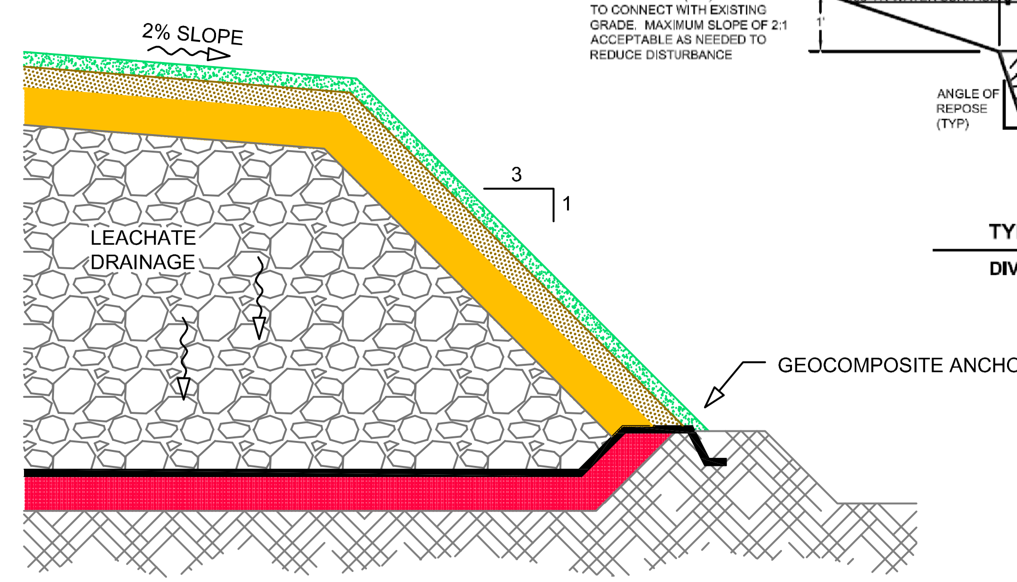
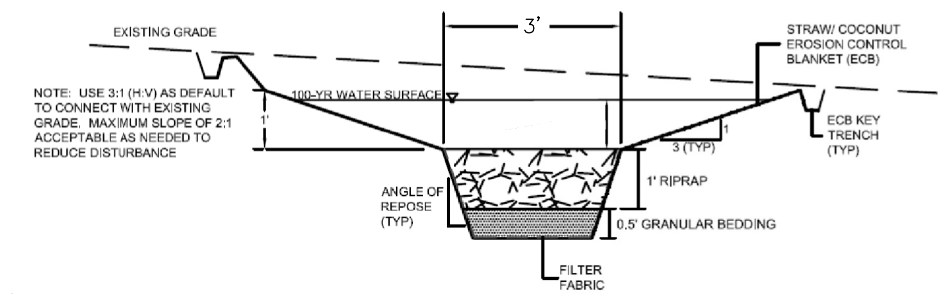


REPOSITORY LINER DETAIL:





REPOSITORY TYPICAL CROSS SECTION AND EDGE DETAIL



TYPICAL SECTION

DIVERSION CHANNEL

NTS

Legend

Contaminated Material to be excavated from the Contact and Sonoma Mines

Surface Water Diversion Channel

Repository Footprint

ecology and environment, inc.

International Specialists in the Environment

Project Number: 900788.0001.010

June 9, 2010

Sonoma and Contact Mine

Alternative 4

Sonoma County, California

Figure 7-5

On-Site Repository

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To select the most appropriate capping configuration, laboratory analytical results, and observations made during the field work have been reviewed. These results indicate that materials from a near-by off-site natural area are desirable for use in the cap because of the relatively low permeability of the material.

The cap would be sloped from the center of the containment outward at a minimum 2% slope to allow for good lateral drainage within the cover section, and to limit erosive velocities of local runoff on the cap. If erosion matting is not used, then the slope should be roughened to prevent rill erosion from forming (Munshower 1994, Goldman, et al 1986).

The contaminated material would be placed in a lined engineered repository with the layers shown in Figure 7-5 and described below (from bottom to top).

- A compacted firm prepared subgrade that is free from contaminated materials.
- A two-foot thick compacted clay liner layer constructed to a hydraulic conductivity of 1x10-6 centimeters per second.
- A geocomposite leachate collection and removal layer that drains to a sump. The sump will have a riser pipe that will allow the leachate to be periodically pumped out.
- Consolidated contaminated material (20-foot typical thickness)
- A 2-foot thick compacted clay liner layer constructed to a hydraulic conductivity of 1x10-6 centimeters per second.
- 12-inch fill layer consisting of common soil sufficient for development of good root support for vegetation, and for moisture storage.
- 6-inch vegetative layer consisting of growth media; soil amendments with the micro-and macro nutrients necessary to sustain growth; and native vegetation and mulch, erosion mats, or other sufficient cover to reduce surface erosion, encourage transpiration, and reduce infiltration through the repository.

This configuration would provide physical protection of the waste material from weathering elements and would limit the infiltration of precipitation and subsequent development of leachate from the contaminated materials.

Because the consolidated material will contain moisture upon placement in the repository, a liner and leachate collection system will be included in the bottom of the repository. This system will consist of a bottom layer, or under-liner, of clay. The repository bottom liner and leachate collection system would have a five-foot high berm constructed around its perimeter. The base grade would be sloped at a minimum 2% towards a corner of the repository. A 12-inch diameter riser pipe would extend from the sump to outside of the berm to allow leachate removal. Leachate would be periodically monitored, pumped, analyzed, and disposed of off-site at an authorized treatment/disposal facility. Leachate removal would be significant initially but then gradually reduce to insignificant once the cap is constructed.

Material Excavation

Contaminated media to be removed from areas of the Site include the soil, mine waste, and tailings at both the Contact and Sonoma Mines, surrounding soils, and miscellaneous contamination source features.

Under this action, a total of approximately 39,000 cy of contaminated material will be removed from the identified waste sources and surrounding areas at the Site. This material will be excavated, hauled to the waste consolidation area within Sonoma Mine, placed, and compacted. The hauling distance will range from 2,500 feet at the farthest most point of contamination from the repository (the north boundary of the Contact Mine) to 0 feet for the material directly adjacent to the waste consolidation area.

The material excavated from the area inside the repository footprint will be separated based on the determination of clean versus contaminated material. The contaminated material will be stockpiled and later placed in the constructed repository. The clean material will be used for either cap fill material or for reclamation of excavated areas over the entire Site. A sampling scheme will be required to determine the appropriate use of all excavated material not previously identified in the EE/CA as contaminated material.

Surface Water Control

The perimeter surface water control system for the repository would consist of a shallow channel system. This system would collect runoff from the surface of the cap, intercept runoff from the cap's internal lateral drainage system, and divert run-on from adjacent slopes away from the repository.

Appropriate stormwater pollution prevention measures and best management practices such as check structures, sediment ponds, or silt fencing will be incorporated into the project to minimize the potential for adverse impacts to water quality during construction. All disturbed areas will be regraded for positive drainage, and then vegetated with native species as soon as practicable in order to minimize construction-related sediment transport. Fugitive dust emissions will be limited by the use of dust palliatives, or sprinkling as appropriate.

Site Reclamation

Because voids or depressions will remain once the contaminated material is removed from the surface of the Site, attention must be paid to the resulting topography. In some areas only the top six inches of material will be removed from the surface (i.e., the middle flat at the Contact Mine). However, at other areas of the Site such as the upper and lower flats at the Contact Mine and the upper flat at the Sonoma Mine, waste will be removed to greater depths, up to 28 feet bgs). The depressions left by the removed materials must be re-graded to direct surface water away from the repository, maintaining remedy protection. Following the removal of all contaminated materials, clean fill will be used for re-grading the area from which the material is taken. The fill used to shape the surrounding area will vary in depth and location depending upon the local terrain and removal excavation contours. The area would be graded for positive drainage, based upon similar drainage patterns. Soil amendments as indicated by agricultural analysis would be added and the remaining surface would be roughened to prevent rill erosion.

Revegetation

Vegetation on the cap surface protects it from gullying and scouring by surface water, thereby minimizing erosion. The cap should be sloped from the center of the containment outward with a minimum of 2% slope to allow for good lateral drainage within the cover section, and to limit erosive velocities of local runoff on the cap. In addition, if erosion matting is not used, then the slope should be roughened to prevent rill erosion from forming.

This action also includes revegetation of all newly disturbed areas, and revegetation of the waste repository areas. Revegetation activities should be implemented on site as soon as practicable after completing construction activities. Site preparation should include necessary soil amendments and/or fertilizer to support vegetation. Growth media may need to be provided in areas where soil does not currently support vegetation, or where soil has been removed.

Based on a successional planting scheme, the recommended initial plantings consist of a mix of plants that include both quick colonizers as well as a few species more adapted to later stages of ecological succession.

The operation and maintenance activities for this alternative would likely include watering and other care required for the success of new vegetation, additional placement of seed in areas of unsuccessful revegetation during the initial attempt, and other needed repairs to the surface of the cap.

Site Access and Institutional Controls

Signs prohibiting trespassing should be posted at the perimeter of the repository. In addition, a permanent chain link fence will be installed around the entire footprint of the repository. The fence and signage is meant to discourage damage to the repository from unauthorized use. Because there will be a significant threat of exposure to site visitors, an interim action of site access restriction should be implemented during construction activities. This could be accomplished by installing a system of locked gates and fences around the perimeter of the construction area as a visual deterrent to unauthorized access and use. These site access restrictions should be kept in place during the construction of this Alternative.

In addition to the above described access controls, temporary or permanent site controls should be considered to prevent damage to the consolidated material. It is recommended that an Administrative Area Closure be considered.

Post Removal Control

Post removal site control (operations and maintenance) for this Site would consist of minor erosion repair to the channel systems and cover surface. Monthly monitoring of the leachate collection system and associated components will be required.

Evaluating the removal action alternative with respect to future land use, it appears that the removal of waste and consolidation in an on-site repository will allow for the development of most areas of the Site, with the exception of the repository area. The consolidation area could likely be used for non vehicular recreation purposes after revegetation efforts have taken hold, so long as cap erosion does not begin to take place. Care must be taken to ensure that the repository is not disturbed during construction or as a result of activities permitted within the new development.

7.4.4.1 Effectiveness

The on-site repository alternative would possibly be effective in attaining the ARARs and RAOs for the Site. The design concepts comprising this action potentially provide an adequate level of environmental protection for the Site considering the chemical and physical characteristics and the physical location of the materials to be addressed; however, it is possible that residual contamination may exist within the surrounding soils after excavation. The action would effectively reduce contaminant mobility by capping the highest risk media sources, primarily mercury-contaminated waste materials, in a secure on-site repository.

A multi-media cap with soil-fill-clay layers should function effectively in preventing percolation through the waste materials by:

- Deflecting runoff;
- Encouraging evapotranspiration;
- Utilizing the molecular affinity for water by the cover soil particles to prevent release into the drainage layer; and
- Utilizing the large difference in hydraulic conductivity between the drainage layer and the waste materials to define the gravel drainage layer as the preferred drainage path to prevent percolation into the waste materials.

Surface water erosion problems and the sediment transport mechanisms associated with the contaminated materials will be potentially corrected through the proposed channel design measures; however, if contamination remains exposed in surrounding soils after excavation, erosion of this material could take place. By removing and immobilizing the majority of the known principal contaminant source areas, infiltration of precipitation through the waste sources and resulting migration of contaminants into the ground and surface water are potentially limited. This alternative contributes a moderate degree of source control, and its long-term effectiveness is limited to the maximum flood design of run-on control.

A full evaluation of representative base materials and placed contaminated materials should be performed to evaluate the geotechnical suitability.

Because all of the work is limited to the project site, the action should be protective of the community during the response action. As all operations are to be conducted on site, potential risks to the public related to the transport of hazardous materials will be limited.

Implementing appropriate worker training should reduce the risk of exposure to the project personnel. Handling of contaminated materials will be performed in a manner that will reduce the risks to workers from exposure that may be associated with construction. Dust palliatives, water sprinkling, and other fugitive dust control methods will be utilized in order to reduce exposure risks associated with fugitive dust emissions during construction. A storm-water pollution prevention plan, using construction sediment transport abatement measures, such as flow diversion, cofferdams, sediment ponds or silt fencing, will be implemented during construction of this action. While there may be a few short-term and mitigable impacts associated with the construction activities (wildlife disturbance through noise and human activity), the long-term environmental impacts of this project are deemed to be positive. At the present time, there is limited habitat available on the Site. Performance of the reclamation elements should potentially enhance the existing habitat and offset any inadvertent adverse impacts to the habitat.

Long-term monitoring and control would be established to track the effectiveness of this action. The technologies proposed under this action can effectively reduce the principal threats posed by the release of contaminants from the Site by reducing the exposure pathways and the mobility of these contaminants in the air, soil, and water; unless elevated levels of mercury still remain in surrounding soils after excavation. While this action does not satisfy the CERCLA preference for treatment, it contributes a moderate degree of source control and could be used as a long-term and permanent source control measure for this Site.

7.4.4.2 Implementability

The actions required for the construction of this action are technically feasible based on available literature and using standard methods and procedures. The concepts are based on normal repository design practices that have been proven to be successful in similar projects. The revegetation and channel stabilization measures proposed are based upon current state of the art practice and rely on natural processes for their long-term success.

The Site is accessible to construction equipment by way of a 16 to 20-foot wide paved road and interconnecting dirt and gravel roads between and within the Contact and Sonoma Mines. The terrain of the area is steep and may limit equipment performance. The necessary equipment, personnel, and services for executing the construction actions of this alternative (excavating, hauling, and placing the waste) are readily available to support implementation of this action. Project sequencing will help maintain drainage during the construction period and avoid run-on related damages to completed portions of the project. If funding is available, the project can be completed within one year.

Conceptual Screening Plan for Removal

Estimations have been made as to the volume of contaminated material to be removed, and in turn, the depth to which the material is to be excavated. Volumes derived in Section 3 of this EE/CA were calculated based on sampling events and visual observations. For example, at the two mine sites, soil borings were used to determine the approximate lower limits of contaminated soils and tailings. Considerations were made of both the recommended human health and ecological risk criteria and the practicality of implementing the remedial action with available construction equipment. Estimations have been made on the vertical limits of contamination; however, as the extent of subsurface contamination may not be fully identified and underlying soils may also be contaminated, it will be necessary to assess the potential extended contamination in the soils beneath and in direct contact with the waste material. Identification of contaminated materials in some areas may require that the media be frequently sampled during implementation of this alternative to ensure that all contamination exceeding the cleanup criteria is completely removed. Once the material is removed to the extents listed in this alternative, confirmation grab samples should be taken at a frequency of one sample per 100 cy of material until XRF or laboratory analyses confirm that concentrations of mercury no longer exceed the clean up criteria. The preceding confirmation sampling method is simply a suggested means of addressing the issue of unknown subsurface conditions. These procedures may require modification upon evaluation in the actual design process.

7.4.4.3 Cost

The estimate for implementing this alternative is $2,877,000 in year 2010 dollars. Annual operating and maintenance costs, as well as estimated indirect capital costs associated with administration, testing, and engineering, have been included. The costs have been included in the total under a present worth analysis over a 30-year design life using a discount rate of 7%. A detailed cost estimate is included in Appendix G.

7.4.5 Alternative 5: Offsite Disposal

The off-site disposal alternative involves excavating all contaminated materials and transporting them off-site to an existing or constructed repository permitted to accept such materials. Relevant off-site disposal options include a solid waste landfill or a RCRA-permitted disposal facility. Materials not accepted by a commercial landfill facility would require disposal in a RCRA Subtitle C (hazardous) landfill. Less toxic materials could possibly be disposed of in a permitted solid waste or municipal sanitary landfill. After complete removal, the site would be reclaimed by regrading and revegetation.

Material Excavation
Contaminated media to be removed from areas of the Site include the soil, mine waste, and tailings at both the Contact and Sonoma Mines, surrounding soils, sediments, and miscellaneous contamination source features. Under this action, a total of approximately 39,000 cy of contaminated material will be removed from the identified waste sources and surrounding areas at the Site. This material will be excavated, loaded into haul trucks, and removed off-site.

Removal to Off-Site Facility
In this alternative, all known contaminated materials throughout the Contact and Sonoma Mines would be loaded and removed to an off-site repository. Ancillary work would also include: design and oversight; mobilization, including equipment movement, communications system, per diem, site facilities, contractor's job planning and coordination time, etc.; major road improvements; site grading; drainage system and erosion control; revegetation; and demobilization. For this scope component, it is assumed that a contracted trucking firm in combination with rail cars will be utilized to support the effort of removal to an off-site facility.

The requirement for disposal in a California commercial landfill is 20 mg/kg total mercury and 0.2 mg/L dissolved mercury. This scope assumes that 80% of the wastes would not pass the requirements for non-hazardous materials disposal in a California facility, and would thus be required to be disposed of as special manifested non-RCRA regulated waste, or in a hazardous waste facility. It is assumed that the remaining 20% of materials removed from the Site could be disposed of at a California permitted solid waste or municipal sanitary landfill. For out-of-state disposal, the criteria that determine hazardous wastes are less restrictive. Facilities in Utah, Idaho, and Nevada require only that waste pass the Toxicity Characteristic Leaching Procedure (TCLP) standard of 0.2 mg/L. This scope assumes that 100% of the material to be removed would pass TCLP, allowing for disposal in an out-of-state facility. Due to a current lack of landfill availability and stricter disposal requirements in the State of California, it is anticipated that out-of-state disposal will be more cost-effective than in-state disposal. A determination of facility capacity availability must be made before commencement of any construction activities under this alternative.

Major Road Improvements
Significant road work would be required to create sufficient access for equipment and hauling. For this scope component, it is assumed that on-site access roads within the mine areas are substantially reconstructed or improved where needed to allow ready access to the Site by tractor trailers and to facilitate access to features throughout the Site. Staging areas will be needed for placement of office trailers, storage of supplies and equipment, and staging of waste stockpiles awaiting off-site disposal. Proper decontamination and tracking control facilities will be necessary to ensure that contamination is not spread outside of the work areas. These measures will support the effort of removal to an off-site facility.

Regrading

Because voids or depressions will remain once the contaminated material is removed from the surface of the Site, attention must be paid to the resulting topography. The depressions left by the removed materials must be regraded to direct surface water into natural channels and drainages. These regraded surfaces will not be revegetated under this Alternative.

Appropriate stormwater pollution prevention measures and BMPs such as drainage swales, sediment ponds, or silt fencing will be incorporated into the project to minimize the potential for adverse impacts to water quality during construction. All disturbed areas will be regraded for positive drainage, and then vegetated with native species as soon as practicable in order to minimize construction-related sediment transport. Fugitive dust emissions will be eliminated by the use of dust palliatives, or sprinkling during excavation and soil disturbance operations in contaminated material, and will conform to the California Code of Regulations and applicable EPA regulations for earth-moving activities in non-contaminated areas.

Post removal site control (operations and maintenance) for this Site would consist of minor erosion repair to the channel systems. When evaluating this removal action alternative with respect to future land use, it appears that the removal of waste will allow for a variety of uses, including recreational activities, in most areas of the Site.

7.4.5.1 Effectiveness

This alternative potentially provides the highest possible level of environmental protection. The complete removal of waste materials from the currently exposed, uncontrolled environment to a permitted facility meets the RAOs and ARARs. The on-site potential for human and ecological exposure through inhalation, ingestion, and dermal contact is potentially greatly reduced, and contaminant migration via surface runoff, soil or wind erosion, and groundwater interaction is potentially eliminated.

Handling of the waste material needs to be conducted in a manner that reduces risks to the workers which may be associated with transportation. Engineering controls should be implemented to reduce exposure. Administrative controls and personal protective equipment may also be required. It is anticipated that there may be several short-term mitigable impacts to the environment during implementation of this alternative, including wildlife disturbance through noise and human activity during construction.

All operations are not confined to BLM property, and the hauling distance to the landfill poses a limited potential exposure to the public. The use of rail lines for waste transport to the landfill reduces accident liability risks as well as the environmental impacts associated with hauling waste by truck over long distances. The off-site commercial landfill alternative has the highest level of long-term effectiveness as the landfill have a post-closure monitoring and maintenance period of 30 years or longer and will presumably have site security, environmental monitoring, maintenance requirements, and other systems required of a commercial facility.

Large amounts of diesel fuel, tires, trucks, equipment and other resources would be utilized and wholly or partially consumed. These are all produced from scarce resources and utilized with direct and indirect environmental and health costs.

There is a significant traffic safety risk associated with thousands of truck trips on the steep, narrow access roads, as well as Pine Flat Road and State Highway 128 which would be traveled once reaching the pavement. These roads have some sharp curves and variable visibility.

This Alternative is considered permanent, and is thus effective in both the short- and long-term.

7.4.5.2 Implementability

The limitations of site access, and the volume of contaminated material within the Site, play a key role in the implementability of this Alternative. This scope will require redevelopment of site access roads to accommodate dump trucks. Environmental impacts will result directly from road and indirectly from improved access. Access from Pine Flat Road to the Site is difficult, and steep slopes and rough terrain will limit equipment performance.

The necessary equipment, personnel, and services for excavating and transporting the waste are readily available to support implementation of this action. Project sequencing will help maintain drainage during the construction period and avoid further contamination or damages to natural or man-made surface water conveyance systems. Given the above assumptions, and if sufficient funding is available, Alternative 5 can be completed in between one and two years.

In determining where the waste may be disposed, the waste will be tested for the RCRA Total Mercury and TCLP (or California WET) analysis. The established acceptance Total Mercury concentration is 20 mg/kg. The established acceptance TCLP or California WET limit is 0.2 mg/L. The required preparation of acceptance confirmation samples for TCLP Mercury follows EPA Methods 1310 or 1311 and analysis by EPA Method 7470 Cold Vapor. Additional sampling may be required for sulfides, cyanides, certain radioactive isotopes, and underlying hazardous characteristics to confirm that waste materials meet Land Disposal Requirements.

Following the removal of the mine tailings and surrounding areas of contamination, confirmation sampling will be conducted to verify that contamination has been fully remediated. Confirmation samples will be collected for total mercury using EPA Method 7471. Once confirmation sampling shows that mercury concentrations are below risk criteria designated for the project, site grading and re-contouring can be completed.

7.4.5.3 Cost

The estimate for implementing this alternative is $11,216,000 in year 2010 dollars. Annual operating and maintenance costs, as well as estimated indirect capital costs associated with administration, testing, and engineering, have been included. The costs have been included in the total under a present worth analysis over a 30-year design life using a discount rate of 7%. A detailed cost estimate is included in Appendix A.

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8 Comparative Analysis of Removal Action Alternatives

The following is a summary of the comparative analysis of the five removal action alternatives compiled in Section 7.

8.1 Alternative 1 – No Action

The No Action Alternative would not be effective in reducing or eliminating the threat to human health and the environment through treatment or containment of the contaminated materials.

8.2 Alternative 2 – Limited Action – Erosion and Institutional Controls

Alternative 2 is presented as an implementable, lower-cost alternative. This Alternative is a limited action, in that it does not provide as comprehensive remediation as those alternatives that address contaminated materials site-wide. Alternative 2 provides only erosion controls and institutional controls. This Alternative is not completely effective, as residual exposed contamination will remain. The actions proposed under Alternative 2 would be feasible using standard methods and procedures. There is a moderate level of operational requirements for activities such as excavation and grading.

8.3 Alternative 3 – Onsite Consolidation, Stabilization, and Capping

The design concepts comprising Alternative 3 provide a high level of human and environmental protection considering the chemical and physical characteristics of the contamination. This Alternative would be effective in significantly limiting the potential for off-site migration. The Alternative would provide stability and containment for the majority of waste material on site. It would also prevent surface water from coming in contact with the waste material that is to be capped. Because all operations would be conducted on site, potential risks to the public related to the transport of hazardous waste would be limited. There is a moderate to high level of operational requirements for construction activities.

8.4 Alternative 4 – Onsite Lined Repository

Alternative 4 is similar to Alternative 3, but provides a higher level of protection through consolidation and capping of all contaminated material on site, providing a more impervious cap, and the installation of a leachate collection system. Alternative 4 better meets the RAOs. This Alternative would be technically and administratively feasible; however, a high level of operational requirements for construction activities, and a higher cost would be incurred.

8.5 Alternative 5 – Offsite Disposal

This Alternative would be the most effective in eliminating the potential for off-site migration, preventing surface water from coming in contact with contaminated materials, and eliminating the potential for direct contact by human or ecological receptors by completely removing the source materials. There would be no residual effects after implementation of this Alternative. A very high level of operational requirements including excavation, consolidation, compaction, grading, and the transport of waste would be incurred. Difficulties would especially be experienced in carrying out hauling scenario logistics. In addition, Alternative 5 may be cost prohibitive.

A comparative analysis of the Removal Action Alternatives with respect to the effectiveness, implementability, and cost criteria is presented in Table 8-1.

Table 8-1 Comparative Alternative Analysis

Evaluation Criteria	Alternative 1: No Action	Alternative 2: Limited Action, Erosion and Institutional Controls	Alternative 3: Onsite Consolidation, Stabilization, and Capping	Alternative 4: Onsite Lined Repository	Alternative 5: Offsite Disposal
EFFECTIVENESS	Overall – Not effective	Overall – Potentially Effective	Overall – Effective	Overall – Effective	Overall – Effective
Protective of public health and community	No	Potentially Yes – with success of perimeter fencing	Yes – with regard to surface of site	Yes – with regard to surface of site	Yes – with regard to surface of site
Protective of workers during implementation	No workers required for implementation	Yes – Engineering controls to be employed	Yes – Engineering controls to be employed	Yes – Engineering controls to be employed	Yes – Engineering controls to be employed
Protective of the environment	No	Potentially Yes	Yes	Yes	Potentially Yes
Complies with ARARs	No	Potentially Yes	Yes	Yes	Potentially Yes
Ability to achieve removal action objectives	No	Not completely. Residual exposed contamination will remain. Possibility of human and ecological exposure due to contact with the remaining surface materials.	Yes	Yes	Yes
Level of treatment / containment expected	None	Low level of containment	Moderate to high level of containment to occur on-site	High level of containment to occur on-site	High level of containment to occur off-site
Degree to which treatment will be irreversible	No treatment specified	No treatment specified	No treatment specified	No treatment specified	No treatment specified
Satisfies the CERCLA preference for treatment	No	No	No	No	No
No residual effect concerns	Significant residual effect concerns remain	Residual effects remain in exposed surface materials.	Residual effects remain in areas not capped	Minimal residual effects.	No residual effects concerning surface wastes
Will maintain control until long-term solution is implemented.	Will not implement any controls	Action is proposed long-term solution	Action is proposed long-term solution	Action is proposed long-term solution	Action is proposed long-term solution
IMPLEMENTABILITY	Overall – Technically implementable, but not administratively implementable	Overall – Implementable	Overall – Implementable	Overall – Implementable	Overall – Implementable
Technical feasibility	No technology required	Feasible using standard methods and procedures	Feasible using standard methods and procedures	Feasible using standard methods and procedures	Feasible using standard methods and procedures
Construction and operational considerations	No construction or operations required	Moderate level of operational requirements – excavation, consolidation, compaction, grading, capping	High level of operational requirements – excavation, consolidation, compaction, grading, capping	High level of operational requirements – excavation, consolidation, compaction, grading, capping	Very high level of operational requirements – excavation, consolidation, compaction, grading, transport of waste
Demonstrated performance/useful life	Performance and useful life of technology is inapplicable	Adequate life expectancy	Adequate life expectancy	Adequate life expectancy	Adequate life expectancy
Adaptable to environmental conditions	Environmental conditions will not make Site more or less of a threat	Yes	Yes	Yes	Yes
Can be implemented in one year	Yes	Yes	Yes	Yes	Yes
Availability	Yes	Yes	Yes	Yes	Yes
Equipment	Requires no equipment	Yes	Yes	Yes	Yes
Personnel and services	Requires no personnel or services	Yes	Yes	Yes	Yes
Outside laboratory testing capacity	Requires no laboratory testing	Yes – sufficient	Yes - sufficient	Yes - sufficient	Yes - sufficient
Off-site treatment and disposal capacity	Requires no off-site treatment or disposal	No offsite treatment or disposal	No offsite treatment or disposal	No offsite treatment or disposal	Offsite disposal is sufficient
Post removal site control and monitoring	Requires no post removal action site control	Required	Required	Required	Not required
Permits required	Permits not required	Permits not required	Permits not required	Permits not required	Permits not required
Easements or rights-of-way required	No	No	No	No	No
Impact on adjoining property	The potential for the Site to impact adjoining property remains unchanged	Impacts to adjoining properties may occur if remaining exposed materials erode or become wind blown	Impacts to adjoining properties may occur through surface water contamination should caps erode.	Impacts to adjoining properties may occur during construction activities.	Impacts to adjoining property may occur during transport of waste to off-site facility.
Ability to impose institutional controls	No institutional controls will be imposed	Yes	Yes	Yes	Yes – during construction activities
Community acceptance	Unknown, but can be determined through public comment	Unknown, but can be determined through public comment	Unknown, but can be determined through public comment	Unknown, but can be determined through public comment	Unknown, but can be determined through public comment
COST	$0	$541,000	$1,264,000	$2,877,000	$11,216,000

9 Recommended Removal Action Alternatives

9.1 Description of Evaluation Process Used to Develop Recommended Action

As directed by EPA guidance, the eight removal action alternatives presented in this EE/CA have been evaluated against three general criteria: effectiveness, implementability, and cost. The specific components of each criterion are defined as follows:

Effectiveness

- Overall protectiveness of human health and environment
- Ability to achieve RAOs/ARARs
- Short- and long-term effectiveness

Implementability

- Technical feasibility
- Administrative feasibility
- Availability of materials and sources
- Community acceptance

Cost

- Capital cost
- Post-removal control cost
- Present worth cost
- Maintenance and monitoring costs

9.2 Recommended Removal Action

Alternative 3, On-Site Consolidation, Stabilization, and Capping, is recommended as the removal action for this site. The on-site consolidation and capping of contaminated material will best meet the criteria established for effectiveness, implementability, and cost.

While this alternative does not meet the California ARAR for a liner and leachate collection system beneath the consolidated and capped material, a properly graded cap will greatly reduce infiltration. This recommendation has been made without comments from the public. After the public comment period, BLM will prepare an Action Memorandum indicating what actions will take place. The Action

Memorandum may adopt one of the alternatives in this EE/CA, a combination of alternatives, or a completely new alternative.

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A Remedial Site Investigation Reports

B Laboratory Results

C Field Notes and Boring Logs

D Photographs

E Toxicological Summaries

F

Details for Cancer and Noncancer Risk Calculations

G Cost Estimate