SECTION 4

Nature and Extent of Contamination

This section describes the nature and extent of contamination associated with the Lava Cap Mine Site. It addresses five primary media potentially impacted by Lava Cap Mine contamination: soil, sediment, groundwater, surface water, and air. The evaluation of chemical characteristics of the five media is based on field investigations conducted between October 1999 and September 2000 as part of the Lava Cap Mine RI. Details of the field investigations are described in Section 3. These field investigations were performed to evaluate the nature and extent of contamination and provide data to conduct human health and ecological risk assessments.

The areas investigated include reference areas (i.e., areas upgradient of, or otherwise not affected by, activities at the mine) and potentially impacted areas. Reference areas were investigated to identify inorganic constituent concentrations that can be compared to inorganic concentrations in potentially impacted areas. The following sections address the nature and extent of contamination in each of four general areas: Lava Cap Mine area (source area and mine area); LCC below the mine; Lost Lake and the Deposition Area; and downgradient of Lost Lake.

The RI focuses on metals and cyanide as the most likely contaminants present in site source materials. Arsenic is the most prevalent contaminant. It is the constituent that most frequently exceeds reference concentrations, EPA's preliminary remediation goals (PRGs), and drinking water standards. Arsenic is also the primary risk driver for human health impacts and is one of the key constituents driving potential risks to ecological receptors (see Section 6). Therefore, distribution of arsenic is the focus of the discussion in this section. In general, arsenic concentrations appear to correlate well with concentrations of other metals: when arsenic is elevated, other constituents are typically elevated, and when arsenic is low, others are also low. In the impacted areas, where it is likely that tailings originating from the mine are deposited, elevated arsenic levels (such as in soils and sediments) are considered indicative of mine-related tailings contamination. Other constituents that contribute significantly to risk in selected areas are also discussed in the following sections.

In addition to metals and cyanide, a select number of shallow soil samples were analyzed for the presence of explosive constituents. These samples were collected in five locations near or within the defunct explosives magazines located at the mine.

4.1 Extent of Contamination Evaluation

The extent of contamination at the Lava Cap Mine Site is evaluated in three ways. First, volumes of waste rock/mine tailings at the mine and tailings in the Deposition Area and Lost Lake are estimated, based on the surficial extent and vertical depth information from the field effort. Second, a peak discharge is calculated for LCC, using rainfall intensity data from the storm associated with the dam's collapse in January 1997 to estimate the potential maximum width of flow in the LCC channel below the Lava Cap Mine log dam. Third, the

extent of contamination is evaluated by comparing sample concentrations in potentially impacted areas with those in reference areas.

4.1.1 Estimation of Waste Rock/Tailings Volumes

The volume of waste rock/tailings at the mine and tailings/soil/sediment mixtures in major accumulation areas at the Lava Cap Mine Site are estimated for three areas: the source area at the mine, the Deposition Area above Lost Lake, and in Lost Lake itself. At the mine, the primary area where waste rock and tailings occur lies between the historic mine buildings and the log dam (Figure 1-2). The Deposition Area north of Lost Lake consists of tailings released from the Lava Cap Mine (Figure 1-4) mixed with some alluvial sediment. The volume of tailings (or tailings/waste rock) in each area is estimated assuming a trapezoidal configuration. The top of the trapezoid corresponds to the ground surface in the accumulation areas as delineated on Figures 1-2 and 1-4. The bottom of the trapezoid corresponds to the historical width of the creek, prior to deposition. The volumes estimated in each area are described in Sections 4.3 and 4.6.

4.1.2 Evaluation of the Extent of Flood Impacts

The flood widths along LCC were approximated by first estimating a peak discharge value, then using that value in conjunction with hydraulic calculations to estimate the flood width along the channel length. The U.S. Army Corps of Engineers' HEC-1 Flood Hydrograph Package was used to model the peak discharge that resulted from the January 2, 1997, rainfall event. The January 2 rainfall data were used, because that day represents the largest, 1-day precipitation amount (over 7 inches) that fell during the 8-day storm. During the 8-day period (12/27/96 through 1/3/97), over 25 inches of precipitation fell in Nevada City. Precipitation information in conjunction with soil runoff potential and other physical characteristics common to the LCC watershed were input to the model and yielded a peak discharge of 908 cfs. The estimated flow rate for the portion of LCC above the mine is 477 cfs. This is the estimated peak flow rate for LCC at the log dam.

To estimate the flood width, the Manning equation, in conjunction with the peak discharge value and channel characteristics, were evaluated from just below the log dam to the confluence with CC. Results of the analysis indicate that flow widths potentially varied from approximately 20 feet for those sections that are narrow and steep to 80 feet for those where the channel is wider and flatter. In general, the wide, flat areas along LCC are more likely to have accumulated tailings/sediment during the dam failure and subsequent releases, because lower flow velocities in these areas enhance sediment accumulation. Figure 4-1 shows the approximate flood width along the LCC channel above the confluence with CC. The extent of flooding and tailings deposition downstream of the confluence in the Deposition Area and around Lost Lake is estimated using analytical results from soil samples, rather than hydrologic modeling. These results are presented in Section 4.6.

During the January 1997 flood event, tailings were carried down LCC in the flood water as suspended solids. These tailings were deposited on the ground surface as flood waters receded to normal levels. In the LCC corridor, flood water levels should have returned to normal quickly after the storm event, because of the relatively steep gradient and confined nature of the stream corridor. A relatively thin coating of tailings probably was deposited over the entire area reached by flood waters. Analytical results from surface soil

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Figure 4-1 (backside)

samples collected upslope from the stream channel confirm that tailings impacts extend well above the normal stream channel (Section 4.5).

Routine seasonal fluctuations in flow rates and associated water levels occur in all the creeks at the Lava Cap Mine Site, but presumably, flow rates have not approached the levels reported in January 1997. Without additional significant releases of tailings from the mine, the volume of tailings accumulated in the area routinely inundated during high water flow in LCC would be expected to decrease each winter as storm events carry the tailings further downstream to the Deposition Area and Lost Lake. Although the process will be relatively slow, tailings deposited by floodwaters outside the normal high-water stream channel would slowly erode and be carried by overland flow back into the LCC stream channel and downstream.

There are three smaller deposition areas along the LCC corridor below the mine but above the confluence with CC. These are associated with wider portions of the LCC channel, where there are marked decreases in slope. The deposition areas are apparent on Figure 4-1 as the areas where the flooded width of LCC is the widest. These deposition areas accumulated much thicker deposits of tailings than the rest of areas flooded in this stretch of LCC during the 1997 event. The first and largest of these deposition areas occurs above Greenhorn Road and extends northward toward the southern boundary of the mine property. A second deposition area occurs on the residential property just south of Greenhorn Road. A third, smaller deposition area is along the north side of Raccoon Mountain Road. The tailings are generally no more than a few inches thick in these LCC deposition areas.

Periodic releases of tailings from the mine site have likely been occurring at least since the mine began processing ore onsite in 1934. The Lost Lake Dam was constructed specifically to create a settling pond for containment of tailings from the mine. The majority of these tailings deposits presumably are in Lost Lake and the upstream Deposition Area. The 1997 flood event likely represented a significant addition to the tailings deposited along the LCC and CC drainages below the mine, but still represents only a small portion of the total quantity of tailings in the primary Deposition Area above Lost Lake and in Lost Lake itself.

The Lost Lake Dam acts as a sediment trap for the LCC/CC watershed during most of the year. Suspended sediments reach the CC corridor below Lost Lake when turbid water flows over the dam's spillway during storm runoff periods. During periods of normal flow over the spillway, lake water is relatively free of sediments and probably contributes a limited amount of dissolved and suspended sediment to CC below Lost Lake.

4.1.3 Sample Concentrations in Potentially Impacted Areas

Sample analytical results have been evaluated for all areas investigated during the field program. Results for each area, including reference areas, are discussed in Sections 4.2 through 4.7. In general, the extent of flooding impacts along LCC (Figure 4-1), combined with the locations of soil/sediment samples with elevated arsenic concentrations, define the lateral extent of contamination related to the Lava Cap Mine Site. Elevated arsenic concentrations can be generally defined as those that exceed both the 95 percent upper confidence limit (UCL) concentrations from the reference areas and EPA Region IX PRGs. As described previously, reference areas are thought to be unimpacted by Lava Cap Mine

releases. The 95 percent UCL concentrations were generated, using a statistical formula applied to the data set from each reference area. The 95 percent UCL values from the reference areas are used in the HHRA (Appendix E) to help estimate background risks for the site vicinity.

EPA Region IX PRGs are conservative, human health risk-based concentrations used as tools to help guide evaluation and cleanup of contaminated sites. EPA Region IX has developed these PRGs to streamline and standardize all stages of the risk decisionmaking process. PRGs are considered only as screening tools and labeled as preliminary, because they are not typically used as the actual cleanup goals for a site. PRGs do not consider site-specific factors, including exposure pathways and receptors, physical conditions, and other extenuating circumstances.

The highest reference area UCL concentration for arsenic is 23.8 mg/kg: EPA's PRG for arsenic is 0.39 mg/kg for cancer risks and 22 mg/kg for non-cancer risks. In general, samples where arsenic concentrations exceed approximately 25 mg/kg can be considered impacted. However, arsenic concentrations in the reference areas are variable, and some do exceed 25 mg/kg, so this value can not be used as an absolute indicator of mine-related impacts.

Locations where arsenic concentrations are detected in surface soil and sediment samples are shown on Figure 4-2 for the entire Lava Cap Mine Site. This figure can be used to infer the general lateral extent of mine-related contamination by reviewing the distribution of arsenic concentrations shown as exceeding 25 mg/kg. The figure shows low arsenic concentrations in areas upgradient of the mine and in CC upstream of the confluence with LCC as well as very high arsenic concentrations associated with source areas. Elevated arsenic concentrations are detected in soils and sediments extending down LCC below the mine all the way to Lost Lake, including the large Deposition Area above Lost Lake, around the lake shoreline, and at the base of the Lost Lake Dam. Arsenic concentrations decrease considerably below Lost Lake Dam.

4.2 Reference Areas

Samples were collected from reference areas to provide a basis for comparing concentrations in areas potentially impacted by Lava Cap Mine activities to environmental conditions in adjacent areas not impacted by mine activities. Samples were collected in three separate reference areas: Reference Area 1 - upgradient from the mine (at locations within and adjacent to LCC and northwest of the mine); Reference Area 2 - CC upgradient of the confluence with LCC; and Reference Area 3 - Little Greenhorn Creek upgradient of the confluence with CC.

The reference areas were chosen specifically because they were upgradient of the Lava Cap Mine or upgradient of drainages impacted by Lava Cap Mine releases. These reference areas are considered very unlikely to have been affected by Lava Cap Mine activities. It has not been established whether these reference areas could have been impacted by other recent or historic mining or other human activities (not related to the Lava Cap Mine) upgradient of the reference areas. However, the relatively low inorganic concentrations detected in the reference areas compared to those detected in the source areas indicate that these areas can serve as reliable reference locations.

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Figure 4-2 (backside)

4.2.1 Reference Area 1

Reference Area 1 is located upgradient of the Lava Cap Mine. This includes the LCC corridor above the mine and other areas uphill from the mine. Reference Area 1 was visually assessed and samples were collected (Figures 3-1 and 3-2) for surface soil, subsurface soil, surface water, sediment, groundwater, air, and biota. The biota results are briefly summarized in Section 4.8 and discussed in detail in the ERA (Appendix F). Sampling results for each abiotic media are discussed below.

At the mine, the human health risk assessment (HHRA), included as Appendix E, identifies arsenic as a COPC and the ERA identifies antimony, arsenic, cadmium, copper, lead, mercury, silver, and zinc as key COPECs. These analytes are the focus of this reference area discussion.

Soil

Fourteen surface soil samples were collected in areas upgradient of the mine over three sample rounds. Nine shallow soil samples were collected from areas uphill and away from of the mine heading toward the northwest, including the surface soil sample at soil boring 1B. The five remaining shallow soil samples were collected from outside the LCC channel approximately 350 to 650 feet above where the creek reaches the waste rock/tailings pile area near the northwest portion of the mine. All sample locations are shown on Figures 3-1 and 3-2.

Table 4-1 provides summary statistics for all analytes detected in surface soil upgradient of Lava Cap Mine. Arsenic is present in all 14 surface soil samples. The maximum arsenic concentration (95.3 mg/kg) is in the surface sample collected at soil boring location 1B-1 (95.3 mg/kg). The mean arsenic concentration among these samples is 20.7 mg/kg. The magnitude and distribution of detected arsenic concentrations in soil is represented on Figure 4-2 (for locations above and away from the mine) and on Figure 4-3 (for locations in proximity to the mine). These figures show that reference soil samples above the mine site are consistently below 25 mg/kg, except the sample at location 1B. The 1B boring location is located on the shoulder of Lava Cap Mine Road. Given that the arsenic concentration is much higher at location 1B than other surface soil locations in Reference Area 1, it appears this sample may be affected by soil transport on vehicles traveling to and from the Lava Cap Mine and not represent a true reference location. Accordingly, surface soil from location 1B is not included as part of the Reference Area 1 data set used to estimate background risks in the HHRA and ERA.

In addition to arsenic, other key ecological risk drivers in the mine area (i.e., antimony, cadmium, copper, lead, mercury, silver, and zinc) are detected in all 14 samples taken upgradient of the mine.

Aluminum, barium, beryllium, chromium, cobalt, iron, manganese, nickel, thallium, and vanadium are detected in all 14 samples collected in Reference Area 1. The maximum aluminum and manganese concentrations exceed the PRG. The maximum concentrations for the other constituents are well below EPA Region IX PRGs (Table 4-1). Selenium is present in only 3 of 14 samples, while cyanide is present in 8 of 14 samples.

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Figure 4-3 (backside)

Subsurface soil conditions are evaluated through analyzing deeper samples collected from two borings (1A and 1B) installed away from the mine. Three subsurface samples were collected from boring 1A between 6 and 103 feet bgs. Arsenic concentrations in these samples range from 4.6 mg/kg (at 6 to 6.5 feet bgs) to non-detect (at 102 to 103 feet bgs). Seven subsurface samples were collected from boring 1B between 9.5 and 152 feet bgs. Arsenic is not detected in five of these seven subsurface samples. Arsenic is in the sample from 105 to 105.5 feet bgs (at 0.8 mg/kg) and the sample from 150 to 152 feet bgs (at 2.2 mg/kg). Overall, subsurface soil samples in Reference Area 1 have much lower arsenic concentrations than those detected in overlying surface soil.

Sediment

Seven sediment samples were collected from three locations in the LCC channel above the mine. Four samples (including a field duplicate) were collected in October 1999, when this portion of LCC was dry. The three locations were resampled in May 2000, when LCC was flowing. These sample locations are shown on Figure 3-2.

Table 4-2 provides a summary of statistics for all analytes detected in sediment along LCC upstream of Lava Cap Mine. Arsenic is present in all seven sediment samples from Reference Area 1. The maximum arsenic concentration is 44.3 mg/kg, detected at location 1I in the May 2000 sampling event. The mean concentration among the seven samples is 25.8 mg/kg. Arsenic concentrations at each of the three sample locations over the two sampling events are generally in a similar range, but the concentrations in the May 2000 samples (average of 32.6 mg/kg) are consistently slightly higher compared to the October 1999 samples (average of 20.7 mg/kg). The magnitude and distribution of arsenic concentrations detected in soil and sediment samples are presented on Figure 4-3. The arsenic concentrations in sediment from LCC above the mine are mostly below 25 mg/kg, with two slightly higher exceptions at 1H (32.1 mg/kg) and 1I (44.3 mg/kg).

Except for antimony, selenium, and cyanide, the other analytes are detected in all seven of the Reference Area 1 sediment samples. Maximum concentrations of all constituents, except arsenic, are well below PRGs (Table 4-2).

Surface Water

A summary of Reference Area 1 surface water data (locations 1H, 1I, and 1J) is provided in Table 4-3. The information represents total concentrations of metals from unfiltered samples. (This is the case for all surface water discussions in Section 4.) The primary ecological risk drivers for surface water in all areas are arsenic, barium, cadmium, cobalt, manganese, and zinc. The concentrations of these constituents are fairly consistent in the three LCC sampling locations, with manganese showing a slight downstream increase. Arsenic is present in all six samples, but at very low concentrations (below 0.5 µg/L). The distribution of arsenic concentrations in surface water across the entire Lava Cap Mine Site and reference areas is shown on Figure 4-4. Beryllium and cadmium are not detected; mercury is detected in three of the six samples, all at less than 4 mg/L.

Concentrations of beryllium, cobalt, and mercury are consistent with those in surface water samples from other reference areas. All other concentrations are significantly lower in Reference Area 1 than in other reference areas.

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Groundwater

The results of Reference Area 1 groundwater analysis are shown in Table 4-4. None of the constituents analyzed in filtered samples from Reference Area 1 groundwater (Well 1B and Soil Boring 1A) are at concentrations above MCLs (Table 4-4).

MCLs are exceeded in one unfiltered sample from Well 1B (collected in November 1999). Aluminum, arsenic, barium, beryllium, chromium, and lead MCLs are all exceeded. This sample is not considered representative of native groundwater because of excessive turbidity. The aluminum concentration in this sample was 229,000 µg/L, which is over 50 times higher than any other sample collected during the RI field effort. Aluminum is typically a good indicator of the presence of suspended solids in a sample. Dissolved aluminum should not exceed 27 µg/L in the pH range of groundwater in the area (Brookins, 1988) unless strong organic complexing agents are present, which is not likely in this environment. A more likely explanation of elevated aluminum concentrations is the presence of suspended solids or colloids (Hem, 1985). These solids also likely contain other metals (arsenic, barium, beryllium, chromium, and lead) that exceeded MCLs. Concentrations detected in the filtered sample from Well 1B, collected concurrent with the unfiltered sample, are far lower. Concentrations from the initial unfiltered sample are not included in the analysis of groundwater reference concentrations.

The average Reference Area 1 arsenic concentration is 23.6 µg/L (standard deviation of 12.6 µg/L), based on one sample from 1A and three samples from 1B. This concentration is below the MCL (50 µg/L). However, it is much higher than arsenic concentrations detected in most residential wells downgradient from the mine (discussed in Sections 4.5 and 4.6), which are generally below 1 µg/L. This indicates that, although the Reference Area 1 groundwater samples were collected from locations not impacted by the Lava Cap Mine, they may not be fully representative of background conditions in at least some groundwater units in the area.

Air

Two rounds of sampling were scheduled for location 1G to evaluate ambient reference concentrations for the study area. However, after reviewing ambient air results from Round 1 collected in October 1999 (Table 4-5) and comparing them with other media sampled in the vicinity (e.g., an arsenic concentration of 95.3 mg/kg in surface soil from location 1B), this site may not be a representative reference location. It is possible that the proximity of the gravel road, which has been used by vehicles transporting material to and from the mine, may have significantly influenced sampling results. Therefore, only one round of sampling for ambient air was conducted at location 1G.

Many analytes are reported as non-detect because of high concentrations in the filter blank samples. Only three analytes are positively quantified in the sample from 1G during Round 1: cobalt, iron, and nickel. Concentrations of these three analytes are 0.0070, 3.8, and 0.014 µg/m^3, respectively (Table 4-5). The nickel concentration exceeds its PRG. Because only one sample was collected and the location may not be representative of reference conditions, it is not possible to make conclusive statements regarding reference ambient air concentrations in the area. However, given the very small mass of inorganic constituents

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detected in air samples collected during the RI, it appears that, for most of the year, background ambient air concentrations are likely negligible. Although, it should be noted that none of the air sampling performed during the RI was done when conditions were conducive to airborne particulate transport (i.e., dry, windy conditions). For the risk assessment, reference area surface soil data along with standard air transport factors were used to estimate the background risk via the inhalation pathway.

4.2.2 Reference Area 2

Reference Area 2 consists of samples taken along the CC corridor upstream of the CC/LCC confluence at the top end of the Deposition Area. Figure 3-3 (and Plates 3 and 4) shows the locations and types of samples collected along CC in Reference Area 2. Samples were collected for surface soil, surface water, sediment, and biota. Biota results are briefly summarized in Section 4.8 and discussed in detail in the ERA (Appendix F). Sampling results for each abiotic medium follow.

Soil

Six surface soil samples were collected outside the stream channel along the CC corridor (Figure 3-3). These sample locations are along CC, between the confluence with LCC and Raccoon Mountain Road. The samples were collected in October 1999 and May 2000.

Table 4-6 provides summary statistics for all analytes detected in surface soils in the CC corridor upgradient of the confluence with LCC. Arsenic is present in all six samples at concentrations ranging from 7.6 to 20 mg/kg, with an average concentration of 13 mg/kg. The highest arsenic concentration was detected at location 2K. None of the arsenic concentrations exceed the PRG. Arsenic concentrations in soil area can be seen as blue dots (less than 25 mg/kg) on Figure 4-2.

Aluminum, antimony, barium, beryllium, cadmium, chromium, cobalt, copper, manganese, mercury, nickel, silver, thallium, vanadium, and zinc are present in all six soil samples collected in Reference Area 2 (Table 4-6). Lead is detected in five of six soil samples. Selenium is not detected in any of the six soil samples, while cyanide is in two of six samples. None of the concentrations detected exceed EPA Region IX PRGs.

Sediment

Six sediment samples were collected along CC between Raccoon Mountain Road and the CC/LCC confluence. Sediment samples were collected at three locations in October 1999 and May 2000. All sample locations are on Figure 3-3.

Table 4-7 provides summary statistics for all analytes detected in Reference Area 2 sediment samples. Arsenic is in all six sediment samples, ranging from 10.9 to 16 mg/kg, with an average concentration of 13 mg/kg.

The magnitude and distribution of arsenic concentrations in sediment and surface soil at the Site, including Reference Area 2, are on Figure 4-2. These arsenic concentrations are consistently below 25 mg/kg. The arsenic concentrations in sediment are consistent with those detected in soil.

Aluminum, antimony, barium, beryllium, cadmium, chromium, cobalt, copper, lead, manganese, mercury, nickel, silver, thallium, vanadium, and zinc are detected in all six

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sediment samples. Selenium is not in any of the six sediment samples, while cyanide is in only one of six samples. None of the concentrations exceed PRGs.

Surface Water

A summary of Reference Area 2 surface water results (locations 2A, 2B, 2C, 2G, and 2H) is provided in Table 4-8. The ecological risk drivers or COPECs in all areas are arsenic, barium, cadmium, cobalt, manganese, and zinc.

Arsenic is in 7 of 10 samples collected during three rounds, with a maximum concentration of 1.1 µg/L. Figure 4-4 shows the distribution of arsenic in surface water at the Lava Cap Mine Site. Cobalt and barium are the only constituents detected in all 10 samples. Cadmium and mercury were not detected in any samples.

Although there is some variation in COPEC concentrations, there does not appear to be a downstream trend in CC. Location 2C contained relatively high concentrations of most constituents in the October 1999 sample. For example, manganese was higher than that measured at the base of the log dam source area sample. The reason for these elevated concentrations is unknown. Concentrations in the second sample collected from 2C (January 2000) are consistent with other reference values.

All surface water concentrations detected in Reference Area 2 are well below MCLs.

4.2.3 Reference Area 3

Little Greenhorn Creek, upgradient of the CC/LGC confluence (approximately 1,000 feet below Lost Lake), is the third reference area. This area was chosen to offset some limitations of the Reference Areas 1 and 2. For example, LCC upgradient of the mine is a seasonal stream that is not directly comparable to CC, which is perennial. This difference in hydrologic regime affects the type of benthic invertebrate communities that are present. Also, no fish were observed in LCC above the mine (Reference Area 1) or in CC (Reference Area 2). LGC was chosen because it represents a perennial stream where benthic invertebrate communities are comparable to those in impacted segments of CC and where fish samples could be collected for comparison to those caught in impacted segments of LCC. Additional discussions of using Reference Area 3 area for biota sample comparisons is included in the ERA (Appendix F). Biota sample results are summarized in Section 4.8.

Little Greenhorn Creek flows into CC, approximately 1,000 feet downgradient from Lost Lake. According to the HHRA, arsenic is the primary risk drivers in the area downgradient of Lost Lake. The ERA also includes cobalt, mercury, manganese, and selenium as potential risk drivers in this area. Therefore, those analytes are the focus of discussion for the single location (Location 20) where a sediment and a surface water sample were collected in Reference Area 3 and for comparison to concentrations in the area downgradient of Lost Lake (Section 4.6). The sample location is shown on Figure 3-4. Surface soil was not collected in Reference Area 3.

Sediment

Arsenic, cobalt, mercury, and manganese are all in these single sediment sample at concentrations of 10.1 mg/kg, 12.4 mg/kg, 0.06 mg/kg, and 693 mg/kg, respectively. These concentrations are consistent with or slightly lower than those detected in Reference Areas 1 and 2.

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The arsenic concentration is below the Reference Area UCL value and the PRG.

Aluminum, antimony, barium, beryllium, cadmium, chromium, copper, lead, nickel, silver, thallium, vanadium, and zinc also are in the sediment sample. Selenium is not detected, and the sample was not analyzed for cyanide.

Surface Water

Arsenic, cobalt, and manganese are present in LGC at location 20. The low concentrations detected, including arsenic at 0.3 µg/L, are consistent with Reference Areas 1 and 2.

4.3 Source Area

Contaminant source areas at the Lava Cap Mine include those areas where mine tailings or other mining wastes are present. The source area also incorporates the continuous mine discharge and the tailings pile seeps, including the base of the log dam. The source areas either have the potential for direct exposure at the mine or have the potential to be transported from the mine, impacting downgradient areas (such as Lost Lake and the Deposition Area). Specifically, the source areas sampled include the soils/wastes in abandoned mine buildings, the waste rock/tailings pile area, the caved-in mine adit discharge, the seasonal seep emanating from the waste rock/tailings pile, and the discharge at the base of the log dam. Biota samples were also collected in the source area. Biota results are briefly summarized in Section 4.8 and discussed in detail in the ERA (Appendix F). Results of the sampling for each of the abiotic media follow.

Volume/Extent of Waste Rock/Tailings

Waste rock refers to the unprocessed rock removed from the mine during mining operations. This rock was not processed, because it was not part of the gold or silver ores mined. The tailings are the fine-grain end product generated through the on-site processing of ore in the Mill and Cyanide Buildings.

Past documents have reported widely varying volumes of waste rock/tailings remaining at the mine. A 1994 document prepared by Bechtel for EPA (EPA, 1994b) estimated that approximately 80,000 cubic yards (cy) of waste rock and mine tailings existed at the Lava Cap Mine, covering approximately 225,000 square feet of the mine. The dimensions of the mill tailings pile behind the dam in 1979 were estimated by the State of California to be 300 feet x 300 feet x 60 feet high (200,000 cy). The catastrophic dam collapse on January 1, 1997, reportedly released over 10,000 cy downstream during a major winter storm (EPA, 1997a).

During the EPA Region IX Emergency Response Action following the January 1997 release, some tailings were moved from the area behind the damaged log dam. The oversteepened slopes of the tailings pile behind the dam were graded and covered with waste rock. There is currently a 4,000 cy tailings pile covered with a clay cap located on the waste rock pile immediately to the north of the original tailings pile (Figure 1-2).

The current volume of waste rock/tailings at the Lava Cap Mine has been estimated as part of this RI. Based on the width of LCC upstream from the mine, it was assumed that the historic creek width at the mine was approximately 50 feet. The historic creek channel

length was estimated at 990 feet, based on the current length of creek across the mine. The average depth of tailings / waste rock is estimated at 28 feet (based on the average depth of tailings / waste rock observed in the six soil borings drilled through this area during the RI field effort).

The approximate surficial area of waste rock / tailings is delineated on Figure 1-2. The estimated contaminated volume of waste rock / tailings is 4,400,000 cubic feet (163,000 cy) in the source area, based on an estimated waste rock / tailings surface area of 259,200 square feet. Adding in the estimated volume of tailings in the tailings stockpile created by EPA brings the estimated total waste rock / tailings volume to approximately 167,000 cy. A review of subsurface conditions in the waste rock / tailings area (partially illustrated on Figure 2-5) indicates that approximately 60 percent of this volume is waste rock (about 95,000 to 105,000 cy) and 40 percent tailings (about 65,000 to 70,000 cy).

Caved Adit

The adit was the horizontal mine entrance that bisected the central shaft and allowed access to the mine shaft and tunnels for workers and equipment. The adit is caved in. Water discharging from the caved adit is groundwater that enters the mine workings through the walls of the old mine tunnels and shafts. A prior study, conducted in the spring of 1984, estimated adit discharge rates ranging from 130 gpm in April to 47 gpm in August (Cole / Mills Associates, 1984). During the RI, adit discharge rates peaked at an estimated 3.9 cfs (nearly 1,800 gpm) in February 2000 and 2.2 and 2.6 cfs in January and March, respectively. These rates include surface water runoff directed into the pond at the adit discharge and are not solely representative of the mine discharge. During most of the year, the only flow at the adit location is direct seepage from the mine. Approximate flow rates observed during the driest portion of the year (late fall, before the rainy season) range from about 50 to 125 gpm. These rates are similar to those reported in the 1984 study.

4.3.1 Soil

Sixteen surface soil samples were collected from source areas at the mine. Seven samples (including one field duplicate) were collected from six soil boring locations on the waste rock / tailings pile (locations 5A, 5B, 5C, 5D, 5E, and 5H). Four samples (including one field duplicate) were collected from inside the Mill Building (locations 6A, 6B, and 6C), and five samples (including one field duplicate) were collected from inside the Cyanide Building (locations 6D, 6E, 6F, and 6M). Sample locations and types are shown on Figure 3-2.

Table 4-9 provides summary statistics for all analytes detected in surface soil in the source area. As previously indicated, arsenic is the primary risk driver for human and ecological receptors in soil at the mine (although many other constituents also contribute to potential ecological risk at the mine). Arsenic is detected in all 16 samples analyzed, with a concentration range of 63.9 to 31,200 mg / kg. All these samples exceed the EPA Region IX PRG and reference area 95 percent UCL concentration.

Arsenic concentrations in source area soil samples are lowest in the waste rock / tailings pile area and highest in the cyanide building. Arsenic concentrations of the waste rock / tailings pile surface samples range from 63.6 to 2,070 mg / kg (average 1,336 mg / kg). Arsenic concentrations of Mill Building surface soil samples range from 848 to 4,730 mg / kg (average 3,240 mg / kg). Arsenic concentrations of Cyanide Building surface soil samples range from

Insert Table 4-9 (8.5x11 one page)

1,620 to 31,200 mg/kg (average 15,400 mg/kg). The maximum concentration of 31,200 mg/kg in the Cyanide Building is at sample location 6E. The magnitude and distribution of arsenic concentrations for surface soils in source areas are presented on Figure 4-3.

Most of the other constituents also are detected in all 16 samples. Maximum concentrations of antimony, cadmium, cyanide, iron, lead, manganese, and nickel exceed their respective PRGs and reference UCL concentrations. All these exceedances are from samples collected in and around the mine buildings.

Twenty-two subsurface soil samples (including 1 field duplicate) were collected from source area soil borings 5A, 5B, 5C, 5D, 5E, and 5H (Figure 3-2) on the waste rock/tailings pile. Summary statistics are provided in Table 4-10.

Arsenic concentrations in subsurface soil samples range from 15.5 mg/kg to 5,360 mg/kg (9 to 10 feet bgs in boring 5A adjacent to the adit). Except at location 5A, arsenic concentrations consistently decrease with depth. The average surface soil arsenic concentration at these boring locations is 1,416 mg/kg, while the average of all source area subsurface soils is 603 mg/kg. Except the soil boring at 5B, bottom samples have arsenic concentrations below 100 mg/kg. For the most part, arsenic concentrations in the subsurface soil samples significantly exceed PRGs and reference area data.

All constituents, except for cyanide and selenium, are present in at least 18 of the 22 samples. Cyanide is detected only twice in source area subsurface samples. Only iron and manganese are at concentrations in excess of reference area concentrations and PRGs.

4.3.2 Sediment

Four sediment samples were collected from the source area: two from the adit pool (3A), one from the seep area (3B), and one from the base of the log dam (4A) (Figure 3-2).

Table 4-11 provides summary statistics for all analytes in the four sediment samples collected from the source area. Arsenic concentrations are very high, ranging from 459 to 34,000 mg/kg, with the maximum concentration detected at the adit pool location (3A). The average arsenic concentration for these samples is 9,201 mg/kg, and all four samples are well above the PRG. The distribution of arsenic in surface soil/sediment samples in the mine area is shown on Figure 4-3. These arsenic concentrations in sediment samples are consistent with the overall trend of high arsenic concentrations in the source area.

Iron and cadmium are the only other constituents that exceed both PRGs and reference area concentrations in sediment samples. All constituents, except cyanide (2 of 4) and selenium (3 of 4), are detected in all four samples.

4.3.3 Surface Water

Surface water samples were collected from seven locations in the source area at the mine. Three of these locations were sumps in the mine buildings (6I, 6K, and 6L), 4A is at the base of the log dam, 3A is the caved adit discharge, and 3B and 3C are tailings pile seeps. These sample locations are shown on Figure 3-2. Locations 3A, 3B, and 4A were sampled nearly monthly throughout the RI field program. Summary statistics for all constituents analyzed in the source area surface water are provided in Table 4-12.

Insert Table 4-10 (8.5x11 one page)

Insert Table 4-11 (8.5x11 one page)

Insert Table 4-12 (8.5x11 – one page)

Ponded water samples collected in sumps in the former mine buildings (6I, 6K, and 6L) all showed significantly elevated concentrations of arsenic and other constituents. The samples from a small sump in the Mill Building (6I) contain the highest concentrations of arsenic (14,300 µg/L) and several other metals. As shown in Table 4-12, concentrations of eight constituents exceed MCLs in source area surface water; most of these exceedances occur in the mine buildings. The ponded water in the mine building sumps is generally contained and does not discharge direct into any surface water channels.

Figure 4-4 shows the distribution and magnitude of arsenic concentrations in surface water through the Lava Cap Mine Site area. Elevated arsenic concentrations detected in the source area are apparent on the figure (indicated by the red circles across much of the mine area).

Sample location 4A (samples from 4A were actually collected in two different locations, 4A1 and 4A2, below the dam, depending on access availability at the time of sampling) provides the most direct assessment of impacts from tailings pile seepage on LCC water. Compared to reference concentrations, samples at 4A are generally elevated for many constituents. The most notable increases are elevated average concentrations of arsenic (163 µg/L), barium (42 µg/L), and manganese (321 µg/L).

Discharge from the mine adit (3A) contains elevated concentrations compared to those detected at the base of the log dam (4A). The adit represents drainage from a large portion of the upper mine workings from both Lava Cap and Banner Mines. Seeps collected from the surface of the tailings pile (3B) contain lower concentrations than 3A, although they are still above reference. The results from location 4A represent a combination of surface seeps from the tailings pile (3B) that flow through the log dam and seepage from the base of the tailings pile that flows out of the bottom of the log dam.

Table 4-13 shows concentrations detected in monthly samples from locations 3A, 3B, and 4A. Figure 4-5 shows the trend in arsenic concentrations over time for the monthly samples from the adit (3A), tailings pile seep (3B), and the base of the log dam (4A). The figure shows that arsenic concentrations are consistently highest at the adit, followed by the log dam, with the seep being slightly lower than the log dam. The arsenic concentrations at all three locations are generally the lowest in the late winter/early spring, when flow rates are the highest and surface runoff from storm events likely dilutes the mine discharge and seeps.

The overall trend in arsenic concentrations in LCC from above the mine downstream to LGC is shown on Figure 4-6. A separate line is shown on the graph for each of the three rounds of RI fieldwork. The source area samples from location 4A are labeled as the Base of the Log Dam location. As the graph illustrates, arsenic concentrations in LCC are generally highest at the sample location after location 4A at the base of the log dam. This location (12F) is just below where the adit water enters LCC. As would be expected, arsenic concentrations generally decrease heading downstream from this point.

TABLE 4-13
Arsenic Concentrations in the Adit Discharge, Tailings Pile Seep, and at the Base of Log Dam
Lava Cap Mine, Nevada County, California

Sample Date	3A Adit Discharge	3B Tailings Pile Seep	4A Base of Log Dam
October 1999	567		146
November 1999	532		342
December 1999	510	145	211
January 2000	199	50	112
February 2000	222	51.2	85.5
March 2000	508	40	87.7
May 2000	489	27.2	146
June 2000	668	235	248
July 2000	559	383	405
September 2000	584		532

Notes:
Results are in micrograms per liter (µg/L).

4.3.4 Groundwater

Monitoring Wells 5A, 5D, 5E, and 5I were installed and sampled to assess the impact to shallow groundwater from activities at the mine site. Specifically, these wells are completed in the native formations directly beneath the waste rock/tailings pile. Well 5A was screened in fractured metasedimentary rock (Pms, see Section 2.5) beneath the site of mine adit discharge; Wells 5D, 5E, and 5I were drilled through the tailings pile and are also screened in either Pms or the overlying conglomerate. Groundwater grab samples from Soil Borings 5B and 5C were collected from the native formation just beneath the waste rock and tailings.

Table 4-14 provides a summary of statistics for all analytes in groundwater in the source area. Arsenic exceeds the MCL in all samples, except the first two rounds in Monitoring Well 5D. There are isolated MCL exceedances of aluminum (in the May sample from 5D) and cyanide (in the grab sample from 5C). No other constituents exceed MCLs.

The arsenic concentration range at each monitoring well is illustrated in Table 4-15. Arsenic concentrations in the groundwater beneath the source area (5A through 5I) are variable but are generally in the 100 to 500 µg/L range. The exception is Well 5D, which showed arsenic concentrations between 10 and 20 µg/L in the first two rounds before increasing to 186 µg/L in Round 3. Arsenic levels in Well 5D dropped back down below 100 µg/L (to 90.3 µg/L) in September 200 sampling event. Figure 4-7 shows the distribution of arsenic in groundwater across the entire site. The elevated source area concentrations are illustrated by the pink and red symbols.

Though initial samples from Well 5D were relatively low in arsenic, the Pms aquifer beneath the source areas is clearly impacted by site activity. The degree of hydraulic connection between mine deposits and the underlying Pms is likely variable, because it depends on fracture distributions and other preferential flow path at the interface. Water levels

Insert Figure 4-5 (8.5x11 B&W)

Insert Figure 4-6 (8.5x11 B&W)

Insert Table 4-14 (8.5x11 1 page)

TABLE 4-15
Arsenic Concentrations in Monitoring Wells
Lava Cap Mine, Nevada County, California

Location	Round 1 November 1999		Round 2 January 2000	Round 3 May 2000		September 2000
	Unfiltered	Filtered	Unfiltered	Unfiltered	Filtered	Unfiltered
1B	55	21.7	36.7	29		22.6
5A	356 (362)	393 (369)	262	300		382
5D	18.8	12.5	15.3 (15.9)	186		90.3
5E	391	399	448	441		434
5I				160 (157)	151	168
13Q				411	235	235
13R				2,180	1,810	2,430 (2,350)

Notes
Results in ( ) are field duplicates.
Units are in micrograms per liter (ug/L).

measured in monitoring wells in the source area (shown in Table 4-16) indicate that a downward gradient is present in the shallow portions of the Pms formation beneath the waste rock/tailings pile. Monitoring Wells 5D and 5E are screened in the very top of the Pms formation, while nearby Well 5I, screened deeper into the formation, has a lower water-level elevation. This indicates that downward movement of groundwater and contaminants is possible in the upper Pms formation.

TABLE 4-16
Groundwater Levels
Lava Cap Mine, Nevada County, California

	11/9/99	1/28/00	05/4-5/00	5/23/00	09/14-15/00
1B		3163.23	3165.33		3164.60
5A	2780.81	2782.21	2781.29		2779.69
5D	2736.85	2746.63	2743.94		2737.01
5E	2736.55	2743.69	2743.09		2736.70
5I				2737.71	2731.79
13Q				2459.79	2460.75
13R				2461.14	2463.35

Insert Figure 4-7 (11x17 color)

Figure 4-7 (backside)

4.3.5 Air

Table 4-17 summarizes results for all analytes sampled in the source area air samples at the mine. Air samples were collected on the waste rock / tailings pile (location 5G); in the Mill Building (location 6G); and in the Cyanide Building (location 6H- Round 1 only). Sample locations are shown on Figure 3-2.

At Site 6H, only results for cyanide concentrations are available from the Round 1 air sample, because the procedure used for this analysis consumed the entire filter. As a result, metals concentrations were unattainable for this round.

For the remaining two sites, arsenic is detected in only one of the four air samples collected. The maximum detected arsenic concentration is 0.021 $\mu g / m^3$ at location 6G. This concentration is almost 50 times greater than the EPA Region 9 PRG value of 0.00045 $\mu g / m^3$. Beryllium (0.0041 $\mu g / m^3$) and nickel (0.018 $\mu g / m^3$) concentrations also are above their respective PRG values at location 6G. Cadmium (0.0067 $\mu g / m^3$) and nickel (0.054 $\mu g / m^3$) concentrations are above their respective PRG values at location 5G in the Round 3 sample. Other constituents detected include antimony, cobalt, and selenium.

As noted previously, climatic conditions during the ambient air sampling events were not ideal for measuring air particulate transport. As such, sample results are not likely representative of potential transport during “worst case” conditions that may occur during drier, windier times of the year. Additional sampling under different conditions (e.g., high wind gusts, dry soils, or significant dirt moving activity) should be performed to better characterize potential air particulate transport of site-related contamination. As is commonly done in preparing risk assessments, the HHRA (Appendix E) makes use of surface soil concentrations and standard air transport factors to estimate risk from inhalation of site contaminants.

4.4 Mine Area

This area refers to all areas at the mine located away from the source areas described previously. The mine area specifically excludes samples collected in and around historic mine buildings, on the waste rock / tailings pile, and from mine discharge and seeps. The mine area was sampled for metals and inorganics in soil, sediment, surface water, groundwater, and air. The results for all media are discussed in this section.

4.4.1 Soil

Thirty-nine surface soil samples were collected in the mine area. Six samples were collected around the abandoned mine buildings in locations biased toward surface water accumulation (locations 7A through 7F). Seven samples (including one field duplicate) were collected from random locations around the mine buildings (8A through 8F). Seven samples (including one field duplicate) were collected around the two residences closest to the waste rock / tailings pile (10A through 10F). Nineteen samples (including field duplicates) were collected in various locations on the mine, but away from the source areas (locations 9A through 9P and the surface sample from soil boring 1A). The sample locations are shown on Figure 3-2.

Insert Table 4-17 (8.5x11 one page)

Table 4-18 provides summary statistics for all analytes detected in surface soil in these mine area samples. As previously indicated, arsenic is the primary risk driver for human and ecological receptors in soil in the mine area (although many other constituents also contribute to potential ecological risk in the mine area). Arsenic is detected in all 39 samples, and the overall concentration ranges from 4.7 to 5,570 mg/kg.

Arsenic concentrations of the random areas around the mine site, some of which are immediately adjacent to the waste rock/tailings pile, range from 4.7 to 1,310 mg/kg (average 203 mg/kg). Arsenic concentrations around the two rental houses on the mine site range from 102 to 1,750 mg/kg (average 726 mg/kg). Arsenic concentrations of randomly located surface soil samples collected around the mine buildings range from 97.3 to 2,480 mg/kg (average 1,385 mg/kg). Arsenic concentrations of the biased surface soil samples collected around the mine buildings range from 380 to 5,570 mg/kg (average 3,083 mg/kg). The three highest arsenic concentrations detected are in samples biased toward accumulation areas around the mine buildings, including 5,570 mg/kg (7A), 5,270 mg/kg (7D) and 3,890 mg/kg (7E).

The distribution of arsenic concentrations in surface soil/sediment in the mine area is shown on Figure 4-3. As illustrated, the series of samples collected 200 to 300 feet west/southwest of the source area are essentially the only samples in the mine area where arsenic concentrations are below reference levels and PRGs (these samples are shown as blue dots on Figure 4-3).

Other constituents that exceed PRGs and reference levels in isolated samples include cadmium, cyanide, iron, lead, and manganese. Most constituents analyzed are in all 39 surface soil samples. Selenium (detected in only 15 of 39 samples) and cyanide (detected in 28 of 39 samples) are the only constituents that are non-detect in a significant number of samples.

Six surface soil samples (including one field duplicate) were also analyzed for explosives constituents using EPA Method 8330. These samples were collected in five locations near or in the abandoned explosives bunkers at the mine (locations 9A through 9E on Figure 3-2). All these results are non-detect, except for sample location 9A, where 2,4,6-trinitrotoluene (TNT) is detected at 0.2 mg/kg. This value was flagged by the laboratory as estimated ("J"). The corresponding organic carbon value for the sample with the detected TNT was 86,700 mg/kg or about 8.67 percent by weight.

The results of the explosives testing were carried through the HHRA and ERA, and the compound was not identified as a COPC or COPEC. The human health PRG for TNT (16 mg/kg) is much higher than the detected concentration. The ecological receptor benchmark concentrations for TNT is 13 mg TNT/kg organic carbon for ecological receptors associated with sediment and 5 mg TNT/kg for tissue samples (Efroymson et al., 1997). The low detected value (0.2 mg/kg) and low frequency of detection (one out of six samples) indicate that TNT is not a significant risk driver at the mine.

4.4.2 Sediment

The single sediment sample from the mine area was collected from the ponded area, where LCC first reaches mine waste rock/tailings deposits (location 4B). Because this one sample is the only mine area sediment sample, no summary statistics table is provided.

Insert Table 4-18 (8.5 – 1 page)

The arsenic concentration is 2,480 mg/kg, which is two orders of magnitude above the PRG and reference area 95 percent UCL value. All other constituents analyzed also are detected, but at concentrations below their respective PRGs.

4.4.3 Surface Water

Summary statistics on the concentrations of all trace elements in mine area surface water are provided in Table 4-19. Samples were collected from just two surface water locations outside of the source areas. These are 4C (the large pond adjacent to the new residence northwest of the mine) and 4D (the ponded area of LCC where it enters the mine).

Arsenic concentrations at location 4D indicate that LCC is quickly affected as it enters the mine area (2.9 µg/L, compared to the reference values of 0.6 µg/L or less). The sediment sample at this location has an elevated arsenic concentration of 2,480 mg/kg, indicating the presence of mine-related impacts in this pond. The large pond (sample location 4C) on the mine property also contains elevated concentrations of arsenic (31.9 µg/L) and other constituents, although nothing in excess of MCLs. The pond near the home is fed at least partially by one of the mine area residential wells (Section 4.4.4). The mine area residential wells all contain arsenic, so it is expected that the pond would contain elevated arsenic as well.

4.4.4 Groundwater

There are four residential wells located on the mine site (10G, 10H, 10I, and 10J, Figure 3-2). Table 4-20 provides a summary of statistics for all analytes in groundwater in the mine area residential wells. The very high mean and maximum concentrations of arsenic shown in Table 4-18 are primarily driven by one well (10I). This well has never been used for drinking water because of the high arsenic concentrations present. The arsenic concentrations and reported well depth (about 180 feet bgs) imply that this well likely was completed in contact with the historic mine workings. As shown in Table 4-21, residential wells 10I and 10J have elevated arsenic concentrations (both above the MCL), whereas residential wells 10G and 10H contain concentrations at or below those detected in the reference well. No other constituents exceed MCLs in groundwater samples from residential wells at the mine.

4.4.5 Air

Table 4-22 provides a summary of results for all analytes in the mine area air sample from location 10C (refer to Figure 3-2). Arsenic was detected in the location 10C air sample from Round 1 at a concentration of 0.067 µg/m^3. This value is nearly 150 times greater than the EPA PRG value of 0.00045 µg/m^3. Other chemicals detected at this sample location include antimony (0.014 µg/m^3) in the Round 3 sample and selenium (0.067 µg/m^3) in the Round 1 sample.

These results indicate that air transport is possible, but they cannot be used to accurately quantify potential worst-case contaminant migration via the air pathway because of the non-ideal conditions during sampling. In the future, additional sampling will be attempted during conditions that could produce higher analyte concentrations (e.g., high wind gusts, dry soils, and significant earth moving activity).

Insert Table 4-19 (8.5 – 1 page)

Insert Table 4-20 (8.5 – 1 page)

TABLE 4-21
Summary of Mine Area Residential Well Arsenic Concentrations
Lava Cap Mine, Nevada County, California

Location	Number of Samples	Arsenic Concentration Range (μg/L)	Average Arsenic Concentration (μg/L)	Groundwater Source
10G	2	11.2 – 33.4	22.3	Pms
10H	1	17.6	--	Pms
10I	2	377 – 528	453	Pms
10J	2	55.1 – 56.8	56	Pms

4.5 Little Clipper Creek below Mine

When the log dam partially failed in 1997, contaminated tailings were transported down LCC toward Lost Lake. As previously discussed, the steep slopes within the stretch of LCC below the mine, but above the Deposition Area reduced the amount of tailings deposition in much of this stretch. However, there are several areas where decreased slope and constricted channel flow resulted in the formation of tailings deposition areas in the creek and adjacent inundated areas.

Soil, sediment, surface water, groundwater, and biota samples were collected at selected locations along this segment of LCC. Biota sample results are briefly summarized in Section 4.8 and are discussed in more detail in the ERA (Appendix F). Analytical results for all other media are discussed in this section. The LCC corridor extending from below the log dam all the way to Lost Lake is termed the midgradient area in the ERA. Here, this midgradient area is split into the LCC below the Mine segment (discussed in this section) and the Deposition Area and Lost Lake area (discussed in Section 4.6).

4.5.1 Soil

Table 4-23 provides the summary statistics for all analytes detected in surface soil in the area along LCC below the log dam at the mine and above the Deposition Area at Lost Lake. Nine surface soil samples (including two field duplicates) were collected just outside of the normal LCC flow channels at the following locations (12A through 12E, 12K, and 12L). These sample locations are shown on Figure 3-5.

Arsenic is detected in all nine samples. The maximum concentration is 908 mg/kg (location 12C), and all samples exceed the reference value and PRG. The mean concentration for arsenic is 599 mg/kg. The sample results indicate that impacts remain along the stream channel in upslope areas where high waters during the flood deposited tailings. The overall distribution of arsenic concentrations in surface soil across the entire site is presented on Figure 4-2.

Insert Table 4-22 (8.5, 1 page)

Insert Table 4-23 (8.5x11- one page)

All other inorganic constituents, except cyanide (2 of 9 samples) and selenium (not detected), also are detected in all nine samples. However, no other constituents exceed PRGs.

4.5.2 Sediment

Table 4-24 provides summary statistics for all analytes detected in sediment from the stretch of LCC between the log dam and Deposition Area above Lost Lake. Five sediment samples were collected in the LCC stream channel at locations 12F through 12J, as shown on Figure 3-5. Arsenic is present in all five samples. The maximum arsenic concentration is 1,150 mg/kg at sample location 12F. This is the location closest to the Lava Cap Mine log dam. The mean concentration for arsenic is 669 mg/kg. The distribution of arsenic in sediment (and surface soil) throughout the Lava Cap Mine Site, including LCC below the log dam, is presented on Figure 4-2. Elevated surface soil and sediment concentrations detected along LCC are illustrated on the figure.

Because this stretch of channel is generally steep, there are limited areas of sediment accumulation in the channel. Thus, sediment sample locations are biased toward areas of accumulation, which also are the areas likely impacted by tailings deposition. The fact that all the sediment samples contain elevated levels of arsenic does not mean that the entire stretch of LCC below the mine is necessarily contaminated. But it does indicate that anywhere sediments can accumulate is significantly impacted by releases from the mine.

All other inorganic constituents also are detected in all five sediment samples, except cyanide (two of five samples), mercury (four of five samples), and selenium (three of five samples). Other than arsenic, no other constituents exceed PRGs.

4.5.3 Surface Water

Summary statistics from surface water samples (12F through 12J) collected from LCC below the log mine and above the Deposition Area at Lost Lake are shown in Table 4-25. These samples (Figure 3-5) contain arsenic concentrations (average of 132 µg/L) that reflect the influence of mine discharge. Table 4-26 shows arsenic results from surface water samples from each sampling location in each LCC/Lost Lake/CC of the three rounds of RI sampling.

These data illustrate the seasonal variability in arsenic concentrations in surface water at the site. The data presented in Table 4-26 are also used to create Figure 4-6, illustrating the upstream-to-downstream trend in arsenic concentrations in LCC for each sampling round.

Concentrations of arsenic (and most other constituents) gradually decrease in the downstream direction. In the stretch of LCC below the mine but above the Deposition Area, arsenic averages 229 µg/L at 12F and lessens to 81 µg/L at 12J (the distribution of arsenic in surface water samples at the mine is also illustrated on Figure 4-4). There is a modest increase between the last two samples in this stretch of LCC (12I and 12J). One sample at 12I is anomalously low in arsenic (19 µg/L), while one sample at 12J is higher than expected (110 µg/L).

Insert Table 4-24 (8.5x11- one page)

Insert Table 4-25 (8.5x11- one page)

Insert Table 4-26 (8.5x11- one page)

The only constituents detected in all 15 samples are arsenic, barium, cobalt, manganese, nickel, and zinc. Arsenic is the only constituent that exceeds MCLs.

4.5.4 Groundwater

Table 4-27 provides a summary of statistics for all analytes sampled in groundwater from residential wells along the LCC drainage below the mine and above Lost Lake. Seven residential wells were sampled in this stretch. The locations of residential well samples are shown on Figure 3-5. No constituents exceed drinking water standards in these wells. Arsenic is not detected in four of the seven residential wells sampled. The average concentrations of arsenic and the range of detected values, at each well in which arsenic is detected are shown in Table 4-28. The three wells in which arsenic presence is confirmed are 11AF (both samples), 11AK (both samples), and 11AL (all four samples). Of these, only Well 11AL contains concentrations above 2 µg/L. The average concentration in four samples collected from Well 11AL is 34.7 µg/L, which is within one standard deviation from the mean reference arsenic concentration (Section 4.4.1). However, the reference monitoring well is not completed in the Pms formation, so the concentrations may not be directly comparable.

4.6 Deposition Area and Lost Lake

Lost Lake was created as a tailings impoundment by the construction of the reinforced dam on the south side of the lake. The lake is fed by perennial and seasonal water flows from the LCC and CC watersheds as well as two smaller unnamed seasonal creeks flowing into the north end of Lost Lake. When sediment-laden stream flows encounter the relatively still waters of Lost Lake, much of the sediment settles out. The accumulation of sediments along CC just upstream of Lost Lake has created a significant Deposition Area that is delineated on Figure 1-4 and readily apparent on Figure 4-8 (Figure 4-8 illustrates the distribution of arsenic concentrations in surface soil/sediment in the Lost Lake area). Since construction of the Lost Lake Dam sometime in the 1930s, the sediment deposition has extended a relatively large delta into Lost Lake that effectively separates the Lake into two separate lobes (northern and southern).

The discussion in this section includes samples from the Deposition Area (including sample areas upslope of the Deposition Area, Deposition Area pools, and CC through the Deposition Area) and from the Lost Lake area (including soils on surrounding properties and shallow and deep sediment samples from the Lake). All sample locations are shown on Figure 3-6 (and Plate 4). The Deposition Area and Lost Lake Area were sampled for metals and inorganics in soil, sediment, surface water, groundwater, air, and biota. Biota results are summarized briefly in Section 4.8 and discussed in more detail in the ERA (Appendix F). The results for all other media are discussed in this section.

Insert Table 4-27 (8.5x11- one page)

TABLE 4-28
Arsenic Concentrations Detected in Residential Wells Along the LCC Drainage Below the Mine and Above Lost Lake
Lava Cap Mine, Nevada County, California

Location[1]	Number of Samples	Concentration Range (µg/L)	Average Concentration (µg/L)	Groundwater Source[2]
11AF	2	1 - 1.8	1.4	Pms
11AK	2	1.2 - 1.2	1.2	Pms
11AL	4	28.5 – 46.3	34.7	Pms

[1] Wells not listed did not contain detectable concentrations of arsenic
[2] Pms Paleozoic Metasedimentary Rock (assumed for these Residential Wells).

Estimation of Tailings-Impacted Sediment Volumes

Based on the existing width of CC upstream from the Deposition Area, it is assumed that the historical creek bed had a relatively flat bottom width of about 30 feet. The length of CC through the Deposition Area is estimated at 1,520 feet. In the Deposition Area, side slopes from surrounding, undisturbed areas are projected to an assumed location of the original stream channel. Cross-sectional areas are then developed for five segments through the Deposition Area for volume calculations. The areal extent of tailings-impacted sediments in the Deposition Area used for the volume calculations is delineated on Figure 1-4.

Tailings-impacted sediment volumes also are estimated for Lost Lake. Although subsurface samples were not collected from beneath the lake bottom, based on site history and borings installed in the adjacent Deposition Area, it is presumed that all sediment filling Lost Lake is tailings-impacted. Sediment volumes are estimated using the surveyed water surface elevations, estimates of the depth of water in the lake, and an estimate of the original stream bed gradient before deposition began. The original stream bed is interpolated from surveyed ground surface elevations just outside of Lost Lake and the Deposition Area and at the base of Lost Lake Dam. Elevations at two points (one at the north end of Lost Lake and the other near the northeast edge of the south lobe of Lost Lake) are related to the surveyed elevation at the base of the Lost Lake Dam to estimate the ground surface elevation along the bed of the original stream channels. Because of the direction of water flow through the lake toward the south, it is assumed that tailings-impacted sediment deposition is negligible in the northwestern portion of the north lobe of Lost Lake. Sample results support this assumption, as arsenic concentrations are low in the far northwestern portion of the lake. Using these assumptions, the calculated volume of potentially tailings-impacted sediments deposited above (Deposition Area) and within Lost Lake is approximately 500,000 cy.

4.6.1 Soil

Table 4-29 provides the summary statistics for all analytes sampled in surface soil in the Deposition Area and the Lost Lake Area. Forty-five surface soil samples were collected in the Deposition Area and around the Lost Lake perimeter and analyzed for the full suite of metals and cyanide. The 45 surface samples consisted of 15 samples from the Deposition Area and 30 samples on residential properties surrounding Lost Lake.

Insert Table 4-29 (8.5x11- one page)

In addition to these samples, 61 screening-level surface soil samples were collected and analyzed for arsenic only. Twenty-one of these screening samples (including one duplicate sample) were collected in the Deposition Area at locations 13-1 through 13-20 (Figure 3-6). The remaining 40 samples were collected in 20 paired locations on the residential properties around the Lost Lake perimeter and are designated 11-1 through 11-40 (Figure 3-6). The paired screening sample locations included one soil sample near the estimated mean high water level and a second sample located approximately 2 vertical feet (approximately 5 to 10 lateral feet) above the first sample. The screening samples were collected prior to the full-suite samples mentioned previously to generate an approximate distribution of tailings-impacted areas around Lost Lake and the Deposition Area and to guide the choice of sampling locations. Many of the full-suite samples were used to sample further upslope around the Deposition Area and Lost Lake to better define the actual lateral extent of the impacted areas.

Arsenic was detected in 104 out of the 106 total samples (including the screening samples) in this area. The maximum arsenic concentrations detected are 913 mg/kg at location 13E in the Deposition Area and 811 mg/kg at location 11X around Lost Lake (Figure 3-6). Arsenic concentrations in the Deposition Area and Lost Lake Area range from 4.15 to 913 mg/kg, with an mean of 339 mg/kg. The distribution of arsenic in surface soil and sediment in the Deposition Area and Lost Lake vicinity is presented on Figure 4-8.

Overall, the Deposition Area surface soil samples have slightly higher concentrations than those detected around Lost Lake. The average arsenic concentration of the Deposition Area soils is 509 mg/kg for screening samples and 362 mg/kg for full-suite samples. The average arsenic concentration around Lost Lake is 315 mg/kg for the screening samples and 251 mg/kg for the full-suite samples.

Higher arsenic concentrations are detected in the screening samples compared to the full-suite samples for both groups, because more of the screening samples are focused on impacted areas. Many of the full-suite samples were taken from higher elevation locations outside the area flooded during the 1997 flood and release of tailings from the mine.

The average arsenic concentration among the full-suite samples collected in the Deposition Area (locations 13A though 13F, 13O, and 13P) is 594 mg/kg, while the average concentration among the higher elevation upslope samples (locations 13I through 13N) is 15.1 mg/kg. These higher elevation concentrations are similar to those observed in the reference areas.

Around Lost Lake, screening samples show relatively high arsenic concentrations (average 315 mg/kg). As previously mentioned, these samples are divided into two groups: those near the mean annual high-water line and those located approximately 2 feet higher in elevation. Arsenic concentrations from the water line samples average 353 mg/kg. The arsenic concentrations in the samples collected approximately 2 feet (vertically) above the water line average 273 mg/kg. These results indicate that both sets of samples are generally within the area impacted by tailings released during the 1997 flood event. The higher elevation sample group is more variable and shows a slightly lower average arsenic concentration.

The full-suite soil samples taken around Lost Lake were used to better characterize near-lake conditions and delimit the vertical extent of tailings impacted soils. The step-out surface soil samples used to delimit the extent of the tailings-impacted area include locations 11A through 11G, 11Q, 11S, and 11T. The arsenic concentrations among the definitive samples along the lake range from 6.5 to 811 mg/kg (at location 11X), with an average of 459 mg/kg. The arsenic concentrations among the step-out samples range from 6.6 to 38.4 mg/kg (at location 11B), with an average of 12.8 mg/kg. These higher elevation arsenic concentrations are similar to reference area concentrations.

In the Deposition Area and around Lost Lake, the extent of contamination from the Lava Cap Mine is based on a review of arsenic concentrations in step-out sample locations collected along the slopes above the Deposition Area and upgradient from Lost Lake. For these upslope sample locations, arsenic is consistently very low (generally less than 25 mg/kg) in all samples collected above elevation 2,468 feet above msl (see the detailed elevation contours shown on Figure 4-8). Thus, it is assumed that the peak water elevation during the 1997 flood event in this area was just below 2,468 feet above msl. Using this elevation (and actual sample results at specific locations) to represent the extent of mine-related impacts, the size of the impacted area is delineated on Figure 4-8.

Besides arsenic, the other constituents where maximum concentrations exceed PRGs and reference area values are aluminum, cadmium, and manganese (Table 4-29). All other constituents are detected, typically in all 45 samples, but at concentrations below PRGs.

Table 4-30 shows summary statistics for the subsurface soil samples (18) collected from soil borings (hand-augered and drilled) in the Deposition Area. The locations of borings where subsurface samples were collected include 13A through 13F (hand auger locations) and 13Q and 13R (drilled locations). All soil boring locations are shown on Figure 3-6. The hand auger samples range from 3 to 10 feet bgs. Boring 13Q was sampled down to 25.5 feet bgs, and boring 13R was sampled down to 15 feet bgs.

Subsurface soil sample arsenic concentrations range from 719 to 2,480 mg/kg, with an average concentration of 1,434 mg/kg. Arsenic concentrations do not appear to attenuate with depth below the ground surface and are similar between the hand auger and drilled boring sample groups. The deepest subsurface soil sample (25 to 25.5 feet bgs at location 13Q) has an arsenic concentration of 875 mg/kg. The deepest sample at location 13R (10 to 15 feet bgs) has an arsenic concentration of 912 mg/kg. These results indicate that tailings-impacts are likely present in essentially all the soil/sediment present in the Deposition Area and Lost Lake. The subsurface soil sample results also confirm that, in addition to the 1997 flood event, there have been significant releases over an extended period of time.

The only constituent besides arsenic to exceed PRGs in the Deposition Area subsurface soil samples is cyanide. Seventeen of the 20 constituents are present in all 18 subsurface samples.

4.6.2 Sediment

Table 4-31 provides the summary statistics for all constituents analyzed in sediment in the Deposition Area and Lost Lake Area. As is shown in Table 4-31, 24 sediment samples were collected in this area. All sample locations are shown on Figure 3-6.

Insert Figure 4-8 (11x17 color)

Figure 4-8 (backside)

Insert Table 4-30 (8.5x11- one page)

Insert Table 4-31 (8.5x11- one page)

Four of the sediment samples were collected in the CC channel in the Deposition Area (locations 14A through 14D). Six samples (including one field duplicate) were collected in proximity to the Deposition Area pools and other recently flooded areas in the Deposition Area (locations 15A through 15E). Eight samples (including two field duplicates) were collected over two rounds in shallow sediment areas in Lost Lake (locations 17A through 17D). Six samples were collected over two rounds in deep sediment areas in Lost Lake (locations 18A through 18C).

Arsenic is present in all 24 sediment samples, with an average concentration of 663 mg/kg and a range of 228 to 1,140 mg/kg. Nearly every sample exceeds the arsenic PRG and reference area 95 percent UCL value by at least an order of magnitude. The distribution of arsenic in sediment (and surface soil) samples in the Deposition Area and Lost Lake are presented on Figure 4-8.

The arsenic levels in sediment are relatively consistent among the Deposition Area pool samples (average of 751 mg/kg), the Lost Lake shallow sediment samples (average of 718 mg/kg), and the Lost Lake deep sediments (average of 670 mg/kg). The sediment collected in the CC channel in the Deposition Area has slightly lower arsenic concentrations than the other three areas, with a range of 228 to 573 mg/kg and an average concentration of 412 mg/kg. These results indicate that the more recent sediment deposition in the CC channel may contain a somewhat lower percentage of tailings relative to the other sediment accumulation areas in the LCC and CC watersheds.

With the following exceptions, all inorganic constituents had a 100-percent detection frequency in the Deposition Area and Lost Lake sediments. Thallium is detected in 22 of 24 samples; nickel is detected in 21 of 24 samples; cyanide is detected in 17 of 23 samples; and selenium is detected at a lower frequency (12 of 24 samples). Outside of arsenic, none of the other constituents are detected in excess of their respective PRGs and reference values.

4.6.3 Surface Water

Summary statistics for surface water in the Deposition Area and Lost Lake are shown in Table 4-32. The two areas are discussed separately.

The three samples from CC below the confluence with LCC (14A, 14B, and 14C) have concentrations well above the reference areas. However, inconsistent trends in concentration are observed in the downstream direction. Arsenic, barium, and mercury tend to follow the decreasing or constant trend observed in the LCC samples immediately upstream. On the other hand, beryllium, cobalt, cadmium, and manganese increase to values more typical of those in the source area at the mine. The accumulation of tailings in this area is the likely explanation for the observed increases. The downward trends are more gradual and may actually represent a steady-state condition (if more samples had been collected, this trend may have been indicated).

Several samples were collected in ponded locations in the Deposition Area (15A, 15C, 15D, and 15F). These samples contain concentrations consistent with those detected in the source area at the mine. The tailings provide a similar chemical signature at this downgradient location, suggesting that similar surface water concentrations will be found in any area where tailings are able to accumulate and remain in contact with standing water for an extended time.

Insert Table 4-32 (8.5x11- one page)

Samples collected in Lost Lake itself (16A, 16B, and 16C) contain elevated concentrations of arsenic (5.8 to 70.6 µg/L) with respect to the reference areas. Concentrations of cobalt and manganese are higher than in upstream waters of CC and above most reference concentrations. The remainder of the constituent concentrations are consistent with reference concentrations. Though diluted by winter runoff and inflow from non-impacted streams, the waters of Lost Lake are in constant contact with tailings in the sediment. This is reflected in these arsenic concentrations.

The overall distribution of arsenic in surface water at the Lava Cap Mine Site, including the Deposition Area and Lost Lake, is shown on Figure 4-4.

In addition to arsenic, antimony and thallium exceeded their respective MCL in one sample. Antimony exceeded the MCL in one of the samples from the Deposition Area permanent pond (location 15A), and thallium exceeded the MCL in CC (location 14C).

4.6.4 Groundwater

Tables 4-33 (Deposition Area groundwater) and 4-34 (residential wells in the Lost Lake vicinity) provide summary statistics for all analytes tested in groundwater in the Deposition Area and Lost Lake vicinity. Arsenic is at very high concentrations in all four Deposition Area sampling locations, but is at or below the analytical detection limit in 10 of the 11 residential wells sampled. Only Residential Well 11AA has a detection of arsenic. Further, it is only detected in one of the two samples from the well and at a concentration of less than 1 µg/L. In general, the residential wells in the Lost Lake vicinity do not contain any arsenic.

For the locations where arsenic was detected (all four locations in the Deposition Area and one residential well in the Lost Lake vicinity), the average arsenic concentrations and the concentration range detected are presented in Table 4-35.

In the Deposition Area, Monitoring Wells 13Q and 13R have average arsenic concentrations of 323 and 2,320 µg/L, respectively. Groundwater grab samples from Soil Borings 13A and 13B contain 2,410 and 841 (estimated) µg/L arsenic.

All four of the Deposition Area sample locations drew on groundwater from tailings-dominated sediments and not from the Pms aquifer in which residential wells are screened. The residential wells closest to the Deposition Area, 11AG and 11AI, have no detectable arsenic. In addition, the pH values measured in these residential wells (4.5 –5.4) are significantly different from those in the Deposition Area samples (6.5 – 7.2). This suggests there may be little hydraulic communication between the unconsolidated tailings/alluvium and the underlying Pms bedrock in this area. Additional data collection is necessary to support this conclusion. Further discussion of geochemistry is provided in Section 5.2.1.

The overall distribution of arsenic in groundwater at the Lava Cap Mine Site, including the Deposition Area and residential wells in the Lost Lake vicinity, is shown on Figure 4-7.

There are MCL exceedances for three other constituents, besides arsenic, in the Deposition Area groundwater grab samples (locations 13A and 13B): aluminum, antimony, and cyanide (Table 4-33).

Insert Table 4-33 (8.5x11- one page)

Insert Table 4-34 (8.5x11- one page)

TABLE 4-35
Detected Arsenic Concentrations in Deposition Area Groundwater and Lost Lake Vicinity Residential Wells
Lava Cap Mine, Nevada County, California

Location[1]	Number of Samples	Concentration Range[2] (µg/L)	Average Concentration (µg/L)	Groundwater Source[3]
11AA	2	<0.4 - 0.64	0.42[4]	Pms
13A	1	2410		MD
13B	1	841 J		MD
13Q	2	235 – 411	323	MD
13R	3	2,180 – 2,430	2,320	MD

Notes
[1] Wells not listed did not contain detectable or confirmable concentrations of arsenic.
[2] Results are from unfiltered samples.
[3] Pms Paleozoic Metasedimentary Rock (assumed for Residential Well 11AA).
[4] Assumed one-half detection limit for non-detect sample in computing average.
MD mine deposits (tailings with some natural alluvium); overlie Pms.
J estimated value.

In the residential wells, the only MCL exceedance is for lead in one sample from Well 11AA (Table 4-34). This single lead exceedance appears to be anomalous.

4.6.5 Air

Ambient air samples were collected at two locations in the Deposition Area (13G and 13H), sampled during November 1999 and May 2000. An ambient air sample was also collected at one location one the Lost Lake Dam (19D). This location was sampled in November 1999. Sample locations are shown on Figure 3-6.

Table 4-36 provides a summary of results for ambient air sampled in the Deposition Area at locations 13G and 13H. Laboratory results indicate that arsenic concentrations are below detection limits in all four air samples collected in the Deposition Area. Both cadmium and cobalt are quantified in one of the four samples with reported concentrations of 0.0066 and 0.0062 $\mu g/m^3$, respectively. At this concentration, cadmium exceeds the PRG level of 0.0011 $\mu g/m^3$. Other analytes detected in this area are antimony and nickel. Antimony is in three of the four samples, with a maximum concentration of 0.0091 $\mu g/m^3$. Nickel is in only one of the four samples at a concentration of 0.033 $\mu g/m^3$, which exceeds the ambient air PRG of 0.004 $\mu g/m^3$.

As shown in Table 4-37, four analytes are detected at location 19D: cobalt, nickel, calcium, and lead. Cobalt has a measured concentration of 0.046 $\mu g/m^3$, which exceeds the ambient air PRG of 0.021 $\mu g/m^3$. Nickel, with a detected concentration of 0.028 $\mu g/m^3$, also exceeds the ambient air PRG. Detected calcium and lead concentrations at this location are 0.85 and 0.0070 $\mu g/m^3$, respectively.

Insert Table 4-36 (8.5x11- one page)

Insert Table 4-37 (8.5x11- one page)

The limited number of samples collected and the lack of conditions that would be expected to produce higher analyte concentrations (e.g., high wind gusts, dry soils, significant earth moving activity) make it difficult to confirm whether or not there is potential for significant transport of contaminants via airborne particulates. Additional sampling during drier, windier conditions is necessary to provide more definitive ambient air results. As noted previously, the HHRA uses surface soil data and air transport formulas to estimate risk via inhalation.

4.7 Downgradient of Lost Lake

Clipper Creek flows over the Lost Lake Dam and continues approximately 1,000 feet downstream, where it joins with Little Greenhorn Creek. Milky white water was reportedly flowing over the Lost Lake Dam during the 1997 flood event. This indicates that some of the suspended tailings did flow past the dam to downgradient locations. The degree of flooding beyond the CC banks in the downgradient locations has not been estimated. During much of the year, very little water (or no water during the late summer to fall time period) flows over the spillway of the Lost Lake Dam. However, there is a continuous flow of water from an active seep at the base of the dam that contributes flow to the CC channel downgradient of the dam.

Samples of soil, sediment, and surface water were collected downgradient of Lost Lake and analyzed for metals, cyanide, and general minerals (surface water only) to assess the impacts of mine-related contamination below Lost Lake. For areas downgradient of Lost Lake, the primary human health and ecological risk driver is arsenic. Additional ecological risk drivers include cobalt, mercury, manganese, and selenium. Soil, sediment, and surface water results are discussed in following sections.

4.7.1 Soil

Three surface soil samples (including one field duplicate) were collected in two separate locations (19H and 19I) outside the CC channel in the area downgradient of Lost Lake. Sample locations are shown on Figure 3-5. Table 4-38 provides the summary statistics for all analytes tested in the surface soil samples downgradient of Lost Lake.

Arsenic is present in all three samples at the following concentrations: 276 and 261 mg/kg at location 19H and 673 mg/kg at location 19I. The difference in arsenic concentration is likely due to the relative position of these two sample locations with respect to the CC channel. Location 19H is well outside of the CC channel in a flat area that appears to be subject to infrequent inundation. Location 19I is located immediately adjacent to the CC channel and is likely to be inundated on a more frequent basis than location 19H. The distribution of arsenic in surface soil and sediment across the entire Lava Cap Mine site, including the area downgradient of Lost Lake, is presented on Figure 4-2.

All inorganic constituents, except selenium, which is non-detect, are present in all three surface soil samples. However, only arsenic exceeds PRGs and reference concentrations.

Insert Table 4-38 (8.5x11- one page)

4.7.2 Sediment

Table 4-39 provides a summary of statistics for all analytes tested in sediments in the CC and LGC channels downgradient of Lost Lake. Seven sediment samples (including two field duplicates) were collected at five locations (19A through 19C and 19G in CC, and 19E in LGC below its confluence with CC). These sample locations are shown on Figure 3-5.

Arsenic is detected in all seven sediment samples at concentrations ranging from 38.5 to 2,110 mg/kg, with an average concentration of 753 mg/kg (Table 4-34). All seven samples exceed the PRG and reference area UCL value. Arsenic concentrations are highest at the base of the Lost Lake Dam at locations 19B (2,110 mg/kg) and 19G (2,060 mg/kg). Arsenic concentrations are lower in the central portion of the CC channel below Lost Lake, as indicated by the two samples from location 19C (382 and 440 mg/kg). Arsenic concentrations declined further at location 19A (176 mg/kg), just above the CC/LGC confluence.

Arsenic concentrations are reduced even more below the CC/LGC confluence. The two samples from location 19E have arsenic concentrations of 38.5 and 63.4 mg/kg. In comparison, the arsenic concentration at location 20 (a Reference Area 3 location upstream on LGC from its confluence with CC) is 10.1 mg/kg. The distribution of arsenic in sediment and surface soil at the Lava Cap Mine site, including the area downgradient of Lost Lake, is presented on Figure 4-2.

Sediment results indicate that arsenic concentrations attenuate to relatively low levels moving downstream from the Lost Lake Dam and into the LGC watershed. However, the levels detected do exceed the PRG and indicate that LGC may have some low-level impacts from Lava Cap Mine-related contaminants. The potential for accumulation of mine-impacted sediments further down the LGC drainage will be assessed in supplemental sampling.

In addition to arsenic, 15 other inorganic constituents are detected in all 7 sediment samples from the area downgradient of Lost Lake. Of these, only manganese in the samples from the base of Lost Lake Dam, exceeds its PRG. Cyanide and selenium are present in five of seven samples, and vanadium in six of seven samples. Cyanide exceeds the PRG in one sample (location 19B from the base of Lost Lake Dam).

4.7.3 Surface Water

Summary statistics for surface water samples downgradient of Lost Lake (locations 19A, 19B, 19C, and 19E) are provided in Table 4-40. The sample locations are shown on Figure 3-5. The highest concentrations for most constituents are found at location 19B, located at the base of the Lost Lake Dam. Continuous seepage from beneath the dam occurs at this location. This seepage likely comes from a combination of deep percolation of the water in the south lobe of Lost Lake through the accumulated sediments or from water flowing laterally through the tailings/sediment at the contact with the underlying native formation. These waters pass through the tailings-impacted sediments in the Deposition Area and Lost Lake and seep through the Lost Lake Dam, carrying a dissolved contaminant load that eventually merges with the CC channel.

Insert Table 4-39 (8.5x11- one page)

Insert Table 4-40 (8.5x11- one page)

Arsenic concentrations average 36 µg/L throughout the area below Lost Lake, including a peak concentration (70.3 µg/L) at the base of the dam that exceeds the MCL. The arsenic concentration of 15.9 µg/L in the furthest downstream sample (19E on LGC) is the lowest of any non-reference area surface water sample collected during the RI field program. However, this concentration and those at location 19A confirm that there is continuous loading of arsenic from the Lava Cap Mine Site mine into the LGC drainage. The overall distribution of arsenic in surface water at the Lava Cap Mine Site is presented on Figure 4-4.

Concentrations of many other constituents are elevated in the upstream portion of this reach (near the Lost Lake Dam), but concentrations at the furthest downgradient location (19E) are generally consistent with reference levels.

4.8 Biota Sampling Results

This section briefly summarizes arsenic results from biota sampling conducted in Round 3 of the Lava Cap Mine RI field program. The summary does not attempt to interpret the data or describe what the results mean in terms of potential impacts to ecological receptors. This detailed data evaluation was performed for the ERA, included as Appendix F and summarized in Section 6.2. The ERA also provides a discussion of additional contaminants of potential environmental concern besides arsenic. The six types of biota analyzed include fish, aquatic invertebrates, frogs, terrestrial plants, terrestrial invertebrates, and small mammals.

4.8.1 Fish

As shown in Table 4-41, arsenic is detected in all 13 fish samples collected. The highest concentrations are in LCC (average of 33.0 mg/kg; maximum of 36.9 mg/kg). The next highest concentrations are in CC below Lost Lake (average concentration of 13.9; maximum of 21 mg/kg). Arsenic results for Lost Lake average 9.4 mg/kg, with a peak of 14.5 mg/kg.

Arsenic concentrations in all three of these areas are in excess of those detected in Reference Area 3 –Little Greenhorn Creek (average concentration of 1.2 mg/kg and a maximum of 1.5 mg/kg).

For the ERA (Appendix F), Hazard Quotients (HQs) for fish were calculated on the basis of median, 90th percentile, and maximum whole-body concentrations of COPECs measured in fish collected from LCC, Lost Lake, Clipper Creek Below Lost Lake, and Reference Area 3 (Little Greenhorn Creek). As available, the median, 90th percentile, and maximum whole-body fish concentrations were compared to literature-based whole-body fish No Observed Effect Concentrations (NOECs) and Lowest Observed Effects Concentrations (LOECs). Exceedance of a NOEC indicates that risk is possible, although it becomes more unlikely if only the 90th percentile or maximum concentration is exceeded. If the maximum concentration exceeds the LOEC, risk is also possible. in contrast, if the 90th percentile or median concentration exceeds the LOEC, risk is likely or high, respectively.

Median, 90th percentile, or maximum whole-body fish concentrations in all areas, including Reference Area 3, exceeded at least one literature-based whole-body benchmark for at least one COPEC. The following summarizes the arsenic results. Complete assessment of all COPECs is included in the ERA.

Insert Table 4-41 (8.5x11- three pages).

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Table 4-41 – Page 2

Figure 4-41 (pg. 3)

For arsenic, the median, 90th percentile, and maximum values at all Lava Cap Mine Site areas exceeded the NOEC, whereas only the 90th percentile and maximum values slightly exceeded the NOEC at Reference Area 3. Non-exceedance by the median value and low HQs for other values indicate that possible risk from arsenic at Reference 3 is unlikely.

Risk from exposure to all other COPECs that exceeded the NOEC is considered to be possible, although only the COPECs that exceeded both the NOEC and LOEC were carried forward to the weight-of-evidence analysis.

Median, 90th percentile, and maximum whole-body concentrations were also compared to literature-based LOECs. Exceedance of the LOEC indicates probable risk, but is also dependent on the concentration. Median, 90th percentile, and maximum whole-body concentrations of arsenic exceeded the LOEC in all areas sampled.

4.8.2 Aquatic Invertebrates

Results for all analytes in the 19 aquatic invertebrate samples are shown in Table 4-42. Table 4-42 indicates that arsenic is detected in all 19 samples. The arsenic concentrations in aquatic invertebrates from Lost Lake, LCC, and CC below Lost Lake are two to three orders of magnitude higher those detected in reference areas. Highest concentrations are in Lost Lake (average of 517 mg/kg; maximum of 1,140 mg/kg). The reference area arsenic concentrations are generally in the 0.5 to 3 mg/kg range.

4.8.3 Frogs

Frogs were sampled only from the adit discharge pond area (two samples). The results of these two samples are presented in Table 4-43. Arsenic concentrations in these two samples are quite variable (73 mg/kg and 4,160 mg/kg). Although no frog samples were collected from reference areas for comparison, the peak arsenic concentration detected in the frog sample from the adit discharge is higher than any other biota sample from the RI.

4.8.4 Terrestrial Plants

Results for all analytes in the 19 terrestrial plant samples are shown in Table 4-44. Table 4-44 shows that arsenic is present in two of the four plant samples from reference areas, with a maximum concentration of 0.3 mg/kg. Arsenic is present in all 15 of the samples from the mine, LCC, Lost Lake/Deposition Area, and downgradient of Lost Lake areas. However, concentrations generally are less than 1 mg/kg. Peak concentrations are highest in the mine area (7.8 mg/kg) and Lost Lake/Deposition Area (2.8 mg/kg).

4.8.5 Terrestrial Invertebrates

Because of difficulties encountered obtaining required sample volumes, fewer samples of terrestrial invertebrates were taken than were originally planned. A total of nine samples were collected (results are summarized in Table 4-45). Three reference area terrestrial invertebrate samples were taken, with arsenic detected in all three at concentrations ranging from 2.3 to 10.7 mg/kg. Arsenic concentrations in the sample from the mine area (53.1 mg/kg) and the two from the Deposition Area (22 and 57.6 mg/kg) are well above the reference area concentrations. The single sample from along LCC has an arsenic

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Table 4-42 page 2

Figure 4-42 (pg. 3)

Figure 4-42 (pg. 4)

Insert Table 4-43 (8.5x11- one page)).

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Insert Table 4-44 (8.5x11- Five pages).

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Table 4-44 pg 3

Table 4-44 pg 4

Table 4-44 page 5

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Table 4-45 page 2

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Insert Table 4-45 pg. 4

concentration (9.7 mg/kg) similar to the reference levels. One of the two samples from downgradient of Lost Lake has a concentration consistent with reference levels (8.3 mg/kg), while the other is higher (18.4 mg/kg). Overall, the terrestrial invertebrate samples are not as elevated above reference levels as the other biota.

4.8.6 Small Mammals

Samples of small mammals were collected from Reference Area 1, the mine area, along LCC, and in the Deposition Area (Table 4-46). A total of 18 small mammal samples were taken; arsenic is detected in all 18. The five reference area concentrations are very consistent, ranging from 0.6 to 1 mg/kg. The arsenic concentrations in samples from all other areas are higher, ranging from 5 to 23 mg/kg in the mine area samples, 5.6 to 6 mg/kg in the LCC samples, and 2.1 to 15.8 mg/kg in the samples from the Deposition Area.

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Table 4-46 page 2

Table 4-46 pg 3