

DRAFT

**PROCESS AREAS (OU-3)
REMEDIAL INVESTIGATION
WORK PLAN**

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PREPARED FOR:

Atlantic Richfield Company

4 CENTERPOINT AVENUE
LA PALMA, CALIFORNIA 90623

PREPARED BY:

**BROWN AND
CALDWELL**

3264 Goni Rd, Suite 153
Carson City, Nevada 89706
(775) 883-4118

AND

integral
consulting inc.

7900 SE 28th St, Suite 410
Mercer Island, WA 98040
(206) 957-0332

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LIST OF ACRONYMS AND SYMBOLS

ABP	Acid-Base Potential	FS	Feasibility Study
ACM	Asbestos-Containing Materials	FSAP	Field Sampling and Analysis Plan
ASHERA	Asbestos Hazard Emergency Response Act	GIS	Geographic Information System
AMSL	Above Mean Seal Level	GPR	Ground Penetrating Radar
ARAR	Applicable, Relevant and Appropriate Requirements	GPS	Global Positioning System
ARC	Atlantic Richfield Company	GRO	Gasoline Range Organics
AST	Above-ground Storage Tank	HASP	Health and Safety Plan
ASTM	American Society for Testing and Materials	HAZWOPER	Hazardous Waste and Emergency Operations
ATSDR	U.S. Agency for Toxic Substances and Disease Registry	HDPE	High-Density Polyethylene
BLM	U.S. Bureau of Land Management	HFA	Hydrogeologic Framework Assessment
BTAG	Biological Technical Advisory Group	HHRA	Human Health Risk Assessment
BTEX	Benzene, Toluene, Ethylbenzene, Xylenes	HUD	U.S. Department of Housing and Urban Development
CCV	Continuing Calibration Verification	ICP-MS	Inductively Coupled Plasma-Mass Spectrometry
CD	Consent Decree	ICV	Initial Calibration Verification
CERCLA	Comprehensive Environmental, Response, Compensation, and Liability Act	IRIS	Integrated Risk Information System
CFR	Code of Federal Regulations	IVP	Individual Value Plots
COC	Chemical of Concern	JSA	Job Safety Analysis
COPC	Chemical of Potential Concern	LBP	Lead-Based Paint
CSM	Conceptual Site Model	LCS	Laboratory Control Sample
DCGL	Derived Concentration Guideline Limits	LOAEL	Lowest-Observed-Adverse-Effects Level
DMP	Data Management Plan	MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
DO	Dissolved Oxygen	MCL	Maximum Contaminant Level
DOT	Department of Transportation	MD	Metal Detection
DQO	Data Quality Objective	MDA	Minimum Detectable Activity
DRO	Diesel Range Organics	MDC	Minimum Detectable Concentration
DSR	Data Summary Report	MDL	Method Detection Limit
EMLL	Electromagnetic Line Location	MO	Motor Oil
EPA	U.S. Environmental Protection Agency	MS/MSD	Matrix Spike/Matrix Spike Duplicate
		MVEC	Mason Valley Environmental Committee

LIST OF ACRONYMS AND SYMBOLS - CONTINUED

MtBE	Methyl tertiary-butyl ether	RI	Remedial Investigation
NAD	North America Datum	RPD	Relative Percent Difference
NDEP	Nevada Division of Environmental Protection	RPM	Remedial Project Manager
NESHAP	National Emission Standards for Hazardous Air Pollutants	SLERA	Screening Level Ecological Risk Assessment
NFA	No Further Action	SOP	Standard Operating Procedure
NOAEL	No-Observed-Adverse-Effects Level	SOW	Statement of Work
NORM	Naturally Occurring Radioactive Material	STEL	Short-Term Exposure Level
NTU	Nephelometric Turbidity Units	SVOC	Semi-Volatile Organic Compound
ORP	Oxidation-Reduction Potential	SWCC	Soil-Water Characteristic Curve
OSHA	Occupational Safety and Health Administration	TBD	To Be Determined
OU	Operable Unit	TCLP	Toxicity Characteristic Leaching Procedure
PAH	Poly-Aromatic Hydrocarbons	TDS	Total Dissolved Solids
PCB	Polychlorinated Biphenyl	TENORM	Technologically Enhanced Naturally Occurring Radioactive Material
PEL	Permissible Exposure Level	TPH	Total Petroleum Hydrocarbons
PFD	Process Flow Diagram	TPH-d	Total Petroleum Hydrocarbons Diesel Range Organics
PID	Photo-Ionization Detector	TPH-g	Total Petroleum Hydrocarbons Gasoline Range Organics
PLM	Polarized Light Microscopy	TPH-mo	Total Petroleum Hydrocarbons Motor Oil Range Organics
PPE	Personal Protective Equipment	TSCA	Toxic Substance Control Act
PQL	Practical Quantitation Limit	UAO	Unilateral Administrative Order
PRG	Preliminary Remediation Goals	USCS	Unified Soil Classification System
PVC	Polyvinyl Chloride	UST	Underground Storage Tanks
QA	Quality Assurance	VLT	Vat Leach Tailings
QC	Quality Control	VOC	Volatile Organic Compound
QAPP	Quality Assurance Project Plan	WAC	Waste Acceptance Criteria
RACM	Regulated Asbestos-Containing Material	XRF	X-Ray Fluorescence
RCRA	Resource Conservation and Recovery Act		

LIST OF ACRONYMS AND SYMBOLS - CONTINUED

bgs	Below Ground Surface
Bq	Becquerels
cpm	Counts Per minute
dpm	Disintegrations Per Minute
g	Gram
gpm	Gallons Per Minute
hr	Hour
kg	Kilogram
kt	Kiloton
L	Liter
lbs	Pounds
m	Meter
mg	Milligram
mL	Milliliter
mm	Millimeter
mV	Millivolt
NaI	Sodium Iodide
pCi	Picocurie
ppb	Parts Per Billion
ppm	Parts Per Million
rem	Roentgen Equivalent Man
s	Second
t	Ton
µg	Microgram
µm	Micrometer
µR	MicroRoentgens
µR/hr	MicroRoentgens Per Hour
%	Percent

SECTION 1.0 INTRODUCTION

The Atlantic Richfield Company (“ARC”) has developed this Draft Process Areas Remedial Investigation Work Plan (“Process Areas RI Work Plan”) pursuant to the Scope of Work (“SOW”) for the Process Areas Operable Unit (“OU”), identified as OU-3 in the SOW. The SOW was attached to the Administrative Order (“Order”) for Remedial Investigation and Feasibility Study (“RI/FS”) for the Anaconda/Yerington Mine Site (“Site”). The Order was issued by the U.S. Environmental Protection Agency – Region 9 (“EPA”) to ARC on January 12, 2007 (EPA, 2007).

This Process Areas RI Work Plan is based the draft revised Conceptual Site Model (“CSM”), dated May 10, 2007 (Integral Consulting and Brown and Caldwell, 2007), currently under review by EPA, and expands previous investigations conducted as part of the *Process Areas Work Plan* dated December 15, 2003 (Brown and Caldwell, 2003). These investigations were conducted pursuant to the Unilateral Administrative Order for Initial Response Activities (UAO 0-2005-2011) issued by EPA to ARC in 2005 (precursor to the 2007 Order). Data from these investigations were presented in two data summary reports: *Data Summary Report for Process Areas Groundwater Conditions* (Brown and Caldwell, 2005a) and *Data Summary Report for Process Areas Soils Characterization* (Brown and Caldwell, 2005b). Radiological components of this Process Areas RI Work Plan, specified in Task 1.3.4 of the SOW, are: 1) based on portions of the *Radiological Data Compilation* for the Site dated December 15, 2005 (Brown and Caldwell, 2005c); and 2) in conformance with the “Multi-Agency Radiation Survey and Site Investigation Manual” (“MARSSIM”) EPA402-R-97-016/NUREG-1575 (EPA, 2000).

This Process Areas RI Work Plan is focused on the continued characterization of soils, groundwater and physical structures with the integrated objectives of: 1) developing remedial action alternatives that will support appropriate re-use of the Process Areas portion of the Site; 2) providing sufficient data for the assessment of human health and ecological risk associated with

the Process Areas; and 3) evaluating groundwater conditions underlying the Process Areas in relation to conditions found beneath other OUs and off-Site locations pursuant to the draft *Remedial Investigation Work Plan for Site-Wide Groundwater (OU-1)* dated June 22, 2007 (Brown and Caldwell, 2007a; currently under review by EPA). A Human Health Risk Assessment (“HHRA”) Work Plan and Screening Level Ecological Risk Assessment (SLERA) Work Plan are provided as Appendices A and C, respectively.

The following study elements, specified in Section 9.0 of the SOW (EPA, 2007), provide guidance for the investigation of Process Areas soils and underlying groundwater conditions, and the characterization of other structural elements within the Process Areas:

- The Remedial Investigation shall address structures and other potential sources of contamination such as buildings, surface and subsurface concrete structures including foundations, containments, leach vats, sumps, above-ground and underground tanks, underground utilities, above-ground utilities, piping, pumps, areas of discolored or odorous soil, and areas of reported spills.
- Collect and analyze existing data, including: any information describing sources, migration pathways, human and environmental receptors; varieties and quantities of wastes disposed of; any sampling that examined physical and/or chemical characteristics; contaminant identification and respective concentrations; all precision and accuracy information; search records of disposal practices and operating procedures and manufacturing processes (such as historical photographs, topographic surveys, operational records, interviews); site-specific information on surface, subsurface, atmospheric, biotic migration pathways, geology, hydrogeology, hydrology, meteorology, ecology; background soil, water, and air quality; demographic and land use information; and common flora and fauna.
- Define structures and other potential sources of contamination, such as buildings, surface and subsurface concrete structures including foundations, containments, leach vats, sumps, above and underground tanks, underground utilities, above ground utilities, piping, pumps, areas of discolored or odorous soil, areas of reported spills.
- Characterize and assess the physical and chemical hazards associated with each of the structures on the Process Areas (including any Arimetco Facilities if available from work being conducted by EPA) including; background conditions; a geologic assessment to evaluate influence of geology on release and movement of contaminants.
- Analyze the fate and transport of each contaminant in each medium using data sufficient to define the extent, origin, direction, and rate of movement of contaminants including:

vertical and horizontal extent of contamination, contaminant concentrations, velocity and direction of contaminant movement, and a description of the contaminant and soil chemical properties and interaction.

- Assess the influence of soil on type and rate of contaminant movement through the subsurface and ultimately to the water table. Determine soil characteristics – type, holding capacity, temperature, biological activity, engineering properties. Determine soil chemistry – solubility, ion speciation, adsorption coefficients, leachability, cation exchange capacity, mineral partition coefficients, chemical and sorptive properties. Determine vadose zone characteristics – permeability, variability, porosity, moisture content, chemical characteristics, and extent of contamination.
- Determine contamination in surface water and sediments, (data shall be sufficient to define the extent, origin, direction, and rate of movement of contaminants), Surface water and sediment contamination including: the horizontal and vertical extent of contamination, direction of contaminant movement, velocity of contaminant movement, horizontal and vertical concentration contaminants, evaluation of factors affecting contaminant movement, description of the chemistry of the contaminant and surface water or sediment properties and interaction, and extrapolation of potential future contaminant movement and fate through modeling.
- Determine contamination in and under structures, piping, disposal areas, ditches, roads and railways, spill areas, low-lying areas (These data shall be sufficient to define the extent, origin, direction, and rate of movement of contaminants) and estimate overall quantity of wastes and contaminants released over time.
- Characterize the extent of contaminant migration via surface and subsurface pathways, including the identification of migration pathways, as well as any changes in each contaminant’s physical or chemical characteristics.
- Describe the contaminant fate and transport from the surface and subsurface soils, including waste lines, into the unsaturated vadose zone via migration, leaching, or volatilization, and into the ambient air via fugitive dust or volatilization.
- Identify any known or potential human or environmental receptors.
- Identify contamination sources, including a description of the location and boundaries (areal extent and vertical depth) of each potential source of contamination, its physical characteristics, chemical constituents, and concentrations, based on sufficient sampling to the detection levels established in the DQOs identified in the QAPP.
- Identify additional information, if needed, to assess risks to human health and the environment.

The Site is located near the City of Yerington, in western Nevada (Figure 1-1). The Process Areas portion of the Site is one of seven OUs specified in the SOW, which are listed in Section

1.2 and described in greater detail in Section 2.0 of this Process Areas RI Work Plan. Figure 1-2 shows the locations of the OUs and the Arimetco Facilities, which are the subject of investigations currently being conducted by EPA.

1.1 Document Organization

The remainder of Section 1.0 of this Process Areas RI Work Plan briefly describes the location and physical description of the Site (Section 1.2), previous investigations within the Process Areas (Section 1.3), and the identification of the project management team (Section 1.4). Section 2.0 provides more specific background information on the Process Areas including operational history, identification and description of processing and ancillary support facilities, and a description of solid and liquid wastes. Section 2.0 also describes elements of the revised CSM, focused on the Process Areas.

Sections 3.0 and 4.0, respectively, present a more detailed summary and interpretation of the results of the previous soils and groundwater investigations conducted within the Process Areas. An interpretation of the possible relationship between specific soils data and underlying groundwater conditions is also presented in Section 4.0. These two sections are supplemented by a number of Appendices attached to this Process Areas RI Work Plan.

Section 5.0 describes the Data Quality Objectives (“DQOs”) for the proposed field and analytical activities. The DQOs are based on the SOW elements listed above, the CSM and the interpretation of the existing soils and groundwater data provided in Sections 3.0 and 4.0. Section 6.0 presents the Field Sampling and Analysis Plan (“FSAP”) for the proposed field activities, subject to the updated Quality Assurance Project Plan (“QAPP”) and the Data Management Plan (“DMP”). The revised QAPP (ESI and Brown and Caldwell, 2007) is currently under review by EPA, and the revised version of the DMP was submitted to EPA for final review on June 25, 2007. Sections 7.0 and 8.0, respectively, address the QAPP and DMP components of the FSAP. Health and safety aspects of the FSAP are presented in Section 9.0

Section 10.0 describes how the data collected will be interpreted and presented in the RI Report for the Process Areas. Section 11.0 lists the references cited in this Process Areas RI Work Plan.

1.2 Site Location and Description

The Site encompasses approximately 3,600 acres of land disturbed by historic copper mining and processing activities located approximately one mile west and northwest of the City of Yerington in Lyon County, Nevada (Figure 1-1). The Site consists of an inactive open pit mine, waste rock piles, leached ore tailings piles, evaporation ponds, and ore processing facilities including tanks, buildings, underground utilities and remnant foundations. The SOW designated seven OUs to focus investigation and remedial activities:

- Site-wide Groundwater (OU-1);
- Pit Lake (OU-2);
- Process Areas (OU-3);
- Evaporation Ponds and Sulfide Tailings (OU-4);
- Waste Rock Areas (OU-5);
- Oxide Tailings Areas (OU-6); and
- Wabuska Drain (OU-7).

Figure 1-2 presents a preliminary map of these OUs, subject to final approval by EPA, which illustrates surface mine units as they relate to the OUs defined in the SOW. The main portion of the Process Areas, approximately 5,000 feet long and 2,000 feet wide (about 230 acres), includes processing and ancillary support facilities located in the central portion of the Site. Peripheral crushing and pumping facilities, discussed in this Process Areas RI Work Plan, are not depicted in Figure 1-2. Spatial relationships of specific Arimetco facilities (i.e., heap leach pads currently subject to remedial investigations by EPA) to the Process Areas are depicted in Figure 1-2.

1.3 Previous Investigations

Previous investigations and reports that include a discussion of the Process Areas are listed below, generally in chronological order, including several documents that were summarized in the *Radiological Data Compilation* for the Site (Brown and Caldwell, 2005c):

- Bureau of Land Management, Carson City Field Office, 2004, *BLM Yerington Mine Health and Safety Plan*. Site health and safety plan prepared for BLM employees working at the Yerington Mine Site. The health and safety plan included an Appendix that summarized radiological survey results in the Process Areas and identified several areas with elevated gamma radiation. Soil samples were collected and analyzed in several areas.
- Technical Resources Group, 2005, *Review of Yerington Mine Characterization Activities*. Consultant report prepared for BLM Nevada State Office for the purpose of checking radiation activity levels and soil chemistry in the previously identified areas in the Process Areas and other areas of the Site. The report identified a disequilibrium in uranium daughter products that may have resulted from the chemical separation and processing in the copper plant.
- U.S. Environmental Protection Agency, 2005, *EPA Radiation and Indoor Environments National Laboratory Scanner Van Survey of the Yerington Mine Site and Surrounding Areas*. A technical memorandum summarizing the data results of the scanner van radiological survey in the Process Areas and other areas on and off the mine site. Results confirmed the presence of the elevated radiological areas identified by BLM and did not find any new radiological areas in the areas covered by the survey.
- Brown and Caldwell, 2005, *Data Summary Report for Process Areas Groundwater Conditions*. Consultant report prepared for ARC, describes the lithologic character and groundwater quality data for the alluvial fan aquifer beneath the Process Areas at the Site. The report also describes the construction of three monitor wells in the Process Areas.
- Brown and Caldwell, 2005, *Data Summary Report for Process Areas Soils Investigation*. Consultant report prepared for ARC, summarizes the analytical results of 550 soil samples collected in the Process Areas in 2004 and 2005. Surface and subsurface sampling was conducted around process components, ancillary buildings, underground pipelines, electrical transformers, and areas of hydrocarbon stained soil.
- Rocky Mountain Environmental Consultants, 2005, *Final Radiological Monitoring Report, October 2004 to April 2005, Yerington Mine Site Investigation Operations*. Consultant report prepared for ARC summarizes the results of radiological health and safety monitoring in the Process Areas during field sampling activities. Includes some fugitive dust air samples collected during ground disturbance activities.

1.4 Project Management Team

The project management team consists of: EPA's Remedial Project Manager ("RPM") and advising technical staff; ARC's Project Manager and technical staff; and the Yerington Technical Workgroup which includes representatives from the BLM, NDEP and others. Technical staff supporting EPA, ARC, or other groups include, at a minimum, geoscientists, engineers, risk assessors, toxicologists, meteorologists, chemists, quality assurance specialists and field sampling personnel. The primary decision maker is EPA's RPM, who is responsible for reviewing and approving work plans and related documents, as well as providing guidance and suggestions for work plan implementation.

EPA's co-RPMs for the Site are Mr. Jim Sickles and Ms. Nadia Hollan-Burke. Technical support to the EPA is provided by Mr. Steve Acree and Dr. Robert Ford with EPA's Robert S. Kerr Environmental Research Center in Ada, Oklahoma, and by EPA's subcontractors, CH2M Hill and Tetra Tech, Inc.

ARC's Project Manager is Mr. Roy Thun, assisted by Mr. John Batchelder. Technical support is provided by Dr. Jim Chatham of ARC and staff from Brown and Caldwell, Integral Consulting, Inc., and Foxfire Scientific, Inc. Mr. Chuck Zimmerman is Brown and Caldwell's project manager, with technical support provided by Mr. Greg Davis, Mr. Guy Graening, Ms. Penny Bassett, Mr. Steve Brooks and Mr. Duane Anderson. Technical support on human health and ecological risk assessment issues is provided by Dr. Rosalind Schoof, Dr. Les Williams and Ms. Alma Cárdenas of Integral Consulting, Inc. Technical support on radiological issues is provided by Dr. Matthew Arno of Foxfire Scientific, Inc.

SECTION 2.0

PROCESS AREAS BACKGROUND INFORMATION

This section describes the Process Areas, including a detailed description of the operational history and the individual physical features (i.e., ore processing components and ancillary support structures or buildings). This section also presents a generalized description of the physical setting of the Site, including geologic and hydrogeologic conditions associated with the Process Areas based on previous investigation activities. Finally, this section presents a description of the revised CSM that is focused on the Process Areas. A process flow diagram (“PFD”) from the Anaconda Mine is reproduced in Appendix B (B-1). The PFD is consistent with EPA’s *Technical Resource Document: Extraction and Beneficiation of Ores and Minerals; Volume 4 – Copper* (EPA, 1994), which is also provided in Appendix B (B-2). Historical aerial photos of the Site, including the Process Areas, are included in Appendix C for reference.

2.1 Process Areas Operational History and Functions

The following descriptions, similar to those presented in the *Process Areas Work Plan* (Brown and Caldwell, 2003), are based on comprehensive research conducted by ARC at the Anaconda Mine archives located in Laramie, Wyoming (managed by the University of Wyoming) and the Site archives located near Yerington, Nevada (managed by the EPA).

2.1.1 Operational History

Copper in the Yerington district was initially discovered in the 1860s, with large-scale exploration of the porphyry copper system occurring in the early 1900s when the area was organized into a mining district by Empire-Nevada Copper Mining and Smelting Co. The Anaconda Mining Company (“Anaconda”) became involved in the Site when they entered into a lease agreement and acquired the claims in 1941. At that time, the Second World War placed heavy demands on metals production and, with assistance from the Federal government, Anaconda developed the ore deposit to meet the demands. The mine began producing copper in 1953, and operated until 1978, producing approximately 1.7 billion pounds of copper. Once

Anaconda divested itself of the Site, subsequent operators (e.g., Arimetco) used some of the buildings within the Process Areas for operational support, although the Anaconda-constructed processing components remained inactive during this period. The following timeline summarizes significant operational and regulatory milestones:

1907	Yerington deposit discovered by Empire-Nevada Copper Mining and Smelting
1941	Anaconda Minerals acquired the property
1951	Construction of the Weed Heights housing community
1952	Construction of the Process Areas plant site
1952	Mining activities began with stripping of overburden
1953	First ore delivered to the leaching plant
1961	Construction of Concentrator for processing sulfide ore and construction of sulfide tailings
1965	Dump leaching of low-grade ore began
1967	Expansion of Concentrator to double capacity
1977	Atlantic Richfield purchased the Site from Anaconda
1978	ARC shut down all mining and processing operations and sold all holdings to Don Tibbals
1979	Unison leased building space in the Process Areas for refurbishing transformers
1982	CopperTek leased the Site for reprocessing tailings using heap leaching and solvent extraction/electrowinning (“SX/EW”)
1988	Don Tibbals sold the Site to Arimetco who took over all heap leaching and processing facilities
1997	Arimetco filed for bankruptcy protection
1999	Arimetco abandoned operations and the Site fell under NDEP emergency management
2005	EPA assumed regulatory oversight responsibilities for the Site
2007	EPA issued the Order to begin the RI/FS process

2.1.2 Description of Process Components and Operations

Processing operations, including volumes and concentrations of materials, changed over time throughout the mine life. General descriptions of Anaconda’s mining and processing activities are provided in this section but the values and tonnages provided are approximate. A representation of the generalized process flow diagram is provided in Appendix B (B-1).

Mining

Anaconda conducted mining only in the main Yerington Pit from the period between 1953 and 1978. Categories of material removed from the pit included: 1) oxide ore; 2) sulfide ore; 3) low-grade dump leach oxide ore; 4) low-grade sulfide ore; and 5) waste rock/overburden. Mining was conducted using electric and diesel shovels, bulldozers, scraper, and 25 ton haul trucks (U.S. Bureau of Mines, 1958). By 1972, approximately 70,000 tons per day were mined, including 28,000 tons of oxide and sulfide ore, 28,000 tons were low-grade dump leach ore, and 14,000 tons of overburden/waste rock. Mined ore characteristics in 1972 were also described by Skillings Mining Review (1972) as follows:

- ore containing >0.3 percent copper was delivered to the primary crusher for plant leaching;
- the overall average grade of oxide ore was 0.55 percent copper and sulfide ore was 0.6 percent copper;
- low-grade oxide ore containing 0.2 to 0.3 percent was delivered to the W-3 dump leach, located just south of Burch Drive, where it was operated as a heap leach system; and
- low-grade sulfide ore was stockpiled in the S-32 area, southeast of the Burch Drive bridge, for possible future treatment.

The open pit was mined in 25-foot benches with a 45 degree pit wall slope. Final dimensions of the mined pit were approximately 6,200 feet long, 2,500 feet wide and 800 feet deep. Groundwater was encountered at approximately 100 to 125 feet below ground surface, and deep wells were installed along the eastern perimeter of the pit to de-water the fractured bedrock as the depth of the pit increased. Water was pumped from these wells at a rate of about 900 gallons per minute (gpm), and the water was used for Weed Heights housing and plant operations (U.S. Bureau of Mines, 1958).

Crushing and Grinding

All oxide and sulfide ore was crushed prior to leaching or processing in the plant. Crushing was a two step process for the oxide ore and a three step process for sulfide ore. All ore underwent coarse crushing in the Primary Crusher which was a 54-inch gyratory crusher that reduced the ore

to 5 inches or less. Coarse ore exited the crusher onto the No. 1 conveyor and was stored in the oxide and sulfide Coarse Ore Storage. Coarse ore was transported to the Secondary Crusher by the No. 2 conveyor and was further reduced in size to 7/16-inch using standard and short-head cone crushers. Fine oxide ore exited the Secondary Crusher through an underground conveyor (No. 6 conveyor) to the Sample Tower where a sample was collected for assay and water was sprayed onto the crushed ore to agglomerate fine material as well as control dust (U.S. Bureau of Mines, 1958 and Anaconda, 1954).

Sulfide ore underwent additional crushing at the Sulfide Ore Crushing and Stockpile area located at the northwest end of the Vat Leach Tanks. Fine grinding of the sulfide ore to a grain size between 20- and 200-mesh particle size was necessary for use in the floatation process, and was accomplished using several rod and ball mills in sequence (Skillings Mining Review, 1972).

Leaching (Oxide Ore)

Oxide ore was loaded into the Vat Leach Tanks by conveyor and overhead loading bridge with the agglomerated ore from the Secondary Crusher. The ore was bedded into a tank in a manner to prevent segregation and allow uninhibited circulation of leach solutions within the tank. Each tank had a capacity to hold approximately 12,000 dry tons of ore and 800,000 gallons of solution when filled to within 6 inches from the top. The vats typically operated on a 96-hour (5-day) or 120hour (6-day) leaching cycle, with an additional 32- to 40-hour wash period, and 24 hours required to excavate and refill. The entire cycle required approximately 8 days, therefore 8 leach vats were installed and used to maximize efficiency (U.S. Bureau of Mines, 1958).

Once the ore was bedded into the tanks, sulfuric acid leach solution was added to cover the ore. The initial concentration of acid during this conditioning period was 20 to 30 grams per liter (g/l), which was re-circulated through the tanks for 3 or more hours by drawing it off the bottom and air-lifting it to the top of the tank until the acid content dropped to 0 to 2 (g/l). The reinforced-concrete bottoms of the tanks were covered with timbers and cocoa matting as a filter to allow bottom drainage of solutions. Solutions were re-circulated and pumped at a rate of

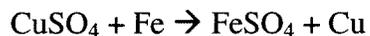
2,000 gpm. The pregnant solution from the conditioning leach was pumped off to one of the two 286,000-gallon Solution Storage Tanks and new solution was transferred from the previous vat while acid was added to bring it up to the desired leaching strength of 40 to 60 g/l. This solution was re-circulated and then transferred to the next vat. This cycle continued for four or five leaching periods.

After leaching, the ore underwent three wash cycles which primarily used discharge water from the Peabody scrubber in the Acid Plant as well as fresh water from the supply well and leach final drain water (Anaconda, 1954). Approximately 1.4 million gallons of water were used per day for leach wash water.

Spent ore, known as oxide tailings or vat leach tailings (“VLT”) was excavated from the Vat Leach Tanks by a clamshell digger mounted on a rolling overhead gantry crane which could position over any of the eight tanks. The digger would drop the leached ore into a hopper under which 25-ton end-dump trucks would drive, receive a load, and then haul the waste material to the oxide tailings or VLT pile (collectively comprising OU-6). The average time to excavate one tank was 16 hours at a rate of 40 truckloads per hour.

Cementation/Precipitation (Oxide Ore)

Copper was recovered from the leach solution by precipitating (i.e., “cementing”) the copper using scrap iron by means of the following chemical conversion:



The Precipitation Plant was divided into five separate banks or individual cells: 1) Primary, 2) Secondary, 3) Stripping/Settling, 4) Scavenger, and 5) Dump Leach. These banks of cells were operated in the following ways (Jacky, 1967 and Anaconda, 1954):

1. Primary Bank. 90,000 pounds of new scrap iron were loaded into each cell. Pregnant solution, with a concentration of approximately 15 to 25 g/l copper and 4-5 g/l sulfuric acid, was pumped through 4” plastic pipes sunk into the concrete bottoms of the launder tanks and percolated upwards through the iron, overflowing to a weir box on the north

east side at a rate of 700 to 900 gpm. The overflow solution discharged to the recirculation sump at the northwest end of the precipitation tanks where it was re-circulated back to the secondary bank. Re-circulation continued for four days, followed by the washing, removal and drying of the copper cement.

2. Secondary Bank. 90,000 pounds of new scrap iron was added to each cell. Solution discharged from the primary bank was re-circulated through the iron in the same manner as the primary bank. Solutions were re-circulated for five days at a pumping rate of 900 to 1,000 gpm, and then washed and excavated. Discharge solutions from the secondary bank were sent to the stripping/settling bank.
3. Stripping/Settling. This section was operated as pairs of tanks where the stripping tank contained iron and the settling tank did not. Solutions entering the stripping tank came solely from the secondary bank where additional copper was removed from the solutions prior to disposal. Solutions were re-circulated through these tanks for approximately 15 days. Final solutions from this area were sent to the Spent Solution Sump, and then ultimately returned to the Acid Plant for use as a slurry agent to wash the calcines from the acid plant to the evaporation ponds (Anaconda, 1954).
4. Scavenger. The purpose of the scavenger was to consume unused iron that was removed from the other precipitation banks after washing and separation in a trommel. Typically the residual iron was much finer and the precipitates form a dense mass. At some point, non-digestible residual material was removed from the system and discarded.
5. Dump Leach Primary and Secondary. Leach solution from the low-grade dump leach was kept entirely separate from the tank leach solutions so that the process waste water could be reused. Dump leach precipitation operated similarly to the vat leach operation, and was initiated in 1965 (Mining Engineering, 1967). These solutions were re-circulated from the dump leach primary to the dump leach secondary through a separate dump leach recirculation sump. Spent solutions were stored in the Dump Leach Surge Pond (KK) and were available for reuse in the plant. Areas of reuse have not been determined.

Following the cementation steps described above, all copper cement product was washed in place, then excavated by overhead gantry crane with clamshell digger, and dropped into the trommel hopper located at the southeast end of the precipitation tanks where it was further washed and the unused scrap iron separated from the copper cement. The copper cement was loaded onto hotplates for drying prior to shipment. The hotplates were large flat drying surfaces that were heated underneath by propane gas to dry the material to approximately 12 percent moisture (Skillings Mining Review, 1972). The copper cement product averaged 83 percent copper, which was hauled by trucks to the Wabuska rail spur and, eventually, to the Washoe Smelter in Anaconda, Montana for final smelting to a pure copper product.

Concentrator (Sulfide Ore)

A froth floatation system was constructed in 1961 for the purpose of processing sulfide ore from the Yerington Pit. Floatation separation was accomplished by mixing very finely ground ore (pulp) with water and a chemical (typically xanthate) to make the sulfide mineral hydrophobic and then sparging air and a surfactant chemical (typically pine oil) through the mixture to create a froth. The actual chemicals used in the Yerington concentrator have not been determined. The sulfide minerals in the pulp attached to the air bubbles in the froth mixture which collects on the surface of the aeration tank in the rougher floatation circuit and are skimmed off as concentrate.

The Yerington concentrator was designed to take this initial concentrate, separate the solids in a 75-foot diameter thickener, and re-grind the thickened solids to an even finer pulp size of minus 325 mesh (<44 microns). This re-ground material was sent through a scavenger floatation circuit, a cleaner circuit and a re-cleaner circuit. The final concentrate was thickened in a 50-foot diameter thickeners and the thickened concentrate was dewatered using a vacuum filter and then dried in a 24-foot rotary dryer. The finished concentrate averaged 28 percent copper, which was hauled by trucks to the Wabuska rail spur and, eventually, to the Washoe smelter in Anaconda, Montana for final smelting to a pure copper product. (Skillings Mining Review, 1972).

Excess pulp after the floatation separation was disposed in the sulfide tailings as a slurry mixture of solids and water. Operation of the concentrator required approximately 3,000 gpm of water, which was obtained from groundwater production wells and recycled water from decanting the sulfide tailings and other plant operations (Skillings Mining Review, 1972).

Sulfuric Acid Production

Sulfuric acid was produced at Yerington in the Fluosolids and Acid Plant from raw sulfur ore shipped to the Site from the Leviathan Mine located in Alpine County, California. The production of sulfuric acid from sulfur ore can be broken down into 5 steps: (1) crushing, (2) grinding, (3) roasting, (4) dust precipitation, and (5) contact acid plant. The final product was

93 percent sulfuric acid that was used in the tank leach and the dump leach of the oxide ore. A summary of the steps used in acid production are provided below (Anaconda, 1954 and U.S. Bureau of Mines, 1958):

1. Crushing. Two stage crushing was completed using a jaw crusher and short-head crusher to reduce the sulfur ore to minus one inch.
2. Grinding. Rod mills were used to further reduce the ore to minus 10 mesh (<2 mm) for feed to the fluosolids roaster.
3. Roasting. Fluosolid roasters were used to roast the sulfur ore, and drive SO₂ gas from the ore, which would then be converted to sulfuric acid in the subsequent steps. The ore was bedded into an 18-foot wide by 25-foot high reactor lined with insulating and fire brick. The bed of material was maintained at five feet and fluidizing air heated by propane was circulated to heat the ore to a temperature of 1,100°F to oxidize the sulfur. The burned ore or “calcines” were removed from the bottom of the reactor and disposed of in the evaporation ponds conveyed in the Calcine Ditch (WW) using spent solution pumped from cementation to sluice the solids to the ponds.
4. Dust Precipitation. Gases leaving the reactor contained 10 to 12 percent SO₂ which were cooled, and sent through the Peabody scrubber and Cottrell electrostatic precipitator to remove dust. Precipitates were collected at a rate of about 800 pounds per day and contained 30 to 40% selenium with silica. Water from the scrubber was recycled and used as wash water in the leaching vats (U.S. Bureau of Mines, 1958). Selenium precipitates were sold and shipped off-site several times per year.
5. Contact Acid Plant. The SO₂ gas entered the contact acid plant by going through a primary and secondary converter where the SO₂ was converted to SO₃. The SO₃ gas then went through a heat exchanger and the adsorption tower where it was contacted with 98 percent sulfuric acid resulting in a diluted 93 percent sulfuric acid product for use in the plant. Approximately 450 tons of 93 percent sulfuric acid was produced per day from 600 tons per day of raw sulfur ore.

2.1.3 Description of Ancillary Support Facilities

Truck Maintenance

All mine vehicles and equipment were serviced on-site in the Truck Shop and other support buildings such as the Wash Rack, Grease Shops, Tire Shop, and Equipment Garage. Descriptions of vehicle maintenance activities and practices have not been found in historical mine records so the following descriptions are based on visual observations at the Site and standard mine practices.

Anaconda maintained a fleet of 30 or more 25-ton haul trucks which were used for hauling ore from the pit to the primary crusher, hauling spent ore from the leach tanks to the VLT pile, and hauling sulfur ore to the acid plant crusher. Additional road trucks were used for hauling copper cement and concentrate to the Wabuska rail spur and hauling scrap iron back from Wabuska to the plant. Based on historical photos, it appears that the fleet was likely parked in the current location of the Equipment Garage (L) where daily vehicle fueling and greasing would have been conducted by a mobile “grease truck”. More extensive maintenance activities such as motor repair and oil changes would have been conducted inside the Truck Shop. Tanks located inside the north end of the Truck Shop likely contained fresh motor oil and other vehicle fluids, and used motor oil was collected and stored in the Used Oil Tank.

Documentation of the final disposition of the used oil has not been found, but it is possible that it was used on the mine and plant roads as a dust suppressant. In addition, uncertainty associated with where floor drains in the Truck Shop drain to, and what types of fluids may have drained, exists. One historic piping diagram shows a drain line labeled “grease pit drain” exiting the north end of the building heading towards the Lower Truck Sludge Pond but the terminus of the drain is off the map.

The Wash Rack is an open concrete area with a sloping floor that collects in a drain sump on the north side and appears to drain to the Upper Truck Sludge Pond (BBB). The wash rack was likely used for hosing off and steam cleaning a variety of mine vehicles and equipment and may have included the use of degreaser soaps or solvents. Drainage from the Wash Rack is the likely source of hydrocarbon contamination found in the Upper Truck Sludge Pond.

Mine excavators, including the digging shovels, dozers, and scrapers, would likely have remained in the pit at all times and would have been serviced by the mobile grease truck in the pit, rather than traveling back to the Process Areas.

Laboratory Services

One primary, and a possible secondary, location in the Process Areas was established for laboratory analysis of mined materials for grade control and waste rock management. The south end of the Warehouse and Assay Lab Building was used as an assay lab, presumably for analysis of rock samples from the mine. Process control samples such as leach solutions, precipitation solutions, and copper cement and concentrates, were also likely analyzed in this lab area. Evidence of sample crushing and drying can be found in the building (e.g., sinks and hood vents indicate that wet chemistry analytical procedures such as sample digestion and atomic absorption were conducted).

Historical maps show a drain line exiting the lab portion of this building to a “dry well” located approximately 50 feet from the southeast corner of the building. It is possible that laboratory wastes were disposed in this dry well. A second lab area was potentially located in the northwest corner of the Change House, based on the observation of a large hood vent (approximately four feet by four feet). The precise purpose and use of this lab area has not been determined.

2.2 Descriptions of Sub-Areas and Associated Features

The process components and ancillary support facilities within the Process Areas were identified and assigned sub-areas in the initial *Process Areas Work Plan* (Brown and Caldwell 2003). For ease of remedial investigation planning and data evaluation, the process components and ancillary support facilities were divided into 12 sub-areas, as identified in Table 2-1. The sub-area designations are generally contiguous, and consist of one or more process component (e.g. leaching or precipitation), a physical feature (e.g. ditch), or general ancillary support features (e.g., administrative and maintenance buildings).

Throughout this Process Areas RI Work, sub-area designations are referred to as Areas (i.e., Area 1 through Area 12).

Sub-Area	Description
Area 1	Administration and Maintenance Support Buildings
Area 2	Truck Shop, Crusher and Miscellaneous Features
Area 3	Leach Vats
Area 4	Solution Tanks
Area 5	Precipitation Plant
Area 6	Sulfide Plant
Area 7	Calcine Ditch
Area 8	Overflow Solution Ditch (former North Solution Ditch)
Area 9	East Solution Ditch
Area 10	North Low Area
Area 11	South Low Area
Area 12	Peripheral Process Components

The North Solution Ditch has been renamed in this Process Areas RI Work Plan to the Overflow Solution Ditch to reflect current understanding of its past use, which was to drain the overflow sump, based on historic operations information. Process components and ancillary support facilities within the sub-areas are listed in Table 2-2, and shown in Figures 2-1 and 2-2.

ID	Component	Sub-Area
A	Administration Building	1
B	Tire Pile	11
C	Equipment Wash Building	2
D	Change House	1
E	School House	1
F	Warehouse and Assay Laboratory	1
G	Large Warehouse Annex	1
H	Small Warehouse Annex	1
I	Fire Engine Storage / Tire Shop	2
J	Grease Shop #1	1
K	Truck Shop	2
L	Equipment Garage	2
M	Truck Wash and Paint Shop	2
N	Carpenter Shop	2
O	Lead Shop	2
P	Leach Vats	3
Q	Quonset Hut	1
R	Emergency Shed	2

Table 2-2. Process Areas Components and Sub-Area Designations - Continued		
ID	Component	Sub-Area
S	Sheet Metal Shop	2
T	Plumbers Shop	1
U	Filling Station #1	1
V	Grease Shop #2	1
W	Filling Station #2	1
X	Filling Station #3	1
Y	Electrical Shop	2
Z	Filling Station #4	1
AA	Core Building	12
BB	Water Tank	12
CC	Primary Crusher	2
DD	Solution Tanks	4
EE	Precipitation Plant	5
FF	Solution Tanks Electrical Building and Pumphouse	4
GG	Sulfide Plant Office	6
HH	Sulfide Plant	6
II	Concrete Ramps	10
JJ	Low Area #1	10
KK	Dump Leach Surge Pond	10
LL	Tar Drum Storage	10
MM	Drain Outlet	11
NN	Stacker Area	2
OO	Secondary Crusher	2
PP	Arimetco Acid Tanks	12
QQ	Arimetco Crusher/Hopper	12
RR	Arimetco Stacker	12
SS	Acid Plant	N/A
TT	Motor Cargo Building	12
UU	Old Crusher Site	12
VV	Tailings Pump Houses	12
WW	Calcine Ditch	7
XX	Acid Plant Pond	N/A
YY	Sulfide Ore Crusher and Stockpile	3
ZZ	Surface Pumps Foundation	12
AAA	Concrete Pump Tank	12
BBB	Upper Truck Sludge Pond	11
CCC	Lower Truck Sludge Pond	11
DDD	Truck Sludge Pond Ditch	11
EEE	East Solution Ditch	9
FFF	Overflow Solution Ditch	8
HHH	Low Area	10, 11
III	Coarse Ore Storage	2

This is a draft report and is not intended to be a final representation of the work done or recommendations made by Brown and Caldwell. It should not be relied upon, please consult the final report.

2.2.1 Area 1 – Administration and Maintenance Support Buildings

Features in Area 1 include the Administration Building (A), Change House (D), School House (E), Warehouse and Assay Laboratory (F), Large Warehouse Annex (G), Small Warehouse Annex (H), Grease Shop #1 (J), Quonset Hut (Q), Plumber's Shop (T), Filling Station #1 (U), Grease Shop #2 (V), Filling Station #2 (W), Filling Station #3 (X), and Filling Station #4.

Administration Building (A)

The Administration Building was used for offices, record storage, gasoline filling station, and a parking garage. The building is currently empty and is in disrepair. The building is located at the southern edge of the Process Areas near Birch Drive. The front portion of the building is accessible to the public. The building contains offices, storage rooms, restrooms, and a 3-bay garage. The only service entrance is a single overhead garage door on the northwest side of the building. A gasoline filling station (pump island with two pumps) was located in the parking lot approximately 50 feet from the northeast side of the building. No potential past chemical sources are associated with this building. The building has an L-shaped floor area of approximately 9,285 square feet. The construction is wood framing, composite siding, asphalt composition roof, and a concrete floor.

Change House (D)

The Change House was used as a dressing room and showers. The building is currently empty. The building is located between the School House to the northwest and the Administration Building to the southeast. A small former laboratory is present at the north corner of the building. The nature of work conducted within the lab is unknown, and no chemicals are currently present. The building has a floor area of approximately 4,400 square feet and is constructed of metal roof and walls on a concrete floor.

School House (E)

The School House was used as a school for on-site training of employees. There is no reason to believe that any chemicals were ever stored or used within the School House. The School House

is adjacent to and aligned parallel with the northwest side of the Change House. A service entrance consisting of a roll-up door is located on the southwest side of the building. No potential past chemical sources are associated with this building. The building is approximately 50 feet long by 25 feet wide (1,250 square feet) and is constructed of metal roof and walls on a concrete floor.

Warehouse and Assay Laboratory (F)

The center section of the Assay Laboratory building was used as a warehouse and shop area, while the south end of the building was used as a laboratory. The assay laboratory represents a potential source of chemicals, which may have been used or stored in the building. Since the building was also used as a shop, the potential exists for residual contamination from the storage of oils and lubricants. Loading docks were located along the southwest, northwest and northeast sides of the building, and a basement below approximately one third of the first floor area is located at the southeast end of the building. The loading dock is an extension of the main floor.

A small wire-cage service elevator serviced the basement and main floor. The southeast end of the building was used for private offices. Two overhead service doors exist along the northeast and southwest sides of the building at the center of the loading dock. The center section of the building was used as a warehouse and shop area. Various laboratory equipment remains inside the building. The building is approximately 200 feet long by 70 feet wide (13,800 square feet) and is constructed of metal roof and walls on a concrete floor.

Large Warehouse Annex (G)

A complete listing of items that were stored over time in the Large Warehouse is uncertain. The building currently contains fittings, supplies, miscellaneous scrap steel, debris and some tools. A 2-inch diameter pipe protrudes from the ground at the north end of the building. A small area of dark-stained soil was observed at the southeast end of the building. Past potential sources of chemicals include those associated with ancillary equipment storage and maintenance (e.g., large equipment, containers of lubricant, oil and solvents). The building is located northeast of and

aligned parallel with the Assay Laboratory. Large sliding service doors are located at each end of the building. The building is approximately 150 feet long by 33 feet wide (4,950 square feet), and is constructed of metal roof and walls on a concrete floor.

Small Warehouse Annex (H)

A complete listing of items that were stored over time in the Small Warehouse is uncertain. The building currently contains 91 used transformers and oil-filled switches, and most of the transformers have been tagged as containing polychlorinated biphenyls (PCBs). Potential past sources of chemicals are those associated with transformers, ancillary equipment storage, and maintenance (e.g., large equipment and containers of lubricant, oil and solvents). The building is located to the northwest of and in line with the Large Warehouse. Large swinging service doors are located at the northwest end of the building. The building is approximately 35 feet by 40 feet (1,400 square feet), and is constructed of metal roof and walls on a concrete floor.

Grease Shop #1 (J)

Grease Shop #1 was used for shop and storage activities involving grease and lubricants. Formerly stored lubricants and oils represent a potential past source of petroleum hydrocarbons. The building is currently empty, and is located northeast of and aligned parallel with the Large Warehouse. Small swinging service doors are located on the northwest side of the building. This small storage building is approximately 20 feet by 20 feet (400 square feet) with metal roof and walls on a concrete floor.

Quonset Hut (Q)

The Quonset Hut and storage yard was apparently used to store electrical equipment and transformers, potential past sources of organic compounds and PCBs. The building currently contains old scrap electrical supplies (e.g., wire, switches, lights, and control equipment). At least one old transformer is still present in the storage yard. The building is located in the northeast edge of the Process Area. A door is located on the northeast side of the building. A fenced-in storage yard is adjacent to the building. A large electrical structure is located

approximately 50 feet north of the building. The Quonset Hut is approximately 100 feet long and 25 feet wide (2,500 square feet) and is constructed of wood. There is no floor in the building.

Plumber's Shop (T)

This building was used for storage of pipe fittings and plumbing supplies, and it may also have been used for maintenance activities. Currently, the building is empty except for scrap piping and a portable generator. The building is located in the southwest edge of the main Process Area, west of the Warehouse/Assay Lab. Potential past chemical sources associated with this building include organic compounds. This small building is approximately 25 feet by 30 feet (750 square feet) with metal roof and walls on a concrete floor.

Filling Station #1 (U)

Filling Station #1 consists of two above-ground storage tanks ("ASTs") currently used for petroleum fueling. The station represents a potential past and present source for impact from petroleum hydrocarbons (e.g., diesel fuel and gasoline). The station is located east of the Large Warehouse and south of Grease Shop #1. The station consists of two ASTs that are not housed in a building. The larger AST has a 10,000-gallon capacity and contains diesel fuel. It has a secondary containment consisting of an earthen berm and plastic liner. The smaller AST has a 1,000-gallon capacity and appears to contain gasoline. It sits on a cradle approximately 6 feet high with no secondary containment. The cradle is mounted to a concrete apron where vehicles park to fill up. The ASTs appear to be constructed of steel.

Grease Shop #2 (V)

Grease Shop #2 was used for shop and storage activities involving grease and lubricants. Formerly stored lubricants and oils represent a potential past source of petroleum hydrocarbons PCBs. The building currently contains dry scrap and debris. The building is located just southeast of Grease Shop #1. A small door is located on the south side of the building. This small building is approximately 15 feet by 18 feet (270 square feet) with a metal roof and walls on a concrete floor.

Filling Station #2 (W)

Filling Station #2 was formerly used for petroleum fueling. The station has been decommissioned, but represents a potential source of diesel fuel and gasoline. The station has fuel pumps located in a shed. Underground pipes (two 2-inch lines) are protruding from the ground outside the southeast end of the building possibly indicating the presence of USTs. The shed was constructed of metal on a concrete pad.

Filling Station #3 (X)

Filling Station #3 was formerly used for petroleum fueling. The station has been decommissioned, but represents a potential past source of diesel fuel and gasoline. The station has fuel pumps located in a shed. Underground pipes are protruding from the ground, possibly indicating the presence of underground storage tanks (“USTs”).

Filling Station #4 (Z)

Fuel pumps were located on a concrete pad and used for fueling mine vehicles. An underground fuel line connects from the above-ground fuel tanks to the concrete pad where the pumps were located. The inactive concrete pad is located between the Assay Laboratory and the Small Warehouse. This feature represents a potential past source of gasoline and diesel.

2.2.2 Area 2 – Truck Shop, Crusher and Miscellaneous Features

Features in Area 2 include the Equipment Wash Building (C), Fire Engine Storage/Tire Shop (I), Truck Shop (K), Equipment Garage (L), Truck Wash and Paint Shop (M), Carpenter Shop (N), Lead Shop (O), Emergency Shed (R), Sheet Metal Shop (S), Primary Crusher Foundation (CC), Stacker Area (NN), Secondary Crusher Area (OO), and the Coarse Ore Storage Area (III).

Equipment Wash Building (C)

It appears that small portable equipment was washed inside the Equipment Wash Building. Cleaning solutions represent a potential past source of organic compounds such as volatile and semi-volatile organic compounds (“VOCs” and “SVOCs”). The stained ground surface

associated with this building could indicate a potential past source for petroleum hydrocarbons. The building is located west of the Truck Wash and Paint Shop. The northeast end of the building contains pipelines that were connected to former “cleaning solution” tanks. A sign mounted on the northeast wall indicates that “cleaning solution” tanks were positioned along that interior wall at one time. A small concrete sump sits along the outside northeast wall of the building; the purpose of the sump is unknown. An area of dark-stained ground surface approximately 2 feet in diameter was observed next to the sump. A drain line leads from the Equipment Wash Building to the Upper Truck Sludge Ponds (BBB). This relatively small building has a floor area of approximately 300 square feet and is constructed of concrete with a concrete floor.

Fire Engine Storage / Tire Shop (I)

The Fire Engine Storage building was originally used to house fire-fighting equipment, fire trucks, and an ambulance. Historic maps identify the building as a Tire Shop, presumably where mine vehicle tires were repaired. Currently, six large used transformers are stored in the building, with some transformers labeled as containing PCBs (the rest of the building is empty). The potential past source of chemicals are those associated with truck storage and maintenance operations (i.e., organic compounds and petroleum hydrocarbons) and storage of the transformers. The building is located southwest of the Truck Shop and is adjacent to the Emergency Shed. A large overhead service door opens up along one side of the building to a 40-foot wide concrete driveway. The building is approximately 60 feet by 35 feet (2,100 square feet), and is constructed of metal walls and roof with a concrete floor.

Truck Shop (K)

The Truck Shop was used for large equipment servicing and transformer storage. Electrical transformers were re-conditioned inside the Truck Shop in the 1980s by Unison. The south half of the building was used as a machine shop, which was partitioned with metal from the north half of the building, and the southeast portion of the building contained offices. Overhead service doors along the northeast side of the building provided access to the large equipment repair shop.

Several areas are present on the concrete floor where former floor drains have apparently been filled in with cement. Two grease pits at the northern end of the machine shop are present near the center of the building, each measuring 4 feet wide by 30 feet long. The potential past source of chemicals in the Truck Shop are those associated with oils, gasoline, solvents and PCBs. The Truck Shop is the largest ancillary building in the Process Areas and is located northwest of and in line with the Assay Laboratory. The building is approximately 350 feet long, 100 feet wide over half its length, and 75 feet wide over the other half (35,000 square feet). The walls and roof are metal, and the floor is concrete.

At the northwest end of the Truck Shop, three oil tanks (approximate 3,000-gallons capacity each) are located outside the building within a concrete secondary containment structure. Dark-stained ground surface is apparent along the edge of the secondary containment. Stained ground surface is also apparent near the outside southwest wall at the northwest corner of the building, along a 2-inch plastic pipeline that is installed between a large secondary containment structure (no tanks are present) and the inside of the building. A floor drain exits the Truck Shop with a discharge point to the ground surface approximately 600 feet to the northeast of the building.

Equipment Garage (L)

The Equipment Garage was used for vehicle and light equipment servicing and storage, and represents a potential past source for oils, gasoline, solvents and PCBs. The building is located to the northeast of and aligned parallel with the Truck Shop. There are six large overhead service doors along the southwest side of the building, and another overhead door at the southeast corner. The northeast corner of the building was occupied by an office. A small sump is located outside the building at the south corner. An area of dark-stained ground surface is apparent along the northeast side of the building. A small fenced compound with an active electrical transformer and visible oil staining is located behind this building. The building is approximately 150 feet long by 65 feet wide (9,750 square feet) and is constructed with a metal roof and walls on a concrete floor.

Truck Wash and Paint Shop (M)

The Truck Wash and Paint Shop building and pad were used to wash and paint vehicles and equipment. The stained ground surface may indicate past sourcing of oil, and the old paint represents a potential past source of lead. The building is located north of the Equipment Garage and east of the Equipment Wash Building. The building has two large overhead service doors on opposing sides where vehicles and equipment entered and exited. Some dark staining is apparent on the ground surface outside of the building overhead doors.

Outside the building, on the southwest side, a large concrete wash pad drains to a nearby sump and discharges to an unlined pit. The building floor area is approximately 45 feet by 45 feet (2,025 square feet) and is constructed of metal roof and walls on a concrete floor.

Carpenter Shop (N)

The Carpentry Shop was likely only used for carpentry work, and included an office and shop area. No evidence exists that the building was ever used for other activities, or that any potential past sources of chemicals were present. The southeast end of the building has overhead service doors. The shop is empty except for scrap supplies and a few tools and equipment. A small concrete sump with a valve is present outside the west wall of the building. This building is located northwest of the Truck Shop. This building has a floor area of approximately 70 feet by 40 feet (2,800 square feet) and is constructed of metal roof and walls on a concrete floor.

Lead Shop (O)

The Lead Shop was likely used to work lead pipes and, perhaps, construct lead pipe joints. The building is aligned with the Carpenter Shop to the northwest. A large service door is on one side of the building, and a steel I-beam inside the building once supported a crane for lifting equipment and stock. This building has a floor area of approximately 20 feet by 40 feet (800 square feet) and is constructed of metal roof and walls on a concrete floor.

Emergency Shed (R)

The nature of past activities conducted inside the Emergency Shed is unknown, although the name suggests that “emergency” supplies were stored inside (e.g., gasoline or diesel for generators). It is not likely that emergency supplies would have included process-related chemical such as acids or solvents. The Emergency Shed may represent a past source of petroleum hydrocarbons or diesel. Currently, the building is empty except for stored soil samples and scraps of materials. There is a 2-inch pipeline protruding from the ground near the southeast corner of the building. The building is located southwest of the Truck Shop and is adjacent to the Fire Engine Storage. The building has a floor area of approximately 50 feet long by 16 feet wide (800 square feet) and is constructed of metal roof and walls on a concrete floor.

Sheet Metal Shop (S)

No historical information exists to indicate that the building was used for any purpose other than as a sheet metal fabrication shop. The building is empty except for scrap and debris on the floor. Potential past sources of chemicals include diesel fuel. This building is located near the southern corner of the Truck Shop and is adjacent to the Electrical Shop. Service doors are located along its northeast side, off the edge of the concrete. An attached shed on the east wall of the building is locked and labeled “Diesel”, and may have stored fuel for portable equipment. This building has a floor plan of approximately 60 feet long by 35 feet wide (2,100 square feet) and is constructed of metal roof and walls on a concrete floor.

Electrical Shop (Y)

The Electrical Shop was formerly used to store electrical equipment and supplies. The building currently contains shelves full of wire, fittings and devices, but there are no containers of any liquids or chemicals inside the building. The small spacing of the aisles and shelves precludes the storage of any large transformers. There is no indication that chemicals were used or stored in this building. The Electrical Shop is located near the southern corner of the Truck Shop and is adjacent to the Sheet Metal Shop. This building has a floor plan of approximately 70 feet long by 25 feet wide (1,750 square feet) and is constructed of metal roof and walls on a concrete floor.

Primary Crusher (CC)

The Primary Crusher (54-inch Traylor gyrator crusher) was used to crush the ore to a 5-inch product before being sent on to the Secondary Crusher. The crushed ore was conveyed to a storage bin using a 48-inch overhead conveyor, which initially started below ground and emerged next to the stockpile and crusher. Historical records indicate that ore crushing was the only activity at this location, and the only potential past source of chemicals would include metals and radiochemicals from the ore and lubricants (i.e., oil for machinery parts) stored or used in this area. All that remains of the Primary Crusher is the concrete foundation and walls, located south of Process Areas near the bridge crossing over Birch Drive. The area of the foundations is approximately 100 feet by 130 feet (13,000 square feet).

Stacker Area (NN)

This conveyance between the primary and secondary ore crushers has had all components removed, and has been re-graded. The potential past chemical sources include metals and radiochemicals associated with crushed ore. The Stacker Area is located in the southern portion of the Process Areas south of the Secondary Crusher.

Secondary Crusher (OO)

The Secondary Crusher was used to further reduce coarsely crushed ore from the Primary Crusher to a nominal 0.5-inch diameter. The potential past chemical sources are metals and radiochemicals associated with crushed ore. The Secondary Crusher is located in the southern portion of the Process Areas near the Fire Engine Storage and Emergency Shed. The crusher cones along the north side of the building have been completely removed, but the concrete foundations remain. An underground concrete conveyor exists underneath the Secondary Crusher cone foundations, between the crusher and the ore stockpile.

Coarse Ore Storage (III)

This area contained two ore stockpile storage buildings, one for coarse oxide ore and the other for coarse sulfide ore. Ore entered the buildings by conveyor belt from the Primary Crusher and

was removed by an underground conveyor belt for feeding to the Secondary Crusher. The remains of the buildings include visible concrete foundations. The potential past chemical sources are metals and radiochemicals associated with crushed ore. The Coarse Ore Storage buildings are located in the southwest corner of the Process Area, several hundred feet west of the Administration Building.

2.2.3 Area 3 – Leach Vats

Area 3 consists of Leach Vats (P) and Sulfide Ore Stockpile Area and Underground Conveyors (YY).

Leach Vats (P)

Eight leach vats were used for the leaching of the copper oxide ores received from the Secondary Crusher. The vats were used to percolate sulfuric acid leach solution through the crushed ore and, subsequently, the application of rinse solution. Each vat was capable of processing 12,000 tons of crushed ore. The potential past sources of chemicals are the acidic solutions that contained metals and radiochemicals. Additionally, the vats were serviced by a permanent overhead rolling crane, which represents a past potential source of oil.

The vats are located along the southwest portion of the Process Areas and northwest of the Truck Shop. Each vat measures 120 feet by 135 feet by 20 feet deep, and was constructed with (average) 18-inch concrete walls and concrete floors (wall thickness is reported to range from one foot thick at the top to three feet thick at the bottom). The interiors of the vats were lined with asphalt mastic (30 percent asphalt and 70 percent sand, reinforced with two layers of thick wire mesh) to protect the concrete from deterioration by the sulfuric acid.

Sulfide Ore Crusher and Stockpile (YY)

This area was used to stockpile sulfide ore supplied to the Sulfide Plant for processing through the flotation and concentration process. Two underground conveyors enclosed in a concrete

tunnel travels under the main roadway to connect the sulfide ore stockpile to the Sulfide Plant. The potential past source of chemicals are metals and radiochemicals associated with the conveyed ore.

2.2.4 Area 4 – Solution Tanks

Features in Area 4 consist of Solution Tanks (DD) and Solution Tanks, Electrical Building and Basement (FF).

Solution Tanks (DD)

Three Solution Tanks were used for short term storage of pregnant acid leach solution from the Leach Vats awaiting precipitation in the Precipitation Plant. The southernmost Solution Tank was most recently used to store chemicals or petroleum products in approximately 280 55-gallon drums and soils in nine plastic 250-gallon containers. Several of the drums had been damaged, and some were labeled as containing PCBs. All of these drums have since been characterized and removed as of July 2003 (Phillips Services Corporation, 2003). The potential past sources of chemicals acid, metals, radiochemicals and the materials stored in the 55-gallon drums.

The tanks are located between the Leach Vats to the southwest and the Precipitation Plant to the northeast. The tanks are constructed of concrete floors and concrete walls and are approximately 90 feet wide and 18 feet deep. The tops of the tanks are at ground level with wall and floor thickness at minimally 12 to 18 inches. Effects of acid pitting and erosion of the inside surfaces of the tanks are visible, possibly reducing wall thickness to less than 12 inches in some areas. The length of the tanks is approximately 360 feet (tank lengths vary from 90 to 140 feet in length).

Solution Tanks Electrical Building and Pumphouse (FF)

The Solution Tanks Electrical Building and Pumphouse area supported the pumps for the solution tanks and precipitation plant. Switchgear is present in the Electrical Building and, although there is no apparent oil staining, the potential for the past use of transformers in this

building exists. The potential past sources of chemicals include acid solutions with metals and radiochemicals, and transformer oil. The Electrical Building and Pumphouse area are located immediately southwest of the three large Solution Tanks. The area is approximately 60 feet wide by 200 feet long (12,000 square feet).

2.2.5 Area 5 – Precipitation Plant

Area 5 has one feature, the Precipitation Plant (EE).

Precipitation Plant (EE)

The Precipitation Plant consists of fifteen parallel “iron launders” that were filled with light gauge scrap iron used to precipitate copper from the sulfuric acid leach solution pumped out of the Leach Vats and temporarily stored in the Solution Tanks. The copper in solution replaced the iron in the scrap materials, creating a copper cement product that was transported off-site for final processing. The waste product from the Precipitation Plant was a ferrous sulfate solution that was conveyed to the evaporation ponds. Pregnant copper solution from dump leaching activities was also sent to the Precipitation Plant, but was kept separate from the vat leach solution.

Historical information indicates that several pumps, sumps and associated piping were constructed to convey solutions along the outside perimeter of the launders. The iron launders still contain scrap iron. Several 55-gallon drums previously stored in one of the launders at the southeast end of the plant were removed in 2003 (Phillips Services Corporation, 2003). The potential past sources of chemicals include solutions and leached solid materials with metals and radiochemicals, and the materials stored in the 55-gallon drums.

The plant is located between the Solution Tanks to the southwest and the North Low Area to the northeast. On the northeast side of the plant, a partially buried concrete trench extends approximately 20 feet from the base of the tanks. Beyond the trench is a concrete and asphalt apron that was used to store scrap iron. On the southeast side of the plant, an overhead crane is

located on a concrete footing and rail. Each concrete launder measures 10 feet by 58 feet by five feet deep, with a 1.25 percent slope to facilitate flow from one launder to the next. The entire Precipitation Plant is approximately 600 feet long.

2.2.6 Area 6 – Sulfide Plant

Features in Area 6 consist of the Sulfide Plant Office (GG) and the Sulfide Plant (HH).

Sulfide Plant Office (GG)

The Sulfide Plant Office building was apparently used for ancillary administrative purposes related to Sulfide Plant operations. The building is currently empty with the exception of archived core samples. No indication of chemical use or storage in the Sulfide Plant Office building has been observed. The building is located between the Sulfide Plant to the northwest and the Solution Tanks to the southeast. This L-shaped concrete building is approximately 50 feet by 25 feet along one wing, and 25 feet by 25 feet at the other (1,875 square feet).

Sulfide Plant (HH)

Sulfide ore was processed in the plant by first crushing the ore and then feeding it through a rough flotation circuit consisting of four concrete rows containing 24 separate cells. The resulting rough concentrate was routed to a 75-foot diameter thickener, then to a fine-grinding mill. From this mill, the concentrate was fed to a scavenger flotation circuit of similar construction to the first, and then conveyed to two 50-foot diameter thickeners. The final concentrate was dried in two six-foot diameter vacuum filters. The potential past sources of chemicals include solutions with metals and radiochemicals associated with the sulfide ore.

All buildings in the Sulfide Plant area have been removed, and only concrete structures remain. These concrete structures cover an area approximately 800 feet by 400 feet (320,000 square feet) and consist of foundations, slabs, columns, trenches, ramps and thickeners. Some of the structures, such as slabs and ramps, appear to be at, and above surface grade, and some of the structures such as trenches and thickeners are partially buried. Two concrete-lined conveyor

ways, each approximately 175 feet long, extend from the bottom of the sulfide fine ore stockpile, underneath the road and up to the Sulfide Plant. All of the circular-shaped thickeners have been filled with alluvial and/or VLT materials.

2.2.7 Area 7 – Calcine Ditch

Area 7 consists of the Calcine Ditch (WW). No other features are present in Area 7.

Calcine Ditch (WW)

Dust from gas produced in the former Acid Plant was removed by wet scrubbers, mist precipitators and cyclones. The resulting wet slurry was directed to four calcine launders (i.e., concrete troughs covered with steel plates), from which the slurry was sent along with calcines (i.e., burned ore) from the former Acid Plant reactors to the evaporation ponds north of the Process Areas. The conveyance along the calcine ditch used spent solution from the precipitation launders as a conveyance medium.

Potential past sources of chemicals include calcines and the collected stack dust with metals and radiochemicals. It is possible that other waste solutions were transported in this ditch. The length of the ditch is approximately 3,200 feet. The 1,200-foot portion of the ditch closest to the source (former Acid Plant) is buried under an Arimetco heap leach pad.

2.2.8 Area 8 – Overflow Solution Ditch

Area 8 consists of one feature, the Overflow Solution Ditch (FFF).

Overflow Solution Ditch (FFF)

The Overflow Solution Ditch was identified by examination of photographs of the Process Areas taken in 1961 and 1964. The surface expression of the ditch starts at approximately the northwest end of the Solution Tanks (DD), and extends about 1,000 feet northeast where it disappears under the sulfide tailings adjacent to the Process Areas. The ditch is unlined, and it is uncertain whether solutions flowed freely in the ditch or were contained in piping that is no

longer in place. Although the precise use of this ditch is uncertain, it may have carried waste solutions or runoff from the Solution Tanks to the sulfide tailings ponds because of its location. The potential past sources of chemicals include solutions with metals and radiochemicals.

2.2.9 Area 9 – East Solution Ditch

Features in Area 9 consist of the East Solution Ditch (EEE), Low Area #1 (JJ), and the Tar Drum Storage area (LL).

East Solution Ditch (EEE)

The East Solution Ditch runs northwest from the Lower Truck Sludge Pond (CCC) along the margin of the sulfide tailings. The ditch can be traced for approximately 1,500 feet to the point where it disappears under the main haul road. The ditch is unlined and was likely used to convey surface drainage from the Truck Wash Pad, Upper and Lower Truck Sludge Ponds, and other localized surface runoff. Hydrocarbon residue is visible along the sides of the ditch and potential past sources of chemicals include gasoline, diesel and motor oil residues.

Low Area #1 (JJ)

This area was identified during the preliminary Process Areas characterization as a low point where storm water was likely to collect, but is covered by the East Solution Ditch (EEE). Potential past sources of chemicals include gasoline, diesel and motor oil residues. This low area is located at the north end of the East Solution Ditch.

Tar Drum Storage (LL)

The Tar Drum Storage area was identified as having contained 23 drums of tar, some of which showed some leakage to the ground. Potential past sources of chemicals include petroleum hydrocarbons. All drums have been characterized and removed from the area (Phillips Services Corporation, 2003). The total area of the storage area is approximately 25 feet by 10 feet.

2.2.10 Area 10 – North Low Area

Features in Area 10 consist of the North Low Area (HHH), Concrete Ramps (II), and Surge Pond (KK).

North Low Area (HHH 1-16)

The North Low Area has been used for general equipment and materials storage and exhibits apparent runoff accumulation from the surrounding topography. The potential past sources of chemicals include solutions and leached solid materials with metals and radiochemicals, and runoff containing oil, solvent or other organic compounds. This is an area located northeast of the Precipitation Plant (EE) at a lower elevation than the general ground surface in the Process Areas.

Concrete Ramps (II)

There are two sloped concrete ramps east of the Sulfide Plant that are approximately 25 feet wide by 50 feet long. Their past use is uncertain, but they may have been used to store or load trucks with copper cement from the Precipitation Plant. The potential past sources of chemicals include solutions and leached solid materials with metals and radiochemicals.

Dump Leach Surge Pond (KK)

The Dump Leach Surge Pond was used for temporary storage of pregnant process solutions from the Dump Leach. The potential past sources of chemicals from the Surge Pond, which may have been clay-lined, include solutions and leached solid materials with metals and radiochemicals. The Surge Pond is approximately 150 by 150 feet with a maximum depth of about 5 feet. It is located approximately 200 feet northeast of the Precipitation Plant.

2.2.11 Area 11 – South Low Area

The features in Area 11 consist of the Tire Pile (B), South Low Area (HHH 17-38), Upper Truck Sludge Pond (BBB), Lower Truck Sludge Pond (CCC), Ditch between Upper and Lower Truck Sludge Ponds (DDD), and Drain Outlet (MM).

Tire Pile (B)

Old tires from haul trucks and other vehicles are stored on the ground in a large pile. There was no discolored soil observed in the area of the Tire Pile, and no indication of equipment storage or repair. The Tire Pile is located at the northeastern edge of the Process Areas and covers an area approximately 200 feet long by 80 feet wide.

South Low Area (HHH 17-38)

General use of the area includes miscellaneous material storage (such as discarded heavy equipment tires), general vehicle roadways, and conveyance of process solutions through above ground pipelines. The area also includes a used oil tank (1,800-gallon capacity) inside an old haul truck bed which serves as secondary containment. The potential past sources of chemicals include solutions with metals and radiochemicals, and petroleum hydrocarbons. This is the continuation of the low area situated between the Process Areas and the VLT pile. The area also includes some of the intermediate elevations areas around the Precipitation Plant and the tire pile.

Upper Truck Sludge Pond (BBB)

This pond or pit area is located just north of the Equipment and Truck Wash areas (C and M) and appears to have been a collection point for wash water from the Wash Pad and possibly other drains from the Truck Shop Building (K). The soil in this area exhibits hydrocarbon contamination. During the initial phase of investigation, this area was not able to support the weight of heavy equipment (drill rig or backhoe). The pit is approximately 10 feet wide and 40 feet long, with an 8-inch diameter drain pipe that drains into this area.

Lower Truck Sludge Pond (CCC)

A second pond area exists in the South Low Area that received additional drainage from the Upper Truck Sludge Pond. This pond appears to have had a synthetic liner installed at one time that might have contained solutions and solids. The solids in the pond exhibit the presence of petroleum hydrocarbons.

Truck Sludge Pond Ditch (DDD)

A possible ditch, or drainage pathway, between the Upper and Lower Truck Sludge Ponds was identified and sampled. Petroleum hydrocarbons would likely be sourced from this feature.

Drain Outlet (MM)

A drain outlet was identified in the South Low Area. The origin of the drain is uncertain, although it is likely that it is related to the Dust Slurry Drain line coming from the Secondary Crusher, which traveled underground and exited to a surface ditch in the area of this pipe and allowed to drain to the Sulfide Tailings or the East Solution Ditch (the drain was previously considered to have originated in the Truck Shop). Potential past sources of chemicals include petroleum hydrocarbons. An 8-inch drain pipe exits to the surface in the southeast portion of the South Low Area at the point of a small embankment.

2.2.12 Area 12 – Peripheral Process Components

The features in Area 12 consist of the Core Building (AA), Water Tank (BB), Acid Tanks (PP), Arimetco Crusher/Hopper (QQ), Arimetco Stacker Area (RR), Former Acid Plant (SS), Motor Cargo Building (TT), Old Crusher Site (UU), Tailings Pump Houses (VV), Former Pond (XX), Surface Pumps Foundation (ZZ), and Concrete Pump Tank (AAA).

Core Building (AA)

The Core Building, used for core storage and logging activities, is located southwest of the Process Areas and contains several hundred boxes of core samples on shelves. The building was constructed a relatively long distance (approximately 0.25 miles) from the edge of the existing Process Areas. The building is constructed of sheet metal on framework without a floor (i.e., a dirt floor).

Water Tank (BB)

There is a single water tank located northwest of Yerington Pit and approximately 1,500 feet southwest of the Leach Vats. The tank was used to supply water for the mine and for Weed

Heights, and is currently out of operation. The capacity of the tank and volume of water remaining inside are unknown. There is no reason to believe that any chemicals were ever used or stored at this location.

Arimetco Acid Tanks (PP)

The Acid Tanks are located approximately one mile northwest of the main Process Areas on top of a VLT pile. The tanks include a 50,000-gallon, two 5,000-gallon and a 10,000-gallon metal sulfuric acid tanks. The contents of the tanks were likely a dilute (approximate one percent) sulfuric acid solution used for leaching of the nearby Arimetco leach pad. Three of the four tanks are situated within secondary containments. Some yellow staining of soil is visible, suggesting possible spillage of sulfuric acid. The contents of all the acid tanks have been drained, but the tanks have not been cleaned out. The volume of residual acid sludge in the tanks is unknown. The potential past source of chemicals in this area is sulfuric acid. The tanks include a 50,000-gallon, two 5,000-gallon and a 10,000-gallon metal sulfuric acid tanks.

Arimetco Crusher/Hopper (QQ)

The Arimetco Crusher/Hopper was located approximately one mile northwest of the main Process Areas, on the north side of the Oxide Ore waste rock area. The components have been removed and the area has been re-graded. The potential past source of chemicals in this area include metals and radiochemicals associated with the crushed ore, and sulfuric acid.

Arimetco Stacker Area (RR)

A lined stockpile existed on the area where the former Stacker was located, approximately one mile northwest of the main Process Areas. Acid-treated crushed ore was placed on the stockpile area. After the Crusher Plant was removed, the stockpile area was excavated and placed on the VLT Leach Pad. The potential past source of chemicals in this area include metals and radiochemicals associated with the crushed ore, and sulfuric acid.

Acid Plant (SS)

The Acid Plant was located where the Arimetco Phase III/South Heap Leach Pad is currently situated. Historic records indicate that the acid plant produced sulfuric acid solution as early as 1954, and continued production of approximately 200 to 450 tons of sulfuric acid per day until at least 1975. The potential past source of chemicals in this area is sulfuric acid.

Motor Cargo Building (TT)

The Motor Cargo Building is located northwest of the Core Building, to the southwest of the Former Acid Plant. The community of Weed Heights operates the building and surrounding fenced-in storage yard for equipment and supplies storage. Several 55-gallon drums of unknown content were observed inside the storage yard. Previously, the building was used for parking and, possibly, repair of trucks that were used to transport oxides and chemicals to and from Wabuska for train shipment. The current nature of operations inside the building is unknown.

Old Crusher Site (UU)

The foundation has no structures or equipment attached. Next to the foundation is an area where a former acid tank may have been located. The ground surface around the former tank area is discolored yellow. The potential past source of chemicals in this area include metals and radiochemicals associated with the crushed ore, and sulfuric acid. A concrete foundation of an old crusher unit exists approximately 2,100 feet southeast of the Administration Building (A) on the south side of the Weed Heights Road north of the Yerington Pit.

Tailings Pump Houses (VV)

Operation of the Tailings Pump Houses most likely involved pumping of fluidized, spent processed ore from the Process Areas to the sulfide tailings. The potential past source of chemicals in this area include metals and radiochemicals associated with the sulfide tailings, sulfuric acid, and lubricant oil from the pumps. Two buildings containing large pumps and associated piping are located east of the Evaporation Ponds. The easternmost building was named the Tailings Pump House and contains two large pumps with approximate 16-inch

diameter piping entering straight into the ground and underground out to the south. The other building consists of large pumps on a raised concrete deck, associated piping and a concrete holding tank with level gauge.

Acid Plant Pond (XX)

A holding pond located adjacent to, and northwest of, the former Acid Plant may have been used to temporarily hold, or evaporate, solutions from the plant (the exact nature of the solution stored in the pond is unknown). The potential past source of chemicals in this pond is likely sulfuric acid.

Surface Pumps Foundation (ZZ)

The structure appears to have collected surface water or fluids from the surrounding topographic low area. The potential past source of chemicals in this area include metals and radiochemicals associated with surface runoff over tailings. An above-ground concrete foundation exists just east of the middle Evaporation Pond in a low area near the northeast boundary of the mine site. The structure is a concrete holding tank approximately four feet deep with a grated inlet on the north side at ground surface, and openings in the top that suggest the presence of large pumps.

Concrete Pump Tank (AAA)

A large abandoned above-ground concrete tank is present at the southern end of the Unlined Evaporation Pond. Potential COCs in the area of the tank include acidic solutions and calcines (the latter if the piping represents a continuation of the Calcine Ditch). The tank is approximately 12 feet high and appears to have had pumps attached to an integral concrete platform above the tank. A manhole with an apparent former valve ahead of the tank is present approximately 60 feet to the south of the tank.

2.2.13 Descriptions of Process and Utility Pipelines, Drains and Ditches

Process and utility pipelines, drains and ditches includes all identified solution conveyance methods within the Process Areas for conveying chemicals, process solutions and wastes. Types of solutions that were conveyed can be subdivided into the following categories:

- Pregnant Process Solutions – Solutions that are metal rich after leaching of the ore;
- Spent Process Solutions – Process solutions that have had the copper removed before reuse or disposal to the waste ponds;
- Acid – Sulfuric acid of varying concentrations produced in the Acid Plant for use in leaching, prior to application to the ore;
- Fuel – Gasoline or diesel fuel lines distributing fuel from the storage tanks to the fuel pumps;
- Drain Lines – Gravity flow drain lines from floor drains, sumps or other sources; and
- Sewer – Sewer lines connecting bathrooms, sinks or other non-process waste points to the sewage disposal and solids separator system.

Process and waste solutions were transferred from point-of-origin to point-of-use to point-of-disposal by a variety of methods, including:

- Above ground piping,
- Underground piping, and
- Gravity flow surface ditches, lined and unlined.

A listing of the identified pipelines and conveyance features is provided in Table 2-3 and are shown on Figure 2-3. Several features, primarily ditches, were initially included as features in the sub-areas and are described in detail in Sections 2.2.1 through 2.2.12, but they are included in this section to provide a complete listing and are referred to by the original sub-area component listed in Table 2-1.

ID	Component	Category
UT-A	Vat Leach Pregnant Solution	Pregnant Solution
UT-B	Dump Leach Pregnant Solution	Pregnant Solution
UT-C	Sulfide Concentrate Slurry	Pregnant Solution
UT-D	Precipitation Plant Spent Solution to Pond	Spent Solution
UT-E	Precipitation Plant Spent Solution to Acid Plant	Spent Solution
UT-F	Sulfide Tails Slurry, North	Spent Solution
UT-G	Strong Sulfuric Acid to Vat Leach	Acid
UT-H	Sulfuric Acid to Dump Leach	Acid
UT-I	Acid Line	Acid
UT-J	Fuel Distribution Pipeline	Fuel
UT-K	Truck Wash Sump Drain	Drain
UT-L	Grease Pit Drain	Drain
UT-M	Fuel Tank Sump Drain	Drain
UT-N	Assay Lab Drain	Drain
UT-O	Secondary Crusher Dust Slurry Drain	Drain
UT-P	Vat Leach Pumphouse Drain	Drain
UT-Q	Sulfide Pumphouse Overflow Ditch	Drain
UT-R	Administration Sewer	Sewer
UT-S	Acid Plant Sewer	Sewer
UT-T	Leach Plant Sewer	Sewer
UT-U	Main Line Sewer	Sewer
UT-V	Weed Heights Sewer	Sewer
UT-W	Sulfide Tails Slurry, South	Spent Solution
EEE	Overflow Solution Ditch	Drain
FFF	East Solution Ditch	Drain
WW	Calcine Ditch	Spent Solution

Pregnant Process Solutions

Pregnant process solutions are typically transported in contained pipelines which are generally laid on the surface or in concrete trenches in order to minimize the loss of valuable metal content.

Three pregnant process solution pipelines have been identified:

Leach Vat Pregnant Solution (UT-A)

Pregnant leach solutions from the Leach Vats were transferred to the Solution Tanks and to the Precipitation Tanks by a 12 inch transite pipe located in the concrete lined ditch which is at ground level and under the roadway between the Leach Vats and the Precipitation Plant. The pipes are fully accessible for observation and repair and any spillage was collected in the Overflow Sump located southwest of the Solution Tanks.

Dump Leach Pregnant Solution (UT-B)

Low grade ore was stockpiled on a liner on the south side of Burch Drive and leached in place with sulfuric acid solution. The pregnant solution was collected on a liner underlying the ore and was transferred to the Precipitation Plant via a 12-inch transite pipe laid on the ground surface. Dump Leach solution was stored in the Dump Leach Surge Pond (KK) and then transferred to the Precipitation Plant by an underground pipeline around the northwest end of the tanks where it was processed separately from the Vat Leach solutions. Most of the piping is still visible on the ground though some of it has been removed as it nears the Dump Leach Surge Pond.

Sulfide Concentrate Slurry (UT-C)

Sulfide concentrates were piped from the floatation cells to various thickeners and settling tanks. Uncertainty exists as to the construction materials and position relative to ground surface for this conveyance, as no evidence exists of the pipes and most of the Sulfide Plant has been dismantled.

Spent Process Solutions

Spent process solutions were transported in above ground pipelines, underground pipelines and surface ditches and the chemistry and makeup of the spent solutions was likely to have been highly variable depending on the source of the waste. Spent solutions often contained solids slurried in the solutions. Six spent process solution pipelines have been identified:

Precipitation Plant Spent Solution to Pond (UT-D)

Spent solution consisted of iron sulfate solution and wash water generated during precipitation of the copper. The spent solution was recirculated and stored in the Spent Solution Sump located at the northwest end of the Precipitation Plant. From there it was piped directly to the Evaporation Ponds or to the Acid Plant for slurry of the calcines. According to the historic plan map, the spent solution exited the sump through underground piping, discharged into an open ditch for approximately 100 feet, and then re-entered an underground pipe that likely discharged to the north end of the Calcine Ditch. The spent solutions were likely transferred to the Acid Plant rather than through this piping system.

Precipitation Plant Spent Solution to Acid Plant (UT-E)

The alternate disposal method for the Precipitation Plant spent solutions was to convey them to the Acid Plant for use in the calcine slurry through enclosed piping located in the main concrete trench between the Leach Vats and Precipitation Plant. The type of piping is uncertain.

Sulfide Tails Slurry, North (UT-F)

Waste solutions from the Sulfide Plant exited the plant at several points in underground and aboveground 12 inch transite pipes. The pipes carried the wastes to the Sulfide Tailings as a slurry of solids and waste water.

Sulfide Tails Slurry, South (UT-W)

A second Sulfide Tails Slurry line was installed which exited the Sulfide Plant and paralleled the Dump Leach Pregnant Solution pipeline for approximately 1000 feet. The pipeline continued to the top of the Sulfide Tailings embankment where it discharged waste solutions to the tailings pond in several places. The Sulfide Tails Slurry Line was constructed of 12 inch transite pipe and was laid on the ground surface. Much of the original pipeline has been removed but remnant sections are still visible as are the anchoring brackets.

Calcine Ditch (WW)

The Calcine Ditch has previously been discussed in Section 2.2.12 as Area 7 Feature WW. It is included here because it is a main conveyance feature for process solutions. The Calcine Ditch was an unlined surface ditch which was used to convey the calcine solid waste from the Acid Plant with the Spent Solution from the Precipitation Plant to the Evaporation Ponds.

Acid

Sulfuric acid was distributed to leaching components in 12 inch transite pipes. Strong acid pipelines were located in concrete lined ditches at ground surface. Weak acid appears to have been conveyed in underground and aboveground pipelines. Three acid pipelines have been identified:

Strong Sulfuric Acid to Vat Leach (UT-G)

Sulfuric acid was distributed from the Acid Pant to the Vat leach Tanks in a 12 inch transite pipe located in the main concrete trench. It is assumed that the 98% sulfuric acid was diluted to a lower concentration for conveyance in the piping but has not been confirmed.

Sulfuric Acid to Dump Leach (UT-H)

Sulfuric acid was also piped to the Dump Leach located south of Burch Drive in underground and aboveground 12-inch transite piping. The piping was primarily aboveground and parallels the return piping of pregnant leach solutions from the Dump Leach. It appears that the acid piping was underground for about 1,000 feet from the Precipitation Plant to the approximate location of the Tire Pile. The acid concentration in this piping is assumed to be weaker than that used in the Vat Leach Tanks, but the actual concentration has not been determined.

Acid Line (UT-I)

A small 4-inch steel line is visible on the surface and is labeled n the Sit map as an acid line. It is unclear how this line is connected to the main acid distribution lines.

Fuel

Fuel lines were buried underground to convey vehicle fuel, diesel and gasoline, from the storage tanks to the fuel pumps. One fuel pipeline has been identified:

Fuel Distribution Pipeline (UT-J)

Four 2 inch underground steel pipelines were used for the transfer of various fuel mixtures from the storage tanks to the fuel pumps located on the concrete island in the middle of the driveway.

Drains

Nine drain lines (i.e., underground pipelines and surface ditches that were gravity drained from minor floor drains and sumps) have been identified. These features did not originate from plant process tanks, but from ancillary support locations such as the Truck Shop or laboratory. Drain lines conveyed much smaller volumes than process solution pipelines.

Truck Wash Sump Drain (UT-K)

A small 2 by 2 ft concrete sump box is located on the north side of the concrete Wash Pad (C). A 6 inch drain line exits the sump and drains underground approximately 50 feet to the Upper Truck Sludge Pond (BBB). Wash water from vehicle or equipment washdowns ran off through the drain line to the pond area.

Grease Pit Drain (UT-L)

Historic Site plan maps show a drain line, identified as the “Grease Pit Drain”, exiting the Truck Shop traveling towards the north east. The line appears to drain to the Lower Truck Sludge Pond (CCC), but connection to the pond is inferred because there is no map coverage of the area to confirm this.

Fuel Tank Sump Drain (UT-M)

Historic Site plan maps show a drain line coming from the fuel tank storage area and draining to the northeast. It is assumed that this drained from a collection sump similar to the Wash Pad sump but cannot be confirmed as tanks and foundations have been removed. Final disposition of the drain line is not known.

Assay Lab Drain (UT-N)

A drain line exits the southeast corner of the Assay Lab (F), travels approximately 100 feet northeast and appears to drain into a dry well. The dry well appears on the Site map as a square feature which might indicate it as a hand-dug well, not likely to be very deep. No expression of the well exists at the surface and is indicated on the map as 4 ft bgs.

Secondary Crusher Dust Slurry Drain (UT-O)

Water was sprayed onto the crushed ore at the Secondary Crusher for agglomeration and dust control. The source and quality of the water is not known and may have been fresh well water or recycled water from other parts of the process, such as wash water from leaching or precipitation. Excess runoff was collected in a sump and conveyed in an underground 8 inch steel pipe until it exited to an unlined surface ditch in Area 11 and drained to the Sulfide Tailings or other surface ditch. The exit point of the dust slurry line is described in Section 2.2.12 as Feature MM.

Vat Leach Pumphouse Drain (UT-P)

Documentation of a drain line from the Vat Leach Pumphouse, previously located at the northwest end of Vat No. 8, to an unidentified “dry well” was found on historical Site maps. The pumphouse has been removed and no evidence of the dry well has been found. The drain line likely was used to collect and dispose of minor floor spillage from leach vat solutions including pregnant and wash solutions.

Sulfide Pumphouse Overflow Ditch (UT-Q)

A third Solution Ditch was identified at the north end of the Process Areas, north of the Sulfide Plant, by the BLM through examination of old aerial photos. This was likely to have been an overflow ditch from the Sulfide Pumphouse. Ground surface examination by Brown and Caldwell and BLM personnel could not locate any remaining surface expression of this ditch.

Overflow Solution Ditch (FFF)

The Overflow Ditch has previously been discussed in Section 2.2.12 as Area 8 Feature FFF and is being included here because it was used as a process solution conveyance feature. The Overflow Ditch is an unlined surface ditch with occasional culverts where it passes under roads. The ditch is visible on historical photos carrying solutions from the Overflow Sump around the northwest end of the Solution Tanks and Precipitation Plant for disposal in the Sulfide Tailings Pond. Source and composition of the solutions is not known.

East Solution Ditch (EEE)

The East Solution Ditch has previously been discussed in Section 2.2.12 as Area 9 Feature EEE and is included here to be comprehensive in the discussion of solution conveyance features. This ditch was likely used to convey stormwater or other runoff solutions that collected at the Lower Truck Sludge Pond to the Calcine Ditch.

Sewer Lines

Sewer lines were constructed of 8 inch steel pipes and were entirely underground. Sewer pipes collected the waste water from toilets and sinks in all ancillary support buildings. All sewer pipes were connected to one system which drained to the Sewage Solids Tank located at the north end of the Process Areas. Solids were settled in this tank and sewage water was transferred to the north end of the mine site to an unknown location. Today the sewage water from this tank is conveyed to the Weed Heights Sewage Lagoons located at the southwest corner of the Lined Evaporation Ponds. Five sewer pipelines have been identified:

Administration Sewer (UT-R)

Several 8 inch steel pipes, typically 8 to 10 ft bgs, collect sewage and waste water from building bathrooms kitchens and sinks. Buildings serviced on this line include: Administrative Building, Change House, School House, Assay Lab, Truck Shop, Electrical Shop, and Primary Crusher.

Acid Plant Sewer (UT-S)

Buildings serviced on this line include: Acid Plant, Vat Leach, Secondary Crusher, and Carpenter's Shop.

Leach Plant Sewer (UT-T)

Buildings serviced on this line include: Solution Tanks Pumphouse and Sulfide Plant Foreman's Office.

Main Line Sewer (UT-U)

The main sewer line connects the upstream points to the Sewage Solids Tank.

Weed Heights Sewer (UT-V)

Buildings serviced on this line include: All Weed Heights residential and community buildings and the Sulfide Plant. This line drains directly to the Sewage Solids Tank.

2.2.14 Descriptions of Electrical Sub-Stations and Transformers

The following five inactive and active electrical sub-stations, and associated transformers, remain on-site:

PA-TR1 is located on the upper road level between the Emergency Shed and the Electrical Shop and consists of four transformer units positioned at ground level inside a chainlink fence enclosure. Labels are visible on all four transformers stating that they do not contain PCBs.

PA-TR2 is located just south of the Lead Shop and west of the Carpenter Shop and consists of three transformers positioned on raised concrete foundations inside a chain link enclosure. Evidence of corrosion is visible around the bottom of one of the transformers. Labels are visible on all three transformers stating that they do not contain PCBs.

PA-TR3 is located just northwest of the Sulfide Plant on the northern boundary of the Process Areas and consists of one small transformer unit elevated approximately 12 feet above the ground surface on a power pole. There is no visible corrosion.

PA-TR4 is located at the southwest corner of the Assay Laboratory and consists of two transformers raised approximately 20 feet above ground level on a power pole. There is no live electrical service to the building so these transformers are inactive.

PA-TR5 is located at the northwest corner of the Secondary Crusher and consists of three transformer units mounted on a concrete slab at ground level enclosed in a chain link fence. There is an active pumping station adjacent to this area that may draw power from at least one of the transformers in this area.

These transformers, mounted on poles or on concrete pads within fenced-in areas, may have leaked oil. The potential past chemicals sources include oil and PCBs. In addition to the five electrical substation/transformer areas described above, the following areas/features currently or previously exhibit electrical transformer servicing, use or storage:

Small Warehouse Annex (H): Previously, 91 used transformers and oil-filled switches were stored in this building. Most of the transformers have been tagged as containing PCBs.

Fire Engine Storage/Tire Shop (I): Currently, six large used transformers are being stored in this building. Some of the transformers have been tagged as containing PCBs.

Quonset Hut (Q): The building was used to store electrical equipment that may have included transformers. The fenced-in storage yard next to the building was formerly used to store transformers (at least one old transformer is still present).

Solution Tanks (DD): The primary former use of the Solution Tanks was to temporarily hold the leach solution from the Leach Vats before being pumped into the Precipitation Plant. However, the southernmost tank was also used to store chemicals or petroleum products in approximately 280 55-gallon drums and soils in nine plastic 250-gallon containers. Several of the drums were damaged, including those labeled as containing PCBs. All of these drums have been characterized and removed.

Solution Tanks, Electrical Building, and Basement (FF): The electrical building near the Solution Tanks serviced the pumps for the tanks. Transformers could have been serviced or stored there as well. Currently, switchgear is present in the building.

Electrical transformer servicing, use, or storage at these areas/features had the potential to release PCBs.

2.3 Physical Setting

The Site is located on the west side of Mason Valley and the Walker River (Figure 1-1). Mason Valley is a structural basin surrounded by uplifted mountain ranges within the Basin and Range physiographic province of west-central Nevada. Mason Valley is bordered by the Singatse Range to the west, the Desert Mountains to the north, and the Wassuk Range to the east. Specifically, the mine site is located on the eastern flank of the Singatse Range along the distal edge of an alluvial fan between the Singatse Mountain Range and fluvial deposits associated with the Walker River.

The head of the alluvial fan on which the Site is located is at an elevation of approximately 4,800 feet above mean sea level (“amsl”) and the base is between 4,380 feet and 4,420 feet amsl. At the lower elevations, the fan deposits merge with the fluvial deposits of the Walker River flood plain. The main portion of the Process Areas is located at an elevation of 4,400 to 4,500 feet.

2.3.1 Geology

The mountain blocks are primarily composed of granitic, metamorphic and volcanic rocks with minor occurrences of limestone outcrops. The Singatse Range has been subject to metals mineralization, as evidenced by the large copper porphyry ore deposit at the Yerington Mine and other nearby mines. Proffett and Dilles (1984) published a geologic map of the Yerington Mining District that describes these features. Seitz et. al. (1982) described the geologic setting of the area around the Site based on existing information and the subsurface information obtained through the drilling of test wells north of the site by the U.S. Geological Survey in 1978. Alluvial fan deposits along the west margin of the valley underlie the process areas and stream- and lake-deposited materials on the valley floor underlie the tailings and evaporation ponds (Seitz et. al.; 1982).

Unconsolidated alluvial deposits derived by erosion of the uplifted mountain block of the Singatse Range and alluvial materials deposited by the Walker River fill the structural basin occupied by Mason Valley in the vicinity of the mine site. These unconsolidated deposits comprise four geologic units: younger alluvium (including lacustrine deposits associated with Lake Lahontan), younger fan deposits, older alluvium and older fan deposits (Huxel, 1969). Based on core samples collected from previous investigations in the Process Areas (Brown and Caldwell, 2005a), the underlying alluvial fan materials consist of fine-grained mud-flow deposits and coarser grained channel deposits. Depth to bedrock in the Process Area is estimated to be approximately 200 feet bgs based on the well log for Anaconda well WW-10. The alluvial-bedrock contact deepens towards the north end of the Site to an estimated depth of 600 to 800 feet bgs in the vicinity of the evaporation ponds.

As part of the Yerington Mining District, the Site is located within a large area characterized by surface expressions of base and precious metals mineralization, and associated hydrothermal alteration, of bedrock outcrops of granitic and volcanic rocks (Proffett and Dilles, 1984). The Yerington ore deposit is a disseminated porphyry copper deposit. Copper mineralization is associated with an intrusion of quartz-monzonite porphyry into a granodiorite mass (U.S. Bureau

of Mines, 1958). The primary ore minerals are chrysocolla, a copper-alumina silicate, and chalcopyrite, a copper sulfide mineral. Other metals commonly associated with porphyry copper deposits (e.g., arsenic, molybdenum, uranium, zinc) often occur in a larger alteration halo around the ore body, which is the case at the Site. The mineralogical characteristics of the ore and waste rock mined at the Site from the open pit resulted in the occurrence of technically enhanced naturally-occurring radioactive materials (“TENORM”).

The occurrence of a potentially extensive alteration halo in the local country rock around the Yerington copper ore body, in conjunction with the alteration haloes associated with the nearby Blue Stone, Bear and MacArthur copper deposits, is likely to result in elevated metals concentrations in the distal alluvial fan deposits underlying the Process Areas. This condition of elevated metals concentrations in soils is consistent with the results of Shacklette and Boerngen (1984) for the Yerington area, and will be evaluated by comparing off-site and Process Areas soils data pursuant to the *Background Soils Work Plan* and EPA guidance (EPA, 2002).

2.3.2 Hydrogeology

The principal source of water in the Yerington area of Mason Valley is from the Walker River (Huxel, 1969). The East and West Forks of the Walker Rivers originate in the Sierra Nevada and merge south of the Site. The Walker River then flows northward through Mason Valley to Walker Gap. From Walker Gap, the river turns eastward and then southeastward to Weber Reservoir and ultimately to its terminus at Walker Lake.

Huxel (1969) estimated the following recharge components to the Mason Valley hydrographic basin: 1) 3 percent from precipitation that falls on the surrounding mountain ranges; 2) 97 percent from the river and associated agricultural diversions; and 3) less than 0.1 percent from direct precipitation on the valley floor. Along the southern margin of the Site, recharge to the alluvium from the adjacent Walker River occurs as a result of the river losing water through seepage. As the river flows to the northeast past the town of Yerington, the Groundhog Hills, a spur of the Singatse Range, likely impedes much of the recharge from the Walker River to the

alluvium underlying the northern half of the mine site. Recharge from the Campbell Ditch immediately east of the Groundhog Hills to the alluvial aquifer would also be impeded by the bedrock. Percolation from irrigated agricultural fields immediately north of the mine site is hypothesized to be the dominant source of groundwater recharge in the northern area of the Site.

Although some degree of resistance to vertical flow exists within the alluvial aquifer, created by the depositional layering of sedimentary deposits and the occurrence of low-permeability layers, some downward migration of mine-related groundwater is likely to have occurred as a result of historic operations at the Site and the influence of agricultural irrigation practices immediately north of the Site.

As described in greater detail in Section 4.0, and presented in the *Data Summary Report for Process Areas Groundwater Conditions* (Brown and Caldwell 2005a), groundwater quality beneath the Process Areas appears to have been locally impacted by past mining and ore processing operations, including up-gradient and local sources. The geochemical signature of mine-related groundwater beneath the Process Areas varies, but is generally reflected by elevated concentrations of metals, radiochemicals, sulfate and total dissolved solids (TDS). In addition, localized occurrences of elevated concentrations of hydrocarbons and other organic compounds were identified during the initial phase of groundwater investigations in the Process Areas (Brown and Caldwell 2005a).

2.4 Conceptual Site Model

This section describes known and potential sources of chemicals in the Process Areas, chemical release mechanisms, chemical transport pathways for media found within the process areas, and the spatial distribution of chemicals of interest in Process Areas soils and groundwater. The chemical sources, release mechanisms, transport pathways, and potential routes of human exposure for the Site are summarized in the CSM (Integral and Brown and Caldwell 2007). A more detailed CSM focused on the Process Areas, and OU-specific potential transport pathways and exposure routes, is provided in the HHRA, attached as Appendix A. Figure 2-4, reproduced

from the revised CSM (Integral Consulting and Brown and Caldwell, 2007), presents the physical processes anticipated to occur throughout the Site, including those from the Process Areas. For the purposes of the OU-specific CSM provided in Appendix A, and subsequent sections of this Process Areas RI Work Plan, the term ‘mine-related chemicals’ are chemicals that appear to have been concentrated in soils or groundwater by past operational practices and the term ‘mine-related groundwater’ is groundwater that appears to have elevated concentrations of iron, sulfate and other chemicals resulting from past operational practices.

Although the Process Areas have been subject to extensive disturbance in the form of buildings, infrastructure, mining equipment and debris, certain plant species grow in small portions of the area. The abandoned buildings and plants may provide shelter or food to wildlife species. In order to improve the OU-specific CSM, an ecological survey described in Appendix C-1 will be conducted to identify vegetation and assess wildlife habitats within the Process Areas. The survey will characterize the quantity and quality of potential plant and wildlife habitat in the Process Areas in order to supplement the CSM and support the screening level ecological risk assessment (“SLERA”, attached as Appendix C-2). The SLERA will be based, in part on OU-specific investigations of chemicals (including radiochemicals) in soils, and on an evaluation of potential plant and wildlife habitat at the site. The SLERA will follow EPA (1997, 2001) guidance to provide estimates of risks to potentially exposed wildlife; the methodology is designed to avoid underestimation of risks to provide a conservative basis for evaluating the potential need for additional site-specific risk assessment.,

2.4.1 Potential Sources and Release Mechanisms

Based on the information presented in Sections 2.1 through 2.3, a brief summary of sources and potential release mechanisms of chemicals to Process Areas soils is provided below:

- Seepage of process solutions from conveyances and ponds – Process solutions (pregnant or spent) conveyed in lined or unlined ditches, or in pipes, and solutions stored in lined or unlined ponds, may have been released at a number of locations.

- Spilling of sulfuric acid solutions – Sulfuric acid may have been released during filling or circulation via piping and pumps within the acid plant and the precipitation plant area, as well as conveyances between these components.
- Seepage of calcines – Calcines conveyed via the calcine ditch to the evaporation ponds may have been released.
- Releases of motor and fuel oil and gasoline – Spills of oils and fuels may have occurred during fueling of mine work vehicles via the mobile fueling truck and during maintenance of work vehicles. Maintenance activities may have also included the use of degreasers and soaps, which could have also been released. Releases may have also occurred via the floor drain located in the Truck Shop. Wash waters and drains may have drained to the Upper and Lower Truck Sludge Ponds.
- Leaks or spills from oil and fuel storage tanks – Underground and aboveground storage tanks were used to store oil and fuel. Leaks from tanks and at filling stations may have occurred over time and spills may have occurred during filling operations where tanks were or are located.
- Releases of laboratory materials – A drain line that leads to a dry well is portrayed on historical maps of the on-site laboratory. Releases of laboratory materials may have occurred via this line.
- Leaks and spills from stored materials – Stored lubricants, oils, solvents, and transformers may have leaked in cases where the integrity of the containers/equipment was compromised.

2.4.2 Potential Transport Pathways

Chemicals resulting from mining and milling activities may originate from the various source areas within the Process Areas. General transport mechanisms for chemicals from primary impacted media to secondary and tertiary impacted media are presented in Figure 2-5.

2.4.3 Surface Soil

Chemicals released directly to surface soils as a result of former mining and milling activities, or unplanned releases, may be transported by wind and surface water runoff. The presence of natural or man-made physical barriers, such as vegetation, concrete slab pads and foundations, and wind barriers (buildings walls, berms, etc) will inhibit or reduce the transport of particles as wind-blown dust. Particulates or fugitive dust transported by wind may be deposited and may accumulate in downwind areas. Areas of dust accumulation may become secondary sources of chemicals to subsurface soil and groundwater via leaching and percolation. In addition, the

migration of volatile chemicals (fuel-related compounds and radon) is influenced by the chemical and physical properties of the soils, and of each individual chemical, will be considered if volatile chemicals are present in the vadose zone and groundwater (EPA, 2002b).

2.4.4 Vadose Zone Infiltration

Infiltration of process solutions into the vadose zone, with the potential to source chemicals to groundwater is a potential release mechanism that likely ceased when operations associated with Anaconda/ARC ownership ended in 1978. The elimination of a driving head at the surface and increased soil moisture storage capacity resulted from the past evaporation of solutions on the surface and 'drying-out' of surface mine units (i.e., Seitz et. al., 1984). Subsequent operators at the Site (e.g., Copper Tek and Arimetco) re-established localized surface head conditions within or adjacent to the Process Areas (e.g., Mega Pond) where heap leach solutions may have resulted in the flux of mine-related chemicals to groundwater. These conditions are currently being addressed by EPA for the heap leach pads constructed by Arimetco in the 1990s (i.e., *Draft Field Sampling Plan for the Arimetco Heap Leach Pads*; CH2M Hill, 2007).

Geochemical processes such as mobilization and attenuation may modify the concentration of chemicals in percolating process solutions or leachate through soils or the underlying vadose zone. There is the potential for precipitation to leach (mobilize) constituents from mine unit materials. Conversely, some chemicals in meteoric water infiltrating through mine units may be attenuated (e.g., via adsorption). Salts and metals may be concentrated near the surface via evaporative reflux in the arid environments at the Site. Given the water balance conditions for the area of the Site, as described by Huxel (1969), the potential for the percolation of direct precipitation through the approximate 100-foot thickness of unsaturated alluvial fan materials underlying the Process Areas is extremely limited or non-existent.

Development of a conceptual model for the fate and transport of residual mine-related chemicals within the vadose zone underlying the Process Areas, and the potential for such chemicals to be sourced to groundwater under existing or anticipated conditions is required to develop vadose

zone characterization activities, as described in the FSAP (Section 6.0), and support predictive hydraulic modeling. The conceptual vadose zone model for the distal alluvial fan materials underlying the Process Areas is, in part, based on the grain size distribution data provided in Appendix D (D-1) for specific intervals of the boreholes that were drilled and logged during previous investigations (Brown and Caldwell, 2005a). The grain size distributions for PA-GW-14 (samples from 25 and 53 feet bgs), PA-GW-17 (samples from 15 and 54 feet bgs), and PA-GW-21 (samples from 16 and 62 feet bgs) suggest that the vadose zone is relatively homogeneous in character beneath the entire extent of the Process Areas. The sample intervals selected for the preliminary grain size analyses represent both silty sand and sandy lean clay soil classification types, as logged in the field.

Despite these generalized conditions, the vadose zone conceptual model must recognize the potential for preferential and fast-seepage toward the underlying alluvial aquifer (i.e., local heterogeneities). Preferential flow is defined as flow that occurs in a non-volume averaged fashion along localized, preferential pathways, by-passing a fraction of the porous space. In heterogeneous soils, such flow may occur along root channels, earthworm burrows, and soil fissure and cracks, as well as at geologic heterogeneities such as fractures or discontinuities in caliche layers. Heterogeneities may be created by depositional conditions, diagenesis of sediments, faulting, fracturing, and differential weathering processes. The heterogeneity of soils and sediments on different scales combined with non-uniform areal precipitation and run-off are primary causes of the phenomenon of multi-scale flow (slow matrix versus fast preferential) in the vadose zone (Looney and Falta, 2000). A conceptual model for water flow in heterogeneous soils is complicated by the following three factors (Looney and Falta, 2000):

- The contrasts in permeability of soils at different locations and depth in the system may be extreme, and very localized (e.g., on the scale of inches);
- The geometry of water flow depends strongly on the interconnection or connectivity of a preferential flow zone network, which makes the confirmation through field monitoring difficult, and very costly and time-consuming at best; and
- Point measurements, typically obtained from field monitoring, can not reveal complex processes that result from the interaction of features at many different scales.

Unsaturated water flow in the vadose zone is controlled by the unsaturated hydraulic conductivity and the hydraulic gradient. Under gravity drainage, the hydraulic gradient is typically considered to be a unit gradient (i.e., 1). Under this condition the magnitude of the unsaturated flux is determined by the unsaturated hydraulic conductivity with the unsaturated hydraulic conductivity being a function of the volumetric water content (θ) of the soil (i.e., $K(\theta)$). The direction of the unsaturated flow flux is determined based on the matric suction or negative pore water pressure (Ψ) value with moisture moving from less negative values (lower suction) to more negative values (higher suction). To solve flow problems for unsaturated soils, a relationship between pore-water pressure and the soil θ value is required. This relationship is represented by the soil-water characteristic curve (“SWCC”).

The most common approach to determine unsaturated hydraulic conductivity is to develop a SWCC from either field or laboratory data, and then use an analytical equation that relates θ for a given soil to the unsaturated hydraulic conductivity (e.g., van Genuchten, 1980). Values for θ and Ψ are affected by the texture and structure of soils (more complex aspects include hysteresis, salinity, and pore-size distribution). Any quantitative assessment of unsaturated flow must account for these uncertainties. Field and laboratory characterization efforts should focus on these primary drivers under ambient flux conditions, and the four vadose moisture profile zones recognized in a (semi-) arid climate, as observed at the Site (Looney and Falta, 2000):

1. Land surface or boundary zone which is directly and immediately affected by episodic climatic events including precipitation, temperature, and wind. This zone extends from the surface to approximately two feet bgs.
2. An intermediate zone extending from the boundary zone to as much as 30 feet bgs. This zone may attenuate land surface climatologic effects, particularly in the semi-arid west, and will act as a short-term storage zone for infiltrated precipitation.
3. A deep vadose zone of virtually constant moisture content, in which the hydraulic gradient is unity, i.e. 1, and there is annual downward water flow. This zone is estimated to extend from the intermediate vadose zone to the capillary fringe above the water table, which may be up to 10 feet in thickness.
4. A capillary fringe zone above the water table.

Land Surface or Boundary Zone

This zone controls the amount of precipitation that infiltrates into the subsurface versus the amount of precipitation that becomes runoff. The hydrologic behavior of this zone can vary seasonally dependent on precipitation intensity and other climatic factors such as temperature, wind and humidity. Measuring and/or mathematically representing the soil surface boundary condition is one of the most challenging tasks in unsaturated zone hydrology. Depending on conditions at this surface boundary, soil water may be in a state of draining, wetting, or drying. Most of the dynamics of soil moisture movement occur in this zone and an accurate understanding and measurement of fluxes across this zone is crucial to measuring site-specific fluxes to the water table.

Near-Surface or Intermediate Zone

This zone is much less dynamic than the boundary zone, and tends to attenuate the climatologic events that occur at the soil surface. It can have seasonally different flux rates and direction depending on climatic conditions. For example, a net positive flux into the deeper soil zone may occur in the winter months due to low potential evaporation rates, whereas, in the summer there may be a flux out of the near-surface soil zone due to high potential evaporation rates. The thickness of this zone can vary both due to climatic conditions and soil properties.

Deep Vadose Zone

This zone is largely insulated from climatic effects at the land surface, or fluctuating water tables caused by larger scale regional hydrologic stresses. It is characterized by largely downward movement of any seepage that infiltrates from the land surface and manages to migrate through the intermediate zone without being extracted via evapotranspiration. The magnitude, timing and location of infiltration through the deep zone will result from the geotechnical properties of, and localized heterogeneities within, the alluvial fan materials.

Past infiltration of mine-related chemicals from Process Areas components through the vadose zone to groundwater may have occurred in localized areas where sufficient volumes of process or

other solutions were present to create the necessary hydraulic head. However, based on the low precipitation rates observed at the Site (i.e., effectively zero recharge rates to groundwater from precipitation; Huxel, 1969) and high evaporation rates, very little infiltration under existing conditions would be expected. The vadose zone conceptual model suggests very limited or no potential for present-day or future migration of mine-related chemicals from the alluvial fan materials underlying the Process Areas to the groundwater pathway.

2.4.5 Groundwater

Mine-related groundwater that may have been sourced from Process Areas components, or from other hydraulically up-gradient surface mine units (e.g., Anaconda or Arimetco leach pads, or Arimetco process facilities), may migrate to other areas of the Site or flow off-Site. Potential physical and chemical pathways are discussed in more detail in the *Site-wide Groundwater Remedial Investigation Work Plan* (Brown and Caldwell 2007a). Additional groundwater data is currently being collected to improve the CSM for groundwater conditions pursuant to the *Second-Step Hydrogeologic Framework Assessment Work Plan* (Brown and Caldwell 2007b).

2.4.6 Surface Water

Erosion and leaching of surface mine units due to surface water runoff (e.g., storm water events or snowmelt) may result in the deposition of chemicals in other down-gradient locations. Storm water may potentially accumulate in the north and south low areas, as well as the calcine ditch and other ditches. Accumulation of water in topographically low areas may occur where otherwise, during dry times of the year, soil would be exposed. Areas of surface water accumulation may become secondary sources of chemicals to subsurface soil and groundwater via leaching and vadose zone infiltration.

2.4.7 Radiation

In addition to migration of chemicals from their sources to other media, radiation may exist where radiochemicals occur in soils, surface water and groundwater, or where such media have contacted buildings, equipment, piping, structures or other features. Transport of the material

may have occurred, or may be occurring, by any of the transport pathways described above. Exposure to external radiation is limited to materials within the upper 6 inches of soil thickness, radiochemicals found below this level are shielded by the top layer of soil. External radiation from materials (e.g., buildings, structures, piping or weathered pipe scale, etc.) is geometrically attenuated even with no interposed shielding materials, (i.e., inverse square law). The effects of elevated levels of external radiation are limited to within a few meters, typically less than 5 meters, and often less than 1 to 2 meters from the source (Cember, 1996).

SECTION 3.0

RESULTS OF PREVIOUS SOILS INVESTIGATIONS

Initial characterization activities of Process Areas soils, documented in the *Data Summary Report for Process Areas Soils Characterization* (Brown and Caldwell, 2005b), provide the framework for additional soils investigations presented in this Process Areas RI Work Plan. The soil characterization activities performed during the fourth quarter of 2004 and the first quarter of 2005 consisted of the following:

- Collection of surface and subsurface samples by sonic core drilling and surface grab sampling;
- Excavation and sampling of underground utility pipelines;
- Excavation and sampling of hydrocarbon stained soils; and
- Analysis of soil samples for a wide variety of chemical classes and analytes.

Most sample locations targeted specific processing components such as buildings, tanks, pumps, and ditches (i.e., biased or judgmental sampling) to evaluate areas most likely to be affected by process-related activities (e.g., solution conveyances, drains, sumps, or piping). The rationale for the sample locations, and figures identifying the location of samples in each designated sub-area (Areas 1 through 12) are provided in Appendix E (E-1). The biased sampling program served to evaluate the perceived “worst-case” conditions in the Process Areas because:

- Significant historical and physical information was available for each feature; and
- The objective of the investigation was to evaluate the Process Areas for the presence or absence of chemicals contamination at levels of concern to human health and the environment.

In addition, at the request of the BLM, grid sampling of a targeted portion (Areas 10 and 11) of the Process Areas was also conducted (all grid sampling areas were located on BLM property). A total of 1,129 samples were collected from 319 locations in the Process Areas from borehole and surface grab samples. All samples were analyzed for the full suite of analytes listed in the

Process Areas Work Plan (Brown and Caldwell, 2003) including: metals, petroleum hydrocarbons, VOCs, SVOCs, acid-base potential (ABP), pesticides, herbicides and PCBs. Samples collected around process components and piping were also analyzed for radiochemicals (samples associated with support buildings such as the administration building and maintenance shops were not sampled for radiochemicals). This section summarizes the analytical results and discusses the occurrence and distribution of chemicals in Process Areas soils by general chemical class (e.g., metals or radiochemicals), and by sub-area (e.g., Area 1 or Area 2). Analytical results for soil samples are tabulated by sub-area and chemical group in Appendix E (E-2).

In a letter dated April 16, 2007 (*EPA Review Comments on Data Summary Report for Process Areas Soils Characterization, dated November 1, 2005 Anaconda Copper Mine Site, Yerington, Nevada*), EPA requested that ARC use a ‘quasi-background’ screening level for assessing the soils data collected during the initial Process Areas soils investigation; the screening level was calculated by multiplying the median concentration of analytical results from a sample set by three (i.e., 3x median value). ARC cannot find EPA guidance for this approach, which was suggested in lieu of the availability of background soils data from off-Site locations for the assessment. In addition to other suggestions for this Process Areas RI Work Plan, to be implemented by ARC, EPA also suggested in their comments letter that:

- “Ambient concentrations for metals and radionuclides such as Radium-226, Radium-228, Thorium-232, and Uranium in soil and groundwater will need to [be] assessed to establish background concentrations at the mine site; and
- “Radium-226 and -228 concentrations exceeding EPA Region 9 [Preliminary Remediation Goals] PRGs should be further delineated in Areas 4, 5, 7, 9, and 12.”

ARC agrees with these recommendations. The first bullet regarding the need for background soils data to use as guidance for defining mine-related chemicals in Process Areas soils is currently being addressed. Field sampling of soils to define background conditions for the Site, pursuant to the *Background Soils Work Plan* (Brown and Caldwell, 2006), was completed in August 2007. Analytical results and statistical analysis of the analytical data for the background soils sampling program, and its comparison to Process Areas soils data, should be available in

November 2007. This schedule will likely precede the implementation of the soils sampling phase of the field investigations, as described in Section 6.0. Therefore, with regard to the use of the 3x median value as a guideline to the soil investigations described in Section 6.0, ARC will request that EPA consider a modification to the FSAP based on the results of the background soils investigation.

For the purposes of this Process Areas RI Work Plan, ARC proposes to use the 3x median or Residential PRG value, whichever is greater, as the screening level for additional soils investigations. Based on local government (City of Yerington and Lyon County) proposed reuse of the Process Areas for light industrial and commercial purposes, as presented in the February 21, 2007 letter and attached map from the Mason Valley Environmental Committee (“MVEC”) to the EPA, ARC reiterates its prior comments to EPA that the use of residential PRGs as a preliminary soils screening tool within the RI/RS process is conservative for the HHRA, given that remedial actions should be based on Site-specific remedial guidelines for light commercial or industrial land uses to be determined based on background soils data and other Site-specific data per EPA guidance (<http://www.epa.gov/oswer/riskassessment/datause/parta.htm>).

Chemical data are presented visually in several ways in Appendix F: box plots and, individual value plots (“IVPs”; Appendix F-1) and perspective subsurface views (Appendix F-2). These graphics can be used in conjunction with the text descriptions and tabulated data provided below to assist in the interpretation of the existing soils data from the Process Areas. The following bullets describe these graphs and visualizations:

- **Box Plots:** Box plots (also referred to as “box and whisker plots”) are used to evaluate differences between multiple groups of environmental data and data spread, central tendency, skewness, and the presence or absence of outliers. The type of box plot used in this analysis is the standard box plot. The box itself contains the center 50 percent of the data (i.e., the interquartile range), and the median is indicated as a horizontal line within the box. The top edge of the box is the 75th percentile and the bottom edge is the 25th percentile. Vertical lines, sometimes called whiskers, extend to the last observation within one step beyond either end of the box. A step is 1.5 times the height of the box. Data points that fall outside one step are considered to be “outliers”, and values that fall

outside of two steps are labeled “extreme”. Outliers and extremes are individually plotted. The box plots provided in Appendix F (F-1) were constructed using Statistica (StatSoft, 2004).

- **Individual Value Plots:** IVPs are similar to univariate plots except in situations when the dataset includes multiple observations of the same magnitude. In those cases, the data points are spread out horizontally from the vertical axis. IVPs were produced using Minitab software (Minitab, 2006). Three comparison values are shown on each IVP: the 3x median value, the Residential PRG value and the Industrial PRG value.
- **Perspective Subsurface Views:** Perspective subsurface views of soil concentration data were created by the Site data management tool. At the top of each view, site structures in their proper location can be seen through a transparent surface layer. Each soil boring is represented by a vertical line that extends to the total depth of the boring (the vertical scale of the site model is exaggerated 30 times for clarity). Soil samples collected at discrete depths in the borings are represented as spheres along the vertical line. The radius of each sphere is proportional to the chemical concentration detected for that depth-specific soil sample. The color of each sphere references the concentration relative to one of four ranges: green for concentrations less than the 3x median value; yellow for concentrations less than the Residential PRG; orange for concentrations less than the Industrial PRG; and red for concentrations exceeding the Industrial PRG.

3.1 Metals Results

Soil samples were analyzed for 27 metals by EPA Methods 6010B and 6020. Although thorium and uranium are analyzed under these methods, the analytical results are discussed under Section 3.2 (Radiochemical Results). The following sections discuss summary statistics, preliminary soil screening levels, comparison of metals results to the 3x median and residential PRG screening criteria, and metals distribution by sub-area and depth. Perspective subsurface views are provided for arsenic, copper and iron.

3.1.1 Summary Statistics

Table 3-1 provides summary statistics of analytical results for metals: sample count, quantity of detections, minimum/maximum, mean, median, standard deviation, and coefficient of variation. Non-detected results were included in the statistics by assuming the metal was present at half the method detection limit (“MDL”).

Eighteen of the 25 metals that were analyzed in soil samples were detected frequently (i.e., 97 to 100 percent detections). Six metals (boron, mercury, molybdenum, selenium, silver, and thallium) were detected less frequently (i.e., 52 to 83 percent detections). These less frequently detected metals also had a high percentage (34 to 9 percent) of trace detections (i.e., estimated values between the MDL and the practical quantitation limit or PQL, normally 3 to 10 times the MDL and considered the lowest concentration that can be accurately measured), indicating that when they were detected, they were typically at low concentrations. Analytical results for antimony had specific quality control issues, which will be discussed in a following section.

Table 3-1. Summary Statistics of Metals Analytical Results for Process Areas Soils

Analyte	Sample Count	Qty. & Percent Detects		Qty. & Percent Trace Detects ⁽¹⁾		Concentration (mg/kg)					Coeff of Var.
						Min.	Mean	Median	Max.	Std. Dev.	
Aluminum	1,103	1,103	100%	0	0%	230	5,630	5,400	15,000	1,850	0.33
Antimony ⁽²⁾	1,103	---	---	---	---	---	---	---	---	---	---
Arsenic	1,103	1,103	100%	0	0%	0.31	5.88	3.5	410	15.1	2.6
Barium	1,103	1,103	100%	0	0%	13	53.2	48	400	27.4	0.52
Beryllium	1,103	1,079	98%	26	2.4%	0.0083	0.26	0.25	1.6	0.106	0.41
Boron	1,103	689	62%	516	75%	0.29	2.64	2.25	17	2.02	0.76
Cadmium	1,103	1,073	97%	1	0.09%	0.037	0.30	0.25	2.5	0.194	0.64
Calcium	1,103	1,103	100%	0	0%	300	5,890	5,600	29,000	3,100	0.53
Chromium, Total	1,103	1,102	100%	3	0.27%	0.28	5.75	4.0	71	6.41	1.1
Cobalt	1,103	1,097	99%	8	0.73%	0.09	3.46	3.2	39	1.98	0.57
Copper	1,103	1,103	100%	0	0%	3.6	382	66	44,000	1,750	4.6
Iron	1,103	1,103	100%	1	0.09%	1.2	11,100	9,400	95,000	6,180	0.56
Lead	1,103	1,103	100%	0	0%	1.2	9.32	3.2	1,300	58.2	6.3
Magnesium	1,103	1,103	100%	0	0%	55	3,010	2,900	18,000	1,120	0.37
Manganese	1,103	1,103	100%	0	0%	2.8	148	150	600	72.0	0.49
Mercury	1,095	732	67%	387	53%	0.00015	0.096	0.003	11	0.529	5.5
Molybdenum	1,103	865	78%	295	34%	0.04	0.802	0.29	20	1.74	2.2
Nickel	1,103	1,096	99%	1	0.09%	0.2	5.04	4.4	82	4.51	0.90
Potassium	1,103	1,102	100%	0	0%	140	1,270	1,200	5,100	489	0.38
Selenium	1,103	574	52%	441	77%	0.16	1.02	0.18	110	4.84	4.8
Silver	1,103	912	83%	789	87%	0.022	0.079	0.053	4.20	0.161	2.0
Sodium	1,103	1,094	99%	0	0%	36	384	240	7,900	631	1.6
Thallium	1,103	881	80%	793	90%	0.0021	0.208	0.053	40.0	1.40	6.7
Thorium-232	502	500	100%	0	0%	1	10.9	6.9	241	20.5	1.9
Uranium	502	496	99%	0	0%	0.5	4.03	1.6	150	9.00	2.2
Vanadium	1,103	1,103	100%	0	0%	1.3	14.4	13	62.0	5.57	0.39
Zinc	1,103	1,086	98%	10	0.92%	2.6	26.7	16	7,100	215	8.0

Notes: (1) Trace detections are estimated values between the MDL and the PQL
(2) Summary statistics for antimony were not calculated due to specific quality control issues

3.1.2 Preliminary Soil Screening Levels

As stated above with regard to the use of available screening criteria for assessing existing soils data, and designing the proposed remedial investigation, the information in Table 3.2 has been compiled to support the selection of appropriate preliminary soil screening levels for metals. The screening levels are set at the 3x median value or Residential PRG value, whichever is greater. Note that Industrial PRGs are also provided in Table 3.2 for comparison of criteria used for characterization activities with criteria that may be used for remedial activities, indicating the conservative nature of the remedial investigation program for Process Areas soils.

Analyte	Concentration (mg/kg)			
	3x Median Value	Residential PRG	Industrial PRG	Screening Level
Aluminum	16,200	76,000	100,000	76,000
Antimony ⁽¹⁾	---	31	410	---
Arsenic	10.5	0.39	1.6	10.5
Barium	144	5,400	67,000	5,400
Beryllium	0.75	150	1,900	150
Boron	6.8	16,000	100,000	16,000
Cadmium	0.75	37	450	37
Calcium ⁽²⁾	16,800	---	---	---
Chromium, Total	12	210	450	210
Cobalt	9.6	900	1,900	900
Copper	189	3,100	41,000	3,100
Iron	28,200	23,000	100,000	28,200
Lead	9.6	400	800	400
Magnesium ⁽²⁾	8,700	---	---	---
Manganese	450	1,800	19,000	1,800
Mercury	0.009	23	310	23
Molybdenum	0.87	390	5,100	390
Nickel	13.2	1,600	20,000	1,600
Potassium ⁽²⁾	3,600	---	---	---
Selenium	0.54	390	5,100	390
Silver	0.159	390	5,100	390
Sodium ⁽²⁾	720	---	---	---
Thallium	0.16	5.2	67	5.2
Vanadium	39	78	1,000	78
Zinc	48	23,000	100,000	23,000

Notes:

- (1) 3 x Median Value for antimony was not calculated due to specific quality control issues
- (2) Screening levels were not created because PRGs have not been established for these metals

The 3x median values provide a preliminary estimation of background values to assist with determining appropriate preliminary soil screening levels for delineation sampling and additional soils investigations in lieu of background soils data from adjacent off-site locations. The PRGs

were developed by EPA as generic criteria using risk-based calculations for potential populations exposed to chemicals at a generic site by various exposure pathways (e.g., inhalation of dust, ingestion or absorption). Both arsenic and iron have 3x median values greater than their corresponding residential PRG values. EPA has not established PRGs for calcium, magnesium, potassium or sodium, which are listed by the EPA as nutrients. Therefore, preliminary soil screening levels were not created for these chemicals.

3.1.3 Comparison of Metals Results to Screening Levels

As presented in Table 3-3, 16 metals (aluminum, barium, beryllium, boron, cadmium, chromium, cobalt, manganese, mercury, molybdenum, nickel, selenium, silver, vanadium, and zinc) had no detections above the preliminary soil screening levels, and are not considered for further investigation.

Analyte	Sample Count	Quantity of Detections	Quantity/Percent Detections ≥ 3x Median Value		Quantity/Percent Detections ≥ Screening Level		Further Investigation Required
			Quantity	Percent	Quantity	Percent	
Aluminum	1,103	1,103	0	0%	0	0%	
Antimony ⁽¹⁾	1,103	---	---	---	---	---	X
Arsenic	1,103	1,103	82	7.4%	82	7.4%	X
Barium	1,103	1,103	12	1.1%	0	0%	
Beryllium	1,103	1,079	2	0.1%	0	0%	
Boron	1,103	689	48	7.0%	0	0%	
Cadmium	1,103	1,073	26	2.4%	0	0%	
Calcium ⁽²⁾	1,103	1,103	11	1.0%	---	---	
Chromium, Total	1,103	1,102	96	8.7%	0	0%	
Cobalt	1,103	1,097	16	1.5%	0	0%	
Copper	1,103	1,103	226	20%	27	2.4%	X
Iron	1,103	1,103	23	2.1%	23	2.1%	X
Lead	1,103	1,103	89	8.1%	2	0.18%	X
Magnesium ⁽²⁾	1,103	1,103	3	0.2%	---	---	
Manganese	1,103	1,103	3	0.2%	0	0%	
Mercury	1,095	732	393	54%	0	0%	
Molybdenum	1,103	865	191	22%	0	0%	
Nickel	1,103	1,096	20	1.8%	0	0%	
Potassium ⁽²⁾	1,103	1,102	3	0.2%	---	---	
Selenium	1,103	574	194	34%	0	0%	
Silver	1,103	912	74	8.1%	0	0%	
Sodium ⁽²⁾	1,103	1,094	77	7.0%	---	---	
Thallium	1,103	881	176	20%	7	0.79%	X
Vanadium	1,103	1,103	6	0.5%	0	0%	
Zinc	1,103	1,086	37	3.4%	0	0%	

Notes: (1) Comparison for antimony is not provided due to specific quality control issues
(2) Screening levels were not created because PRGs have not been established for these metals

Four metals (calcium, magnesium, potassium, and sodium) do not have PRGs and are also not considered for further investigation. Five metals (arsenic, copper, iron, lead and thallium) exhibited one or more detections above the screening level and require further investigation. Antimony also requires further investigation due to specific quality control issues.

3.1.4 Metals Distribution

The distribution of each of the 25 metals is briefly discussed below. Also provided for each metal is the recommendation whether to include or eliminate the metal from the analyte list in the proposed remedial investigation of Process Areas soils based on the extensive data available from the initial investigation.

- **Aluminum:** detected in all 1,103 samples above the PQL. Aluminum results ranged from 230 mg/kg to 15,000 mg/kg with a mean of 5,630 mg/kg and a median of 5,400 mg/kg. No results were above the 3x median value of 16,200 mg/kg or the preliminary soil screening level of 76,000 mg/kg. The box plots and IVPs indicate aluminum is distributed uniformly throughout the Process Areas and at depth. Aluminum is to be removed from the analyte list for subsequent soil investigation.
- **Antimony:** Matrix spike recoveries for antimony in soil samples were very poor, resulting in rejection or estimation (due to low bias) of all 1,103 results. During the 2004-2005 investigation, 74 pairs of matrix spikes were analyzed. The range of recoveries for antimony was 0 to 18 percent with an average recovery of 4 percent. Statistics and a 3x median value were not calculated for antimony. A new sample preparation method is proposed in a following section to improve antimony detection in subsequent samples. Antimony is to remain on the analyte list for subsequent soil investigations.
- **Arsenic:** detected in all 1,103 samples above the PQL. Arsenic results ranged from 0.31 mg/kg to 410 mg/kg with a mean of 5.88 mg/kg and a median of 3.5 mg/kg. The maximum concentration of 410 mg/kg occurred in Area 7 at sample depth 9-10 feet bgs at location PA-WW4-10. A total of 82 of 1,103 (7.4 percent) detections were above the preliminary soil screening level (set at the 3x median value) of 10.5 mg/kg. Appendix F (F-2) provides an oblique view of subsurface arsenic concentrations. The area box plots indicate that arsenic is prevalent throughout the Process Areas. The highest concentrations are in Areas 4 and 7 through 12. Areas 1, 2, 3, 5, and 6 have low concentrations of arsenic. The box plots indicate that arsenic is prevalent throughout the subsurface to depths of 25 feet bgs. Arsenic concentrations tend to be lowest below 20 feet bgs. Arsenic is to remain on the analyte list for subsequent soil investigations.

- Barium: detected in all 1,103 samples above the PQL. Barium results ranged from 13 mg/kg to 400 mg/kg with a mean of 53.2 mg/kg and a median of 48 mg/kg. No results were above the preliminary soil screening level of 5,400 mg/kg. The box plots and IVPs indicate barium is distributed uniformly throughout the Process Areas and throughout sampling depth. Barium is to be removed from the analyte list for subsequent soil investigations.
- Beryllium: detected in 1,079 of 1,103 (98 percent) samples with few (2.4 percent) trace detections. Beryllium results ranged from 0.0083 mg/kg to 1.6 mg/kg with a mean of 0.26 mg/kg and a median of 0.25 mg/kg. No results were above the preliminary soil screening level of 150 mg/kg. The box plots and IVPs indicate beryllium is distributed uniformly throughout the Process Areas and throughout sampling depth. Beryllium is to be removed from the analyte list for subsequent soil investigations.
- Boron: detected in 689 of 1,103 (62 percent) samples with many (75 percent) trace detections. Boron results ranged from 0.29 mg/kg to 17 mg/kg with a mean of 2.64 mg/kg and a median of 2.25 mg/kg. No results were above the preliminary soil screening level of 16,000 mg/kg. The box plots and IVPs indicate boron is distributed uniformly throughout the Process Areas and throughout sampling depth. Boron is to be removed from the analyte list for subsequent soil investigations.
- Cadmium: detected in 1,073 of 1,103 (97 percent) samples with only one trace detection. Cadmium results ranged from 0.037 mg/kg to 2.5 mg/kg with a mean of 0.3 mg/kg and a median of 0.25 mg/kg. No results were above the preliminary soil screening level of 37 mg/kg. The box plots and IVPs indicate cadmium is distributed uniformly throughout the Process Areas and throughout sampling depth. Cadmium is to be removed from the analyte list for subsequent soil investigations.
- Calcium: detected in all 1,103 above the PQL. Calcium results ranged from 300 mg/kg to 29,000 mg/kg with a mean of 5,890 mg/kg and a median of 5,600 mg/kg. A preliminary soil screening level was not created because PRGs have not been established for calcium. The area box plots indicate that calcium concentrations are fairly consistent throughout all areas. The depth box plots indicate that calcium concentration is fairly consistent throughout all depth intervals. Calcium is to be removed from the analyte list for subsequent soil investigations.
- Chromium, Total: detected in all but one of 1,103 samples with only three trace detections. Chromium results ranged from 0.28 mg/kg to 71 mg/kg with a mean of 5.75 mg/kg and a median of 4.0 mg/kg. No detections were above the preliminary soil screening level of 210 mg/kg. The area box plots indicate that chromium concentrations are highest in Area 7 followed by Area 9. The next highest chromium concentrations occur in Areas 4, 11, and 12. Areas 1, 2, 3, 5, 6, 8 and 10 have low concentrations of chromium. The area box plots indicate that chromium concentrations are fairly consistent throughout all areas. The depth box plots indicate that chromium concentration is fairly consistent throughout all depth intervals. Chromium is to be removed from the analyte list for subsequent soil investigations.

- Cobalt: detected in 1,097 of 1,103 (99 percent) samples with few (0.73 percent) trace detections. Cobalt results ranged from 0.09 mg/kg to 39 mg/kg with a mean of 3.46 mg/kg and a median of 3.2 mg/kg. No detections were above the preliminary soil screening level of 900 mg/kg. The area box plots indicate that cobalt concentrations are fairly consistent throughout all areas. The depth box plots indicate that cobalt concentration is fairly consistent throughout all depth intervals. Cobalt is to be removed from the analyte list for subsequent soil investigations.
- Copper: detected in all 1,103 samples above the PQL. Copper results ranged from 3.6 mg/kg to 44,000 mg/kg with a mean of 382 mg/kg and a median of 66 mg/kg. The maximum concentration of 44,000 mg/kg occurred in Area 5 at a sample depth of 0-0.5 feet bgs at location PA-EE6-1. Twenty-seven (2.4 percent) detections were above the preliminary soil screening level of 3,100 mg/kg. Appendix F (F-2) provides a perspective view of subsurface copper concentrations. The area box plots indicate that copper is uniformly present across the central portion of the Process Areas with the highest values in Area 5. The next highest copper concentrations occur in Areas 3, 4, and 12. Areas 1 and 6 have low concentrations of copper. The depth box plots indicate that copper is most prevalent in the 0-1 feet and 1-5 feet depth intervals and its occurrence decreases with depth. The highest copper concentrations are found in the 0-1 foot depth interval. Copper is to remain on the analyte list for subsequent soil investigations.
- Iron: detected in all 1,103 samples with only one trace detection. Iron results ranged from 1.2 mg/kg to 95,000 mg/kg with a mean of 11,100 mg/kg and a median of 9,400 mg/kg. The maximum concentration of 95,000 mg/kg occurred in Area 7 at sample depth 9-10 feet bgs at location PA-WW4-10. A total of 23 of 1,103 (2.1 percent) detections were above the preliminary soil screening level (set at the 3x median value) of 28,200 mg/kg. Appendix F (F-2) provides an perspective view of subsurface iron concentrations. The area box plots indicate that iron is most prevalent in Areas 8 through 11. Iron concentrations tend to be lowest below 20 feet bgs, with few detections at depths greater than 25 feet bgs. Iron is to remain on the analyte list for subsequent soil investigations.
- Lead: detected in all 1,103 samples above the PQL. Lead results ranged from 1.2 mg/kg to 1,300 mg/kg with a mean of 9.32 mg/kg and a median of 3.2 mg/kg. The maximum concentration of 1,300 mg/kg occurred in two locations in Area 2: PA-O2-1 at sample depth 0.5-2.5 feet bgs near the southeastern corner of the Lead Shop; and grab surface sample PA-UT36 near the drain line leading from the Secondary Crusher. Two (0.18 percent) detections were above the preliminary soil screening level of 400 mg/kg. The two detections were at 1,300 mg/kg mentioned previously. Note that lead results in soil samples from the Truck Wash and Paint Shop (where lead paint may have been used) were not above the screening level. The area box plots indicate that lead concentrations are fairly consistent throughout all areas. The depth box plots indicate that lead is most prevalent in the 0-1 feet depth interval and its occurrence decreases slightly with depth. The highest lead concentrations are found in the 0-1 foot depth interval. Although lead impacts tend to be isolated to two locations in Area 2 only (the Lead Shop and drain line from the Secondary Crusher), lead is to remain on the analyte list for subsequent soil investigations.

- **Magnesium**: detected in all 1,103 samples above the PQL. Magnesium results ranged from 55 mg/kg to 18,000 mg/kg with a mean of 3,010 mg/kg and a median of 2,900 mg/kg. A total of 3 of 1,103 (0.3 percent) detections were above the 3x median value of 8,700 mg/kg. A preliminary soil screening level was not created because PRGs have not been established for magnesium. The area box plots indicate that magnesium concentrations are fairly consistent throughout all areas. The depth box plots indicate that magnesium concentration is fairly consistent throughout all depth intervals. Magnesium is to be removed from the analyte list for subsequent soil investigations.
- **Manganese**: detected in all 1,103 samples above the PQL. Manganese results ranged from 2.8 mg/kg to 600 mg/kg with a mean of 148 mg/kg and a median of 150 mg/kg. No results were above the preliminary soil screening level of 1,800 mg/kg. The box plots and IVPs indicate manganese is distributed uniformly throughout the Process Areas and at depth. Manganese is to be removed from the analyte list for subsequent soil investigations.
- **Mercury**: detected in 732 of 1,095 (67 percent) samples with many (53 percent) trace detections. A total of 8 results were rejected due to low bias associated with problems on ICV, CCV or column performance checks. Mercury results ranged from 0.00015 mg/kg to 11 mg/kg with a mean of 0.096 mg/kg and a median of 0.003 mg/kg. No results were above the preliminary soil screening level of 23 mg/kg. The box plots and IVPs indicate mercury is distributed uniformly throughout the Process Areas. The depth box plots indicate that mercury is most prevalent in the 0-1 foot depth interval and its occurrence decreases slightly with depth. The highest mercury concentrations are found in the 0-1 foot depth interval. Mercury is to be removed from the analyte list for subsequent soil investigations.
- **Molybdenum**: detected in 865 of 1,103 (78 percent) samples with many (34 percent) trace detections. Molybdenum results ranged from 0.04 mg/kg to 20 mg/kg with a mean of 0.80 mg/kg and a median of 0.29 mg/kg. No results were above the preliminary soil screening level of 390 mg/kg. The box plots and IVPs indicate molybdenum is distributed uniformly throughout the Process Areas and throughout sampling depth. Molybdenum is to be removed from the analyte list for subsequent soil investigations.
- **Nickel**: detected in 1,096 of 1,103 (99 percent) samples with one trace detection. Nickel results ranged from 0.2 mg/kg to 82 mg/kg with a mean of 5.0 mg/kg and a median of 4.4 mg/kg. No results were above the preliminary soil screening level of 1,600 mg/kg. The box plots and IVPs indicate nickel is distributed uniformly throughout the Process Areas and throughout sampling depth. Nickel is to be removed from the analyte list for subsequent soil investigations.
- **Potassium**: detected in all but one of 1,103 samples above the PQL. Potassium results ranged from 140 mg/kg to 5,100 mg/kg with a mean of 1,270 mg/kg and a median of 1,200 mg/kg. A preliminary soil screening level was not created because PRGs have not been established for potassium. The area box plots indicate that potassium concentrations

are fairly consistent throughout all areas. The depth box plots indicate that potassium concentration is fairly consistent throughout all depth intervals. Potassium is to be removed from the analyte list for subsequent soil investigations.

- **Selenium:** detected in 574 of 1,103 (52 percent) samples with many (77 percent) trace detections. Selenium results ranged from 0.16 mg/kg to 110 mg/kg with a mean of 1.0 mg/kg and a median of 0.18 mg/kg. No results were above the preliminary soil screening level of 390 mg/kg. The box plots and IVPs indicate selenium is distributed uniformly throughout the Process Areas and throughout sampling depth. Selenium is to be removed from the analyte list for subsequent soil investigations.
- **Silver:** detected in 912 of 1,103 (83 percent) samples with many (87 percent) trace detections. Silver results ranged from 0.022 mg/kg to 4.2 mg/kg with a mean of 0.079 mg/kg and a median of 0.053 mg/kg. No results were above the preliminary soil screening level of 390 mg/kg. The box plots and IVPs indicate silver is distributed uniformly throughout the Process Areas and throughout sampling depth. Silver is to be removed from the analyte list for subsequent soil investigations.
- **Sodium:** detected in 1,094 of 1,103 (99 percent) samples above the PQL. Sodium results ranged from 36 mg/kg to 7,900 mg/kg with a mean of 384 mg/kg and a median of 240 mg/kg. A preliminary soil screening level was not created because PRGs have not been established for sodium. The area box plots indicate that sodium concentrations are fairly consistent throughout all areas. The depth box plots indicate that sodium concentration is fairly consistent throughout all depth intervals. Sodium is to be removed from the analyte list for subsequent soil investigations.
- **Thallium:** detected in 881 of 1,103 (80 percent) samples, with many (90 percent) trace detections. Thallium results ranged from 0.0021 mg/kg to 40 mg/kg with a mean of 0.21 mg/kg and a median of 0.053 mg/kg. The maximum concentration of 40 mg/kg occurred in Area 7 at sample depth 9-10 feet bgs at location PA-WW4-10. Seven (0.79 percent) detections were above the preliminary soil screening level of 5.2 mg/kg. The area box plots indicate that thallium concentrations are highest in Area 7 followed by Area 9. The next highest thallium concentrations occur in Areas 4, 11, and 12. Areas 1, 2, 3, 5, 6, 8 and 10 have low concentrations of thallium. The depth box plots indicate that thallium concentration is fairly consistent throughout the 0-1 feet, 1-5 feet, 5-10 feet, and 10-15 feet depth intervals. Thallium concentrations tend to be lowest below 20 feet. Thallium is to remain on the analyte list for subsequent soil investigations.
- **Vanadium:** detected in all 1,103 samples above the PQL. Vanadium results ranged from 1.3 mg/kg to 62 mg/kg with a mean of 14 mg/kg and a median of 13 mg/kg. No detections were above the preliminary soil screening level of 78 mg/kg. The area box plots indicate that vanadium concentrations are fairly consistent throughout all areas. The depth box plots indicate that vanadium concentration is fairly consistent throughout all depth intervals. Vanadium is to be removed from the analyte list for subsequent soil investigations.

- **Zinc:** detected in 1,086 of 1,103 (98 percent) samples with few (0.92 percent) trace detections. Zinc results ranged from 2.6 mg/kg to 7,100 mg/kg with a mean of 27 mg/kg and a median of 16 mg/kg. No detections were above the preliminary soil screening level of 23,000 mg/kg. The area box plots indicate that zinc concentrations are fairly consistent throughout all areas. The depth box plots indicate that zinc concentration is fairly consistent throughout all depth intervals. Zinc is to be removed from the analyte list for subsequent soil investigations.

3.2 Radiochemical Results

Soil samples were analyzed for radium-226 and radium-228 by HASL 300, and for thorium and uranium by EPA Method 6020. The thorium and uranium analyses were elemental analyses that can be assumed to represent thorium-232 and uranium-238 concentrations. Each of these radiochemicals is representative of a section of a natural radioactive decay chain. The radioactive progeny of uranium-238 and uranium-234 are considered to be in equilibrium down to radium-226. Radium-226 may or may not be in equilibrium with uranium-238, but will be in equilibrium with its progeny down to lead-210. Radium-228 may or may not be in equilibrium with thorium-232, but will be in equilibrium with its progeny down to stable lead-208. This is based on the assumption that radon (Rn-222) and thoron (Rn-220) exhalation is negligible, which is conservative and reasonable for the purposes of soil concentrations.

3.2.1 Summary Statistics

Table 3-4 summarizes the radiochemical results for Process Areas soils. All four radiochemicals were detected frequently (83 to 99 percent).

Table 3-4. Summary Statistics of Radiochemical Analytical Results 2004-2005									
Analyte	Sample Count	Quantity/Percent Detections		Concentration (pCi/g)					Coeff of Var.
				Min.	Mean	Median	Max.	Std. Dev.	
Radium-226	502	482	96%	0.4±0.08	1.5	1.4	18±0.6	1.2	0.78
Radium-228	502	419	83%	0.2±0.2	1.7	1.5	24.4±1.6	2.0	1.2
Thorium-232	502	500	99%	1	10.9	6.9	241	20.5	1.9
Uranium-238	502	496	99%	0.5	4.03	1.6	150	9.0	2.2

This is a draft report and is not intended to be a final representation of the work done or recommendations made by Brown and Caldwell. It should not be relied upon, please consult the final report.

3.2.2 Preliminary Soil Screening Levels

The preliminary soil screening levels for radiochemicals are shown in Table 3-5. With the exception of uranium-238, the 3x median value is greater than the residential PRG value.

Analyte	Concentration (pCi/g)			Screening Level
	3x Median Value	Residential PRG	Industrial PRG	
Radium-226	4.2	0.19	3.7	4.2
Radium-228	4.5	0.26	8.4	4.5
Thorium-232	21	3.1	174	21
Uranium-238	4.8	16	200	16

3.2.3 Comparison of Radiological Results to Screening Levels

Detected results are compared to the preliminary soil screening levels in Table 3-6. All four radiochemicals were detected above screening levels and warrant further investigation. Radium-226 and -228, and thorium-232 had 3x median values greater than their respective residential PRG values.

Analyte	Sample Count	Quantity of Detections	Quantity/Percent Detections \geq 3x Median Value		Quantity/Percent Detection \geq Screening Level		Further Investigation Required
			Quantity	Percent	Quantity	Percent	
Radium-226	502	482	11	2.3%	11	2.3%	X
Radium-228	502	419	19	4.5%	19	4.5%	X
Thorium-232	502	500	33	6.6%	32	6.4%	X
Uranium-238	502	496	78	16%	22	4.4%	X

3.2.4 Radiochemical Distribution

The distribution of radiochemicals in Process Areas soils is discussed below (Areas 1 and 2 were not analyzed for radiochemicals given the absence of process materials in those locations with the possible exception of VLT materials used for road base). Box plots, IVPs and perspective subsurface views presented in Appendix F provide the context for the following discussion:

- **Radium-226:** detected in 482 of 502 (96 percent) samples above the PQL. Radium-226 results ranged from 0.4 ± 0.08 pCi/g to 18 ± 0.6 pCi/g with a mean of 1.5 pCi/g and a median of 1.4 pCi/g. The maximum concentration of 18 ± 0.6 pCi/g occurred in Area 4

at sample depth 0.5-1.0 feet bgs at location PA-DD5-1. A total of 11 of 482 (2.3 percent) detections were above the preliminary soil screening level (set at the 3x median value) of 4.2 pCi/g. The area box plots indicate that radium-226 is prevalent throughout the Process Areas. The highest detections are in Areas 4, 5, 7, and 9. Radium-226 is present at low levels in Areas 3, 6, 8, and 10. The depth box plots indicate that radium-226 concentrations are consistent in the subsurface to a depth of 25 feet bgs. Radium-226 is recommended to remain on the analyte list for subsequent soil investigation.

- Radium-228: detected in 419 of 502 (83 percent) samples above the PQL. Radium-228 results ranged from 0.2 ± 0.2 pCi/g to 24.4 ± 1.6 pCi/g with a mean of 1.7 pCi/g and a median of 1.5 pCi/g. The maximum concentration of 24.4 ± 1.6 pCi/g occurred in Area 9 at sample depth 0.5-2.5 feet bgs at location PA-EEE17-1. A total of 19 of 419 (4.5 percent) detections were above the preliminary soil screening level (set at the 3 x Median Value) of 4.5 pCi/g. The area box plots indicate that radium-228 is prevalent throughout the Process Areas except for Area 8. The highest detections are in Areas 7, and 9. The depth box plots indicate that radium-228 concentration is fairly consistent throughout the subsurface to a depth of 25 feet. Radium-228 is recommended to remain on the analyte list for subsequent soil investigation.
- Thorium-232: detected in all but two of 502 samples. Thorium-232 results ranged from 0.25 mg/kg to 241 mg/kg with a mean of 10.9 mg/kg and a median of 6.9 mg/kg. The maximum concentration of 241 mg/kg occurred in Area 9 at sample depth 0.5-2.5 feet bgs at location PA-EEE17-1. A total of 32 of 502 (6.4 percent) detections were above the preliminary soil screening level (set at the 3x median value) of 21 mg/kg. The area box plots indicate that thorium-232 concentrations are highest in Area 7 and Area 9. The depth box plots indicate that thorium-232 concentration is fairly consistent throughout the 0-1 feet, 1-5 feet, 5-10 feet, and 10-15 feet depth intervals. Thorium-232 concentrations are highest in the 0-1 feet interval and lowest below 20 feet. Thorium-232 is to remain on the analyte list for subsequent soil investigations.
- Uranium-238: detected in 496 of 502 (99 percent) samples above the PQL. Uranium-238 results ranged from 0.25 mg/kg to 150 mg/kg with a mean of 4.0 mg/kg and a median of 1.6 mg/kg. The maximum concentration of 150 mg/kg occurred north of the Precipitation Plant at sample depth 1.5-2.5 feet bgs at location PA-UT29. A total of 74 of 502 (15%) detections were above the 3x median value, and 22 (4.4 percent) detections were above the preliminary soil screening level of 16 mg/kg. The area box plots indicate that uranium-238 is most prevalent and has the highest detections in Areas 5, 7, 9, and 11. Uranium-238 is present at low levels in Areas 3, 6, 8, and 10. The depth box plots indicate that uranium-238 concentration is fairly consistent throughout the 0-1, 1-5, 5-10 and 10-15 foot depth intervals. Uranium-238 concentrations are highest in the subsurface to 10 feet bgs and lowest below 20 feet. Uranium-238 is to remain on the analyte list for subsequent soil investigations.

3.3 Petroleum Hydrocarbons Results

The 2004-2005 petroleum hydrocarbon investigations in the Process Areas were based on State of Nevada regulatory guidance, with a preliminary screening level of 100 mg/kg for total petroleum hydrocarbons (“TPH”), which in turn are based on federal regulations (40CFR280). Soil samples were analyzed by EPA Method 8015M for TPH in three carbon ranges: C4-C12 gasoline range organics (TPH-g), C12-C23 diesel range organics (TPH-d), and motor oil range organics (TPH-mo).

3.3.1 Summary Statistics

Summary statistics for petroleum hydrocarbon analytical results are provided in Table 3-7. TPH-mo was the carbon range detected most frequently (54 percent), but more than half (65 percent) of the results were trace detections. TPH-d was detected less frequently (32 percent) than TPH-mo with few (9.1 percent) trace detections. TPH-g was infrequently (10 percent) detected and most results (82 percent) were trace detections. All sets of carbon range analyses had high coefficients of variation (i.e., greater than 1.0) indicating a wide distribution of concentrations.

Analyte	Sample Count	Quantity/ Percent Detections		Quantity/ Percent Trace Detections ⁽¹⁾		Concentration (mg/kg)					Coeff of Var.
						Min.	Mean	Median	Max.	Std. Dev.	
TPH-g	1,081	108	10%	89	82%	0.29	14	0.44	7,400	241	17
TPH-d	1,103	352	32%	32	9.1%	0.415	140	1.4	19,000	1,066	7.6
TPH-mo	1,103	600	54%	390	65%	0.95	403	2.1	60,000	2,931	7.3

Notes: (1) Trace detections are estimated values between the MDL and the PQL

3.3.2 Preliminary Soil Screening Levels

In lieu of EPA-developed PRGs for petroleum hydrocarbons, Nevada State corrective action levels, as defined by Nevada Administrative Code 445A.2272, are used as preliminary soil screening levels for evaluating hydrocarbon-impacts as shown in Table 3-8.

Analyte	Concentration (mg/kg)	
	Nevada Corrective Action Levels	Screening Levels
TPH-g	100	100
TPH-d	100	100
TPH-mo	100	100

3.3.3 Comparison of Petroleum Hydrocarbon Results to Screening Levels

Detected results are compared to the preliminary soil screening levels in Table 3-9. All three carbon range analyses warrant further investigation in specific areas.

Analyte	Count	Quantity/Percent Detections		Quantity/Percent Detections \geq Level		Further Investigation Required
		Count	Percent	Count	Percent	
TPH-g	1,081	108	(10%)	6	(5.6%)	X
TPH-d	1,103	352	(32%)	51	(14%)	X
TPH-mo	1,103	600	(54%)	85	(14%)	X

3.3.4 Petroleum Hydrocarbon Distribution

The distribution of each petroleum hydrocarbon range in Process Areas soil is discussed below. Box plots, IVPs and perspective subsurface views presented in Appendix F provide the context for the following discussion:

- **TPH-g:** detected in 108 of 1,081 (10 percent) samples and most (82 percent) were trace detections. TPH-g results ranged from 0.29 mg/kg to 7,400 mg/kg with a mean of 14 mg/kg and a median of 0.44 mg/kg. The maximum concentration of 7,400 mg/kg occurred in Area 11 at sample depth 3-4 feet bgs at location PA-UT23. A total of 6 of 108 (5.6 percent) detections were above the preliminary soil screening level of 100 mg/kg. The area box plots indicate that TPH-g impacts are only present in Area 11 (including pipeline utility locations within Area 11). The depth box plots indicate that the highest TPH-g concentrations are at depths from 5 feet to 25 feet.
- **TPH-d:** detected in 352 of 1,103 (32 percent) samples and few (9.1 percent) were trace detections. TPH-d results ranged from 0.415 mg/kg to 19,000 mg/kg with a mean of 140 mg/kg and a median of 1.4 mg/kg. The maximum concentration of 19,000 mg/kg occurred in Area 1 at sample depth 0.5-2.5 feet bgs at location PA-W1-1. A total of 51 of 352 (14 percent) detections were above the preliminary soil screening level of 100 mg/kg. Figure 3-8 provides an perspective view of subsurface TPH-d concentrations. The area

box plots indicate that TPH-d is present primarily in Areas 2, 4, 9, and 11 with the majority of high concentrations in Areas 9 and 11. The depth box plots indicate that TPH-d is primarily in the 0-1 feet bgs depth interval and decreases with depth.

- **TPH-mo:** detected in 600 of 1,103 (54 percent) samples and most (65 percent) were trace detections. TPH-mo results ranged from 0.95 mg/kg to 60,000 mg/kg with a mean of 403 mg/kg and a median of 2.1 mg/kg. The maximum concentration of 60,000 mg/kg occurred in Area 2 from a grab surface sample at location PA-UT36. A total of 85 of 600 (14 percent) detections were above the preliminary soil screening level of 100 mg/kg. Figure 3-9 provides an perspective view of subsurface TPH-mo concentrations. The area box plots indicate that TPH-mo is present primarily in Areas 2, 4, 9, and 11 with the majority of high concentrations in Areas 9 and 11. The depth box plots indicate that TPH-mo is primarily in the 0-1 feet bgs depth interval and decreases with depth.

3.4 Other Chemical Results

In addition to metals, radiochemicals, and petroleum hydrocarbons, samples from the first phase of soil investigations were analyzed for VOCs, SVOCs, pesticides, herbicides, PCBs, and ABP.

3.4.1 VOCs

A total of 68 VOCs were analyzed by EPA Method 8260B. Summary statistics are calculated in Table 3-10 only for VOCs detected in any sample more than once. The most frequently detected (greater than 1 percent) VOCs were: 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, acetone, benzene, toluene, ethylbenzene, xylenes (BTEX compounds), isopropylbenzene, methylene chloride, naphthalene, n-propylbenzene, p-cymene, sec-butylbenzene, styrene, tetrachloroethylene (PCE), trichloroethylene (TCE), and trichlorofluoromethane. Of these frequently detected compounds, only eight were detected above their respective preliminary soil screening levels (which are set at the Residential PRGs): 1,2,3-trichloropropane, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, BTEX compounds, and PCE.

VOCs, as well as TPH-g, were only detected above screening levels at locations within Area 11 at the Lower Truck Sludge Pond and at the gasoline line coming from Filling Station #3 (X). Note that the association is not likely to be coincidental, because these VOCs are often in gasoline fuel mixtures (e.g., BTEX compounds) or are used in vehicle maintenance activities (e.g., PCE and other solvents).

Table 3-10. Summary Statistics of Detected VOCs Analytical Results

Analyte	Sample Count	Quantity/ Percent Detections		Concentration (mg/kg)					Coeff of Var.
				Min.	Mean	Median	Max.	Std. Dev.	
1,1,2,2-Tetrachloroethane	1,089	3	0.3%	0.00024	0.009	0.00054	0.027	0.015	1.6
1,1,2-Trichloroethane	1,094	3	0.3%	0.00019	0.000	0.00027	0.00064	0.000	0.6
1,1-Dichloroethane	1,094	8	0.7%	0.00013	0.003	0.0018	0.0078	0.002	1.0
1,1-Dichloropropene	1,093	2	0.2%	5.5E-05	0.000	0.000083	0.00011	0.000	0.47
1,2,3-Trichloropropane	1,088	4	0.4%	0.00027	0.122	0.04915	0.39	0.184	1.5
1,2,4-Trichlorobenzene	1,035	3	0.3%	0.0023	0.010	0.0067	0.02	0.009	1.0
1,2,4-Trimethylbenzene	1,089	45	4.1%	5.4E-05	25.288	0.00077	380	79.989	3.2
1,2-Dibromo-3-Chloropropane	1,083	4	0.4%	0.00068	0.015	0.0148	0.031	0.016	1.1
1,2-Dichloropropane	1,072	3	0.3%	0.00011	0.000	0.00016	0.00018	0.000	0.2
1,3,5-Trimethylbenzene	1,092	26	2.4%	7.2E-05	12.602	0.00205	110	29.178	2.3
1,3-Dichloropropane	1,087	9	0.8%	5.9E-05	0.000	0.000067	0.00037	0.000	1.0
Acetone	28	3	11%	0.0042	0.006	0.0042	0.011	0.004	0.6
Benzene	1,088	56	5.1%	4.8E-05	0.017	0.00014	0.82	0.110	6.5
Chlorobenzene	1,093	2	0.2%	0.00037	0.001	0.000595	0.00082	0.000	0.5
Chloroform	1,094	3	0.3%	0.00012	0.000	0.00023	0.00097	0.000	1.1
Chloromethane	1,094	3	0.3%	0.0012	0.0012	0.0012	0.0012	0.0	
Dibromochloromethane	1,093	2	0.2%	0.0039	0.004	0.0041	0.0043	0.000	0.07
Dichlorodifluoromethane	1,089	8	0.7%	0.00011	0.000	0.00027	0.00047	0.000	0.4
Ethylbenzene	1,093	30	2.7%	0.00016	0.754	0.0004	20	3.666	4.9
Isopropylbenzene (Cumene)	1,092	16	1.5%	0.00003	0.396	0.00039	3.9	1.030	2.6
Methylene Chloride	1,094	114	10%	0.0003	0.001	0.00081	0.018	0.002	1.5
Naphthalene	1,050	41	3.9%	5.3E-05	1.375	0.00049	47	7.418	5.4
n-Butylbenzene	1,068	4	0.4%	0.0001	0.003	0.00018	0.011	0.005	1.9
n-Propylbenzene	1,090	18	1.7%	0.00012	1.956	0.0037	15	4.039	2.1
p-Cymene	1,075	13	1.2%	0.00011	1.500	0.0013	14	3.964	2.6
sec-Butylbenzene	1,081	5	0.5%	7.5E-05	1.569	0.013	7.7	3.428	2.2
Styrene	1,078	59	5.5%	4.9E-05	0.077	0.0001	4.1	0.535	6.9
t-Butylbenzene	1,084	7	0.6%	4.3E-05	0.197	0.00048	1.3	0.487	2.5
Tetrachloroethylene (PCE)	1,093	37	3.4%	7.3E-05	0.060	0.00035	1.6	0.275	4.6
Toluene	1,094	149	14%	0.00011	0.187	0.00023	26	2.134	11
Trichloroethylene (TCE)	1,093	11	1.0%	0.0001	0.000	0.00018	0.0014	0.000	1.0
Trichlorofluoromethane	1,094	205	19%	5.4E-05	0.001	0.00044	0.0079	0.001	1.3
Xylenes, Total	1,065	37	3.5%	0.00035	13.276	0.00083	450	73.956	5.5

3.4.2 SVOCs

A total of 67 SVOCs were analyzed by EPA Method 8270C. Summary statistics are calculated in Table 3-11 only for VOCs detected in any sample more than once.

Table 3-11. Summary Statistics of Detected SVOCs Analytical Results

Analyte	Sample Count	Quantity/Percent Detections		Concentration (mg/kg)					Coeff of Var
				Min.	Mean	Median	Max.	Std. Dev.	
2-Methylnaphthalene	1,103	8	0.7%	0.037	6.887	2.8	33	11	1.6
4-Bromophenyl phenyl ether	1,103	2	0.2%	0.031	0.032	0.0315	0.032	0.001	0.02
Acenaphthene	1,103	3	0.3%	0.096	0.112	0.12	0.12	0.01	0.1
Benzo(a)anthracene	1,103	12	0.1%	0.023	0.268	0.082	1.8	0.5	1.9
Benzo(a)pyrene	1,103	6	0.5%	0.037	0.397	0.14	1.7	0.6	1.6

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Table 3-11. Summary Statistics of Detected SVOCs Analytical Results - Continued

Analyte	Sample Count	Quantity/Percent Detections		Concentration (mg/kg)					Coeff of Var
Benzo(b)fluoranthene	1,103	9	0.8%	0.037	0.600	0.17	3.1	1.0	1.7
Benzo(g,h,i)perylene	1,102	9	0.8%	0.032	0.173	0.1	0.9	0.3	1.6
Benzo(k)fluoranthene	1,103	5	0.4%	0.073	0.391	0.16	1.2	0.5	1.2
Benzoic acid	1,097	14	1.3%	0.096	0.290	0.265	0.51	0.1	0.3
Benzyl butyl phthalate	1,103	15	1.4%	0.026	1.128	0.19	7.3	2.0	1.8
bis(2-ethylhexyl) phthalate	1,103	50	4.5%	0.018	0.502	0.2	9	1.3	2.6
Chrysene	1,103	14	1.2%	0.027	0.454	0.105	2.6	0.8	1.7
Dibenz(a,h)anthracene	1,103	6	0.5%	0.025	0.044	0.0385	0.073	0.02	0.4
Diethyl phthalate	1,103	28	2.5%	0.014	0.208	0.029	4.2	0.8	3.8
Di-n-butyl phthalate	1,103	19	1.7%	0.014	0.032	0.023	0.13	0.03	0.8
Fluoranthene	1,103	17	1.5%	0.02	0.755	0.061	4.4	1.3	1.8
Fluorene	1,103	11	1.0%	0.025	0.300	0.027	2.3	0.7	2.3
Indeno(1,2,3-c,d)pyrene	1,103	11	1.0%	0.017	0.120	0.062	0.62	0.2	1.4
Naphthalene	1,103	7	0.6%	0.063	5.689	0.88	23	9.1	1.6
Phenanthrene	1,103	22	2.0%	0.036	1.105	0.72	4	1.2	1.1
Pyrene	1,103	16	1.5%	0.025	0.736	0.225	3.3	1.1	1.5

Notes: (1) Trace detections are estimated values between the MDL and the PQL

The most frequently detected (greater than 1 percent) SVOCs were: benzoic acid, benzyl butyl phthalate, bis(2-ethylhexyl) phthalate, chrysene, diethyl phthalate, di-n-butyl phthalate, fluoranthene, fluorene, indeno(1,2,3-c,d)pyrene, phenanthrene, and pyrene. Of these frequently detected compounds, only four were detected above their respective preliminary soil screening levels (which are set at Residential PRGs): benzo(a)anthracene, benzo(b)fluoranthene, benzo(a)pyrene, and dibenz(a,h)anthracene. SVOC impacts were fairly widespread and occurred in six areas: Area 4 (PA-DD10), Area 6 (PA-HH6), Area 9 (PA-EEE1), Area 11 (PA-HHH19 and PA-HHH33), one location along utility pipelines (PA-UT27), and one location near the transformers (PA-TR3). Nearly all SVOC impacts were in surface soil (0-2.5 feet bgs). Benzo(a)pyrene was the most frequently detected SVOC above screening levels and had concentrations up to 1.7 mg/kg.

3.4.3 Pesticides

A total of 22 pesticides were analyzed by EPA Method 8081A. Summary statistics are calculated in Table 3-12 only for pesticides detected in any sample more than once.

Analyte	Sample Count	Quantity/ Percent Detections		Concentration (mg/kg)					Coeff of Var.
				Min.	Mean	Median	Max.	Std. Dev.	
Aldrin	1,100	15	1.4%	0.00025	0.005	0.00085	0.038	0.011	2.1
Alpha BHC	1,100	70	6.4%	0.00018	0.005	0.00089	0.053	0.010	2.0
Alpha Endosulfan	1,100	8	0.7%	0.00021	0.005	0.000295	0.021	0.007	1.5
Alpha-Chlordane	1,100	6	0.5%	0.00032	0.006	0.000515	0.033	0.013	2.2
Beta BHC	1,100	28	2.5%	0.00043	0.007	0.0021	0.067	0.014	2.0
Beta Endosulfan	1,100	10	1.0%	0.0004	0.004	0.00195	0.012	0.005	1.1
Delta BHC	1,100	36	3.2%	0.00031	0.003	0.000745	0.026	0.005	1.8
Dieldrin	1,100	16	1.5%	0.00035	0.009	0.00395	0.039	0.012	1.3
Endosulfan Sulfate	1,100	15	1.4%	0.00032	0.002	0.0007	0.0082	0.002	1.3
Endrin	1,100	13	1.1%	0.00044	0.008	0.0025	0.05	0.014	1.8
Endrin Aldehyde	1,086	6	0.5%	0.00053	0.008	0.001015	0.029	0.012	1.5
Endrin Ketone	1,100	7	0.6%	0.001	0.008	0.0035	0.02	0.008	0.97
Gamma BHC (Lindane)	1,099	22	2.0%	0.00025	0.004	0.0022	0.014	0.004	1.1
Gamma- Chlordane	1,100	2	0.2%	0.00045	0.001	0.000725	0.001	0.000	0.54
Heptachlor	1,100	19	1.7%	0.00028	0.004	0.0014	0.035	0.008	2.2
Heptachlor Epoxide	1,100	22	2.0%	0.00029	0.002	0.00084	0.012	0.003	1.4
Methoxychlor	1,100	29	2.6%	0.00041	0.016	0.0024	0.14	0.031	1.9
p,p'-DDD	1,100	44	4.0%	0.00042	0.051	0.011	0.58	0.105	2.1
p,p'-DDE	1,100	80	7.2%	0.0002	0.031	0.0046	0.48	0.075	2.4
p,p'-DDT	1,101	130	12%	0.00074	0.105	0.00575	3	0.393	3.7

Notes: (1) Trace detections are estimated values between the MDL and the PQL

The most frequently detected (greater than 1%) pesticides were: aldrin, alpha/beta/gamma/delta BHC, beta endosulfan, dieldrin, endosulfan sulfate, endrin, heptachlor, heptachlor epoxide, methoxychlor, and p,p'-DDD/DDE/DDT. Of these frequently detected compounds, only three were detected above their respective preliminary soil screening levels (which are set at the Residential PRGs): aldrin at 0.038 mg/kg, dieldrin at 0.039 mg/kg, and p,p'-DDT at 3.0 mg/kg. Pesticide impacts above the screening level are limited to only three areas: Area 2 (PA-I1), Area 9 (PA-EEE1), and Area 11 (PA-HHH36). Pesticides, as a chemical group, are to be removed from the analyte list for subsequent soil investigations.

3.4.4 Herbicides

A total of ten herbicides were analyzed by EPA Method 8151. Summary statistics are calculated in Table 3-13 only for pesticides detected in any sample. Herbicides were infrequently detected (most considerably less than 1%) in soil samples. No herbicides results were above their respective preliminary soil screening levels (set at the Residential PRG). Herbicides, as a chemical group, are to be removed from the analyte list for subsequent soil investigation.

Analyte	Sample Count	Quantity/ Percent Detections		Concentration (mg/kg)					Coeff. of Var.
				Min.	Mean	Median	Max.	Std. Dev.	
2,4 DB	1,079	1	0.1%	0.44			0.44		
2,4,5-T	1,085	4	0.3%	0.011	0.012	0.012	0.012	0.000	0.04
2,4-D	1,084	2	0.2%	0.011	0.043	0.043	0.075	0.045	1.1
Dicamba	1,084	2	0.2%	0.018	0.021	0.021	0.024	0.004	0.2
Dinoseb	971	1	0.1%	0.015			0.015		
MCPA	1,075	4	0.4%	1.4	1.425	1.4	1.5	0.050	0.04
MCPP	1,076	8	0.7%	0.87	2.221	1.7	6.7	1.914	0.9
Silvex (2,4,5-TP)	1,094	1	0.1%	0.012			0.012		

Note: (1) Trace detections are estimated values between the MDL and the PQL

3.4.5 PCBs

A total of eight PCBs were analyzed by EPA Method 8082. Summary statistics are calculated in Table 3-14 below only for PCBs detected in any sample. PCBs were infrequently detected (most considerably less than 1%) in soil samples. PCB-1254 was the only PCB detected above preliminary soil screening levels (which are set at Residential PRGs) with one detection at 5.6 mg/kg. The PCB-1254 detection was located at PA-DD10 in Area 4 Solution Tanks.

Analyte	Sample Count	Quantity/ Percent Detections		Concentration (mg/kg)					Coeff of Var.
				Min.	Mean	Median	Max.	Std. Dev.	
PCB-1016	1,100	2	0.2%	0.036	0.718	0.718	1.4	0.964	1.3
PCB-1242	1,100	1	0.1%	0.052			0.052		
PCB-1248	1,100	1	0.1%	0.39			0.39		
PCB-1254	1,100	7	0.6%	0.02	0.842	0.049	5.6	2.098	2.5
PCB-1260	1,100	8	0.7%	0.0089	0.176	0.028	1.1	0.377	2.1

Note: (1) Trace detections are estimated values between the MDL and the PQL

Samples associated with the electrical substations and transformers (PA-TR1 through PA-TR5) did not yield PCB results above screening levels. With the exception of delineating impacts near the Solution Tanks, PCBs as a chemical group are to be removed from the analyte list for subsequent soil investigations.

3.4.6 ABP

Acid/base potential (“ABP”) results (acid generating potential, neutralization potential and Acid/Base Potential), using EPA Method M600/2-78-054 1.3 (Sobeck 1978), for Process Areas

soils are summarized in Table 3-15. ABP is calculated by subtracting the neutralization potential of a sample from the acid generating potential of the sample, and expressing the results in tons of CaCO₃ per kiloton of material (t/kt). ABP results and associated summary graphs are provided in Appendix E (E-3).

Analyte	Sample Count	Quantity/Percent Detections		Concentration (mg/kg)				Std. Dev.	Coeff. of Var.
				Min.	Mean	Median	Max.		
Acid Generating Potential	1,096	498	45%	1	6.2	3	65	7.1	1.1
Neutralization Potential	1,096	1,015	93%	1	13	13	86	6.9	0.52
Acid/Base Potential	1,096	1,096	100%	-64	9.1	11	85	11	1.2

In general, most soils within the Process Areas exhibit positive ABP potential (i.e., are not expected to generate acid). In Areas 1, 2 and 6, all soil samples had positive ABP values. Soil samples near the Vat Leach Tanks (Area 3), Copper Solution Tanks (Area 4) and Precipitation Plant (Area 5), produced negative ABP results, as described below:

- Near the Vat Leach Tanks, negative ABP results were detected at borings PA-P2 (-6 t/kt at 15 ft bgs) and PA-P3 (-4 t/kt at 15 ft bgs).
- Near the Copper Solution Tanks, negative ABP results were detected at boring PA-FF3 (-3 t/kt at 10 ft bgs).
- Near the Precipitation Plant, negative ABP values were detected at PA-EE19 and PA-EE20. These two borings are located at the northwest end of the Precipitation Plant near the subgrade solution recirculation sump. ABP values reported for soil samples from PA-EE19 included the following: -5 t/kt at 20 ft bgs, -25 t/kt at 25 ft bgs, and -14 t/kt at 30 ft bgs. ABP values reported for soil samples from PA-EE20 included the following: -9 t/kt at 25 ft bgs and -12 t/kt at 30 ft bgs.

In Areas 10 and 11, most soil samples had positive ABP values, except for a few statistical outlier observations (e.g., Area 11) that had slightly negative to moderately negative ABP values. In Area 10, negative ABP values were detected at numerous locations, but were typically more negative in soil samples located to the southeast of the Dump Leach Surge Pond (aka WR-3

pond). Examples include PA-HHH8 (-29 t/kt at 25 ft bgs) and PA-HHH16 (-24 t/kt at 25 ft bgs). In Area 11, negative ABP values were generally detected in soil borings PA-CCC1 through PA-CCC4, which are located near Area 9 (East Solution Ditch).

In Area 8, slightly more than 7 percent of the soil samples have positive ABP values. Negative ABP values (as low as -22 t/kt) were detected in soil samples from borings PA-FFF15, PA-FFF-16 and PA-FFF17. These three boring are located in a topographic low area where Areas 8 and 9 intersect. In Area 9 (the East Solution Ditch), approximately 50 percent of the soil samples have positive ABP values. Negative ABP values typically occur along the East Solution Ditch itself, and some of the most negative ABP results in the Process Areas occur in this area. Table 3-16 summarizes the ABP data for these areas. In Area 7, the more negative ABP values occur in the lower segment of the Calcine Ditch (i.e., PA-WW-1 through PA-WW-4), with the most negative ABP value detected in soil at PA-WW4 (-64 t/kt at 10 ft bgs).

Table 3-16. ABP for Soil Samples Along the East Solution and Calcine Ditches (values in t/kt)

Depth (ft bgs)	PA-EEE21	PA-EEE20	PA-EEE17	PA-EEE16	PA-EEE15	PA-EEE14	PA-EEE13	PA-EEE12	PA-EEE11	PA-EEE8	PA-EEE2
1	NS	NS	-11	-23	-14	NS	NS	-9	-3	-23	-9
5	NS	-8	-9	-10	-9	-7	-3	-2	-15	-11	-15
10	NS	-16	-13	-17	-7	-20	-4	-4	-14	-0.7	-1
15	-4	-10	-14	-19	-2	-4	-4	NS	-14	-2	-9
20	-10	-40	-23	-13	-9	-9	-10	NS	-11	-49	NS
Depth (ft bgs)	PA-EEE5	PA-WW1	PA-WW2	PA-WW3	PA-WW4	PA-WW5	PA-WW6	PA-WW7	PA-WW8	PA-WW9	PA-WW10
5	-13	-13	-11	NS	-0.1	-5	-11	-8	-0.9	NS	-0.7
10	-8	-13	-4	-8	-64	-6	-2	NS	-1	NS	NS
15	-11	-13	-17	-6	-16	-11	NS	-2	-2	-0.6	NS
20	-7	-6	-18	-6	-11	-11	NS	-0.8	-1	NS	NS

PA-EEE samples collected along or near the East Solution Ditch; PA-WW applies to samples collected along or near the Calcine Ditch; NS – not sampled

3.5 Discussion of Results by Area

Table 3-17 provides the quantity of results above the preliminary soil screening level grouped by chemical and area/feature in the Process Areas.

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Chemical Group	Analyte	Area/Feature														
		1	2	3	4	5	6	7	8	9	10	11	12	EX	UT	TR
Metals	Arsenic	0	1	0	7	2	0	16	8	19	5	5	11	2	4	1
	Copper	0	1	2	5	5	0	0	0	0	1	2	6	1	4	0
	Iron	0	0	0	3	0	0	2	3	7	3	1	2	0	2	0
	Lead	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0
	Thallium	0	0	0	0	0	0	5	0	1	0	0	1	0	0	0
Petroleum Hydrocarbons	TPH-g	0	0	0	0	0	0	0	0	0	0	4	0	0	2	0
	TPH-d	4	7	0	3	1	0	0	0	10	0	11	0	7	8	0
	TPH-mo	2	10	0	9	3	0	1	2	17	0	14	1	9	14	3
Radiochemicals	Radium-226	0	0	0	3	1	0	2	0	3	0	0	1	0	1	0
	Radium-228	0	0	0	1	0	0	5	0	12	1	0	0	0	0	0
	Thorium-232	0	0	0	2	0	0	7	0	13	0	1	0	0	7	0
	Uranium	0	0	0	0	1	0	2	0	15	0	2	0	0	2	0
Other	VOCs	0	0	0	0	0	0	0	0	0	0	10	0	0	6	0
	SVOCs	0	0	0	3	0	1	0	0	1	0	2	0	0	1	1
	Pesticides	0	1	0	0	0	0	0	0	2	0	2	0	0	0	0
	Herbicides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	PCBs	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0

3.5.1 Results Summary for Area 1 - Administration and Maintenance Areas

As shown in Table 3-18, TPH-d and TPH-mo were the only chemicals detected above preliminary soil screening levels in soil samples collected in Area 1.

Location	Sample	TPH (mg/kg)	
		Diesel Components	Motor Oils
Screening Level		100	100
PA-A1	PA-A1-1		250
PA-W1	PA-W1-1	19,000	3,000
	PA-W1-5	410	
	PA-W1-10	870	
PA-Z1	PA-Z1-1	220	

TPH impacts are isolated to three areas in surface soils (0-2.5 feet bgs). TPH-mo was detected at sample location PA-A1-1 at 250 mg/kg near the Administration Building garage. TPH-d up to 19,000 mg/kg and TPH-mo at 3,000 mg/kg were detected at boring PA-W1 near the Filling Station #2. TPH-d impacts extend down to 10 feet bgs at this location and the concentration of

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19,000 mg/kg was the maximum TPH-d detection for the 2004-2005 investigation. TPH-d was detected at sample location PA-Z1-1 at 220 mg/kg near the used oil tank location across from the Truck Shop.

3.5.2 Results Summary for Area 2 - Truck Shop and Crushers

As shown in Table 3-19, six chemicals were detected above preliminary soil screening levels in soil samples collected in Area 2: arsenic, copper, lead, TPH-d, TPH-mo, and p,p'-DDT. These chemicals were near surface occurrences (depth interval of 0-2.5 feet bgs) with the exception of TPH-mo, which extended further to 10 feet bgs.

Location	Sample	Metals (mg/kg)			TPH (mg/kg)		Pesticide (mg/kg)
		Arsenic	Copper	Lead	Diesel Components	Motor Oils	P,P'-DDT
Screening Level		10.5	3,100	400	100	100	1.7
PA-C1	PA-C1-5				290	200	
PA-I1	PA-I1-1				810		3
PA-K4	PA-K4-1				620	2,100	
PA-K5	PA-K5-1				1,900	11,000	
PA-K8	PA-K8-1				120	1,200	
PA-K9	PA-K9-1					190	
PA-L1	PA-L1-1				450	3,100	
PA-L2	PA-L2-1					180	
PA-M2	PA-M2-1		3,500		3,200	4,700	
PA-O2	PA-O2-1			1,300			
PA-CC2	PA-CC2-1	13				560	
PA-OO3	PA-OO3-10					150	

Arsenic, copper, and lead were all detected once above screening levels at concentrations of 13 mg/kg, 3,500 mg/kg, and 1,300 mg/kg. Area 2 has been impacted with petroleum hydrocarbons which is consistent with the historical operations. TPH-d and TPH-mo were detected up to 3,200 mg/kg and 11,000 mg/kg at the Equipment Wash (PA-C1), Fire Engine Storage (PA-I1), Truck Shop (PA-K4, PA-K5, PA-K8, and PA-K9), Equipment Garage (PA-L1 and PA-L2), Truck Wash and Paint Shop (PA-M2), Primary Crusher Foundation (PA-CC2), and Secondary Crusher

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Area (PA-OO3). The pesticide p,p'-DDT was detected above its screening level at a concentration of 3.0 mg/kg near the Fire Engine Storage (PA-I1) indicating it may have been stored or used there.

3.5.3 Results Summary for Area 3 - Vat Leach Tanks

As shown in Table 3-20, copper was the only chemical detected above preliminary soil screening levels in soil samples collected in Area 3. At sample location PA-YY near the sulfide ore stockpile northwest of the leach vats, copper concentrations were 6,500 mg/kg at 12-14 feet bgs and 5,200 mg/kg at 17-18 feet bgs.

Location	Sample	Metals (mg/kg)
		Copper
Screening Level		3,100
PA-YY2	PA-YY2-1	6,500
	PA-YY2-5	5,200

3.5.4 Results Summary for Area 4 - Solution Tanks

As shown in Table 3-21, 12 chemicals were detected above preliminary soil screening levels in soil samples collected in Area 4: arsenic, copper, iron, radium-226, radium-228, thorium-232, TPH-d, TPH-mo, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and PCB-1254. A total of 13 samples in Area 4 had at least one of these chemicals detected, and 12 of the samples were collected in the 0.5-2.5 feet depth interval. These occurrences indicate that impacts are most likely limited to surface soils around the solution tanks. Arsenic, copper, and iron had between three and seven detections above their screening levels at concentrations up to 34 mg/kg, 6,100 mg/kg, and 60,000 mg/kg, respectively.

Radium-226, radium-228, and thorium-232 were detected at concentrations up to 18±0.6 pCi/g, 5.5±0.4 pCi/g, and 40.2 mg/kg. Note that the 18±0.6 pCi/g detection of radium-226 at sample location PA-DD5-1 at a depth interval of 0.5-1.0 feet bgs was the maximum detection in the

Process Areas for all radium-226 results. Several compounds had just one detection each above screening levels: benzo(a)anthracene at 1.8 mg/kg, benzo(a)pyrene at 1.7 mg/kg, benzo(b)fluoranthene at 3.1 mg/kg, and PCB-1254 at 5.6 mg/kg. The PCB-1254 result of 5.6 mg/kg at PA-DD10-1 was the only detection above the screening level of 0.22 for the entire investigation.

Table 3-21. Area 4 Samples Exceeding Preliminary Screening Levels													
Location	Sample	Metals (mg/kg)			Radiochemicals (pCi/g)			SVOCs (mg/kg)			TPH (mg/kg)		PCBs (mg/kg)
		Arsenic	Copper	Iron	Thorium-232	Radium-226	Radium-228	Benzo(A)Anthracene	Benzo(B)Fluoranthene	Benzo(A)Pyrene	Diesel Components	Motor Oils	PCB-1254 (Arochlor 1254)
Screening Level		10.5	3,100	28,200	21	4.2	4.5	0.62	0.62	0.062	100	100	0.22
PA-DD4	PA-DD4-1		3,300								3,100	490	
PA-DD5	PA-DD5-1		3,200			18						160	
PA-DD6	PA-DD6-1											110	
PA-DD7	PA-DD7-1	13										440	
PA-DD8	PA-DD8-1	34		60,000	39.1								
PA-DD9	PA-DD9-1	15										170	
PA-DD10	PA-DD10-1	20	3,200	37,000		4.3		1.8	3.1	1.7	110	1,000	5.6
PA-DD11	PA-DD11-1		6,100									140	
PA-DD13	PA-DD13-1	18											
PA-FF2	PA-FF2-1										2,300	9,200	
PA-FF3	PA-FF3-1	20		38,000	40.2	13.7	5.5					110	
	PA-FF3-5	20											
PA-FF4	PA-FF4-1		3,500										

3.5.5 Results Summary for Area 5 - Precipitation Plant

As shown in Table 3-22, six chemicals were detected above preliminary soil screening levels in soil samples collected in Area 5: arsenic, copper, radium-226, uranium, TPH-d, and TPH-mo. The impacts were all in surface soil (0-2.5 feet bgs) and were located on all sides of the Precipitation Plant except the northwest side. Copper was the most frequently detected (five samples) with concentrations up to 44,000 mg/kg. Arsenic, uranium, and radium-226 had one or

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two detections above the screening level at concentrations up to 63 mg/kg, 22 mg/kg, and 5±0.6 pCi/g, respectively. One TPH-d was detected at 440 mg/kg and three TPH-mo were detected up to 1,000 mg/kg. The TPH-mo detections were all along the southwest side of the Precipitation Plant near the concrete footing and rail for the former overhead crane.

Table 3-22. Area 5 Samples Exceeding Preliminary Screening Levels

Location	Sample	Metals (mg/kg)		Radiochemicals (pCi/g)		TPH (mg/kg)	
		Arsenic	Copper	Uranium	Radium-226	Diesel Components	Motor Oils
Screening Level		10.5	3,100	16	4.2	100	100
PA-EE1	PA-EE1-1		24,000				
PA-EE2	PA-EE2-1		4,800			440	
PA-EE4	PA-EE4-1	13					
PA-EE6	PA-EE6-1	63	44,000	22			
PA-EE8	PA-EE8-1						560
PA-EE9	PA-EE9-1		11,000				530
PA-EE11	PA-EE11-1		3,700				
PA-EE17	PA-EE17-1				5±0.6		1,000

3.5.6 Results Summary for Area 6 - Sulfide Plant

As shown in Table 3-232, benzo(a)pyrene was the only chemical detected above preliminary soil screening levels in soil samples collected in Area 6. There are no petroleum hydrocarbon impacts in this area. At sample location PA-HH6-1 near the northwest edge of the sulfide plant, benzo(a)pyrene concentration was 0.27 mg/kg at 1-3 feet bgs.

Table 3-23. Area 6 Samples Exceeding Preliminary Screening Level

Location	Sample	SVOC (mg/kg)
		Benzo(A)Pyrene
Screening Level		0.062
PA-HH6	PA-HH6-1	0.27

3.5.7 Results Summary for Area 7 - Calcine Ditch

As shown in Table 3-24, eight chemicals were detected above preliminary soil screening levels in soil samples collected in Area 7: arsenic, iron, thallium, radium-226, radium-228, thorium-232,

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uranium, and TPH-mo. Unlike other areas, the highest detections in Area 7 were at a depth interval of 10-15 feet bgs. Arsenic was the most frequently detected chemical above its screening level in Area 7 at 16 sample locations and a depth interval of 5-20 feet bgs.

Table 3-24. Area 7 Samples Exceeding Preliminary Screening Levels

Location	Sample	Metals (mg/kg)			Radiochemicals (pCi/g)				TPH (mg/kg)
		Arsenic	Iron	Thallium	Thorium-232	Uranium	Radium-226	Radium-228	Motor Oils
Screening Level		10.5	28,200	5.2	21	16	4.2	4.5	100
PA-WW1	PA-WW1-10	18							
PA-WW2	PA-WW2-10				172	32.9		20±0.3	
	PA-WW2-15	19							
	PA-WW2-20					18.5			
PA-WW3	PA-WW3-10	73	37,000	6.7			4.6±0.4		
	PA-WW3-15	63		8.8					
	PA-WW3-20	38		7.1					
	PA-WW3-5	12							
PA-WW4	PA-WW4-10	410	95,000	40	25.4				
PA-WW5	PA-WW5-10	140		5.6					
	PA-WW5-15	39							
	PA-WW5-20	24							
	PA-WW5-5	120					6±0.5		
PA-WW7	PA-WW7-15	14			41.4			4.7±0.4	
	PA-WW7-20	21			57			8±0.5	
PA-WW8	PA-WW8-10				30.6				
	PA-WW8-15	11			44.5			5.4±0.8	
	PA-WW8-20	15			87.4			8.8±0.9	
PA-WW9	PA-WW9-10	16							
PA-WW10	PA-WW10-5								160

The maximum detections for all results in the Process Areas for arsenic (410 mg/kg), iron (95,000 mg/kg) and thallium (40 mg/kg) occurred at sample location PA-WW4-10 about mid-length along the calcine ditch at a depth interval of 9-10 feet bgs. Thorium-232 was the next most frequently detected (seven sample locations), with concentrations up to 172 mg/kg. Radium-226, radium-228, and uranium were less frequently detected (five or fewer detections)

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with concentrations up to of 6 ± 0.5 pCi/g, 20 ± 0.3 pCi/g, and 32.9 mg/kg, respectively. Area 7 has little petroleum contamination and only one sample location, PA-WW10-5 at 3.5-5.0 feet bgs, had a detection of 160 mg/kg for TPH-mo that exceeded the screening level.

3.5.8 Results Summary for Area 8 - Overflow Solution Ditch

As shown in Table 3-25, three chemicals were detected above preliminary soil screening levels in soil samples collected in Area 8 – Overflow Solution Ditch: arsenic, iron, and TPH-mo. Arsenic and iron impacts extend to a depth of 25 feet bgs while TPH-mo appears limited to surface soil (0-2.5 feet bgs). Arsenic was detected above the screening level in eight samples at concentrations up to 21 mg/kg. Arsenic concentrations were consistent throughout depth. Iron and TPH-mo were detected up to 45,000 mg/kg and 240 mg/kg, respectively.

Location	Sample	Metals (mg/kg)		TPH (mg/kg)
		Arsenic	Iron	Motor Oils
Screening Level		10.5	28,200	100
PA-FFF3	PA-FFF3-1	19		120
PA-FFF9	PA-FFF9-1			240
PA-FFF16	PA-FFF16-10	21	34,000	
	PA-FFF16-15	13	39,000	
PA-FFF17	PA-FFF17-1		45,000	
	PA-FFF17-5	17		
	PA-FFF17-10	17		
	PA-FFF17-15	18		
	PA-FFF17-20	14		
	PA-FFF17-25	18		

3.5.9 Results Summary for Area 9 - East Solution Ditch

Table 3-26 summarizes the analytical results for Area 9 – East Solution Ditch.

Table 3-26. Area 9 Samples Exceeding Preliminary Screening Levels													
Location Name	Sample Name	Metals (mg/kg)			Radiochemicals (pCi/g)				TPH (mg/kg)		SVOC (mg/kg)	Pesticide (mg/kg)	
		Arsenic	Iron	Thallium	Thorium-232	Uranium	Radium-226	Radium-228	Diesel Components	Motor Oils	Benzo(A)Pyrene	Aldrin	P,P'-DDT
Screening Level		10.5	28,200	5.2	21	16	4.2	4.5	100	100	0.062	0.029	1.7
PA-EEE1	PA-EEE1-1								120	720	0.17		2.0
	PA-EEE1-5									130			
PA-EEE2	PA-EEE2-1	15			110	36.6	5.7	14.4	4,100	24,000			
	PA-EEE2-5	20			34.7				370	1,600			
	PA-EEE2-10	11	30,000			29.6							
PA-EEE5	PA-EEE5-1	40	32,000		52.4			5.4					
PA-EEE8	PA-EEE8-1	43	52,000		36.6	20		5.2		540			
	PA-EEE8-5	38			23.4	42.4		4.7					
	PA-EEE8-10	11				20.1							
PA-EEE11	PA-EEE11-1	53			73.8	27.9		6.4	170	1,900			
	PA-EEE11-5	29				16.2							
	PA-EEE11-10					18							
PA-EEE12	PA-EEE12-1									120			
	PA-EEE12-10								800	8,100			
PA-EEE13	PA-EEE13-1	43			66.3	40.9	5.1	9.3	1,100	7,300			
PA-EEE14	PA-EEE14-1	31			157	53.8		16.9	1,700	13,000			
	PA-EEE14-5	42			31	24.8							
	PA-EEE14-10	14				16.1							
PA-EEE15	PA-EEE15-1	81	43,000	15						1,600			
PA-EEE16	PA-EEE16-15		30,000										
PA-EEE17	PA-EEE17-1	31	32,000		241	42.8	4.9	24.4		550			
	PA-EEE17-5	62	36,000		76	21.2		7.6					
	PA-EEE17-10	33						6.1					
	PA-EEE17-15	14			40.8			7.2		160			
	PA-EEE17-20	13			36.7	20		5.8					
PA-EEE18	PA-EEE18-15									300			
PA-EEE20	PA-EEE20-1								250	2,000			
	PA-EEE20-5								940	6,100			
	PA-EEE20-10								3,100	17,000		0.038	

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The East Solution Ditch was used to convey surface drainage from the Truck Wash Pad, Upper and Lower Truck Sludge Ponds, and other localized surface runoff. As shown in Table 3-26, 12 chemicals were detected above preliminary soil screening levels in soil samples collected in Area 9: TPH-d, TPH-mo, arsenic, iron, thallium, radium-226, radium-228, thorium-232, uranium, benzo(a)pyrene, aldrin, and p,p-DDT. The highest detections were typically at the surface and impacts extended to 10 feet bgs. Petroleum hydrocarbon concentrations of TPH-d up to 4,100 mg/kg and TPH-mo up to 24,000 mg/kg were analyzed from the ditch. Arsenic values above the preliminary screening level were detected at 19 sample locations.

Radium 228, thorium-232, and uranium were also frequently detected (12 to 15 sample locations) at concentrations up to 24.4 ± 1.6 pCi/g, 241 mg/kg and 53.8 mg/kg, respectively. The maximum detections (among all 2004-2005 results) for radium-228 of 24.4 ± 1.6 pCi/g and for thorium-232 of 241 mg/kg occurred at PA-EEE17-1 at a sample depth interval of 0.5-2.5 feet bgs. Iron and radium-226 were less frequently detected (seven or fewer sample locations) above screening levels with concentrations up to 52,000 mg/kg and 5.7 ± 1.0 pCi/g. Four chemicals had only one detection each above their screening levels: thallium at 15 mg/kg, benzo(a)pyrene at 0.17 mg/kg, aldrin at 0.038 mg/kg, and p,p-DDT at 2.0 mg/kg.

3.5.10 Results Summary for Area 10 - North Low Area

Table 3-27 indicates that five chemicals were detected above preliminary screening levels in Area 10 – North Low Area: arsenic, copper, iron, radium-228, and thorium-232. There are no significant petroleum hydrocarbon impacts in this area. Arsenic, copper, and iron impacts extend to a depth of 20 feet bgs. Arsenic, copper, and iron were detected in at least one of seven samples at concentrations up to 43 mg/kg, 3,900 mg/kg, and 34,000 mg/kg, respectively. Radium-228 was detected once at 5.1 ± 0.6 pCi/g and thorium-232 was detected twice up to 30.2 mg/kg, just above their respective screening levels.

Location	Sample	Metals (mg/kg)				Radio-chemical (pCi/g)
		Arsenic	Copper	Iron	Thorium-232	Radium-228
Screening Level		10.5	3,100	28,200	21	4.5
PA-HHH1	PA-HHH1-1	14				
PA-HHH8	PA-HHH8-5			34,000		
	PA-HHH8-20			31,000		
PA-HHH16	PA-HHH16-1	43		32,000		
	PA-HHH16-5	34				
PA-II3	PA-II3-1	13	3,900			
PA-KK3	PA-KK3-10				30.2	
	PA-KK3-15	16			27	5.1

3.5.11 Results Summary for Area 11 - South Low Area

Table 3-28 indicates a number of chemical groups were detected above preliminary screening levels in Area 11 – South Low Area: TPH-g, TPH-d, TPH-mo, arsenic, copper, iron, thorium-232, uranium, PCE, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, benzo(b)fluoranthene, dibenz(a,h)anthracene, p,p'-DDT, and dieldrin. Petroleum hydrocarbons in all three carbon ranges were detected with values that exceed screening levels to depths of 25 feet bgs. TPH-g and VOCs were detected above their respective screening levels at the Lower Truck Sludge Pond and the gasoline line coming from Filling Station #3.

In the Lower Truck Sludge Pond (PA-CCC2 and PA-CCC4), TPH-g, TPH-d, and TPH-mo were detected at concentrations up to 1,900 mg/kg, 4,000 mg/kg, and 22,000, respectively. In the ditch between the Upper and Lower Truck Sludge Ponds, TPH-mo was detected at 620 mg/kg. At five boring locations in the Low Area (HHH), TPH-d, and TPH-mo were detected at concentrations up to 12,000 mg/kg, and 27,000, respectively. Arsenic, copper, and iron were detected in Area 11 up to concentrations of 41 mg/kg, 5,500 mg/kg, and 29,000 mg/kg, respectively. Thorium-232 was detected once at 30.3 mg/kg and uranium was detected twice up to 42.9 mg/kg. Benzo(b)fluoranthene, dibenz(a,h)anthracene, p,p'-DDT, and dieldrin were each detected once above screening levels at concentrations of 1.1 mg/kg, 0.073 mg/kg, 1.9 mg/kg, and 0.039 mg/kg, respectively.

Table 3-28. Area 11 Samples Exceeding Preliminary Screening Level

Location Name	Sample Name	Metals (mg/kg)			Radiochemicals (pCi/g)		VOCs (mg/kg)			SVOCs (mg/kg)		TPH (mg/kg)			Pesticides (mg/kg)	
		Arsenic	Copper	Iron	Thorium-232	Uranium	Tetrachloroethylene (PCE)	1,2,4-Trimethylbenzene	1,3,5-Trimethylbenzene (Mesitylene)	Benzo(B)Fluoranthene	Dibenzo(A,H)Anthracene	Diesel Components	Gasoline C4-C12	Motor Oils	P,p'-DDT	Dieldrin
Screening Level		10.5	3,100	28,200	21	16	0.48	52	21	0.62	0.062	100	100	100	1.7	0.03
PA-CCC2	PA-CCC2-5	17		29,000			0.54					4,000		22,000		
	PA-CCC2-10				30.3	42.9		210	50			2,900	920	9,300		
	PA-CCC2-15							110	25			950	680	3,300		
	PA-CCC2-20	16						380	94			2,500	1,600	7,200		
PA-CCC4	PA-CCC4-5					19.3										
	PA-CCC4-15						1.6					860		3,700		
	PA-CCC4-25							76	34			2,200	1,900	6,600		
PA-DDD3	PA-DDD3-1													620		
PA-HHH19	PA-HHH19-1			4,600										390		
	PA-HHH19-5									1.1				150		
PA-HHH21	PA-HHH21-1													19,000		
	PA-HHH21-5	19												27,000		
PA-HHH23	PA-HHH23-1													4,900		
PA-HHH25	PA-HHH25-1	41	5,500											21,000		
PA-HHH27	PA-HHH27-1													660		
PA-HHH33	PA-HHH33-10										0.073					
PA-HHH34	PA-HHH34-25	13														
PA-HHH36	PA-HHH36-10														1.9	0.039

3.5.12 Results Summary for Area 12 - Peripheral Process Components

Table 3-29 indicates that six chemicals were detected above preliminary screening levels in soil samples collected from Area 12 – Peripheral Process Components: arsenic, copper, iron, thallium, radium-226, and TPH-mo (arsenic, copper, iron and thallium exceedances extend to a depth of 20 feet bgs). At the Concrete Pump Tank (PA-AA1), arsenic, iron, and thallium were detected at concentrations up to 60 mg/kg, 41,000 mg/kg, and 5.8 mg/kg, respectively. At the Acid Tanks (PA-PP1 and PA-PP2), arsenic was detected up to 14 mg/kg. At the Old Crusher Site (PA-UU1 and PA-UU2), copper was detected up to 8,700 mg/kg. At the Tailings Pump Houses (PA-VV1 and PA-VV2), arsenic and copper were detected up to 23 mg/kg and 5,100 mg/kg, respectively. At the Surface Pump Foundation (PA-ZZ1), arsenic was detected up to 15 mg/kg. In the peripheral areas, occurrences of radiochemicals and petroleum hydrocarbons were limited to the Tailings Pump Houses (PA-VV1 and PA-VV2) with radium-226 and TPH-mo detections of 4.8±0.5 pCi/g and 110 mg/kg, respectively, in surface soil (0-2.5 feet bgs).

Table 3-29. Area 12 Samples Exceeding Preliminary Screening Levels							
Location	Sample	Metals (mg/kg)				Radiochemicals (pCi/g)	TPH (mg/kg)
		Arsenic	Copper	Iron	Thallium	Radium-226	Motor Oils
Screening Level		10.5	3,100	28,200	5.2	4.2	100
PA-AAA1	PA-AAA1-10	59		35,000			
	PA-AAA1-15	60		41,000	5.8		
PA-PP1	PA-PP1-1	14					
	PA-PP1-5	11					
PA-PP2	PA-PP2-5	11					
PA-PP3	PA-PP3-1	13					
PA-UU1	PA-UU1-1		5,700				
	PA-UU1-5		3,900				
PA-UU2	PA-UU2-1		8,700				
	PA-UU2-10		8,300				
	PA-UU2-5		5,700				
PA-VV1	PA-VV1-1		5,100				110
	PA-VV1-10	12					
PA-VV2	PA-VV2-1					4.8	
	PA-VV2-10	18					
	PA-VV2-20	23					
PA-ZZ1	PA-ZZ1-5	15					
	PA-ZZ1-10	11					

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3.5.13 Results Summary for Utility Pipeline Areas

The purpose of utility pipeline sampling was to locate as many underground lines as possible and sample each line at several points. Historical maps of the Process Areas provided locations of originally installed sewer lines, drain lines and water and gas lines. Because the facility has undergone changes over the years, the accuracy of the map was determined to be questionable during the field investigations (e.g., utility pipelines may no longer exist and the maps may not include all pipelines in the Process Areas). Section 2.2.14 described the pipelines, drains, and ditches used to convey pregnant and spent process solutions, acids, fuels and waste materials.

For the previous investigation, targeted sample points included pipe terminus into sumps or manholes, intermediate joints, and locations where the pipe made a turn. A private utility locating service was engaged to try to locate, by surface survey, as many pipelines as possible. It became apparent that a majority of the lines were constructed of non-conducting materials that were not picked up by the survey equipment. A field determination was made that the most feasible method for locating the pipes was to use a backhoe to excavate areas where pipelines were shown on the historical maps or areas where manholes could be opened and pipes observed. A backhoe was used to excavate down to suspected pipe locations, ranging in depth from 1 foot to 12 feet bgs. When a pipe was located, the excavation would continue along the pipe until a connecting joint was located, at which point a sample was collected from 6 to 12 inches directly beneath the bottom of the piping at the closest pipe junction or connection. In locations where two or more pipes occurred in the same corridor, samples were collected under each pipe separately at each pipe's joint or connection.

A total of 60 locations (PA-UT1 through PA-UT60) were excavated that encountered underground, or in some cases surface, piping, and one sample was collected from each location. All utility samples were analyzed for the full suite of analytes, including radiochemicals. As shown in Table 3-30, multiple chemicals were detected above preliminary soil screening levels in soil samples collected from utility pipe area: six metals; one radiochemical (radium-226); five VOCs; one SVOC [benzo(a)pyrene]; and all three petroleum hydrocarbon ranges.

Table 3-30. Utility Pipeline Samples Exceeding Preliminary Screening Levels

Location	Sample	Metals (mg/kg)				Radiochemicals (pCi/g)				VOCs (mg/kg)						SVOCs (mg/kg)			TPH (mg/kg)		
		Arsenic	Copper	Iron	Lead	Thorium-232	Uranium	Radium-226	Benzene	1,2,3-Trichloropropane	1,2,4-Trimethylbenzene	1,3,5-Trimethylbenzene (Mesitylene)	Xylenes, Total	Benzo(A)Pyrene	Diesel Components	Gasoline C4-C12	Motor Oils				
	Screening Level	10.5	3,100	28,200	400	21	16	4.2	0.64	0.034	52	21	270	0.062	100	100	100				
PA-UT04	PA-UT04														140		770				
PA-UT05	PA-UT05														4,100		16,000				
PA-UT06	PA-UT06																370				
PA-UT07	PA-UT07														340		1,500				
PA-UT16	PA-UT16					22											120				
PA-UT17	PA-UT17																550				
PA-UT23	PA-UT23								0.82	0.39	320	110	450		7,900	7,400	7,400				
PA-UT25	PA-UT25									0.098					7,200	970	1,400				
PA-UT27	PA-UT27													0.11							
PA-UT28	PA-UT28	12				33.9															
PA-UT29	PA-UT29	21				235	150	4.6±0.2							200		490				
PA-UT31	PA-UT31	11															140				
PA-UT36	PA-UT36	25	4,600	42,000	1,300										8,300		60,000				
PA-UT40	PA-UT40					73.9	25.7														
PA-UT41	PA-UT41					55.6															
PA-UT42	PA-UT42					65.3															
PA-UT43	PA-UT43			31,000																	
PA-UT46	PA-UT46																140				
PA-UT48	PA-UT48					41.6											130				
PA-UT53	PA-UT53		8,600														230				
PA-UT56	PA-UT56		3,400																		
PA-UT60	PA-UT60		5,400											2,300			9,200				

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The utility pipeline results may be further summarized as follows:

- Dump Leach Pregnant Solution (UT-B): Sample locations PA-UT43 and PA-UT60 along the aboveground transite pipe had metals and petroleum hydrocarbon results that exceeded screening levels: copper at 5,400 mg/kg, iron at 31,000 mg/kg, TPH-d at 2,300 mg/kg and TPH-mo at 9,200 mg/kg.
- Precipitation Plant Spent Solution to Pond(UT-D): Sample locations PA-UT27, PA-UT28, and PA-UT29 along the ditch leading north from the Precipitation Plant had metal, radiochemical, SVOC, and petroleum hydrocarbon results that exceeded screening levels: arsenic up to 21 mg/kg, uranium-238 at 150 mg/kg, thorium-232 up to 235 mg/kg, radium-226 at 4.6±0.2 pCi/g, benzo(a)pyrene at 0.11 mg/kg, TPH-d at 200 mg/kg, and TPH-mo at 490 mg/kg. PA-UT29 was a surface sample collected from a ditch where solutions temporarily exited a pipeline, flowed through an open ditch for 20 to 30 feet, then re-entered another pipe. Sediment had accumulated in the ditch and the area had elevated gamma radiation readings with the handheld gamma meter (no readings exceeded site safety levels).
- Secondary Crusher Dust Slurry (UT-I): Sample locations PA-UT36 and PA-UT40 along the underground pipeline leading from the Secondary Cursher had metal results that exceeded screening levels: arsenic at 25 mg/kg, copper at 4,600 mg/kg, iron at 42,000, and lead at 1,300 mg/kg. These locations had radiochemical results above screening levels: thorium-232 at 73.9 mg/kg and uranium-238 at 25.7 mg/kg. These locations also had TPH-d at 8,300 and TPM-mo at 60,000 mg/kg (the maximum TPH-mo detection among 2004-2005 investigation results).
- Fuel Distribution Pipeline (UT-L): At locations PA-UT23 and PA-UT25 near the underground fuel line, a total of five VOCs (1,2,3-trichloropropane, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, benzene, and xylenes) and all three petroleum hydrocarbon ranges were detected above screening levels. The soil at these sample locations was visibly stained and smelled of petroleum hydrocarbons. The maximum detection of TPH-g (for the entire 2004-2005 investigation) of 7,400 mg/kg was detected at PA-UT23. TPH-d and TPH-mo were detected up to 7,900 mg/kg and 1,400, respectively.
- Miscellaneous Occurrences: In addition to the above occurrences, soils results from other utility pipelines exhibited copper, thorium-232, TPH-d, and TPH-mo up to 8,600 mg/kg, 22 mg/kg, 4,100 mg/kg, and 16,000 mg/kg, respectively.

3.5.14 Results Summary for Stained Soil Areas and Excavations

During the investigation, four small areas (PA-EX01 through PA-EX04) were identified as having stained soil most likely from petroleum hydrocarbons and were candidates for limited excavation. Two areas (PA-EX01 and PA-EX04) met the excavation criteria defined in the Process Areas Work Plan, and visibly contaminated soil was excavated and stockpiled. The

excavations were limited in size to less than 10 by 10 feet by 3 feet deep, in accordance with the Process Areas Work Plan. At the time of the excavation, the soils were monitored with a real time Organic Vapor Photo-Ionization Detector (PID) to assist in determination of the extent of oil seepage as well as monitor for employee health and safety. The PID readings were very low throughout the excavation and final determination of extent was done visually rather than based on equipment readings. The remaining two areas (EX-02 and EX-03) did not meet the criteria for excavation.

At all four areas (PA-EX01 through PA-EX04), a preliminary grab sample was collected of the stained soil near the surface. At the excavation areas, samples were collected from the bottom and sidewalls of the excavation. A composite sample was collected from the stockpiles to complete the characterization profile. As shown in Table 3-31, four chemicals (arsenic, copper, TPH-d, and TPH-mo) were detected above preliminary soil screening levels in soil samples collected from the four areas (PA-EX01 through PA-EX04). All but one result from the four locations exceeded the screening criteria for TPH-d and TPH-mo confirming the visual indications of staining.

Location	Sample	Metals (mg/kg)		TPH (mg/kg)	
		Arsenic	Copper	Diesel Components	Motor Oils
Screening Level		10.5	3,100	100	100
PA-EX01	PA-EX01-1			430	1,700
	PA-EX01-2				250
	PA-EX01-3			1,600	4,700
	PA-EX01-A			7,800	15,000
PA-EX02	PA-EX02-A	11		9,400	23,000
PA-EX03	PA-EX03-A	12	3,900	16,000	33,000
PA-EX04	PA-EX04-1			1,400	7,400
	PA-EX04-2				300
	PA-EX04-3			1,900	8,200

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3.5.15 Results Summary for Electrical Substation and Transformer Sites

Surface grab samples were collected from underlying and adjacent soils associated with five transformer sites in the Process Areas (PA-TR1 through PA-TR5). The samples were analyzed for the full suite of analytes except radiochemicals. No visible oil staining was observed around any of the transformers that were sampled.

As shown in Table 3-32, only three chemicals were detected above preliminary soil screening levels in soil samples collected from five electrical substation/transformer sites: arsenic, benzo(a)pyrene, and TPH-mo. The detections occurred at PA-TR1, PA-TR3, and PA-TR5. The samples were all surface grab samples collected from soil underlying and adjacent to the transformers. Arsenic and benzo(a)pyrene each had one detection above screening levels at concentrations of 15 mg/kg and 0.095 mg/kg, respectively. TPH-mo was detected three times above screening levels at concentrations up to 480 mg/kg. PCBs were not detected in any of the samples.

Location	Sample	Metals (mg/kg)	SVOC (mg/kg)	TPH (mg/kg)
		Arsenic	Benzo(A)Pyrene	Motor Oils
Screening Level		10.5	0.062	100
PA-TR1	PA-TR1-1	15		430
PA-TR3	PA-TR3-1		0.095	120
PA-TR5	PA-TR5-1			480

In addition to the five electrical substation/transformer areas, several mining areas/features had electrical transformer servicing, use, or storage: Small Warehouse Annex; Fire Engine Storage/Tire Shop; Quonset Hut; Solution Tanks; and Solution Tanks, Electrical Building, and Basement. Electrical transformer servicing, use, or storage at these areas/features had the potential to release PCBs; however, only one location (PA-DD10-1 near the Solution Tanks) had a PCB result above screening levels (PCB-1254 at 5.6 mg/kg).

3.5.16 Underground Storage Tanks

An initial survey was completed to determine the presence of possible USTs remaining on the property. Areas around former fueling stations were investigated in a preliminary fashion to determine if any fuel or liquid is still remaining in those tanks. Follow-up investigations presented in this Process Areas RI Work Plan will be based on the following Nevada regulations:

- NRS 459.800-856 “Storage Tanks”
- NRS 590.700-920 “Cleanup of Discharged Petroleum”

3.6 Comparison of Primary Sample and Duplicate/Split Sample Results

Duplicate soil samples were collected at a ratio of 1 to 10 concurrently with primary samples during the initial Process Areas soils investigations. A total of 51 primary/duplicate sample pairs were analyzed for radiochemicals and 119 pairs were analyzed for metals, petroleum hydrocarbons, and other chemical groups. The relative percent difference (“RPD”) of the primary/duplicate sample results are summarized in Table 3-33 for metals, radiochemicals, and petroleum hydrocarbons. As is common with soil analytical results at most environmental sites, there is some variability in the analytical results of duplicate soil samples with primary samples.

For metal results, the average RPDs ranged from 5.8 percent for silver to 36 percent for mercury. The average RPD for most metals was below 20 percent. For radiochemical results, the average RPDs were slightly higher than metals and ranged from 17 percent for thorium-232 to 35 percent for radium-228. For petroleum hydrocarbon results, the average RPD for TPH-d and TPH-mo were 29 percent and 20 percent, respectively. The average RPD for TPH-g was low, primarily due to the large quantity of non-detected results.

EPA also collected split samples for analyses at a laboratory other than the project laboratory. A total of 41 primary/split sample pairs were analyzed for metals, radiochemicals, petroleum hydrocarbons, and other chemical groups. The RPD of the primary/split sample results are

summarized in Table 3-34 for metals, radiochemicals, and petroleum hydrocarbons analyzed by the EPA laboratory. For metal results, the average RPDs ranged from 5.3 percent for silver to 110 percent for mercury.

Table 3-33. Relative Percent Difference of Primary and Duplicate Soils Results						
	Sample Pair Count	Relative Percent Difference				Coeff. of Variation
		Min	Max	Mean	Std Dev	
Metals						
Arsenic	119	0.0	65	16.42	13.99	0.85
Aluminum	119	0.0	96	16.38	15.82	0.97
Antimony	11	0.0	149	19.82	47.58	2.4
Barium	119	0.0	58	15.13	13.46	0.89
Beryllium	119	0.0	68	13.64	11.47	0.84
Boron	119	0.0	183	8.66	30.76	3.6
Cadmium	119	0.0	112	16.66	16.10	0.97
Calcium	119	0.0	101	16.03	16.93	1.1
Chromium, Total	119	0.0	131	17.31	21.04	1.2
Cobalt	119	0.0	118	16.12	17.60	1.1
Copper	119	0.0	115	22.47	22.29	0.99
Iron	119	0.0	88	14.50	14.97	1.0
Lead	119	0.0	83	17.16	16.77	0.98
Magnesium	119	0.0	78	13.73	14.71	1.1
Manganese	119	0.0	102	15.96	18.38	1.2
Mercury	119	0.0	199	35.73	50.62	1.4
Molybdenum	119	0.0	172	21.30	33.48	1.6
Nickel	119	0.0	143	15.33	19.14	1.3
Potassium	119	0.0	106	15.55	17.73	1.1
Selenium	119	0.0	177	9.13	24.48	2.7
Silver	119	0.0	67	5.83	12.46	2.1
Sodium	119	0.0	187	19.72	23.96	1.2
Thallium	119	0.0	188	7.39	24.19	3.3
Vanadium	119	0.0	69	11.78	11.18	0.95
Zinc	119	0.0	104	14.59	17.79	1.2
Radiochemicals						
Radium-226	51	0.0	169	26.61	35.05	1.3
Radium-228	51	0.0	189	35.41	44.05	1.2
Thorium-232	51	0	157	17.12	23.97	1.4
Uranium-238	51	0	156	20.65	26.32	1.3
Petroleum Hydrocarbons						
TPH-g	117	0.0	31	0.40	3.11	7.7
TPH-d	119	0.0	188	28.62	43.37	1.5
TPH-mo	119	0.0	183	20.28	38.12	1.9

For radiochemical results, the average RPD for radium-226 and radium-228 were 71 percent and 54 percent, respectively. The analytical results for uranium and thorium could not be compared because the project laboratory and EPA laboratory used different methods that are not comparable (e.g., results in mass versus activity). For petroleum hydrocarbon results, the average RPD for TPH-d and TPH-mo was 19 percent and 24 percent, respectively. The average RPD for

TPH-g was quite low primarily due to the large quantity of non-detected results. Note that the hydrocarbon ranges for analytical methods from the primary and EPA laboratories may vary and the results may not be comparable.

Table 3-34. Relative Percent Difference of Primary and Split Soils Results						
	Sample Pair Count	Relative Percent Difference				Coeff. of Variation
		Min	Max	Mean	Std Dev	
Metals						
Arsenic	40	3	139	34.58	28.17	0.81
Aluminum	40	1	76	22.18	17.50	0.79
Antimony	2	0	0	0.00	0.00	
Barium	40	0	79	29.33	23.00	0.78
Beryllium	40	0	61	20.90	16.93	0.81
Cadmium	40	0	142	55.25	40.04	0.72
Calcium	40	2	118	30.10	25.73	0.85
Chromium, Total	40	0	119	44.05	30.50	0.69
Cobalt	40	2	121	47.10	26.66	0.57
Copper	40	1	193	45.83	44.78	0.98
Iron	40	1	67	19.00	15.22	0.80
Lead	40	0	199	35.43	46.38	1.3
Magnesium	40	1	55	16.58	13.77	0.83
Manganese	40	0	135	26.30	24.55	0.93
Mercury	40	0	199	109.55	84.52	0.77
Nickel	40	2	98	27.00	22.17	0.82
Potassium	40	1	71	21.78	18.02	0.83
Selenium	40	0	191	8.35	37.26	4.5
Silver	40	0	107	5.33	23.51	4.4
Sodium	40	1	88	27.68	19.55	0.71
Thallium	40	0	0	---	---	---
Vanadium	40	9	89	48.28	20.81	0.43
Zinc	40	1	159	37.20	33.84	0.91
Radiochemicals						
Radium-226	24	2	188	71.38	51.14	0.72
Radium-228	24	0	176	53.75	53.54	1.00
Petroleum Hydrocarbons⁽¹⁾						
TPH-g	24	0	90	6.15	22.24	3.6
TPH-d	41	0	178	18.59	41.48	2.2
TPH-mo	41	0	195	23.83	53.84	2.3

Notes: (1) Hydrocarbon ranges for analytical methods from project and EPA laboratories may vary

3.7 Data Gaps

Based on the Process Areas soils investigation results, and subsequent evaluation of available information, the following three general types of data gaps have been identified:

- Areas/features with incomplete delineation requiring additional sampling;
- Areas/features identified since last investigation; and
- Quality control issues requiring corrective action.

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3.7.1 Areas/Features with Incomplete Delineation Requiring Additional Sampling

The delineation of contaminant extent may require additional iterations of step-out borings, collecting and analyzing soil samples, and interpreting results, as recommended in Section 6.0.

3.7.2 Areas/Features Identified Since Last Investigation

Investigations will be performed at the following potential UST locations:

- Administration Building (A);
- Emergency Shed (R);
- Filling Station #2 (W);
- Filling Station #3 (X); and
- Filling Station #4 (Z).

Additional areas for investigations, identified since the 2004-2005 investigation, include:

- Area 4: overflow sump southwest of the Solution Tanks.
- Area 5: trench box for the main pipeline between Solution Tanks and Precipitation Plant; dump leach recirculation sump associated with the Precipitation Plant; and pump house northwest of the Precipitation Plant.
- Area 6: Sulfide Plant pump house overflow ditch.
- Area 8: southwest end of the Overflow Solution Ditch (FFF).
- Area 9: north end of the East Solution Ditch (EEE).

3.7.3 Quality Control Issues Requiring Corrective Action

Quality control issues addressed in Section 6.0 include:

- Poor Recovery of Antimony: The method for antimony analysis will be changed from EPA Method 6020 to Method 6010B in order to reduce the likelihood of rejection of data due to matrix spike recovery outside of acceptable limits. ARC is currently working with the laboratory to identify a digestion method that will provide the best results. Poor antimony matrix spike recoveries in soil are common. In theory, the antimony in the spiking solution forms insoluble antimony oxychloride when added to soil containing low concentrations of chloride. The antimony is subsequently removed during filtration of the digestate. The answer to the problem seems to be the addition of hydrochloric acid (HCl)

to form soluble antimony trichloride prior to filtration. Method 6010 is then necessary because the HCl causes interference or analytical problems with ICP/MS equipment associated with Method 6020. Use of Method 6010 results in a reporting limit (RL) of 10 mg/kg, which is higher than the 1.0 mg/kg RL currently listed in the QAPP for Method 6020. However, ARC maintains that the 10 mg/kg Method 6010B RL is acceptable because it is well below the 31 mg/kg Residential PRG and 410 mg/kg Industrial PRG for antimony.

- Detection Limits for Thorium (-232): The method for total thorium will be EPA Method 6020 [which reports results in units of concentration (mg/kg)], with a reporting limit of 0.5 mg/kg, and the HASL 300 method [which reports results units of activity (pCi/g)] for thorium-232 with a reporting limit of 1.0 pCi/g.
- Difficulty With ENCORE Sampling for VOCs: As requested by the EPA, the ENCORE sampling method will be used to prepare soil samples for VOC analysis described in Section 6.0.
- Omission of Methyl tertiary-butyl ether (MtBE): MtBE was omitted from analysis of soil samples in the 2004-2005, but will be added to the list of VOC analytes for sampling described in Section 6.0.

3.8 Area/Features Requiring No Further Action

A number of sub-areas and features within the Process Areas do not require additional soils investigation based on the results presented above. No further action (“NFA”) is recommended for the sub-areas and features and features in Table 3-35. Such NFA determination can be made throughout the RI/FS process as a means to focus efforts on other locations where impacts are known or indicated.

Area	Feature	2004-2005 Investigation	Rationale
11	Tire Pile (B)	Site inspection.	No discolored soil observed; no indication of equipment chemical storage.
1	Change House (D)	Site inspection and 2 borings PA-D1 and PA-D2.	No discolored soil observed and no soil sample results above screening levels.
1	School House (E)	Site inspection and 2 borings PA-E1 and PA-E2.	No discolored soil observed and no soil sample results above screening levels.
1	Plumber’s Shop (T)	Site inspection.	No discolored soil observed and no indication of chemical use or storage.

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Table 3-35. Area/Features Requiring No Further Action - Continued			
Area	Feature	2004-2005 Investigation	Rationale
2	Carpenter Shop (N)	Site inspection and 1 boring PA-N1.	No discolored soil observed and no soil sample results above screening levels.
2	Electrical Test Shop (Y)	Site inspection.	No discolored soil observed and no indication of chemical use or storage.
2	Coarse Ore Storage (III)	Site inspection.	No discolored soil observed and no indication of chemical use or storage.
6	Sulfide Plant Office (GG)	Site inspection and one boring PA-GG1	No discolored soil observed and no soil sample results above screening levels.
12	Core Building (AA)	Site inspection.	No discolored soil observed and no indication of chemical use or storage.
12	Water Tank (BB)	Site inspection.	No discolored soil observed and no indication of chemical use or storage.
12	Motor Cargo Building (TT)		Used by the community of Weed Heights

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SECTION 4.0

RESULTS OF PREVIOUS GROUNDWATER INVESTIGATIONS

Groundwater flow conditions in the alluvial aquifer underlying the Process Areas were evaluated in a preliminary fashion resulting from initial investigations, as summarized in the *Data Summary Report for Process Area Groundwater Conditions* (Brown and Caldwell, 2005a). These data, and subsequent groundwater elevation data from the monitor wells installed in the Process Areas and other groundwater monitor wells are consistent with Site-wide information presented in the *Draft Revised Conceptual Site Model, Yerington Mine Site, Nevada* (Integral Consulting and Brown and Caldwell, 2007) and the *Draft Site-Wide Groundwater Remedial Investigation Work Plan* (Brown and Caldwell and Integral Consulting, 2007).

4.1 Local Groundwater Flow Conditions

As described in Section 2.3.2, the north-northwest groundwater flow direction beneath the Site results from recharge from the Walker River at the southeast margin of the Site (i.e., in the vicinity, and south, of the Yerington Pit). Bedrock outcrops (i.e., the 'Groundhog Hills', a structural spur of the Singatse Range) located east of the Process Areas and west of the Walker River likely impede recharge from the river to the alluvium beneath the Process Areas. Based on groundwater elevation data obtained from monitor wells PA-MW-1 through PA-MW-3 and, to a lesser extent, on water levels measured in open boreholes, the northwest flow direction is also observed beneath the Process Areas. Figure 4-1 depicts the locations of the borehole grab samples and monitor wells PA-MW-1 through PA-MW-3.

Because measurements in open boreholes, or boreholes with temporary screens installed, are not typically used to represent static water level conditions, there are limitations in using these data to evaluate localized groundwater flow patterns beneath the Process Areas. As shown on the hydrograph presented in Figure 4-2, water level measurements in the open boreholes (one-time measurements) were generally consistent with the water level measurements initially obtained from a pre-existing well (UA-1) and the three wells installed within the Process Areas (PA-MW-

1 through PA-MW-3). Some inconsistencies include: 1) clearly anomalous measurements in PA-GW-14, PA-GW-19 and PA-GW-27; and 2) apparently low measurements at several other locations (e.g., PA-GW-20, PA-GW-8, PA-GW21 and PA-GW-18). In general, higher groundwater elevations were measured in open boreholes in the southeastern portion of the Process Areas and lower groundwater elevations were measured in open boreholes in the northwestern portion of the Process Areas. Localized flow patterns will be further characterized pursuant to Section 6.3 of this Process Areas RI Work Plan.

4.2 Results of Previous Groundwater Investigation

The *Data Summary Report for Process Area Groundwater Conditions* (Brown and Caldwell, 2005a) presented the results of the initial investigation of the two-dimensional distribution of chemicals in the alluvial aquifer underlying the Process Areas. The groundwater characterization activities included:

- drilling of 27 boreholes using a roto-sonic core drilling rig;
- lithologic logging of the cores;
- construction of groundwater monitor wells in three of the drilled boreholes;
- collection of grab groundwater samples from the uppermost portion of the alluvial aquifer in each borehole not constructed as a well, and the collection of a groundwater sample from each of the three monitor wells;
- analysis of the groundwater sample for mine-related chemicals; and
- abandonment of all boreholes not constructed as monitor wells.

Most groundwater sample locations targeted specific Process Areas components with the potential to have sourced chemicals to groundwater during operations (e.g., leach vats, copper solution tanks, precipitation plant, sulfide plant, solution conveyances, drains, sumps, or piping). This biased sampling program evaluated “worst-case” groundwater conditions in the underlying alluvial aquifer. The borehole grab sample and monitor well locations provided a reasonable distribution of head data and, potentially locations that may have represented background water quality conditions relative to the Process Areas.

A total of 27 samples were initially collected and analyzed for metals, radiochemicals, petroleum hydrocarbons, VOCs, SVOCs, pesticides, herbicides and PCBs. Laboratory analytical results are presented in Appendix G (G-1) for the grab samples and the samples collected from the three installed monitor wells (PA-MW-1 through PA-MW-3) including all results from subsequent routine quarterly monitoring Appendix G (G—2). Time-concentration plots for specific chemicals from PA-MW-1 through PA-MW-3 are also provided in Appendix G (G-3).

The results of initial groundwater investigations are summarized below, including a discussion of the occurrence and distribution of chemicals in the alluvial aquifer underlying the Process Areas by general chemical class and by area (classes include metals, radiochemicals, TPH, organic compounds, etc.). In addition, groundwater data are compared with specific soils data from proximal soil sample locations, and the locations of surface features that may represent a source of chemicals to the vadose zone and underlying alluvial aquifer, to assess the occurrence of spatial correlations. The information presented below will focus the proposed remedial investigation of Process Areas groundwater conditions and identify data gaps regarding the occurrence and distribution of chemicals in the underlying alluvial aquifer.

4.2.1 Metals Results

Based on the analytical results provided in Appendix G, summary statistics of the laboratory results for metals analyses from the grab samples are presented in Table 4-1 including the number of samples analyzed, number of detections, minimum/maximum, mean, median, standard deviation, and coefficient of variation. Non-detect results were included in the statistics by assuming the metal was present at half the MDL. Box plots for the Process Areas groundwater data are provided in Appendix H.

Of the 25 metals that were analyzed in groundwater samples, 16 were detected frequently (i.e., greater than 80 percent). Five metals (antimony, cadmium, lead, thallium, and zinc) were detected less frequently (i.e., 40 to 80 percent detections). Aluminum, beryllium, and silver were detected infrequently (i.e., less than 40 percent detections). The less frequently detected metals

also had a high percentage (30 to 94 percent) of trace detections (i.e., estimated values between the MDL and the PQL) indicating that when they were detected, they were typically present at low concentrations.

Table 4-1. Summary Statistics of Metals Analytical Results

Analyte	Units	Count	Qty. & % Detects		Qty. and % Trace Detects ⁽¹⁾		Min	Mean	Median	Max	Std Dev	Coeff of Var.
Aluminum	mg/L	27	6	22%	0	0%	0.0065	40.62	0.0105	920	177	4.36
Antimony	µg/L	27	13	48%	2	15%	0.0435	0.54	0.345	2.6	0.53	0.99
Arsenic	µg/L	27	27	100%	1	4%	0.57	8.87	3.9	70	15	1.64
Barium	µg/L	27	27	100%	0	0%	19	244.19	52	1,900	524	2.15
Beryllium	µg/L	27	8	30%	2	25%	0.0185	2.20	0.0185	24	5.90	2.68
Boron	mg/L	27	27	100%	0	0%	0.32	1.83	1.8	3.7	0.77	0.42
Cadmium	µg/L	27	11	41%	4	36%	0.009	0.98	0.009	18	3.51	3.57
Calcium	mg/L	27	27	100%	0	0%	46	229.59	130	680	195	0.85
Chromium, total	µg/L	27	27	100%	0	0%	0.56	28.63	4.4	390	76	2.66
Cobalt	µg/L	27	27	100%	2	7%	0.59	75.95	4	1,400	268	3.53
Copper	µg/L	27	27	100%	0	0%	1	130.60	5.9	1,300	324	2.48
Iron	mg/L	27	22	81%	7	32%	0.0015	105.46	0.14	1,400	334	3.16
Lead	µg/L	27	11	41%	6	55%	0.0115	4.70	0.023	67	15	3.09
Magnesium	mg/L	27	27	100%	0	0%	7.4	117.75	28	800	185	1.57
Mercury	µg/L	19	7	37%	4	57%	0.0125	0.108	0.013	0.96	0.22	2.06
Manganese	µg/L	27	27	100%	0	0%	130	4483.33	1600	54,000	10,405	2.32
Molybdenum	µg/L	27	27	100%	0	0%	11	109.59	73	1,000	183	1.67
Nickel	µg/L	27	27	100%	0	0%	1.8	69.19	13	1,100	210	3.03
Potassium	mg/L	27	26	96%	1	4%	3.5	19.01	12	130	23.99	1.26
Selenium	µg/L	27	27	100%	0	0%	1.1	25.17	11	280	53.84	2.14
Silver	µg/L	27	6	22%	4	67%	0.009	0.13	0.009	2.5	0.48	3.71
Sodium	mg/L	27	27	100%	0	0%	52	278.74	280	530	109	0.39
Thallium	µg/L	27	16	59%	15	94%	0.008	0.13	0.021	1.5	0.32	2.54
Vanadium	µg/L	27	27	100%	4	15%	0.26	28.95	4.6	340	74	2.57
Zinc	µg/L	27	19	70%	0	0%	0.8	180.10	5.5	3,700	709	3.93

Note: (1) Trace detections are estimated values between the MDL and the PQL.

4.2.2 Comparison of Metals Results to Screening Criteria

Table 4-2 compares Process Areas groundwater concentrations to the EPA maximum contaminant level (“MCL”). Based on the information presented in Table 4-2, the following metals exceed their respective MCLs: arsenic, beryllium, cadmium, chromium, copper, nickel, and selenium.

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Table 4-2. Groundwater Screening Levels for Metals					
Analyte	Units	Min	Max	MCL	Frequency of Results that Exceed the MCL
Aluminium	mg/L	< 0.013	920	NA	NA
Antimony	µg/L	< 0.087	2.6	6	0%
Arsenic	µg/L	0.57	70	10	19%
Barium	µg/L	19	1,900	2,000	0%
Beryllium	µg/L	< 0.037	24	4	15%
Boron	mg/L	0.32	3.7	NA	NA
Cadmium	µg/L	< 0.018	18	5	4%
Calcium	mg/L	46	680	NA	NA
Chromium, Total	µg/L	0.56	390	100	7%
Cobalt	µg/L	0.59	1,400	NA	NA
Copper	µg/L	1	1,300	1300	4%
Iron	mg/L	< 0.003	1,400	NA	NA
Lead	µg/L	< 0.023	67	150	0%
Magnesium	mg/L	7.4	800	NA	NA
Manganese	µg/L	130	54,000	NA	NA
Mercury	µg/L	< 0.025	0.96	2	0%
Molybdenum	µg/L	11	1,000	NA	NA
Nickel	µg/L	1.8	1,100	100	11%
Potassium	mg/L	5.4	130	NA	NA
Selenium	µg/L	1.1	290	50	11%
Silver	µg/L	< 0.018	2.5	NA	NA
Sodium	mg/L	52	530	NA	NA
Thallium	µg/L	< 0.016	1.5	2	0%
Vanadium	µg/L	0.26	340	NA	NA
Zinc	µg/L	< 1.6	3,700	NA	NA

Background chemical data is provided in Table 4-3 from wells B/W-13, B/W-14 and B/W-15, which are located up-gradient of the Site (metals and radiochemicals). The chemical data from these wells, and other background wells to be constructed as part of the *Second Step Hydrogeologic Framework Assessment Work Plan* (Brown and Caldwell, 2007) and/or *Site-Wide Groundwater RI Work Plan* (Brown and Caldwell and Integral Consulting, 2007) can also be used as preliminary screening criteria for Process Areas groundwater conditions. Background

groundwater concentrations are all lower than those of the Process Areas with the exception of arsenic (the background maximum value is 120 µg/L; a maximum arsenic concentration of 70 µg/L is from the Process Areas).

Table 4-3. Summary Statistics from Background Wells B/W-13, B/W-14 and B/W-15

Analyte	Units	Count	Detects	Trace	Min	Max	Std Dev
Aluminum	mg/L	3	1	0	0.02	0.056	0.02
Antimony	µg/L	3	3	3	0.25	0.47	0.11
Arsenic	µg/L	3	3	0	6.1	120	65.36
Beryllium	µg/L	3	0	0	0.0375	0.038	0.00
Boron	mg/L	3	3	0	0.22	0.46	0.12
Cadmium	µg/L	3	2	2	0.0125	0.062	0.02
Calcium	mg/L	3	3	0	4.2	43	19.45
Chromium, total	µg/L	3	3	3	0.61	1.2	0.32
Cobalt	µg/L	3	3	3	0.23	0.64	0.21
Copper	µg/L	3	3	2	0.64	5.1	2.48
Iron	mg/L	3	1	0	0.0075	0.15	0.08
Lead	µg/L	3	1	1	0.02	0.16	0.08
Magnesium	mg/L	3	3	0	1.1	8	3.56
Manganese	µg/L	3	3	0	94	630	280.26
Molybdenum	µg/L	3	3	0	6.9	51	24.12
Nickel	µg/L	3	1	1	0.175	0.63	0.26
Potassium	mg/L	3	3	0	1.7	3.7	1.10
Selenium	µg/L	3	2	1	0.15	2.3	1.19
Silver	µg/L	3	0	0	0.0125	0.013	0.00
Sodium	mg/L	3	3	0	32	84	28.22
Thallium	µg/L	3	0	0	0.075	0.075	0.00
Thorium-232	mg/L	3	0	0	0.0005	0.0005	0.00
Uranium	mg/L	3	2	0	0.0002	0.007	0.00
Vanadium	µg/L	3	3	0	2.5	6.5	2.23
Zinc	µg/L	3	2	1	4.6	33	14.29

4.2.3 Metals Distribution

To assist with the discussion of metals, contour plots illustrating the spatial distribution of metals in groundwater are included in Appendix I. The occurrence and distribution of each of the 27 metals is briefly discussed below:

- Aluminum: detected in only 6 (i.e., 22 percent) of the 27 samples. Aluminum results ranged from <0.021 to 920 mg/L and have a median of 0.0105 mg/L. An MCL has not been established for aluminum. The contour plot indicates a distinct of area of elevated concentration to be PA-GW-4 (920 mg/L) extending north to PA-GW-7 (76 mg/L) and PW-GW-8 (76 mg/L).
- Antimony: detected in 15 (i.e., 48 percent) of the 27 samples. Antimony results ranged from <0.087 to 2.6 µg/L with a median of 0.345 mg/L. The MCL for antimony is 6 µg/L. Contour plots indicated relatively equal spatial distribution with elevated levels in PA-GW-13 (2.6 µg/L) and PA-GW-12 (1.3 µg/L).
- Arsenic: detected in all 27 samples above the PQL. Results ranged from 0.57 to 70 µg/L with a median of 3.9 µg/L. The MCL for arsenic is 10 µg/L; leading to a 19 percent frequency for exceedance of the MCL. Contour plots illustrate a relatively uniform distribution of arsenic throughout much of the Process Areas, with elevated values located in PA-GW-4 (70 µg/L), PA-GW-5 (19 µg/L), PA-GW-7 (33 µg/L) and PA-GW-8 (28 µg/L). These boreholes are clustered in a single area to be discussed later in this section.
- Barium: detected in all 27 samples above the PQL. Results ranged from 19 to 1900 µg/L with a median of 52 µg/L. The MCL for barium is 2000 µg/L. The contour plots show barium is distributed uniformly at lower concentrations through the Process Areas with elevated concentrations located at PA-GW-4 (1900 µg/L), PA-GW-7 (1,300 µg/L) and PA-GW-8 (1,800 µg/L).
- Beryllium: detected in 8 (i.e., 30 percent) of 27 samples. Results ranged <0.037 to 24 µg/L with a median of 0.0185 mg/L. The MCL for beryllium is 4 µg/L. The maximum concentration is located in PA-GW-23 (24 µg/L). Elevated beryllium was also detected in PA-GW-4 (20 µg/L).
- Boron: detected in all 27 samples above the PQL. Concentrations ranged from 0.32 to 3.7 mg/L with a median of 1.8 mg/L. The MCL for boron is 3.7 mg/L; therefore, the frequency for exceedance of the MCL is 0 percent. Boron has a relatively uniform distribution through the Process Areas with elevated concentration detected in groundwater from PA-GW-10 (3.7 mg/L) and PA-GW-25 (2.5 mg/L).
- Cadmium: detected in 11 (i.e., 41 percent) of 27 samples. Concentrations range from <0.018 to 18 µg/L with a median of 0.009 µg/L. The MCL for cadmium is 5 µg/L; therefore, the frequency for exceedance of the MCL is 4 percent. The distribution of cadmium in the Process Areas is relatively uniform at lower concentrations, with elevated values in PA-GW-23 (18 µg/L) and in PA-GW-4 (4.5 µg/L).
- Calcium: detected in all 27 samples above the PQL. Concentrations ranged from 46 to 680 mg/L with a median of 130 mg/L. An MCL has not been established for calcium. Calcium concentrations are elevated in the area of PA-GW-4 (680 mg/L) and PA-GW-7 (300 mg/L), and additionally in the area of PA-GW-18 (540 mg/L) and PA-GW-19 (560 mg/L).

- Chromium, Total: detected in all 27 samples above the PQL. Concentrations ranged from 0.56 to 390 µg/L with a median of 4.4 µg/L. The chromium MCL is 100 mg/L; therefore, the frequency for exceedance of the MCL is 7 percent. Low concentrations of chromium occur throughout the Process Areas with elevated concentrations in PA-GW-4 (390 mg/L), PA-GW-7 (110 mg/L) and PA-GW-8 (64 mg/L).
- Cobalt: detected in all 27 samples above the PQL. Concentrations range from 0.59 to 1400 µg/L with a median of 4 µg/L. An MCL has not been established for cobalt. Cobalt concentrations throughout the Process Areas are generally low, with a localized elevated concentration in PA-GW-23 (1,400 µg/L).
- Copper: detected in all 27 samples above the PQL. Concentrations ranged from 1 to 1,300 µg/L with a median of 5.9 µg/L. The MCL for copper is 1,300 µg/L; therefore, the frequency for exceedance of the MCL is 4 percent. Copper concentrations are generally low throughout much of the Process Areas; however, elevated concentrations were detected in PA-GW-4 (920 µg/L), PA-GW-7 (1,300 µg/L), and PA-GW-8 (710 µg/L).
- Iron: detected in 23 (i.e., 85 percent) of 27 samples with concentrations ranging from <0.003 to 1,400 mg/L with a median of 0.14 mg/L. An MCL has not been established for iron. Elevated concentrations of iron were detected at PA-GW-23 (1,400 mg/L) and PA-GW-4 (1,100 mg/L).
- Lead: detected in 11 (i.e., 41 percent) of 27 samples. Concentrations range from <0.023 to 67 µg/L with a median of 0.023 µg/L. The MCL for lead is 150 µg/L and the frequency of exceeding the MCL is 0 percent. Lead concentrations are generally low throughout the Process Areas and exhibit no spatial distribution, except for elevated concentrations in PA-GW-4 (67 µg/L), PA-GW-7 (32 µg/L) and PA-GW-8 (24 µg/L).
- Magnesium: detected in all 27 samples above the PQL. Concentrations range from 7.4 to 800 mg/L with a median of 28 mg/L. An MCL has not been established for magnesium. Elevated concentrations of magnesium were detected at PA-GW-20 (800 mg/L), PA-GW-23 (350 mg/L), PA-GW-24 (390 mg/L), PA-GW-18 (320 mg/L) and PA-GW-4 (390 mg/L).
- Manganese: detected in all 27 samples above the PQL. Concentrations range from 130 to 54,000 µg/L with a median of 1,600 µg/L. An MCL has not been established for manganese. Manganese appears to be evenly distributed at low concentrations throughout the Process Areas with a high concentration located in PA-GW-23 (54,000 µg/L).
- Mercury: detected in 7 (i.e., 37 percent) of 19 samples. Concentrations range from <0.025 to 0.96 µg/L with a median of 0.0125 µg/L. The MCL for mercury is 2 µg/L; therefore, the frequency for exceeding the MCL is 0 percent. Mercury has no distinct spatial distribution through the Process Areas. The elevated concentration was observed at PA-GW-4 (0.96 µg/L).

- Molybdenum: detected in all 27 samples above the PQL with concentrations ranging from 11 to 1,000 µg/L with a median of 73 µg/L. An MCL has not been established for molybdenum. The Process Areas have low to no spatial distribution, except for an elevated detection in PA-GW-14 (1,000 µg/L).
- Nickel: detected in all 27 samples above the PQL. Concentrations range from 1.8 to 1100 µg/L with a median of 13 µg/L. The MCL for nickel is 100 µg/L; the frequency for the exceedance of the MCL is 11 percent. Nickel appears to be evenly distributed at low concentrations in the Process Areas with a single elevated detection in PA-GW-23 (1,100 µg/L).
- Potassium: detected in all 27 samples above the PQL at concentrations ranging from 5.4 to 130 mg/L, with a median of 12 mg/L. An MCL has not been established for potassium. Potassium appears to be evenly distributed at low concentrations in the Process Areas with higher concentrations in PA-GW-4 (130 mg/L) and PA-GW-7 (43 mg/L). Potassium was also detected in samples from PA-GW-20, PA-GW-23 and PA-GW-24 at concentrations ranging from 20 to 33 mg/L.
- Selenium: detected in all 27 samples above the PQL. Concentrations range from 1.1 to 290 µg/L with a median of 11 µg/L. The MCL for selenium is 50 µg/L; the frequency for exceedance of the MCL is 11 percent. Selenium appears to be evenly distributed at low concentrations in the Process Areas with a single elevated concentration in PA-GW-16 of 280 µg/L.
- Silver: detected in 6 (i.e., 22 percent) of 27 samples. Concentrations range from <0.018 to 2.5 µg/L with a median of 0.009 µg/L. An MCL has not been established for silver. Silver appears to be evenly distributed at low concentrations throughout the Process Areas with a localized elevated concentration in PA-GW-7 (2.5 µg/L).
- Sodium: detected in all 27 samples above the PQL. Concentrations range from 52 to 530 mg/L with a median of 280 mg/L. An MCL has not been established for sodium. Low concentrations of sodium were detected at PA-GW-14 (74 mg/L) and PA-GW-17 (52 mg/L), and elevated concentrations of sodium were detected at PA-GW-25 (530 mg/L).
- Thallium: detected in 16 (i.e., 59 percent) of 27 samples. Concentrations range from <0.016 to 1.5 µg/L with a median of 0.021 µg/L. The MCL for thallium is 2 µg/L; therefore, the frequency for the exceedance of the MCL is 0 percent. Thallium appears to be evenly distributed at low concentrations throughout the Process Areas with elevated concentrations in PA-GW-4 (1.5 µg/L) and PA-GW-7 (0.75 µg/L).
- Vanadium: detected in all 27 samples above the PQL. Concentrations range from 0.26 to 340 µg/L with a median value of 4.6 µg/L. An MCL has not been established for vanadium. Vanadium appears to be evenly distributed at low concentrations throughout the Process Area with elevated concentrations in PA-GW-4 (340 µg/L) and PA-GW-7 (180 µg/L).

- Zinc: detected in 19 (i.e., 70 percent) of 27 samples. Concentrations range from <1.6 to 3700 µg/L and a median of 5.5 µg/L. An MCL has not been established for zinc. Zinc appears to be evenly distributed at low concentrations throughout the Process Areas with higher concentration in PA-GW-4 (420 µg/L), PA-GW-7 (150 µg/L), PA-GW-8 (110 µg/L) and PA-GW-23 (3,700 µg/L).

Based on the contour plots provided in Appendix I, the following three areas of mine-related groundwater have been identified:

- 1) Precipitation Plant Area: This area includes the Precipitation Plant (EE), based on data from PA-GW-18, and may also include the Copper Solution Tanks (FF) and the Leach Vats (P);
- 2) Northern Area: The northern area includes the area of the former Sulfide Plant (HH), the Overflow solution ditch (FFF), and the Dump Leach Surge Pond (KK);
- 3) Southern Area: The southern area consists of the Assay Laboratory (F) and the Truck Shop (K).

4.3 Relationship of Groundwater and Soil Analytical Results

Chemical contour plots (Appendix I) identify localized concentrations that may represent mine-related groundwater in boreholes PA-GW- 4, -18, -23 and -27, and monitor well PA-MW-1, within the three areas listed above. These locations have been compared to the occurrence of elevated concentrations of these chemicals in Process Areas soils from samples collected adjacent to the borehole and monitor well locations. Appendix J presents a series of concentration vs. depth graphs developed for these soil sample locations, and the comparison is summarized below:

Precipitation Plant Area

The Precipitation Plant Area includes the Precipitation Plant (Area 5), Copper Solution Tanks (Area 4) and the Leach Vats (Area 3). In the Precipitation Plant Area, data from PA-GW-18 indicate elevated concentrations of zinc and uranium in groundwater. PA-GW-18 is located

down-gradient of the deep sub-grade sump on the northwest end of the iron launders used to re-circulate process solutions. Elevated uranium and zinc soil values are evident on the box and whisker plots (Appendix H), which suggests the potential for locally impacted soils.

To evaluate where elevated soil concentrations occur locally within Area 5, the top 20 highest uranium and zinc detections were tabulated in Table 4-4 and ranked from highest to lowest. For comparative purposes, summary statistics for all of the soil samples within Area 5 are also listed in Table 4-4. Relative to an average uranium concentration of 2.5 mg/kg for all soil samples within Area 5 (see Table 4-4), elevated uranium concentrations are typically associated with shallow soils (e.g., 22 mg/kg in PA-EE6 at one foot bgs), but also occur at depth in samples from PA-EE19 (12.1 mg/kg at 30 feet bgs and 3.2 mg/kg at 25 feet bgs) and PA-EE20 (4.5 mg/kg at 25 feet bgs and 4.7 mg/kg at 30 feet bgs). These boreholes are located toward the northwest end of the iron launders near the sub-grade re-circulation sump.

Relative to an average zinc concentration of 24,958 ug/kg for all soils within in Area 5 (see Table 4-4), elevated zinc concentrations are typically associated with shallow soils (e.g., 270,000 ug/kg in PA-EE6 at one foot bgs), but also occur at depth in samples from PA-EE19 (43,000 ug/kg at 30 feet bgs and 28,000 ug/kg at 25 feet bgs) and PA-EE20 (23,000 ug/kg at 30 feet bgs and 22,000 ug/kg at 20 feet bgs). Table 4-4 also presents the 20 maximum detections in Areas 3 and 4 and the summary statistics for all soil samples in these two areas. As indicated in Table 4-4, uranium concentrations in all soil samples within Areas 3 and 4 average 1.5 and 1.7 mg/kg, respectively, which are lower than the average uranium soil concentrations in Area 5 (2.5 mg/kg).

Zinc concentrations in all soil samples within Area 3 average 18,583 ug/kg, which is a lower average value than the combined average zinc concentrations in soils samples from Areas 4 and 5 (approximately 24,000 ug/kg). This comparison suggests that the elevated uranium and zinc in groundwater at the PA-GW-18 location may be related to the infiltration of process solutions from the re-circulation sump at the northwest end of the iron launders rather than being sourced from the Vat Leach Tanks.

Northern Area

The northern area is identified by elevated metals primarily in the groundwater grab sample from PA-GW-23, and at somewhat lower concentrations in the grab samples from PA-GW-19, PA-GW-20, and PA-GW-21. Elevated metals in PA-GW-23 include beryllium, cadmium, cobalt, iron, magnesium, manganese, nickel and sulfate. PA-GW-23 is located near numerous pipes and ditches that historically conveyed leach and wash solutions (see Figure 4-1). Also, based on the current understanding of groundwater flow within the Process Areas, PA-GW-23 is considered to be located down-gradient of several historic processing facilities including the Leach Vats (P), Copper Solution Tanks (DD), Precipitation Plant (EE), Dump Leach Surge Pond (KK), and possibly the Sulfide Plant (HH).

Potential impacts to groundwater associated with historic processing activities can be evaluated by assessing the occurrence of sulfate, iron and copper. Sulfate concentrations in groundwater within the Process Areas are highest at PA-GW23, and are also elevated in PA-GW-19, PA-GW-20, and PA-GW-21. Iron is also elevated in PA-GW-23, but the distribution in groundwater, based on the grab samples results, is less extensive probably due to attenuation of this metal. Elevated iron/copper ratios, which indicate enrichment of iron relative to copper due to releases of iron-bearing launder solutions, are highest in the Northern Area (e.g., data from PA-GW-23, PA-GW-19, PA-GW-20, and PA-GW-21 in Table 4-5).

Southern Area

Mine-related groundwater in the Southern Area may be identified based on the chemical concentrations observed from PA-GW-4 (located in Area 1) and, to a lesser extent, in PA-GW-7 (located in Area 2). Based on the current understanding of groundwater flow in the Process Areas, PA-GW-4 is considered to be located hydraulically up-gradient of the Assay Laboratory (F) and PA-GW-7 is considered to be located hydraulically down-gradient of the Truck Shop (K). The groundwater sample from PA-GW4 contained elevated concentrations of 19 metals including aluminum, arsenic, barium, beryllium, calcium, cadmium, chromium, copper, iron,

lead, mercury, magnesium, manganese, nickel, potassium, selenium, silver, thallium and vanadium. The groundwater sample from PA-GW-7 contained elevated concentrations of six metals including silver, barium, copper, lead, thallium and vanadium.

Elevated concentrations of metals in PA-GW-4 and PA-GW-7 do not appear to be caused by impacted soils within Areas 1 and 2, or by locally impacted soils in borings near PA-GW-4 or PA-GW-7. Box plots (Appendix H), which represent the statistical distribution of chemicals in Process Areas soils, indicate that the concentrations of various metals in soils within Areas 1 and 2 are generally lower than the metals concentrations in the Process Areas in general. Additionally, the average metals concentrations in soil samples from borings located near PA-GW-4 (e.g., PA-A1, PA-D1, PA-D2, PA-E1 and PA-F4) are generally similar to the average metals concentrations in soils throughout Area 1 (Table 4-6), with the exception of copper. Elevated concentrations of copper at the soil sampling locations near PA-GW-4 typically occur in samples collected from one foot bgs (e.g., data from samples PA-A1-1, PA-D2-1, PA-E1-1 and PA-F1-1), and are likely associated with historic activities at the Primary Ore Crusher (CC).

Uranium												Zinc											
Area 3				Area 4				Area 5				Area 3				Area 4				Area 5			
Location	Sample Name	Type	Uranium mg/kg	Location	Sample Name	Type	Uranium mg/kg	Location	Sample Name	Type	Uranium mg/kg	Location	Sample Name	Type	Zinc ug/kg	Location	Sample Name	Type	Zinc ug/kg	Location	Sample Name	Type	Zinc ug/kg
PA-P13	PA-P13-10	N	4.3	PA-DD10	PA-DD10-1	N	11.0	PA-EE6	PA-EE6-1	N	22.0	PA-P1	PA-P1-15	N	37,000	PA-DD10	PA-DD10-1	N	90,000	PA-EE6	PA-EE6-1	N	270,000
PA-P15	PA-P15-15	N	4.1	PA-DD8	PA-DD8-1	N	8.2	PA-EE19	PA-EE19-30	N	12.1	PA-P1	PA-P1-15B	N	30,000	PA-DD4	PA-DD4-1	N	85,000	PA-EE9	PA-EE9-1	N	85,000
PA-P16	PA-P16-25	N	3.4	PA-FF3	PA-FF3-1	N	6.5	PA-EE9	PA-EE9-1	N	8.7	PA-P10	PA-P10-1	FD	28,000	PA-FF4	PA-FF4-1	N	64,000	PA-EE8	PA-EE8-1	N	52,000
PA-P10	PA-P10-1	FD	3.3	PA-FF3	PA-FF3-1B	FD	4.2	PA-EE14	PA-EE14-15	N	4.9	PA-P10	PA-P10-5	N	28,000	PA-DD13	PA-DD13-1B	FD	50,000	PA-EE1	PA-EE1-1	N	52000 J
PA-P10	PA-P10-5	N	3.2	PA-DD9	PA-DD9-1	N	3.1	PA-EE17	PA-EE17-1	N	4.8 J	PA-P10	PA-P10-10	N	28,000	PA-FF3	PA-FF3-10	N	45,000	PA-EE1	PA-DUP-A4	FD	52000 J
PA-P10	PA-P10-10	N	2.3	PA-DD5	PA-DD5-1	N	2.5	PA-EE20	PA-EE20-30	N	4.7	PA-P10	PA-P10-15	N	28,000	PA-DD8	PA-DD8-1	N	44,000	PA-EE16	PA-EE16-1	N	51,000
PA-P12	PA-P12-15	N	2.2	PA-DD11	PA-DD11-1	N	2.3	PA-EE18	PA-EE18-5	N	4.7	PA-P10	PA-P10-20	N	27,000	PA-FF3	PA-FF3-1	N	44,000	PA-EE18	PA-EE18-1	N	48,000
PA-P19	PA-P19-20	N	2.2	PA-FF1	PA-FF1-10	N	1.8	PA-EE20	PA-EE20-25	N	4.5	PA-P12	PA-P12-5	N	27,000	PA-DD11	PA-DD11-1	N	43,000	PA-EE2	PA-EE2-1	N	45000 J
PA-P13	PA-P13-5B	N	2.1	PA-DD4	PA-DD4-1	N	1.7	PA-EE1	PA-EE1-1	N	4.4	PA-P12	PA-P12-10	N	25,000	PA-FF3	PA-FF3-1B	FD	43,000	PA-EE19	PA-EE19-30	N	43,000
PA-P13	PA-P13-15	N	2.1	PA-FF2	PA-FF2-1	N	1.7	PA-EE1	PA-DUP-A4	FD	4.1	PA-P12	PA-P12-15	N	23,000	PA-DD5	PA-DD5-1	N	40,000	PA-EE13	PA-EE13-1B	FD	15,000
PA-P17	PA-P17-5	N	2.1	PA-DD12	PA-DD12-15	N	1.7	PA-EE8	PA-EE8-1	N	3.8	PA-P12	PA-P12-20	N	23,000	PA-FF4	PA-FF4-5	N	38,000	PA-EE17	PA-EE17-1	N	33,000
PA-P10	PA-P10-20	N	2.0	PA-DD6	PA-DD6-1	N	1.6	PA-EE17	PA-EE17-25	N	3.8	PA-P12	PA-P12-25	N	23,000	PA-DD13	PA-DD13-1	N	36,000	PA-EE7	PA-EE7-1	N	31,000
PA-P13	PA-P13-20	N	2.0	PA-DD2	PA-DD2-10	N	1.6	PA-EE7	PA-EE7-1	N	3.3	PA-P13	PA-P13-5B	N	22,000	PA-FF2	PA-FF2-1	N	34,000	PA-EE16	PA-EE16-25	N	29,000
PA-P18	PA-P18-5	N	2.0	PA-DD13	PA-DD13-20	N	1.6	PA-EE19	PA-EE19-25	N	3.2	PA-P13	PA-P13-5	N	22,000	PA-DD6	PA-DD6-1	N	29,000	PA-EE19	PA-EE19-25	N	28,000
PA-P10	PA-P10-15	N	1.9	PA-FF2	PA-FF2-20	N	1.5	PA-EE20	PA-EE20-20	N	3.1	PA-P13	PA-P13-10	N	21,000	PA-DD9	PA-DD9-1	N	25,000	PA-EE15	PA-EE15-20	N	26,000
PA-P13	PA-P13-25	N	1.9	PA-DD3	PA-DD3-10	N	1.5	PA-EE15	PA-EE15-20	N	2.2	PA-P13	PA-P13-15	N	21,000	PA-FF4	PA-FF4-20	N	25,000	PA-EE11	PA-EE11-1	N	26,000
PA-P13	PA-P13-5	N	1.7	PA-DD12	PA-DD12-20	N	1.4	PA-EE14	PA-EE14-20	N	2.0	PA-P13	PA-P13-20	N	21,000	PA-DD7	PA-DD7-1	N	24,000	PA-EE16	PA-EE16-20	N	26,000
PA-P12	PA-P12-5	N	1.6	PA-DD2	PA-DD2-1B	FD	1.4	PA-EE16	PA-EE16-25	N	2.0	PA-P13	PA-P13-25	N	20,000	PA-DD14	PA-DD14-5	N	23,000	PA-EE20	PA-EE20-30	N	23,000
PA-P14	PA-P14-10	N	1.6	PA-DD1	PA-DD1-10	N	1.4	PA-EE10	PA-EE10-1	N	2.0	PA-P14	PA-P14-5	N	20,000	PA-FF2	PA-FF2-20	N	20,000	PA-EE20	PA-EE20-20	N	22,000
PA-P15	PA-P15-20	N	1.6	PA-FF3	PA-FF3-10	N	1.3	PA-EE2	PA-EE2-1	N	1.9	PA-P14	PA-P14-10	N	19,000	PA-DD2	PA-DD2-10	N	17,000	PA-EE10	PA-EE10-1	N	20,000
Uranium Statistics for All Area 3 Soils (mg/kg)				Uranium Statistics for All Area 4 Soils (mg/kg)				Uranium Statistics for All Area 5 Soils (mg/kg)				Zinc Statistics for All Area 3 Soils (ug/kg)				Zinc Statistics for All Area 4 Soils (ug/kg)				Zinc Statistics for All Area 5 Soils (ug/kg)			
Minimum			1.1				1.1				<0.5				9,300				11,000				8,200
Average ⁽¹⁾			1.5				1.7				2.5				18,583				24,846				24,958
Maximum			4.3				11				22				37,000				90,000				270,000

Notes:
N - Normal sample.
FD - Field duplicate.
J - Estimated result.
R - Rejected result. Laboratory reported result was rejected and not used for any purpose.
⁽¹⁾ Mathematical average. Non-detected results are averaged as one half the value of the minimum detection limit.

Table 4-5. Key Constituents in North Area Groundwater						
Name	Iron (mg/L)	Flag	Copper (mg/L)	Fe/Cu	Sulfate (mg/L)	Flag
PA-MW3	0.015	UJ	0.0014	11	320	
PA-MW2	0.54		0.0012	450	510	
PA-MW1	0.004	UJ	0.001	4	660	
PA-GW9	0.012	J	0.0013	9	390	
PA-GW8	83		0.71	117	130	
PA-GW7	82		1.3	63	330	
PA-GW6	0.0085	J	0.0023	4	440	
PA-GW5	0.043	J	0.0031	14	220	
PA-GW4	1100		0.92	1,196	6.9	
PA-GW27	0.12		0.0028	43	670	
PA-GW26	0.019	J	0.0049	4	450	
PA-GW25	0.14		0.0072	19	1300	
PA-GW24	37		0.0063	5,873	3500	
PA-GW23	1400		0.03	46,667	5300	
PA-GW22	0.89		0.0047	189	780	
PA-GW21	41		0.38	108	1900	
PA-GW20	4		0.043	93	4100	J
PA-GW19	22		0.0032	6,875	2800	
PA-GW18	70		0.023	3,043	3300	
PA-GW17	0.015	J	0.041	0	390	
PA-GW16	6.2		0.0068	912	800	
PA-GW15	0.11	J	0.0025	44	400	
PA-GW14	0.0044	UJ	0.0036	1	100	
PA-GW13	0.014	J	0.0041	3	330	
PA-GW12	0.003	U	0.0088	0	590	J
PA-GW11	0.0088	J	0.0059	1	320	
PA-GW10	0.22		0.008	28	530	

Similarly, the average metals concentrations in soil samples from boreholes near PA-GW-7 (e.g., PA-K1, PA-L2 and PA-L3) are generally similar to the average metals concentrations in soils throughout Area 2 (Table 4-7). Because metal concentrations in soils throughout both Areas 1 and 2, and locally in soils near PA-GW-4 and PA-GW-7, are not elevated with respect to other areas within OU-3, the elevated groundwater concentrations in PA-GW-4 and PA-GW-7 do not appear to be associated with the Assay Laboratory (F) and the Truck Shop (K). Elevated metals in groundwater beneath the Southern Area may have resulted from historic ore processing activities located to the south (i.e., hydraulically up-gradient) of the Process Areas.

Table 4-6. Comparison of Select Metals in Soil Borings Near Groundwater Grab Sample PA-GW4																						
Summary Statistics for Metals in Soil Samples from Select Borings Near Groundwater Grab Sample PA-GW4																						
Location	Sample Name	Sample Type	Aluminum	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium, Total	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Selenium	Silver	Thallium	Vanadium
			mg/kg	ug/kg	ug/kg	ug/kg	ug/kg	mg/kg	ug/kg	ug/kg	mg/kg	ug/kg	mg/kg	ug/kg	mg/kg	ug/kg	mg/kg	ug/kg	ug/kg	ug/kg	ug/kg	
PA-A1	PA-A1-1	N	4,800	6,300	63,000	240	430	5,300	5,600	830,000	10,000	9,000	3,200	170,000	0.15	6,300	1,200	1,100	1100 J	170 J	280 J	19,000
PA-A1	PA-A1-5	N	3,700	4,100	72,000	260	400	6,500	4,700	83,000	9,700	3,300	3,300	220,000	0.015	6,300	850	< 330	< 330	72 J	88 J	20,000
PA-A1	PA-A1-10	N	4,500	5,300	76,000	240	350	4,900	14,000	100,000	9,000	3,200	2,800	320,000	< 0.00014	5,700	1,000	< 330	< 330	68 J	79 J	21,000
PA-D1	PA-D1-1	N	5,700	3,700	67,000	280	400	8,000	4,800	91,000	9,600	4,100	3,300	200,000	0.0099 J	5,900	1,200	< 370	< 370	82 J	70 J	16,000
PA-D1	PA-D1-5	N	8,300	3,800	61,000	310	440	6,400	5,000	69,000	13,000	4,000	4,500	220,000	0.0097 J	6,200	1,600	< 340	< 340	71 J	84 J	16,000
PA-D1	PA-D1-10	N	3,800	5,900	54,000	240	400	3,900	3,000	48,000	6,000	3,100	2,200	170,000	0.00026 J	4,300	930	< 330	< 330	67 J	61 J	15,000
PA-D2	PA-D2-1	N	4,800	2,900	37,000	230	260	6100 J	3,200	200000 J	8,100	2,400	2,700	120,000	0.012 J	4,200	890	< 330	< 330	< 47	40 J	14,000
PA-D2	PA-D2-5	N	4,900	3,800	54,000	250	380	8,000	4,400	57,000	7,500	3,000	2,600	170,000	0.0052 J	5,000	970	< 330	< 330	< 54	60 J	17,000
PA-D2	PA-D2-10	N	6,400	5,200	71,000	330	480	9,200	4,200	91,000	9,200	3,600	3,000	180,000	0.015	5,800	910	< 340	< 340	< 71	95 J	16,000
PA-E1	PA-E1-1	N	4,700	8,200	130000 J	610	970	6,100	12,000	380,000	7,700	9,700	2,600	440,000	0.023	14,000	1,400	< 350	< 350	84 J	230 J	39000 J
PA-E1	PA-E1-5	N	5,700	2,400	35,000	160	310	5,900	2,600	43,000	5,100	2,500	2,200	130,000	0.0057 J	3,800	1,100	< 330	< 330	< 38	44 J	11,000
PA-E1	PA-E1-10	N	5,000	2,100	43,000	230	380	2,800	3,500	66,000	8,500	2,900	2,800	170,000	0.0033 J	5,600	930	< 340	< 340	< 56	68 J	12,000
PA-F1	PA-F1-1	N	4,100	1,400	29,000	170	280	3,100	3,300	57,000	7,700	2,400	3,000	110,000	< 0.00014	4,100	1,100	< 330	< 330	< 50	42 J	12,000
PA-F1	PA-F1-5	N	6,000	4,100	67,000	300	490	3,700	5,000	78,000	8,800	3,900	3,000	210,000	0.0073 J	7,900	1,400	< 340	< 340	< 59	79 J	19,000
PA-F1	PA-F1-10	N	7,400	4,000	88,000	320	440	8,500	6,100	140,000	11,000	3,400	4,900	200,000	0.0021 J	8,400	1,600	< 340	< 340	< 67	98 J	18,000
PA-F4	PA-F4-1	N	6,200	4,700	56,000	250	320	4,600	3,900	130,000	10,000	4,000	3,000	190,000	0.02	4,700	1,100	< 330	< 330	59 J	97 J	18,000
PA-F4	PA-F4-5	N	6,200	2,600	47,000	210	210	6,700	5,100	48,000	11,000	2,300	3,800	150,000	< 0.00014	6,400	1,500	420	420 J	32 J	61 J	14,000
PA-F4	PA-F4-10	N	8,000	4,100	50,000	300	400	6,900	5,100	150,000	15,000	4,200	3,900	200,000	< 0.00014	5,800	1,200	< 340	< 340	110 J	74 J	22,000
Minimum			3,700	1,400	29,000	160	210	2,800	2,600	43,000	5,100	2,300	2,200	110,000	< 0.00014	3,800	770	420	< 330	32	40	11,000
Average ⁽¹⁾			5,533	4,076	56,600	270	403	5,753	5,271	170,053	9,329	4,019	3,105	192,857	0.023	6,019	1,140	--	--	--	94	16,500
Maximum			8,300	8,200	88,000	610	970	9,200	14,000	830,000	15,000	9,700	4,900	440,000	0.180	14,000	1,600	1,100	1,100	170 J	280	22,000
Summary Statistics for All Soil Data in Area 1																						
Minimum			3,300	1,400	29,000	160	210	2,400	2,600	36,000	5,100	2,200	1,900	95,000	< 0.00014	3,500	730	< 160	< 160	< 32	< 29	10,000
Average ⁽¹⁾			6,242	3,454	57,330	284	419	6,622	4,744	130,088	9,992	4,302	3,405	190,165	0.02	5,431	1,437	305	305	91	91	15,143
Maximum			11,000	8,200	130,000	610	970	29,000	16,000	1,200,000	16,000	35,000	6,300	440,000	0.35	14,000	2,900	2,700	2,700	2,000	400	39,000
Total Analyzed (incl. dup)			91	91	91	91	91	91	91	91	91	91	91	91	91	91	91	91	91	91	91	91
Total Non-Duplicate			78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78
Number Detected			91	91	91	91	91	91	91	91	91	91	91	91	67	91	91	47	47	76	88	91
Freq. of Detection			100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	74%	100%	100%	52%	52%	84%	97%	100%
Number Estimated			0	0	5	0	0	2	0	4	0	2	0	2	47	0	3	45	45	67	85	1
Frequency Estimated			0%	0%	5%	0%	0%	2%	0%	4%	0%	2%	0%	2%	52%	0%	3%	49%	49%	74%	93%	1%
Number Rejected			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Frequency Rejected			0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Screening PRG ⁽²⁾			920,000	260,000	67,000,000	1,900,000	450,000	NA	2,500,000	41,000,000	310,000	NA	NA	19,000,000	310	20,000,000	NA	5,100,000	5,100,000	5,100,000	67,000	1,000,000
Number >PRG			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Frequency >PRG			0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Notes:

NA - Not applicable, no screening level established N - Normal sample. FD - Field duplicate. J - Estimated result. R - Rejected result. Laboratory reported result was rejected and not used for any purpose.

⁽²⁾ Screening PRG based on EPA Region IX Industrial Worker Preliminary Remediation Goal

Table 4-7 Metals Concentrations in Select Borings Near Groundwater Grab Sample PA-GW7																						
Summary Statistics for Metals Concentrations in Select Borings Near PA-GW7																						
Location	Sample Name	Sample Type	Aluminum	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium, Total	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Vanadium
PA-K1	PA-K1-1	N	4100	2700	48000	210	300	7500 J	3100	47000	6600	2500	2400	130000	0.0077 J	4200	1200	< 340	58 J	340	55 J	11000
PA-K1	PA-K1-5	N	5700	5000	39000	250	330	7900	3300	58000	8800	2800	3600	140000	0.0033 J	4500	1100	< 330	52 J	160	< 52	13000
PA-K1	PA-K1-10	N	5300	3200	45000	240	330	5900	3000	50000	8000	2600	2800	140000	< 0.00014	4200	960	< 330	48 J	170	< 46	12000
PA-L2	PA-L2-1	N	6800	2900	45000	250	250	6200	3800	120000	10000	4100	3400	160000	0.025	4200	1600	< 240	< 37	240	86 J	12000
PA-L2	PA-L2-5	N	8100	2200	53000	310	380	5000	4400	52000	12000	3700	4100	240000	< 0.0019	4800	1900	< 200	47 J	200	77 J	14000
PA-L2	PA-L2-10	N	7100	2200	51000	270	310	7100	3500	53000	11000	3400	3700	190000	0.0035 J	4200	1600	< 170	< 21	180	63 J	13000
PA-L3	PA-L3-1	N	7100	2600	54000	300	290	6900	4100	68000	10000	3200	3500	170000	< 0.00014	4900	1400	< 170	< 27	280	67 J	13000
PA-L3	PA-L3-5	N	7600	3200	74000	240	210	15000	3300	580000	11000	2600	4000	120000	0.0033 J	4400	2000	1100	< 27	230	50 J	17000
PA-L3	PA-L3-10	N	6700	3400	44000	270	260	16000	3600	59000	10000	2900	3600	140000	< 0.0006	4500	1300	< 190	< 16	390	55 J	14000
Minimum			4100	1700	39000	210	210	5000	3000	47000	6600	2500	2400	120000	< 0.00014	4200	960	< 170	< 21	160	50	11000
Average ⁽¹⁾			6500	3044	50333	260	296	8750	3567	120778	9711	3089	3456	158889	--	4433	1451	--	--	243	65	13222
Maximum			8100	5000	74000	310	380	16000	4400	580000	12000	4100	4100	240000	0.025	5000	2000	1100	58 J	390	86	17000
Summary Statistics for All Soil Data in Area 2																						
Minimum			2,100	1,400	15,000	120	<130	2,800	1,600	29,000	3,300	1,200	1,500	72,000	<0.00014	2,500	460	<160	<16	80	<2.1	6,000
Average ⁽¹⁾			5,964	3,840	52,579	261	353	6,714	4,760	204,310	9,502	23,648	3,250	163,222	0.12	4,990	1,268	1,283	95	244	115	13,746
Maximum			11,000	16,000	160,000	500	1,200	25,000	50,000	3,500,000	17,000	1,300,000	6,700	320,000	7.7	12,000	2,900	82,000	4,200	1,100	1,800	20,000
Total Analyzed (incl. dup)			126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126
Number Detected			126	126	126	126	121	126	126	126	126	126	126	126	94	126	126	38	76	126	100	126
Freq. of Detection			100%	100%	100%	100%	96%	100%	100%	100%	100%	100%	100%	100%	75%	100%	100%	30%	60%	100%	79%	100%
Number Estimated			2	0	2	0	0	4	6	6	2	4	2	6	56	2	5	34	63	3	95	0
Frequency Estimated			2%	0%	2%	0%	0%	3%	5%	5%	2%	3%	2%	5%	44%	2%	4%	27%	50%	2%	75%	0%
Number Rejected			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Frequency Rejected			0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Screening PRG ⁽²⁾			920,000	260,000	67,000,000	1,900,000	450,000	NA	2,500,000	41,000,000	310,000	NA	NA	19,000,000	310	20,000,000	NA	5,100,000	5,100,000	NA	67,000	1,000,000
Number >PRG			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Frequency >PRG			0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Notes:

NA - Not applicable, no screening level established.

N - Normal sample.

FD - Field duplicate.

J - Estimated result.

R - Rejected result. Laboratory reported result was rejected and not used for any purpose.

⁽¹⁾ Mathematical average. Non-detected results are averaged as one half the value of the minimum detection limit.

⁽²⁾ Screening PRG based on EPA Region IX Industrial Worker Preliminary Remediation Goal

4.4 Radiochemical Results

Groundwater samples from the Site characterization program were analyzed for the radiochemicals listed in Table 4-8, which provides a statistically summary of these data. The number of samples analyzed, quantity of detections, minimum/maximum, mean, median, standard deviation, and the coefficient of variation are provided in Table 4-8. Non-detect results were included in the statistics by assuming the metal was present at half the MDL.

Analyte	Units	Count	Quantity/% Detections		Quantity/% Trace Detections		Min.	Mean	Median	Max.	Std. Dev.	Coeff. of Var.
Thorium-232	mg/L	27	4	15%	0	0%	0.0005	0.00	0.0005	0.025	0.00	2.67
Uranium	mg/L	27	27	100%	0	0%	0.0012	0.10	0.0416	0.81	0.16	1.70
Radium-226	pCi/L	27	11	41%	0	0%	0.1	0.44	0.1	3.8	0.79	1.78
Radium-228	pCi/L	27	5	19%	0	0%	0.5	1.17	0.5	6.2	1.77	1.50

The distribution of each radiochemical in Process Areas groundwater is discussed below. The contour plots in Appendix I provide the basis for the conclusion that, in general, no correlation exists between uranium, thorium and radium-226/228 within individual samples.

- **Radium-226:** detected in 11 (i.e., 41 percent) of 27 samples. Activities ranged from <0.2 to 3.8 pCi/L with a median of 0.1 pCi/L. The MCL for radium-226 is 5 pCi/L; therefore, the frequency for the exceedance of the MCL is 0 percent. Radium-226 appears to be evenly distributed at low activities throughout the Process Areas with elevated activities at PA-GW-24 (3.8 pCi/L) and PA-GW17 (2 pCi/L).
- **Radium-228:** detected in 5 (i.e., 19 percent) of 27 samples. Activities ranged from <1 to 6.2 pCi/L with a median of 0.5 pCi/L. The MCL for radium-228 is 5 pCi/L; therefore there is an 11 percent frequency of exceedance of the MCL. Radium-228 appears to be evenly distributed at low activities throughout the Process Areas with two areas of somewhat elevated activities: the first is in PA-GW-4 (6.1 pCi/L) and the second in PA-GW-10 (5.8 pCi/L) and PA-GW-11 (6.2 pCi/L).
- **Thorium:** detected in 4 (i.e., 15 percent) of the 27 samples. Activities ranged from <0.001 to 0.025 mg/L with a median of 0.005 mg/L. An MCL has not been established for thorium. Elevated thorium concentrations were detected in PA-GW-4 (0.025 mg/L) and PA-GW-24 (0.008 mg/L).

- **Uranium:** detected in all 27 samples above the PQL. Concentrations range from 0.0012 to 0.0416 mg/L with a median of 0.0416 mg/L. The MCL for uranium is 0.03 mg/L; therefore, the frequency for the exceedance of the MCL is 56 percent. Elevated concentrations of uranium were detected at PA-GW-18 (0.81 mg/L), PA-GW-20 (0.282 mg/L), PA-GW-19 (0.242 mg/L) and PA-GW-21 (0.210 mg/L). Lower, but also slightly elevated, concentrations of uranium were detected at PA-GW-5 (0.0584 mg/L), PA-GW-7 (0.0726 mg/L) and PA-GW-13 (0.949 mg/L).

Table 4-9 presents the radiochemical data relative to their respective MCLs. As stated previously for metals, data from existing (Table 4-3) and future background wells at the Site will be used to evaluate radiochemical concentrations in mine-related groundwater.

Analyte	Units	Min.	Max.	MCL	Number >MCL	Freq. Exceed MCL
Radium-226	pCi/L	< 0.2	3.8	5	0	0%
Radium-228	pCi/L	< 1	6.2	5	3	11%
Thorium	mg/L	< 0.001	0.025	NA	NA	NA
Uranium	mg/L	0.0003	0.81	0.03	15	56%

4.5 Petroleum Hydrocarbon Results

Ancillary support activities during mining and processing operations in the Process Areas included vehicle fueling and maintenance. Figures 1-3 and 4-1 shows the location of the Truck Shop where these activities were conducted, along with the locations of the piping associated with the building floor drains and filling stations. To evaluate potential impacts associated with these facilities and historic activities, groundwater grab samples were analyzed for TPHs. TPH analyses included TPH as gasoline range organics (TPH-g), TPH as diesel range organics (TPH-d), and TPH as motor oil (TPH-mo). TPH-g was analyzed to include a carbon range of C4-C12, TPH-d in the range of C12-C23, and TPH-mo in the range of C23-C40. Summary statistics for the TPH analyses are presented in Table 4-10.

Analyte	Units	Count	Quantity/ % Detections		Quantity/ % Trace Detections		Min.	Mean	Median	Max.	Std. Dev.	Coeff. of Var.
TPH-d	µg/L	27	26	96%	1	4%	10.5	1997.685	1700	11000	2758	1.38
TPH-g	µg/L	27	12	44%	0	0%	25	146.2963	25	1100	254	1.74
TPH-mo	µg/L	27	16	59%	10	63%	46	2604.963	410	29000	5976	2.29

The distribution of each petroleum hydrocarbon range in Process Areas groundwater is discussed below. Contour plots for TPH compounds are provided in Appendix I-2.

- **TPH-g:** detected in 12 (i.e., 44 percent) of 27 samples. Concentrations ranged from 25 to 1,100 µg/L with a median of 1,700 mg/L. Elevated TPH-g concentrations were detected in PA-GW-10 (1,100 µg/L) and extend to PA-GW-26 (590 µg/L). In addition, PA-GW-23 has an elevated concentration of 280 µg/L.
- **TPH-d:** detected in 26 (i.e., 96 percent) of 27 samples. Concentrations ranged from 10.5 to 11,000 µg/L with a median of 1,700 µg/L. Elevated TPH-d concentrations were detected at PA-GW-22 (11,000 µg/L) and PA-GW10 (9,400 µg/L). TPH-d was also detected at PA-GW-14 and PA-GW-15 at somewhat lower concentrations ranging from 4,400 to 4,500 µg/L.
- **TPH-mo:** detected in 16 (i.e., 59 percent); however, 63% of those were trace detections. Concentrations ranged from 46 to 29,000 µg/L with a median of 410 µg/L. Elevated TPH-mo was detected at PA-GW-14 (29,000 µg/L), PA-GW-21 (13,000 µg/L), and PA-GW-12 (7,300 µg/L).

4.6 Other Organic Chemical Results

In addition to metals, petroleum hydrocarbons and radiochemicals, groundwater samples from were analyzed for VOCs, SVOC, pesticides, herbicides, and PCBs. Contour plots for a select number of these organic compounds are provided in Appendix I.

4.6.1 VOCs

Groundwater samples were analyzed for a total of 55 VOCs. Summary statistics are calculated in Table 4-11 only for VOCs detected in any sample more than once. With the exception of benzene, chloroform, tetrachloroethylene, toluene, and trichloroethene, VOCs were either not

detected or only infrequently detected (i.e., less than 25 percent of the grab sample locations) in the borehole grab samples (when detected, the VOCs were present at concentrations that were at, or generally near, the detection limit, and had no distinct spatial distribution).

Table 4-11. Summary Statistics for VOCs

Analyte	Units	Count	Quantity/ %		Quantity/ %		Min.	Mean	Median	Max.	Std. Dev.	Coeff. of Var.
			Detections	Detections	Trace Detections	Trace Detections						
1,1,2-Trichloroethane	µg/L	27	2	7%	2	100%	0.027	0.116	0.027	1.9	0.36	3.11
1,1-Dichloroethene	µg/L	27	5	19%	5	100%	0.065	0.182	0.065	0.65	0.19	1.03
1,2,3-Trichlorobenzene	µg/L	27	1	4%	1	100%	0.06	0.140	0.06	1.2	0.24	1.73
1,2,4-Trimethylbenzene	µg/L	27	5	19%	2	40%	0.055	3.481	0.055	64	12.69	3.65
1,2-Dibromoethane (Ethylene Dibromide)	µg/L	27	1	4%	1	100%	0.095	0.200	0.095	0.95	0.25	1.24
1,2-Dichloroethane	µg/L	27	6	22%	2	33%	0.0465	3.657	0.0465	77	14.94	4.09
1,2-Dichloropropane	µg/L	27	1	4%	1	100%	0.03	0.081	0.03	0.9	0.17	2.15
1,3,5-Trimethylbenzene (Mesitylene)	µg/L	27	4	15%	1	25%	0.044	0.989	0.044	19	3.69	3.73
Benzene	µg/L	27	15	56%	10	67%	0.032	39.194	0.13	660	133.15	3.40
Carbon Tetrachloride	µg/L	27	3	11%	3	100%	0.0345	0.096	0.0345	0.8	0.16	1.70
Chloroethane	µg/L	21	1	5%	1	100%	0.11	0.231	0.11	1.1	0.31	1.32
Chloroform	µg/L	27	7	26%	5	71%	0.06	0.260	0.06	1.8	0.42	1.61
Ethylbenzene	µg/L	27	4	15%	2	50%	0.0435	1.602	0.0435	40	7.68	4.79
Isopropylbenzene (Cumene)	µg/L	27	3	11%	1	33%	0.032	0.335	0.032	5.3	1.06	3.15
Methylene Chloride	µg/L	27	4	15%	3	75%	0.028	0.187	0.028	1.6	0.38	2.05
Naphthalene	µg/L	27	4	15%	2	50%	0.04	4.398	0.04	38	10.98	2.50
N-Propylbenzene	µg/L	27	1	4%	0	0%	0.0485	0.421	0.0485	8.6	1.64	3.91
P-Cymene (P-Isopropyltoluene)	µg/L	27	1	4%	1	100%	0.0395	0.168	0.0395	2.5	0.47	2.83
Styrene	µg/L	27	4	15%	3	75%	0.055	0.321	0.055	4.4	0.88	2.73
Tetrachloroethylene (PCE)	µg/L	27	11	41%	6	55%	0.06	0.460	0.13	3.7	0.84	1.83
Toluene	µg/L	27	21	78%	12	57%	0.033	18.444	0.26	280	57.56	3.12
Trichloroethylene (TCE)	µg/L	27	7	26%	3	43%	0.06	0.309	0.06	1.5	0.43	1.38
Xylenes, total	µg/L	27	4	15%	0	0%	0.18	20.931	0.18	380	76.40	3.65

Of the five VOCs detected in more than 25 percent of the borehole groundwater grab samples (i.e., benzene, chloroform, tetrachloroethylene, toluene, and trichloroethene), concentrations of these constituents were below their respective MCLs except for benzene. Appendix I-3 includes contour plots of the five frequently detected VOCs. The higher benzene concentrations occurred in PA-GW-10 (at 660 mg/L) and in PA-GW-26 (at 200 mg/L), which are located near the two former filling stations, #2 and #3 (see Figures 1-3 and 4-1). PA-GW-26 appears to be located

down-gradient of PA-GW-10 based on the current understanding of groundwater flow within the Process Areas. Analytical results also indicate that VOCs and TPH are present at low concentrations in groundwater beneath the former Sulfide Plant (HH).

4.6.2 SVOCs

A total of 65 SVOCs were analyzed for groundwater concentrations. Summary statistics are presented in Table 4-12 only for SVOCs detected in any sample more than once. SVOCs detected in more than four percent of the samples include were: bis(2-ethylhexyl)phthalate, di-n-butylphthalate, naphthalene, and phenol. Most SVOC detections were trace detections and none exceeded their respective MCL.

Analyte	Units	Count	Quantity/ % Detections		Quantity/ % Trace Detections		Min.	Mean	Median	Max.	Std. Dev.	Coeff of Var.
2-Methylphenol (O-Cresol)	µg/L	27	1	4%	1	100%	0.5	0.70	0.55	2.6	0.45	0.64
4-Methylphenol (P-Cresol)	µg/L	27	1	4%	1	100%	0.9	1.52	0.95	12	2.21	1.45
Benzyl Alcohol	µg/L	27	1	4%	1	100%	0.85	1.25	0.9	5.5	1.10	0.88
BIS(2-Ethylhexyl) Phthalate	µg/L	27	10	37%	6	60%	1.2	10.89	1.4	170	33.06	3.04
DI-N-Butyl Phthalate	µg/L	27	4	15%	4	100%	0.9	1.64	0.95	7.2	1.52	0.93
Naphthalene	µg/L	27	4	15%	0	0%	1.7	7.00	1.8	56	12.90	1.84
Phenol	µg/L	27	3	11%	2	67%	0.95	2.52	1	33	6.17	2.44

4.6.3 Pesticides

A total of 22 pesticides were analyzed for concentration in groundwater. Summary statistics are presented in Table 4-13 only for pesticides detected in any sample more than once. Pesticides detected in more than four percent of the samples include: alpha BHC, beta BHC, delta BHC, gamma BHC, and heptachlorepoide. However, most detections were only trace detections. Of these frequently detected pesticides, none exceeded their respective MCL.

4.6.4 Herbicides

A total of ten herbicides were tested for in groundwater. Summary statistics are presented in Table 4-14 only for herbicides detected in any sample more than once. The only detected herbicide in groundwater was dalapon, at a concentration of 6.1 µg/L, which did not exceed the MCL of 200 µg/L.

Analyte	Units	Count	Quantity/ %		Quantity/ %		Min.	Mean	Median	Max.	Std. Dev.	Coeff. of Var.
			Detections	Detections	Trace	Detects						
Aldrin	µg/L	26	1	4%	1	100%	0.0045	0.63	0.0165	7.5	1.68	2.66
Alpha BHC (Alpha Hexachlorocyclohexane)	µg/L	26	2	8%	2	100%	0.00375	0.51	0.0143	6	1.34	2.62
Beta BHC (Beta Hexachlorocyclohexane)	µg/L	26	2	8%	0	0%	0.0047	0.67	0.025	7.5	1.67	2.50
Delta BHC (Delta Hexachlorocyclohexane)	µg/L	27	5	19%	1	20%	0.006	0.80	0.05	9.5	2.09	2.61
Gamma BHC (Lindane)	µg/L	26	2	8%	0	0%	0.00425	0.58	0.017	6.5	1.46	2.50
Heptachlor	µg/L	26	1	4%	0	0%	0.0047	0.64	0.0065	7.5	1.67	2.63
Heptachlor Epoxide	µg/L	26	2	8%	1	50%	0.006	1.01	0.0195	12	2.69	2.67
P,P'-DDT	µg/L	26	1	4%	1	100%	0.0105	7.92	0.05	95	21.44	2.71

Analyte	Units	Count	Quantity/ %		Quantity/ %		Min.	Mean	Median	Max.	Std. Dev.	Coeff. of Var.
			Detections	Detections	Trace	Detects						
Dalapon	µg/L	26	1	4%	0	0%	0.16	0.71	0.46	6.1	1.27	1.79

4.6.5 PCBs

A total of eight PCBs were analyzed for concentrations in groundwater. PCBs were not detected above the PQL in any of the groundwater samples.

SECTION 5.0

DATA QUALITY OBJECTIVES

The DQOs described in this Process Areas RI Work Plan have been developed to ensure that reliable data are acquired for decision making by the project management team described in Section 1.3. A systematic seven-step planning approach outlined in the EPA quality assurance document *Guidance on Systematic Planning Using the Data Quality Objective Process* (EPA, 2006) is used to establish performance or acceptance criteria, which serve as the basis for designing a plan for collecting data of sufficient quality and quantity. The DQO process consists of the following seven iterative steps:

- Step 1: State the Problem
- Step 2: Identify Study Goals
- Step 3: Identify Information Inputs
- Step 4: Define the Boundaries of the Study
- Step 5: Develop an Analytical Approach
- Step 6: Specify Performance or Acceptance Criteria
- Step 7: Develop the Plan for Obtaining the Data.

5.1 Problem Statement

The planning steps for each of the DQOs are described below, and summarized in Table 4-1. The following general problem statement provides the framework for all DQOs:

- The Process Areas of the Yerington Mine Site consisted of buildings, processing equipment (e.g., precipitation plant, leach tanks, crushers), pipelines, ditches and ponds for transporting, or temporary storage of, process solutions, and other general ancillary support activities such as truck maintenance or laboratory services. Activities that occurred in this area involved the use of raw ore, chemicals, and process solutions with high chemical concentrations. Also, vehicle maintenance required the use and storage of hydrocarbon fuels and greases. Any of these activities may have resulted in the release of

chemicals (e.g. metals, radiochemicals, or organic compounds) to soils in the Process Areas. Chemicals released to the soils may have migrated to groundwater underlying the Process Area.

- Previous investigations provided a substantial framework for the occurrence and distribution of potential mine-related chemicals, and identified areas with elevated concentrations of metals, radiochemicals, and hydrocarbons in Process Areas soils at the surface and in the subsurface. The three-dimensional extent of these areas that exceed preliminary screening criteria has not yet been completely determined. Not all source and release mechanisms of chemicals to soils in the Process Areas have been defined.
- The fate and potential transport pathways of mine-related chemicals in soils have not been fully evaluated. Although mine-related chemicals sourced from process components at, or very near, the surface of the Process Areas may have reached groundwater during past operations, there is insufficient information to determine if there is a potential for current or future transport of mine-related chemicals through the vadose zone to impact groundwater in the alluvial aquifer at a depth of approximately 100 feet bgs.
- Buildings or process equipment may have chemical or physical hazards associated with them which have not been fully evaluated. Some process equipment, such as the large leaching, solution and precipitation tanks, may have leaked solutions into the underlying soils and are now a physical impediment to characterizing the soils underneath. Full characterization of the soils may require the demolition and removal of some of the Site structures. These structures may contain contaminants or construction materials, such as asbestos, that will require special demolition and disposal procedures. The physical and chemical hazards associated with Process Areas structures have not been evaluated.
- The potential exposure to and risks from chemicals to human health and the environment have not been evaluated.

5.2 Study Boundary

In order to focus the investigation on the key items of interest, it is necessary to define the target population of interest that is needed for the decision-making process related to a specific study goal. The target populations included in this Process Areas RI Work Plan consist primarily of sample media, such as soil and groundwater, which are identified in Table 5-1 for each listed DQO. The study boundary is defined in terms of the geographic (spatial) boundary, both vertically and horizontally, that the investigation area is limited to, as well as the temporal boundary if there is a limitation to the time frame when sampling can occur.

The geographical study boundary for the Process Areas OU is limited to the main Process Areas, bounded on the northeast by the Sulfide Tailings, on the northwest by the Calcine Ditch and the Oxide Tailings, on the southwest by the Phase IV Heap Leach Pad and Mega Pond, and on the southeast by Burch Drive (Figures 2-1- and 2-2). Small peripheral Process Areas, such as crushing and pump stations, located away from the main Process Areas, are also included in the study boundary. Arimetco's process facilities are located southeast of Burch drive and, although these facilities are not a direct target area for this investigation, they are included as a potential source for chemicals that occur in mine-related groundwater within the alluvial aquifer underlying the Process Areas, as described in Section 4.2.3.

The vertical boundary for evaluation of soils for risk assessment is limited to 0 to 2 feet bgs for surface soils, and 2 to 10 feet bgs for subsurface soils. The boundary for the vertical delineation of chemicals in soils is limited to 25 feet bgs. The boundary for the evaluation of vadose zone characteristics is limited to the area of unsaturated alluvial fan materials between the ground surface and the top of the water table, approximately 100 feet bgs.

The temporal boundary for the FSAP activities described in Section 6.0 extends from late 2007 through 2009, and will likely extend further relative to: 1) the sampling of soils beneath buildings and structures that will eventually be demolished and removed; and 2) ongoing groundwater monitoring from existing and proposed monitor wells. FSAP activities can generally be conducted during any time of the year, recognizing the potential for short-term weather-related delays. One exception is that radiation exposure rate measurements will be limited to periods of low to moderate moisture content in the soil and no snow cover because moisture content can inhibit detection of radiation.

5.3 Study Goals/Data Quality Objectives

Based on the SOW elements presented in Section 1.0 of this Work Plan, the following seven DQOs have been identified:

- DQO #1 - Evaluate and characterize the occurrence and distribution of mine-related chemicals in soils and groundwater, and radioactivity associated with soils and buildings or other structures.
- DQO #2 - Evaluate and characterize the occurrence and distribution of mine-related chemicals in soils, including delineation of previously identified impacted areas and sampling of new areas not previously identified.
- DQO #3 - Evaluate and characterize the occurrence and distribution of mine-related chemicals in groundwater associated with Process Areas facilities in conjunction with the implementation of the Site-side Groundwater RI Work Plan.
- DQO #4 - Determine fate and transport of chemicals from surface and subsurface soils to groundwater or other media through the vadose zone.
- DQO #5 - Determine physical and chemical hazards of all structures and their potential to contribute to soil contamination and identify any demolition and disposal requirements.
- DQO #6 - Evaluate and characterize the occurrence and distribution of petroleum hydrocarbon contamination, remove previously identified impacted soils, and investigate areas where possible USTs may have existed.
- DQO #7 - Evaluate the potential risks from chemicals identified in the Process Areas to human health and the environment.

Proposed field investigations necessary to address the problem statements of these DQOs are described in the FSAP (Section 6.0).

Practical limitations to perform soils investigations around and beneath buildings, structures and process components that ARC does not own or control are addressed in the FSAP. In addition, specific DQO details summarized in Table 5-1 would be modified as a result of the availability of background soils data. The schedule for the background soils data to become available would not delay the proposed soils investigations, and would result in a more efficient characterization program.

Table 5-1. Data Quality Objective Steps							
DQO	Step 1 Problem Statement	Step 2 Identify Study Goals	Step 3 Identify Information Inputs	Step 4 Study Boundaries	Step 5 Develop the Analytical Approach	Step 6 Specify Performance or Acceptance Criteria	Step 7 Develop the Plan for Obtaining Data
DQO #1	<p><u>General Problem Statement:</u></p> <p>Ore processing, material transfer and storage, and mining maintenance activities that occurred in the Process Areas may have resulted in releases of chemicals to the environment.</p> <p>Previous investigations have provided a framework for the occurrence and three-dimensional distribution of mine-related chemicals in Process Areas soils and groundwater.</p> <p>Sources and release mechanisms of mine-related chemicals have not been fully defined.</p> <p>Transport pathways and the environmental fate and transport of mine-related chemicals in the vadose zone have not been defined.</p> <p>The potential risks from chemicals to human health and the environment have not been evaluated.</p>	<p>Characterize:</p> <p>1) the occurrence and distribution of mine-related chemicals in Process Areas soil relative to preliminary screening criteria and background soils data, and</p> <p>2) radiological impacts to buildings and structures.</p>	<p>Gamma activity survey results measured over open ground surface as well as inside accessible, potentially impacted buildings and process equipment/tanks to identify impacted areas.</p> <p>MARSSIM radiation survey and site investigation requirements.</p> <p>Analytical results from soil samples to define radio-chemistry and isotopes of impacted soils and materials identified during gamma survey.</p> <p>Background levels for gamma activity levels for comparison to Process Areas results.</p> <p>Screening levels for radiological activity as well as radiochemical concentrations.</p>	<p><u>General Spatial Boundary:</u></p> <p>The spatial study boundary is defined as the Process Areas OU boundary which consists of the main Process Areas and Ancillary Process Areas. The main portion of the Process Areas is bounded on the northeast by the Sulfide Tailings, on the northwest by the Oxide Tailings, on the southwest by the Phase IV Heap Leach Pad, and on the southeast by the Waste Rock areas. Ancillary Process Areas, such as crushing and pump stations, are located in peripheral areas of the Site away from the main portion of the Process Areas.</p> <p>The temporal study boundary will be limited to periods when the soils have moderate to low moisture and no snow cover because moisture content can inhibit measurement of radiation exposure rates.</p> <p>Radiation survey readings will be conducted at one meter above ground level.</p> <p>The target population is soil and materials of construction, including building floors and walls, tank floors and walls, piping, and other exposed debris. Building and structure surveys will be limited to the insides of the structures and will be limited to floor level and walls up to 6 feet above the floor.</p>	<p>Areas that demonstrate elevated gamma activity levels above background levels will be determined to have radiological impacts. If any of those areas exceed health or ecological screening levels, then the activity or radiochemical will be further evaluated in the risk assessment.</p> <p>If radiometric activity is identified above the specified screening level, then a surface and subsurface soil samples will be collected to confirm radiochemical concentrations and to determine vertical extent.</p>	<p>Acceptance of analytical results will be based on verification and validation criteria specified in the QAPP.</p> <p>Comparison of Site soils to background soils will be based on an two population hypothesis test.</p>	<p>Initial delineation samples will be collected around the initial sample locations that have at least one sample interval that exceeds the preliminary soil screening criteria, based on Residential PRGs (EPA, 2004) with the exception of arsenic, iron, thorium, and Radium-226, -228, which are based on 3 times the median of previous soil data collected in the Process Areas to represent an equivalent of possible background concentrations. This may be modified by the availability of site-specific background soils data.</p> <p>Step-out boring locations will be approximately 20 feet in four principal directions (or fewer if accessibility is limited.) Delineation samples will be collected from a borehole at depth intervals of 0-2 feet, 4-5 feet, and 5-10 feet. Samples will be collected to a maximum depth equivalent to 5 feet deeper than the deepest sample that exceeded the preliminary soil screening criteria.</p> <p>The list of analytes that will be analyzed on the samples will be restricted to the analytical suite that exceeded the preliminary soil screening criteria (e.g., metals, TPH, VOC).</p> <p>Previously untested areas will be analyzed for all analytical suites (metals, radiochemicals, TPH, VOC, SVOC, pesticide, herbicide, and PCB) to a depth of 10 feet.</p>

Table 5-1. Data Quality Objective Steps - Continued							
DQO	Step 1 Problem Statement	Step 2 Identify Study Goals	Step 3 Identify Information Inputs	Step 4 Study Boundaries	Step 5 Develop the Analytical Approach	Step 6 Specify Performance or Acceptance Criteria	Step 7 Develop the Plan for Obtaining Data
DQO #2	<p>The general problem statement, as previously presented in DQO #1 is applicable without modification to this DQO.</p>	<p>Complete the characterization of the occurrence and distribution of mine-related chemicals in Process Areas soils in previously identified areas, and in any new areas identified by research of historical records.</p> <p>Provide an assessment of the occurrence and distribution of mine-related chemicals in Process Areas soils in the context of preliminary screening criteria and the results of background soils sampling and analysis.</p>	<p>Analytical results from soil samples from previous Process Areas investigations and new soil samples collected during this phase of investigation.</p> <p>Preliminary soil screening criteria and site-specific background concentrations of chemicals in soil.</p> <p>Historical operating procedures, process flow diagrams and site photos and maps will be used to determine locations of potentially impacted soils.</p> <p>Historical process records for information on chemical characteristics and concentrations of process solutions, TENORM characteristics, and organic compounds used and stored in the Process Areas.</p>	<p>The target population is surface (0 to 2 feet) and subsurface (2 feet to a maximum of 25 feet) soils.</p> <p>The spatial study boundary will be limited to the Process Areas described in DQO #1.</p> <p>Seasonal variations are not expected to affect soil investigations. There is no temporal boundary for the collection of soil samples.</p>	<p>If soil sample results identify any chemicals above preliminary soil screening criteria and/or background soils concentrations, whichever is greater, additional delineation sampling and analysis will be conducted to delineate the boundary of the occurrence and distribution of these chemicals.</p> <p>If historical documents provide evidence of spill locations or additional process components that have not been previously identified or adequately evaluated, those areas will be included for additional surface and subsurface soil sampling.</p>	<p>Acceptance of analytical results will be based on verification and validation criteria specified in the QAPP.</p>	<p>Initial delineation samples will be collected around the initial sample locations that have at least one sample interval that exceeds the preliminary soil screening criteria, based on Residential PRGs (EPA, 2004) with the exception of arsenic, iron, thorium, and Radium-226, -228, which are based on 3 times the median of previous soil data collected in the Process Areas to represent an equivalent of possible background concentrations. This may be modified by the availability of site-specific background soils data.</p> <p>Step-out boring locations will be approximately 20 feet in four principal directions (or fewer if accessibility is limited.) Delineation samples will be collected from a borehole at depth intervals of 0-2 feet, 4-5 feet, and 5-10 feet. Samples will be collected to a maximum depth equivalent to the deepest sample that exceeded the preliminary soil screening criteria.</p> <p>The list of analytes that will be analyzed on the delineation samples will be restricted to the analytical suite that exceeded the preliminary soil screening criteria (e.g., metals, TPH, VOC).</p> <p>Previously untested areas will be analyzed for all analytical suites (metals, radiochemicals, TPH, VOC, SVOC, pesticide, herbicide, and PCB) to a depth of 10 feet.</p>
DQO #3	<p>The general problem statement, as previously presented in DQO #1 is applicable without modification to this DQO.</p>	<p>Identify mine-related groundwater in the alluvial aquifer underlying the Process Areas and, if possible determine if the occurrence is associated with Process Areas facilities or facilities located up-gradient of the Process Areas.</p> <p>Monitor seasonal and annual variations in groundwater quality and elevation.</p> <p>Evaluate the occurrence and distribution of chemicals in groundwater and characterize groundwater flow and contaminant migration pathways.</p>	<p>Collect water quality samples from various locations in the Process Areas.</p> <p>The horizontal and vertical gradients and aquifer porosity will be used to determine groundwater flow rate and direction.</p>	<p>The target population is groundwater located underneath the Process Areas as defined in DQO #1. The integration of Process Areas groundwater data with groundwater conditions underlying other OUs and at other Site and off-Site locations will extend the boundaries of this DQO.</p> <p>There is no limitation to the timeframe in which monitor wells can be installed and initial groundwater samples collected. On-going sampling to monitor water quality over time will be conducted quarterly in order to identify seasonal variations.</p>	<p>Core drilling and installation of groundwater monitor wells will be used for the collection of water quality samples, the measurement of groundwater elevations, and for the evaluation of the chemical and physical properties of aquifer materials.</p> <p>The locations of new groundwater monitor wells and sample collection depths will be based on the goals and previous results of the Site-Wide Groundwater investigation, as well as the specific goals and results of the Process Areas groundwater investigation.</p>	<p>Groundwater measurement and analytical data acceptance criteria will be in accordance with the approved site-specific QAPP.</p>	<p>Eight new monitor wells will be installed in the main portion of the Process Areas. Zonal samples will be collected during drilling and a well with a screen interval located near the bedrock contact, or approximately 200 feet bgs, whichever is shallowest, will be installed. Shallow and intermediate monitor wells may be placed later depending on the results of the zonal sampling. Quarterly water quality samples will be collected following the installation of the wells, and groundwater elevation measurements will be collected on a monthly basis (minimum frequency).</p> <p>Zonal samples will be analyzed for a limited list of analytes and field parameters and the quarterly samples will included a more comprehensive list of analytes as specified in the Site-Wide Groundwater RI Work Plan and Section 6.0.</p>

Table 5-1. Data Quality Objective Steps - Continued							
DQO	Step 1 Problem Statement	Step 2 Identify Study Goals	Step 3 Identify Information Inputs	Step 4 Study Boundaries	Step 5 Develop the Analytical Approach	Step 6 Specify Performance or Acceptance Criteria	Step 7 Develop the Plan for Obtaining Data
DQO #4	The general problem statement, as previously presented in DQO #1 is applicable without modification to this DQO.	<p>The purpose of vadose zone data collection, monitoring and data analysis program is to: obtain in-situ data; quantify vadose soil infiltration potential, and obtain estimates of current recharge fluxes under existing surface conditions within the Process Areas.</p> <p>Determine fate and transport of chemicals from the surface and subsurface soils to groundwater beneath the Process Areas through the vadose zone.</p> <p>Implement vadose zone monitoring to confirm the conceptual model and to support unsaturated zone modeling, if required.</p>	<p>Physical, geochemical and geotechnical data from alluvial materials within the vadose zone to determine</p> <ul style="list-style-type: none"> ▪ soil type ▪ soil chemistry (e.g. solubility, ion speciation, adsorptive coefficient, leachability) ▪ vadose zone characteristics (e.g. permeability, porosity, moisture content). <p>Use existing information to determine depth to groundwater.</p> <p>Compare analytical results from previous groundwater samples to overlying soil samples and process components.</p>	<p>The target population is the unsaturated alluvial materials within the vadose zone at targeted locations within the Process Areas (i.e., the zone between ground surface and the top of the saturated groundwater zone or water table).</p> <p>The spatial study boundary will be limited to the Process Areas described in DQO #1. There is no limitation to the timeframe in which this activity can occur.</p>	Results of vadose zone geotechnical and geochemical testing and field monitoring will be used to evaluate the current and future potential for mine-related chemicals to migrate through the vadose zone to groundwater.	Acceptance of analytical results will be based on verification and validation criteria specified in the QAPP and American Society of Testing and Materials (ASTM) geotechnical testing standards.	Vadose zone materials will be collected for laboratory analysis of soil properties describing unsaturated flow properties including: grain size distribution including hydrometer for clay percentage; moisture content, bulk density, Atterberg Limits, and a seven point SWCC including the saturated hydraulic conductivity. Samples will be collected from boreholes used for monitor well drilling or other boreholes in areas suitable for field instrumentation (if required), known or potential source areas, and from a representative number of both coarse and fine-grain materials in the soil column.
DQO #5	The physical and chemical hazards associated with Process Areas structures (e.g., buildings, foundations, containments, sumps, tanks, utilities, and piping) have not been evaluated.	Determine special hazards and disposal requirements for structures should the determination be made that demolition and disposal is required for site closure or evaluation of sub-structure soils.	<p>Conduct building/structure inspection and sampling for:</p> <ul style="list-style-type: none"> ▪ asbestos content in construction materials ▪ lead paint on painted surfaces ▪ chemical saturation/RCRA hazardous waste in construction materials 	<p>The target population includes all construction materials for buildings and process equipment that may be disposed of, including:</p> <ul style="list-style-type: none"> ▪ metal sheeting ▪ exterior tiles and roofing materials ▪ interior drywall and framing materials ▪ concrete foundations, walls, tanks ▪ exposed piping (e.g. transite pipes) <p>The spatial study boundary will be limited to the Process Areas described in DQO #1.</p> <p>Building, equipment and infrastructure investigations will be limited to structures constructed by Anaconda before 1978 and does not include any structures built by Arimetco or other site owners after 1978. Also, ancillary structures outside of the main portion of the Process Areas such as pumping stations or crushing units related to process or mining activities will be included.</p>	<p>If a structure is likely to be dismantled and removed, the results of the inspection and material sampling will be used to determine any special disposal requirements.</p> <p>Results will be compared to landfill disposal restrictions, NESHAP requirements for asbestos removal (40 CFR, Part 61, Subpart M), RCRA hazardous waste disposal requirements or other applicable handling or disposal requirements.</p>	The mean concentration of samples collected from the same construction material from the same structure will be used to determine if the structure exceeds the disposal requirement.	<p>A preliminary evaluation will be made of the buildings and structures discussion with the stakeholders as to which structures may require demolition.</p> <p>A Comprehensive Asbestos Survey will be conducted by a qualified contractor for the structures identified, materials sampled may include exterior tiles, roof shingles, drywall, concrete foundations, and transite pipe.</p> <p>Painted surfaces will be sampled by coring or collecting paint chips from interior and exterior surfaces of structures.</p> <p>Buildings or process equipment that have been in contact with metal rich solutions that may have penetrated the construction materials (e.g. concrete, wood) will be sampled by coring method and analyzed for TCLP RCRA metals.</p>

Table 5-1. Data Quality Objective Steps - Continued							
DQO	Step 1 Problem Statement	Step 2 Identify Study Goals	Step 3 Identify Information Inputs	Step 4 Study Boundaries	Step 5 Develop the Analytical Approach	Step 6 Specify Performance or Acceptance Criteria	Step 7 Develop the Plan for Obtaining Data
DQO #6	<p>Mining maintenance activities that occurred in the Process Areas may have resulted in releases to the environment of petroleum hydrocarbons.</p> <p>There are areas of visible hydrocarbon staining/ contamination and indications of underground storage tanks (USTs).</p>	<p>Complete the characterization of the occurrence and distribution of petroleum hydrocarbon contamination in Process Areas soils in previously identified areas, and in any new areas identified by research of historical records.</p> <p>Remove remaining USTs and visibly stained soil.</p>	<p>Analytical results from soil samples from previous Process Areas investigations and new soil samples collected during this phase of investigation.</p> <p>Visual observations and field measurements of petroleum hydrocarbons during excavation.</p> <p>Historical Site maps, photos or other documents.</p>	<p>The target population is surface and subsurface soil in areas of known or suspected hydrocarbon contamination and areas where above-ground or underground fuel storage tanks or supply lines were located, based on historical information.</p> <p>The spatial study boundary will be limited to the Process Areas described in DQO #1.</p> <p>Impacted soils will be removed to a depth no greater than 15 feet bgs.</p>	<p>If soils are visibly stained with hydrocarbons, then the soils will be excavated for offsite disposal. Field instruments will be used to guide the excavation limits and confirmation samples will be collected from the floor and side walls.</p> <p>The results of the confirmation samples will be compared to human health and environmental risk assessment screening levels to determine if further remediation is required.</p>	<p>Acceptance of analytical results will be based on verification and validation criteria specified in the QAPP.</p>	<p>Remove visibly stained soil and collect samples from excavation for analysis. Excavate additional soil as necessary.</p> <p>Geophysical surveys will be conducted using appropriate detection methods such as metal detection, ground penetrating radar, and electromagnetic line location methods to investigate for USTs or other buried pipelines. If the presence or absence of a suspected buried feature cannot be confirmed through surface survey, the area will be excavated by backhoe or other equipment.</p> <p>All USTs found during the survey will be removed along with any visibly stained soil surrounding the tank. Soil samples will be collected from UST excavation for analysis. Excavate additional soil as necessary.</p>

Table 5-1. Data Quality Objective Steps - Continued							
DQO	Step 1 Problem Statement	Step 2 Identify Study Goals	Step 3 Identify Information Inputs	Step 4 Study Boundaries	Step 5 Develop the Analytical Approach	Step 6 Specify Performance or Acceptance Criteria	Step 7 Develop the Plan for Obtaining Data
DQO #7	The general problem statement, as previously presented in DQO #1 is applicable without modification to this DQO.	Estimate potential risks for exposure to mine-related chemicals in the Process Areas OU to human and ecological receptors.	<p>Validated analytical sampling results for onsite media and site-specific background data for soil and groundwater.</p> <p>Revised human health and ecological conceptual site models that outline potential receptors and exposure routes relevant to the Process Areas.</p> <p>Exposure parameters for human and ecological exposure scenarios.</p> <p>Screening level values for the identification of COPCs protective of exposure routes applicable to the Process Areas from the following sources:</p> <ul style="list-style-type: none"> ▪ EPA Ecological Soil Screening Levels (Eco-SSLs) ▪ EPA Soil Screening Levels (SSLs) for human health <p>These values will be supplemented by additional sources of information that may include:</p> <ul style="list-style-type: none"> ▪ EPA Region 9 Biological Technical Advisory Group (BTAG) Toxicity Reference Values (TRVs; De Vries 2007) ▪ Sample et al. (1996) - Toxicological benchmarks for wildlife ▪ Efroymsen et al. (1997) - Toxicological benchmarks for terrestrial plants ▪ EPA EcoTox Database ▪ ATSDR toxicological profiles ▪ Risk Assessment Information System (RAIS) <p>Human health and ecological toxicity values will be obtained from:</p> <ul style="list-style-type: none"> ▪ EPA's IRIS database ▪ ATSDR toxicological profiles ▪ EPA Region 9 BTAG TRVs ▪ ORNL toxicological benchmarks (Sample et al. 1996, Efroymsen et al. 1997). ▪ EPA EcoTox Database 	<p>The physical boundaries of the study will be determined through step-wise sampling discussed in the process areas work plan. Within this area:</p> <ul style="list-style-type: none"> ▪ The human population boundaries will be defined by current and future land use of the Process Areas. ▪ The ecological population boundaries will be defined by current and future land use and habitat survey data. 	<p>If the HHRA indicates that complete exposure pathways and representative exposure point concentrations result in unacceptable risk, then the identified area presenting risk to receptors will be further evaluated in the feasibility study.</p> <p>If the SLERA indicates that complete exposure pathways and maximum concentrations exceed SLVs, then a risk management decision will be made to either include or exclude the identified area from a site-wide baseline ecological risk assessment.</p>	<p>Risk estimates are generally upper-bound estimates of risk, which limits the potential for underestimating potential risks to receptors.</p> <p>Input from EPA is necessary to determine tolerable risk ranges/thresholds for human health and ecological receptors.</p>	EPA Region 9 toxicologists and ecologists will be consulted to determine appropriate human health and ecological receptors, exposure parameters, screening levels, and tolerable risk thresholds.

SECTION 6.0

FIELD SAMPLING AND ANALYSIS PLAN

This FSAP is based on: 1) current knowledge of the ore processing and related operational activities conducted in the Process Areas described in Section 1.0; 2) the OU-specific CSM presented in Section 2.0 and OU-specific HHRA and SLERA provided in Appendix A and C, respectively; 3) analytical results from previous soil and groundwater investigations performed in 2004-2005, and the interpretation of these results, provided in Sections 3.0 and 4.0, respectively; and 4) the DQOs described in Section 5.0. Specific activities described in the FSAP will also be based on the results of field investigations, and associated laboratory analyses, for current characterization activities (July-August 2007 time frame) performed by EPA in the Process Areas (surface and subsurface radiometric surveys) and targeted Arimetco facilities (CH2M Hill, 2007), and by ARC at an adjacent off-site location west of the Process Areas (i.e., the background soils study area). Integration of the results of these 2007 activities into this FSAP will result in a more efficient remedial investigation.

Integration of the 2007 data into the planning framework for the RI will not delay the completion of the RI because of the iterative nature and phasing requirements for FSAP implementation. ARC anticipates four phases for the RI that, based on preceding characterization phases, may also result in targeted interim removal actions (e.g., radiological control area or similar features, hydrocarbon-impacted soils, USTs, etc.). The four phases of investigation and removal activities, and general time frames anticipated for these activities, are listed below:

Phase 1 (Q4 2007 through Q3 2008)

- Phase 1-1 Radiometric Survey
- Phase 1-2 Hydrocarbons Soils and UST Investigation
- Phase 1-3 Groundwater Investigations
- Phase 1-4 Vadose Zone Investigations
- Phase 1-5 Preliminary Building, Equipment, and Infrastructure Assessment

Phase 2 (Q2 2008 through Q4 2008)

- Phase 2-1 Removal of Radioactive Materials (as required)
- Phase 2-2 Removal of Hydrocarbon-Impacted Soils and USTs (as required)
- Phase 2-3 Vadose Zone Monitoring (if required)
- Phase 2-4 Soils Investigations (Delineation Sampling)
- Phase 2-5 Additional Groundwater Investigations (second iteration, as required)

Phase 3 (Q2 2009 through Q3 2009)

- Phase 3-1 Additional Soils Investigations (third iteration, as required)
- Phase 3-2 Additional Groundwater Investigations (third iteration, as required)

Phase 4 (To be Determined)

- Phase 4-1 Final Characterization of Process Components Buildings, Structures, etc.
- Phase 4-2 Demolition/Removal of Process Components, Buildings and Structures
- Phase 4-3 Characterization of Soils Beneath Removed Buildings, Structures, etc.

The duration of Phase 4 activities is uncertain given that: 1) neither EPA nor ARC owns any buildings or structures in the Process Areas (or at any other Site locations), and the final disposition of these facilities is unclear at the present time given Arimetco's bankruptcy and Quaterra's option to purchase the Site; 2) the input of local governments (i.e., Lyon County and the City of Yerington) and business interests for mining and/or commercial/light industrial re-use may influence the timing of the demolition or re-use of the facilities; and 3) the iterative aspect of Phase 4 activities (demolition and removal of facilities followed by soils investigations under facility footprints and, potentially, further delineation sampling). ARC does not anticipate that the timing of Phase 4 activities will be affected by preceding investigations, unless renewed mining and ore processing activities at the Site occurs by Q4 2008.

Each of the activities listed above for the first two phases are anticipated to occur simultaneously, with minor variations in start dates based on the type of activity, and the reliance on the results and interpretation of preceding investigations. For example, the radiometric survey will be the first Phase 1 activity to be implemented and remaining Phase 1 activities would likely start at

approximately the same time. The proposed soils investigations, to be performed as a Phase 2 activity, will benefit from: 1) the results of EPA's and ARC's radiometric field surveys, allowing potential correlations between existing soils radiochemical data and the survey results to be developed; and 2) the use of the background soils data, which will provide the site-specific screening levels needed to optimize the soils investigation. A detailed schedule for the Phase 1 and 2 investigations will be established once EPA and ARC agree on the approach for this Process Areas RI Work Plan. Descriptions for the Phase 1 and 2 FSAP activities for these sub-areas are provided below (note that vadose zone monitoring (that may not be implemented as a result of preceding characterization and modeling activities). Less detailed descriptions of Phase 3 and 4 activities are also presented below.

6.1 Radiometric Field Survey

The following describes the approach to the MARSSIM-based area classification and gamma surveys of the entire Process Areas, and associated surface soil sampling targeted in areas with the highest observed radiometric count rates.

Area Classification

In accordance with MARSSIM guidance (EPA, 2000), each of the 15 sub-areas identified within the Process Areas (12 original sub-areas plus three additional sub-areas including stained soils, transformers and utility pipelines) have been classified as to the likelihood that there may be radiological contamination present in excess of Derived Concentration Guideline Limits ("DCGLs"). Since final DCGLs are not presently available for the Site, the preliminary soil screening levels (EPA Region 9 Residential PRGs or the 3x median value, whichever is greater) for soil sample results from the 2004-2005 soils investigations have been used for this preliminary classification. Due to the inherent conservatism of PRGs, final DCGLs are anticipated to be greater than the Residential PRGs or the 3x median values used as preliminary screening levels and some of the areas listed in Table 6-1 could be re-classified.

Process Areas sub-areas with individual sample results or 95th percentile results greater than the preliminary screening levels, or bimodal distributions have been classified as Class 1, likely to exceed the DCGLs. Units not expected to have much contamination based on historical knowledge are classified as Class 3, not likely to exceed the DCGLs. All other units are deemed to be Class 2, with some potential to exceed the DCGLs. Table 6-1 lists the sub-areas by Class.

Class 1		Class 2		Class 3	
Area #	Description	Area #	Description	Area #	Description
4	Solution Tanks	3	Vat Leach Tanks	1	Admin. & Maint. Areas
5	Precipitation Plant	6	Sulfide Plant	2	Truck Shop & Crushers
6	Sulfide Plant	8	Overflow Solution Ditch	TR	Transformers
9	East Solution Ditch	10	North Low Area	EX	Stained Soils
12	Peripheral Process Components	11	South Low Area		
UT	Utility Pipelines				

Gamma Survey

The entire Process Areas, encompassing all 15 survey units, will be scanned with gamma scanning equipment with the objective of achieving coverage at 100 percent. Inaccessible areas may include portions of the interiors of specific buildings, slopes too steep or unstable to permit scanning, and other areas unsafe for worker access. Scanning will be performed with 3”x 3” NaI detectors connected to GPS-enabled dataloggers at a height of one meter above the ground surface. Equipment specifications are provided in Appendix K (K-1). At a height of two meters, the detector has a “view” of a circle of the ground surface of at least a two-meter horizontal radius, although the field of view can be considered to be as much as a radius of 2.3 meters (Nielson 2005). With a one m/s second scanning speed, four meter wide swath of viewed surface, and a two second data logging interval, the detector will record a data point for each eight square meters of ground surface traversed. A series of transects four meters apart will result in a 100 percent scanning coverage.

Nielson et. al. (2005) calculates an anticipated detection limit for Ra-226 for this type of detector of approximately 0.016 Bq/g, equivalent to 0.43 pCi/g for 100 square-meter (m²) areas with a scan speed of 0.5 m/s, a one meter detector height and a two second count interval. A 100 m² area can be considered to be an infinite planar source, rendering the scan speed irrelevant for detection of average concentrations. This detection capability is sufficient to detect anticipated natural background concentrations of Ra-226.

NUREG-1507 provides scanning efficiencies for smaller NaI detectors in different source-detector geometries which can be used to establish approximate detection efficiency ratios for detecting natural thorium (Th-232) and uranium relative to radium-226. Table 6-2 lists the anticipated Minimum Detectable Concentration (“MDC”) ratios and Scan MDC values recalculated from NUREG-1507. The NUREG table for scan Minimum Detectable Activity (“MDA”) is based on a detector height of 10 cm and a 56 cm diameter hot spot. Recalculating the MDA based on a detector height of one meter and a uniform concentration over a one meter radius circle yields the Scan MDC values in Table 6-2.

Table 6-2. 3"x 3" NaI Detector Anticipated MDCs		
Radiochemical	NUREG-1507 MDC Ratio	Scan MDC pCi/g
Ra-226	1	0.43
Th-232 alone	6.6	2.8
Th-232 decay series (Ra-228)	0.65	0.27
Uranium ^a	29	13

Notes: ^aU-234, U-235, & U-238 without including contributions from decay products

The actual scanning MDCs will be determined by obtaining composite samples of the surface material at multiple locations in the process area. Since the various areas within the Process Areas may exhibit different ratios of uranium, thorium, and radium-226 and -228, it is possible that different radiochemical-specific MDCs may be present in different areas.

Surface Soil Sampling

The ore processing operations that occurred in the Process Areas may have caused the selective concentration of various radiochemicals with respect to their relative concentrations present in unprocessed ore. In addition, different ratios may be observed for (chemically) unprocessed ore handling areas, oxide ore and sulfuric acid leach solution handling areas, oxide ore copper precipitation areas, and sulfide ore concentrator areas. Therefore, Process Areas soils may reflect these differences and the surface sampling activity designed to support the radiometric survey will include the collection of ten composite samples based on the radiometric readings, as described below. Each composite sample will consist of four minimum half-liter samples at a distance of one meter from the center point evenly spaced around the perimeter, and one half-liter sample at the center point. This number and spacing of composite samples corresponds to: 1) the expected contribution of radiochemicals directly underneath the detector; and 2) offset by one meter to the total gamma activity registered by a radiation detector (Hamilton et. al., 2004). Soil samples will be analyzed for isotopic radium (Ra-226, -228), uranium (U-234, -235, -238), thorium (Th-228, -230, -232) and gamma spectroscopy.

The count rate at the center point will be measured immediately prior to collecting the soil samples. Sample locations will be identified by selecting areas with a distribution of count rates observed during the gamma surveys within the ore handling or processing areas described above, and representative of the surface area scanned by the detector as illustrated in Figure 6-1. Ten composite samples will also be taken of the representative background area, described in the *Background Soils Work Plan* (Brown and Caldwell, 2006), to establish local background concentrations and dose rate correlations. Each sample will be collected from the top 15 cm (6 inches) of soil in accordance with the soil sampling procedures described in SOP-11. Each set of 5 samples shall be composited and homogenized prior to removal of aliquots for analysis.

Radiological characterization of subsurface soils, as described below, is intended to serve as characterization surveys for the Class 1 and 2 areas listed in Table 6-1, and to provide sufficient data for a final status survey for the Class 3 areas. The final criteria for the final status survey

cannot be established until final DCGLs are determined for the Site. However, sufficient information is available to design a survey which should provide the necessary information to support final status survey analysis. Therefore, the minimum requirements of the soil sampling plan in support of the radiometric survey are based on MARSSIM guidance for final status surveys of Class 3 areas. The sampling plan has been augmented to provide additional detail to support remediation decisions for Class 1 and 2 areas, but is not necessarily intended to provide the level of rigor suggested by MARSSIM for final status surveys of Class 1 or 2 areas.

Given that the distribution of radiochemicals in Site soils has resulted from technical enhancement of naturally occurring materials, the same radiochemicals should occur in background soils (to be established based on the results of the *Background Soils Work Plan*; Brown and Caldwell, 2006). As a preliminary guide, and based on the results of the initial Process Areas soils investigations, estimated background concentrations for each radiochemical are provided in Table 6-3. These ‘hypothetical’ background concentrations are based on the observed mean and 95th percentile concentration of the Process Areas samples with the lowest concentrations for each radiochemical.

Radiochemical	Mean (pCi/g)	95th Percentile (pCi/g)
Uranium	1.3	3.5
Thorium	7.0	12
Radium-226	1.3	2.0
Radium-228	1.0	2.3

The expected scanning MDCs listed in Table 6-2 are less than the hypothetical background levels provided in Table 6-3, with the exception of uranium. However, the MDC is less than the residential PRG (16 pCi/g) for uranium. Therefore, the gamma survey should be capable of detecting materials present below the anticipated final DCGL values for these radiochemicals.

In theory, the gamma surveys alone should be sufficient to constitute a final status survey for Class 3 areas. However, as a confirmatory measure, soil samples will also be taken. The number of soil samples does not need to be based on satisfying statistical tests for uranium and thorium due to the substantial variation between anticipated background levels and the preliminary screening levels, but do need to provide sufficient information to conduct statistical tests for radium-226 and radium-228. Once bimodal distributions are removed, both the radium-226 and radium-228 concentrations for each survey area exhibit an average approximate standard deviation of 0.6 pCi/g. Since the screening levels are more than twice sigma greater than the hypothetical background concentrations, a relative shift of at least 2.0 is plausible.

Assuming Type I and Type II error rates of five percent, this yields a minimum sample size of 13 samples for each survey area. The addition of a 20 percent increase to the number of samples results in a sample data set size of 16 soil samples. Therefore, a minimum of 16 samples will be taken in each Class 3 survey unit. Each sample will be from the top 15 cm (6 inches) of soil in accordance with the soil sampling procedures described in SOP-11 of the revised QAPP (ESI and Brown and Caldwell, 2007).

6.1.1 Removal of Radioactive Materials

Phase 2-1 of the FSAP, if implemented to protect worker health and safety and improve the efficiency of subsequent investigation activities, would consist of the removal of soils and materials based on the results of the radiometric survey and surface soil sample results collected during Phase 1-1 (note that this phase of investigation activities is not intended to meet any final cleanup criterion that may be established for the Process Areas OU). The cleanup level to be implemented during this removal phase is not yet determined, and would be targeted based on prudent worker radiation exposure rates and/or contamination control limits in concert with EPA decision makers. Any materials identified for removal will be disposed off-site at a landfill permitted to accept radiological waste as required by the characterization of the waste. Waste removal and transportation will be conducted by a certified contractor qualified in the handling of radioactive materials, asbestos and hazardous wastes. ARC anticipates that a separate Work Plan for such removal activities will be provided to EPA for approval.

Waste Determination and Landfill Acceptance

Waste determination will be completed by evaluating the analytical results from Phase 1-1 sampling, and determining the maximum and average concentrations of radiochemicals in the sampled materials. The average concentration is representative of the entire material that the landfill would receive, but the maximum concentration will be used as guidance in evaluating landfill waste acceptance criteria in order to ensure the landfill will not be receiving a class of waste material that they are not permitted to receive.

Several disposal facilities that accept radiological wastes are located in the western United States. Waste acceptance criteria (“WAC”) for these facilities will be reviewed in order to determine which facility is best suited to receive the waste. Selection of the landfill will be based on determined waste characteristics, landfill WAC, disposal cost and transportation cost. Potential disposal facilities include, but are not limited to:

- US Ecology (Richland, Washington) – Accepts Class A, B and C low-level radioactive waste.
- US Ecology (Grand View, Idaho) – Accepts RCRA/TSCA wastes as well as NORM/TENORM and other NRC exempt low level radioactive materials.
- Envirocare (Clive, Utah) – Accepts low-level Class A radioactive waste, NORM/TENORM waste, and mixed wastes that contain both radioactive and RCRA hazardous waste components.

Excavation Procedures

Any excavation activities will be completed utilizing a small track excavator (Caterpillar 312 or similar) to facilitate the removal of the materials to be managed off-site. Excavated soils will be stockpiled and staged in an area immediately adjacent to the cleanup area to determine radiological activity and physical composition necessary to properly complete the waste profile and shipping documents. For example, transite pipe materials that exhibit known elevated radiometric readings will be loaded whole, where possible, and thoroughly wet for sections that would require breaking into smaller lengths before loading. If practical, pipes will be loaded in such a way that allows placement of soil in and around the pipe, to fill voids and optimize the load size.

Excavation and removal activities will not be performed during adverse weather conditions with moderate to strong winds. Dust suppression methods, including application of water spray over the work area and waste stockpiles, will be implemented during the waste removal activities to minimize airborne particles.

Wastes will be transported to the disposal facility in fully enclosed and lined roll-off containers that typically hold approximately twenty yards of material. Waste containers will be properly placarded, according to Department of Transportation (“DOT”) shipping requirements, and prepared for transport to the disposal facility. A waste manifest document will be completed and signed by an ARC representative. Upon receipt at the disposal facility, the manifest will be signed by a representative of the facility and a copy returned to ARC for recordkeeping and submittal to EPA in a report that documents the radiological waste removal process.

Excavation Monitoring

Radiometric readings will be taken throughout the removal activity to monitor the location and relative activity of remaining contamination and to determine if unanticipated levels of contamination are encountered at depth. Surveys will be completed at least once per hour and will consist of a qualified radiation technician walking several transit lines, spaced approximately one meter apart, over the floor of the excavation area. A μrem meter or tissue equivalent gamma survey meter will be used to conduct the survey and the readings will be measured at waist height. Alternatively, a μR meter calibrated with a radium-226 standard may be used. The results and times of the surveys will be documented in the field notes.

Procedure for Unanticipated Situations

Although all potential scenarios cannot be anticipated, the most probable unanticipated situations that may arise during excavation activities include:

- Encountering buried pipes in the excavation area;
- Encountering a buried sealed radiation source, such as a density gauge;

- Encountering increased levels of radiochemical contamination at depth in the soils; or
- Encountering another contaminant, such as hydrocarbons or PCBs, that were not previously identified or described in the waste profile.

In the event that any of these or other unanticipated situations arise during the implementation of these Phase 2-1 activities, all on-going removal activities will be suspended while the scope of the situation is evaluated by the on-site ARC field manager, a health physicist and/or industrial hygienist, and the waste removal contractor field manager. Any buried materials, other than contaminated soils, will be left intact and not opened or disturbed until an external radiological survey is completed.

If the radiometric levels are within levels that can be handled by the qualified personnel onsite and the discovered item can be moved using the existing equipment without causing damage, the material will be moved from the excavation area and set aside for further evaluation or waste characterization. Protective barricades and signs will be placed around the material to restrict access and samples will be collected for submittal to a laboratory, if applicable.

Verification Survey and Sampling

Upon completion of the waste removal activity, at least three verification soil samples will be collected from the excavated area to assess remnant soil contaminant levels. If no site-specific cleanup levels have been determined, the verification sample results will only be used to document the as-left conditions following waste removal. As action levels are determined in the future, based on a risk assessment evaluation, a comparison of the results of the verification samples can be made to those action levels to determine any additional remediation requirements.

A radiometric survey will be done at the completion of the waste removal activity to document the external dose levels remaining in the cleanup area. The radiometric survey will be completed

similar to the surveys conducted during Phase 1-1. The survey will be conducted on a meter grid at the 1-cm and waist-high levels, although additional readings may be obtained as necessary to fully document the as-left condition.

6.2 Petroleum Hydrocarbon Soils Characterization and UST Investigation

The initial Process Areas soils investigations (Brown and Caldwell, 2005b) resulted in a preliminary indication of petroleum hydrocarbon impacts associated with vehicle maintenance and fuel storage, conveyance, and use. In addition, USTs appear to exist at several locations. Phase 1-2 of the FSAP is focused on the delineation of the extent of petroleum hydrocarbon impacts in soils and the confirmation of the presence of USTs within the Process Areas. Removal actions will be performed, as necessary, to remove USTs and soil impacted with petroleum hydrocarbons (Phase 2-2) pursuant to State of Nevada regulations:

- NRS 459.800-856 “Storage Tanks”
- NRS 590.700-920 “Cleanup of Discharged Petroleum”

6.2.1 Petroleum Hydrocarbon Soils Characterization and Removal

The 2004-2005 soils investigation indicated petroleum hydrocarbon impacts at the following areas/features:

- Upper Truck Sludge Pond (BBB) – This pond or pit area appears to have been a collection point for wash water from the Wash Pad and possibly other drains from the Truck Shop Building (K). The area is visibly stained with petroleum hydrocarbons.
- Upper Truck Sludge Pond (CCC) – A second pond received additional drainage from the Upper Truck Sludge Pond. This pond appears to have had a synthetic liner installed at one time that might have contained solutions and solids. The area is visibly stained with petroleum hydrocarbons.

The decision tree for petroleum hydrocarbon soils characterization and removal is provided in Figure 6-2. The iterative sequence of activities is outlined below.

- 1) Identify surface areas or excavations where soil is visually stained or soil sample results exceed preliminary soil screening levels.
- 2) Excavate soil until visible staining is absent and field instruments indicate low soil gas levels.
- 3) Collect soil samples from bottom and sidewalls of excavation. If groundwater is encountered, a grab sample will be collected.
- 4) Analyze samples for petroleum hydrocarbons on an expedited schedule.
- 5) Compare analytical results to screening levels and continue excavating, if necessary.

The soil samples will be analyzed for the three petroleum hydrocarbon ranges, gasoline (TPH-g), diesel TPH-d, and motor oil (TPH-mo) on a quick turn-around time (e.g., 24 hours). The analytical results will be used to determine the need for additional excavation and sampling while the field team is mobilized. Regulatory agencies will be immediately updated (i.e., same-day basis) as delineation of the impacts progresses, and when key decisions are needed.

6.2.2 UST Investigations

Based on the previous Process Areas investigations, USTs may exist at several areas/features, as described below:

- Administration Building (A) – In the parking lot approximately 50 feet from the northeast side of the building, a refilling station pump island with two pumps was removed in 1998. An underground utility locating service was not able to locate evidence of a UST at this location, so it is assumed that the tank was removed at the time the pumps were removed.
- Emergency Shed (R) – The nature of past activities conducted inside the building is unknown, although the name suggests that “emergency” supplies were stored inside (e.g., gasoline or diesel for generators). A pipe protrudes out of the ground near the north corner possibly indicating the presence of a UST.
- Filling Station #2 (W) – The station was formerly used for petroleum fueling. The station has fuel pumps located in a shed. Underground pipes (two 2-inch lines) are protruding from the ground outside the southeast end of the building possibly indicating the presence of USTs.
- Filling Station #3 (X) – The station was formerly used for petroleum fueling. The station has fuel pumps located in a shed. Underground pipes are protruding from the ground, possibly indicating the presence of USTs.

- Filling Station #4 (Z) – Fuel pumps were located on a concrete pad and used for fueling mine vehicles. An underground fuel line connected the fuel pumps to former above-ground fuel tanks. Although the fuel pumps and above-ground tanks have been removed, the underground piping remains.

The decision tree for the UST investigation is provided in Figure 6-3. The sequence of activities is outlined below.

- 1) Perform geophysical surveys to identify anomalous areas that may indicate the presence of USTs and associated piping.
- 2) Dig test pits to determine the reason for the anomaly. Record lithologic data during the excavation.
- 3) If USTs or piping are found, remove them from the Site.
- 4) If soil in the excavation appears impacted, proceed to the Petroleum Hydrocarbon Stained Soil Removal Decision Tree.

Geophysical Surveys

Prior to any geophysical survey activities, all surface metal and other miscellaneous debris will be removed to minimize interference and “false positives.” Since the buried debris could be variable and include both ferrous and non-ferrous metal as well as non-metallic debris, several different geophysical methods are being proposed. Magnetic detection (“MD”), ground penetrating radar (“GPR”), and electromagnetic line location (“EMLL”) methods will be used in conjunction to investigate for USTs, as described below:

- The MD method is used to detect shallow subsurface metal objects that may represent a UST. However, interference from nearby buildings and above ground metal features may preclude the use of magnetics.
- The GPR method is used to image variations in the electrical properties of the shallow subsurface. These variations can provide information on the locations and dimensions of buried objects and fill boundaries.
- The EMLL is used to locate detectable utility alignments. This information can be used to further characterize the source of the MD and GPR detected objects. In addition, the EMLL and GPR methods can be used to investigate any nearby proposed borehole sites for detectable utility alignments and drilling obstructions.

Subsurface UST Investigation and Removal

The need for subsurface investigations will depend on the results of the initial geophysical survey. If the geophysical survey indicates an anomaly the size or shape of a UST, or if results are inconclusive, then a test pit will be dug to determine whether USTs and associated piping are actually present. If a UST is found, the excavation will be expanded to remove the tank and associated piping. If impacted soil is indicated by visual inspection or field instrumentation, the location will enter the decision tree for petroleum hydrocarbon stained soils described in Section 6.2.1. If the geophysical results do not show an anomaly the size or shape a UST, then it will be presumed that the tank was removed, or never was installed, and no subsurface investigation will be conducted. If a UST removal action is conducted, the following steps will be implemented.

- Protection of On-Site Workers and Site: Appropriate precautions will be taken to protect the on-site workers from any work activities and to reduce impact on the site from the removal activities. All litter and debris will be cleaned up daily and placed in containers for proper disposal. All containers will be emptied at least once a week and promptly removed from the UST location at the end of the work.
- Excavation: This activity will consist of uncovering each UST and removing soil within two feet of each tank wall, if possible. Excavated soils will be stockpiled adjacent to each excavation. Contaminated soils will be stockpiled separately from clean soils for subsequent sampling and for disposal at a suitable off-site location. Contaminated soil will be identified by field screening techniques using a photo ionization detector (PID) during the excavation process and will be segregated based on readings. All excavated soil removed from the excavation will be removed from the site, characterized, and properly disposed.
- Destructive Sampling of Tanks and Piping: This activity will consist of destructive sampling (pumping, inerting, removal, cleaning, and disposal) of the UST and associated piping. All tankage and piping removed from the excavation will be suitably cleaned on-site to allow off-site transport and disposal for recycling. The UST may require a washout to remove residual materials from tank before it can be transported.
- Penetration of Slabs (if present): If the UST was strapped down to a slab, this activity will consist of the penetration of concrete slabs underlying the UST to allow for the collection of soil samples from below the slab.
- Sampling: There are three types of samples that may be collected: in the excavation, along the piping and from the stockpiles. These are discussed below.
 - UST Excavation: In accordance with local requirements, one soil sample will be collected from each of the four side wall within the UST excavation and two soil samples from under the UST or the concrete slab (if present). Appropriate locations

will be determined at the time of removal. If readings from a PID indicate elevated readings (>100 ppm), then additional soil samples may be collected from those areas in the excavation. Otherwise, the sidewall samples will be collected at the bottom of the UST. If groundwater is present in the excavation, then a grab water sample will be collected.

- Piping: One soil sample will be collected every 20 feet of pipeline.
- Stockpiles: Four grab samples will be collected and composited into one sample from each of the stockpiles of apparently affected material excavated from around the USTs (i.e., one composite soil sample per UST stockpile).
- Analysis: Samples will be analyzed for the three petroleum hydrocarbon ranges: TPH-g, TPH-d, and TPH-mo.
- Backfilling: Each excavation will be backfilled to the surface with nominally compacted material. Backfill material will consist of imported fill material composed of 1.5-inch drainage rock from the total depth of excavation to approximately 8-inches below grade and aggregate base rock from 2-inches to 8-inches below grade.
- Compaction: Backfill will be moisture conditioned to within 3 percentage points of optimum moisture content and compacted to 90 percent relative compaction (to ASTM D-1557). These standards will meet local requirements.
- Security: If it is necessary to leave an excavation open overnight, the contractor will be responsible for securing the excavation opening and designating the area with caution tape and night-flashing barriers. All excavations will be secured with fencing if left open over night. Barricades, caution tape and/or night-flashing barriers may be required.

6.3 Groundwater Investigations

Proposed groundwater investigations (Phase 1-3) are focused on expanding the existing monitor well network in the Process Areas and collecting additional depth-specific samples during borehole drilling. The additional monitor wells will provide information regarding subsurface geology, groundwater flow directions, vertical gradients, chemical distributions and contaminant transport pathways. Figure 6-4 shows the locations of existing monitor wells PA-MW-1 through PA-MW-3, and the locations of groundwater monitor wells (OU1-ONMW3 and OU1-ONMW5) to be installed pursuant to the *Draft Site-Wide Groundwater Remedial Investigation Work Plan*. Nine additional groundwater monitor wells at six locations (PA-MW-4 through PA-MW-8) are proposed to be installed as part of this Process Areas RI Work Plan, as summarized in Table 6-4.

Table 6-4. Rationale for Additional Process Areas Monitor Wells					
Well ID	Nearby Location	Rationale	Sampling	Anticipated Shallow Well Screen Interval	Anticipated Deep ⁽¹⁾ Well Screen Interval
PA-MW-4	PA-GW4	Obtain lithologic information regarding thickness of alluvial sediments in the southern portion of the Process Areas. Assess hydrogeologic conditions and the vertical distribution of chemicals in groundwater, hydraulically upgradient of the PA-GW4 hot spot near the assay laboratory, and downgradient of the Arimetco heap leach pads and solution pond.	Zonal sampling to bedrock	4,350 - 4,330	None ⁽²⁾
PA-MW-5	PA-GW18	Establish local groundwater flow directions and vertical gradients within the northern portion of the Process Areas based on head data from wells PA-MW-5 through PA-MW9 and OUI-ONMW5. Assess the vertical distribution of chemicals in groundwater beneath and downgradient of the subgrade solution recirculation sump at the north end of the former iron launders, where elevated chemicals were detected in groundwater grab sample PA-GW18; obtain lithologic information regarding thickness of alluvial sediments and the presence/absence of the shallow and deep clay intervals.	Zonal sampling to bedrock	4,350 - 4,330	4,275 - 4,255 ⁽³⁾
PA-MW-6	PA-GW19	Assess the vertical distribution of chemicals in groundwater beneath and downgradient of the "Low Area #2" (see Figure 2-1), where elevated chemicals were detected in groundwater grab sample PA-GW19; obtain lithologic information regarding thickness of alluvial sediments and the presence/absence of the shallow and deep clay intervals.	Zonal sampling to bedrock	4,340 - 4,320	TBD ⁽⁵⁾
PA-MW-7	PA-GW22 and PA-GW23	Assess the vertical distribution of chemicals in groundwater beneath and downgradient of the Sulfide Plant (see Figure 2-1), where elevated chemicals were detected in groundwater grab samples PA-GW22 and PA-GW23; obtain lithologic information regarding thickness of alluvial sediments and the presence/absence of the shallow and deep clay intervals.	Zonal sampling to bedrock	4,340 - 4,320	TBD ⁽⁵⁾
PA-MW-8	PA-GW21	Assess the vertical distribution of chemicals in groundwater beneath and downgradient of the Process Areas (at the northern boundary), where elevated chemicals were detected in groundwater grab sample PA-GW21; obtain lithologic information regarding thickness of alluvial sediments and the presence/absence of the shallow and deep clay intervals.	Zonal sampling to bedrock	4,340 - 4,320	TBD ⁽⁵⁾

Notes:

- (1) In this Process Areas RI Work Plan, these wells are referred to as deep wells ; however, the anticipated screen elevations of these proposed wells are approximately equivalent to the screen elevations of other Site-wide wells that are referred to as intermediate wells.
- (2) The saturated thickness of alluvial sediments in the southern portion of the Process Areas is anticipated to be limited, and not warrant installation of a deep well at this location, based on: 1) the conceptual site model that alluvium in the structural graben beneath the mine site thins to the south and approaches zero feet in thickness near the Yerington pit; and 2)the approximate 100 feet of saturated alluvial sediments at WW-10 (which is located at the north end of the vat leach tanks) and the lack of water detected in borehole PA-GW1 (which is located approximately 800 feet south of the Process Areas).
- (3) Bedrock at this location is anticipated at an elevation of 4,255 feet amsl based on the borehole log from WW-10. A 20 foot long well screen is assumed. Well design will be modified as necessary based on the lithology encountered during drilling and the zonal groundwater sample results.
- (4) Pursuant to the Site-Wide Groundwater Remedial Investigation Work Plan (Brown and Caldwell 2007), zonal groundwater sample results and lithologic information will be used to determine the need for and design of other wells at this location.
- (5) Zonal groundwater sample results and lithologic information will be used to determine the need for and design of a deep well at this location.

The proposed monitor wells include five shallow and four deep wells (the four “deep” wells in the Process Areas have anticipated screen elevations that are equivalent to the screen elevations of “intermediate” wells at off-Site locations north of the Site. The rationale for the locations, generally in areas where existing (shallow) groundwater grab sample data indicated elevated chemical concentration described in Section 4.0, and information regarding drilling and sampling approaches at each location are summarized in Table 6-4 and discussed below:

- PA-GW18, PA-GW19, PA-GW20, PA-GW21, PA-GW22 and PA-GW23, which are located hydraulically downgradient of the inactive iron launders, Sulfide Plant and Dump Leach Surge Pond (referred to in some previous reports as “Low Area #2”); and
- PA-GW4 and PA-GW7, which may have resulted from historic ore processing activities located to the south of the Process Areas.

Proposed monitor well PA-MW-4 is located in the southern portion of the Process Areas where the saturated thickness of alluvial materials is expected to be limited, and the installation of a deep well at this location is not warranted. The limited saturated alluvial thickness in this area is anticipated because: 1) the alluvium in the structural graben beneath the mine site thins to the south and approaches zero feet in thickness near the Yerington Pit; 2) depth to water and depth to bedrock at WW-10 are approximately 100 feet and 200 feet bgs, respectively, which indicates that saturated alluvial sediments at the north end the vat leach tanks are approximately 100 feet thick; and 3) groundwater was not encountered in borehole PA-GW-1, which is located approximately 800 feet south of the Process Areas.

The proposed monitor well locations will improve the understanding of groundwater flow conditions beneath the Process Areas (i.e., flow direction, horizontal and vertical gradients). In addition, the three-dimensional distribution of field parameters from depth-specific sampling and shallow and deep screen intervals will provide a sound basis for comparing water quality conditions with off-site locations.

Proposed monitor well PA-MW-5 is located near borehole PA-GW18 and well WW-10 where the saturated thickness of the alluvial materials is anticipated to be approximately 100 feet, and

bedrock is expected to be encountered at an elevation of approximately 4,255 feet amsl (based on an estimated ground surface elevation of 4,455 feet amsl at WW-10). As indicated in Table 6-4, a shallow and a deep well will be installed at this location. The proposed screen interval for the shallow well is anticipated to be approximately 4,350 to 4,330 feet amsl based on water levels in nearby wells PA-MW-2 and PA-MW-3. The screen interval for the deep well is anticipated to be from 4,275 to 4,255 feet amsl, based on the assumption that the bedrock will be encountered at approximately 4,455 feet amsl and that the well will be constructed with a 20-foot screen. Well design will be modified as necessary based on the zonal groundwater sample results and lithologic information obtained during drilling at this location.

The proposed locations of PA-MW-6 through PA-MW-8 are in areas where the saturated thickness and depth to bedrock is anticipated to increase relative PA-MW-5. Borings at these locations will penetrate the alluvium to the underlying bedrock contact, if encountered, or to a maximum depth of approximately 4,220 feet amsl. This depth is consistent with the intermediate wells installed north of the Site as part of the First- and Second-Step HFA investigations, and those proposed for installation pursuant to the Draft Site-Wide Groundwater RI Work Plan. Based on water level measurements in PA-MW-2, PA-MW-3 and UW-1 (located to the north of the Process Areas), which range from approximately 4,337 to 4,345 feet amsl (Figure 6-4), the screen intervals for the shallow wells at these locations are expected to be approximately 4,345 to 4,325 feet amsl. These depths will be finalized based on lithologic and zonal groundwater sampling information. Similarly, the total depth of drilling and screen installations for the deep wells at these locations will be based on zonal groundwater sample results and lithologic information encountered during drilling.

Depth-specific groundwater sampling will be conducted at these locations in accordance with the procedures and decision criteria previously approved by the EPA for the First- and Second-Step HFA investigations and the Draft Groundwater RI Work Plan. ARC anticipates that the criteria for the collection of zonal samples may be different than other Site investigations depending upon the presence or absence of the shallow and/or deep clay horizons within the Process Areas.

6.3.1 Borehole/Monitor Well Installation

The saturated thickness of alluvial materials is expected to be limited, and the proposed monitor wells are anticipated to penetrate the alluvium to the underlying bedrock contact, at a depth of approximately 200 feet bgs. Depth-specific groundwater sampling will be conducted at these locations in accordance with the procedures and decision criteria previously approved by the EPA for the First- and Second-Step HFA investigations.

Depth-specific groundwater sample results and lithologic information will be used to determine the need for, and design of, shallow and/or intermediate wells at these locations. The nine monitor wells installed pursuant to this Process Areas RI Work Plan will be constructed with a 20-foot screen interval. Where warranted due to lithologic information and/or zonal groundwater results, a shorter screen length may be proposed. Once constructed, the monitor wells will be developed, surveyed and sampled for the laboratory analysis, as described below. Drilling will be conducted using a sonic core drilling rig equipped with a continuous core barrel to facilitate detailed lithologic logging of aquifer materials and to collect depth-specific samples of groundwater (procedures for drilling and depth-specific sampling will be consistent with the EPA-approved procedures presented in the Second Step-HFA Work Plan).

6.3.2 Lithologic Logging and Depth-Specific Sampling

Upon retrieval from the sonic core barrel, alluvial materials will be described in general accordance with the ASTM 1992, Standard D 2487-92 – Classification of Soils for Engineering Purposes Unified Soil Classification System (“USCS”). Core samples will be archived at the Site in core boxes to preserve their soil texture. Consistent with procedures used during the Second-Step HFA characterization activities, zonal sample intervals at new borehole locations will be determined based on lithologic logging and visual estimation of transmissive properties of soil cores, including the occurrence of clay-rich alluvial horizons. Criteria used to select depth-specific groundwater sample intervals include:

- Within the first five feet immediately beneath the first encountered water table;
- At the bottom of the shallow (hydrostratigraphic) zone above the first clay horizon;

- At the first transmissive zone immediately below the first shallow clay horizon (if present);
- In the middle of the intermediate (hydrostratigraphic) zone, at elevations consistent with the screen intervals of nearby domestic wells and/or where transmissive zones are encountered;
- At the bottom of the intermediate (hydrostratigraphic) zone;
- At the first transmissive zone immediately below the deep clay (if present); and
- At elevations consistent with the screen intervals of nearby domestic wells.

6.3.3 Temporary Well Installation and Development

The methods, rationale, and procedures for temporary well installation and development, criteria for depth specific sample collection, and field meter calibration will be consistent with the EPA-approved methods implemented during the Second-Step HFA. Based on previous field experience, sonic drilling may encounter: 1) heaving (flowing) sands, generally comprising the water bearing intervals; and/or 2) the density/hardness of the formation that will require utilizing make-up water to wash down the six-inch casing. As during previous characterization activities, make-up water will be obtained from well WW-36. Water quality in well WW-36 is monitored quarterly and analytical results from this well have been previously reported.

Field parameters for the make-up water will be measured daily for comparison to the field parameters measurements of ground water during low-flow purging. Field parameter measurements that will be obtained for the make-up water included pH, specific conductivity, temperature, oxidation-reduction potential (“ORP”), dissolved oxygen (“DO”), sulfate, total alkalinity, total iron and ferrous iron. Procedures for obtaining these field parameter measurements are described below. The volume of make-up water added during drilling, and the extraction rate(s) and duration of development required to remove the added water prior to conducting low-flow purging, will be recorded on field sampling forms.

The six-inch diameter outer casing will be washed down to the bottom of the intended screened interval by pumping make-up water into the casing. Once the casing is washed down and the borehole is open to the intended depth, the temporary well (consisting of three-inch nominal

diameter stainless-steel wire-wrap screen, k-packer, and low-carbon steel riser) will be installed to the intended depth. The six-inch casing will be pulled up five feet exposing the screen to the borehole. The k-packer will maintain a seal between the temporary well and the six-inch casing, which will isolate the column of water in the casing from the screened interval.

Temporary wells will initially be developed with a submersible pump. Subsequently, a low-flow bladder pump will be used to purge the temporary well and collect samples for field and/or laboratory analysis. The submersible pump (one horsepower) will be installed into the temporary well with the pump intake just above the top of the screen in an effort to prevent the pump water level from exposing the screen to the atmosphere. During development, a minimum of twice the volume of make-up water utilized to wash-down the six-inch casing to the intended depth will be removed from the well with the submersible pump. Techniques utilized to enhance development of the temporary wells will include periodically raising and lowering the pump as a swab, and periodically cycling the pump on and off as to induce a surge effect. Field forms will be used to document development of the depth-specific zones.

6.3.4 Depth-Specific Sample Collection Criteria

After the temporary wells have been developed, a stainless-steel bladder pump will be installed to allow low-flow purging, measurement of field parameters and collection of groundwater samples. The bladder pump will be installed in the temporary well with the intake at the top of the screen. Compressed gas will be utilized to pump the groundwater between 200 and 500 milliliters per minute (ml/min) through ¼-inch polyvinyl tubing. The pumping rate and initial turbidity of the pumped water will be measured and recorded on field forms. The riser/discharge tubing will be connected to the influent port on the flow-through cell. Field experience indicates that connection of in-line pre-filter(s) ahead of the flow-through cell is needed to reduce turbidity to acceptable levels. As field conditions dictate, 10-, 5- or 1- micrometer (μm) in-line pre-filters will be used individually, or in combination, to verify that the turbidity of the water monitored in the flow cell is less than 10 nephelometric turbidity units (“NTUs”).

Groundwater parameters will be monitored in an air-tight flow cell equipped with a YSI 556 MPS multi-probe field meter (or equivalent), and turbidity will be measured from the discharge point with a Hach 2100P portable turbidity meter (or equivalent). Field parameters will be monitored and recorded at time intervals sufficient to evacuate the volume of the flow-through cell. Samples will be collected once volumetric and field parameter stabilization criteria are met, or after a maximum of approximately one hour of purging. The volume-based criteria require that a minimum of two times the volume of water in the well screen and casing below the bottom of the packer be purged prior to sampling. The parameter-based stabilization criteria include three consecutive readings that met the following:

- Temperature is ± 3 percent relative percent difference (“RPD”)
- pH is ± 0.1 standard pH unit
- Conductivity is ± 3 percent RPD
- ORP is ± 10 millivolts (mV)
- DO is ± 10 percent RPD

Turbidity is ± 10 percent RPD when turbidity exceeds 10 NTUs. Additional procedures to address high turbidity and help ensure the reliability of field stabilization data include the following:

- Prior to connection to the flow cell, purge one screen volume from well.
- Collect a water sample and measure and record its turbidity. If turbidity is <30 NTU, connect to flow cell and begin measuring and recording stabilization parameters. If turbidity is >30 NTU, install an in-line pre-filter(s) prior to connection to flow cell and begin measuring and recording stabilization parameters.
- Following purging of a second screen volume and achievement of well stabilization according to field parameter readings, disconnect from flow cell and disconnect pre-filter(s). Collect a water sample and measure and record its turbidity.
- Collect unfiltered and filtered water samples according to requirements for laboratory analyses.

Field Meter Calibration

The field meter will be calibrated at the beginning of each day prior to use (standard solutions will be obtained from a vendor). A two-point calibration method will be performed for pH. A one point calibration method will be performed for conductivity, dissolved oxygen and ORP. After calibration, a second calibration solution will be read for conductivity and dissolved oxygen. If a single sample is collected for the day, an initial calibration will be conducted followed by drift readings after the sample is collected. Drift readings will be collected utilizing the same solutions as utilized for the initial calibration. If two or more samples are collected, an initial calibration will be performed, a drift check and recalibration will be conducted after the first sample is collected, followed by a drift check after the final sample for the day is collected. These activities will be documented in field notebooks.

The turbidity meter will be rented from, and calibrated by, the vendor. Turbidity standards provided by the manufacturer will be read and documented each day prior to use. If results exceeded the manufacturer's specified accuracy, the meter will be sent back to the vendor and another meter will be obtained. These activities will be documented in field notebooks.

6.3.5 Depth-Specific Sample Collection Procedures

Once the volumetric and field parameter stabilization criteria are met, or after one hour, the flow-through cell will be disconnected from the riser/discharge tubing. A 0.45 µm in-line filter will be connected to the riser/discharge tubing to allow collection of a groundwater sample for laboratory analysis of dissolved (i.e., filtered) parameters identified in Table 6-5. Similar to the field activities conducted in the First- and Second-Step HFA Work Plans, depth-specific samples will be collected in lab-supplied bottles, preserved, cooled, documented, and sent to the laboratory for the analyses listed above.

Groundwater analyses will be conducted pursuant to this Process Areas RI Work Plan and revised QAPP. Aliquots of the 0.45-µm filtered water will also be collected for field measurement of sulfate utilizing a HACH DR/2400 portable lab spectrophotometer, total

alkalinity using a HACH alkalinity titration kit, and total iron and ferrous iron using a CHEMetrics, Inc. colorimetric field analysis kit. Field measurements of sulfate and total alkalinity will be made in accordance with HACH Methods 8051 and 8203, respectively. Total and ferrous iron will be made in accordance with CHEMetrics, Inc. Method K-6010. The results of the field kit field measurements will be recorded on field sampling forms.

Accuracy of the field analyses will be achieved by using the Standard Solution Method for sulfate and the Standard Additions Method for alkalinity, as recommended by the manufacturer. Standard solutions will be created daily for sulfate, and will be used to adjust the spectrophotometer to the standard solution prior to each analysis. Accuracy of the field measurements for total and ferrous iron will be achieved using the colorimetric reference standards provided by CHEMetrics, Inc. with the field kit.

After collection of filtered samples, the 0.45 um in-line filter and any other in-line pre-filters will be removed and a groundwater sample will be collected for laboratory analysis of total (i.e., unfiltered) parameters identified in Table 6-5. A final turbidity measurement of the unfiltered ground water will be obtained using the HACH field kit and recorded on a field sampling form.

Measurement / Parameter	Field / Laboratory	Method	Measurement / Detection Limit	Units
pH	Field Meter	EPA 150.1, Meter	0.1	Standard Unit
Conductivity	Field Meter	EPA 150.1, Meter	1	uS/cm
Temperature	Field Meter	Standard Methods 212, Thermometer	0.1	° Centigrade
Dissolved Oxygen (DO)	Field Meter	EPA 360.1, Probe	0.1	mg/L
Oxidation-Reduction Potential (ORP)	Field Meter	SM 2580 B	1	mV
Iron (Total)	CHEMetrics, Inc Water Analysis Kit	CHEMetrics, Inc Method K-6010, Colorimetric	0.02 – 3.0	mg/L
Iron (Ferrous)	CHEMetrics, Inc Water Analysis Kit	CHEMetrics, Inc Method K-6010, Colorimetric	0.02 – 3.0	mg/L
Sulfate	HACH Field Water Analysis Kit	HACH Method 8051 (SulfaVer 4 Method)	2	mg/L

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Table 6-5. Proposed Field and Analytical Laboratory Parameter List for Depth-Specific Samples - Continued				
Measurement / Parameter	Field / Laboratory	Method	Measurement / Detection Limit	Units
Alkalinity as CaCO ₃	HACH Field Water Analysis Kit	HACH Method 8203 (Phenolphthalein Method)	10	mg/L
Uranium (total and dissolved)	Laboratory	EPA 6020, ICP-MS	0.001	mg/L
Uranium-234, 235, 238 ⁽¹⁾	Laboratory	EPA 907.0	1.0	pCi/L
Total Organic Carbon (TOC)	Laboratory	EPA 415.1 (combustion/oxidation)	2.0	mg/L

Note: At select borehole locations only, as specified in the Work Plan text below.

After the depth-specific zonal sample is collected, the pump will be removed and the temporary well will be pulled from the borehole. The six-inch casing will be washed down to the bottom of the last core run and drilling with the core barrel recommenced. This method of coring, washing down casing, installing the temporary well, purging, collecting a groundwater sample, washing down casing, and coring again will be generally repeated in 20-foot intervals between the upper water bearing zone and the target depth of each borehole.

6.3.6 Well Construction, Development, and Sampling

As described above, screen intervals for the deep monitor well installation in each new borehole will be based on: 1) lithologic information obtained during drilling; 2) field parameter measurements and analyses of the depth-specific groundwater samples obtained during drilling; and 3) available construction details for nearby domestic wells and PA-B/W series monitor wells. The nine new onsite monitor wells will be constructed, developed, and sampled according to the following methods and procedures (described in the EPA-approved Second-Step HFA):

Well Construction Methods

All monitor wells would be constructed to allow for the collection of groundwater elevation measurements and groundwater quality samples. Monitor wells will be constructed with a nominal 15-foot long, 6-inch diameter steel surface casing, and 2-inch diameter schedule 40

polyvinyl chloride (“PVC”) tubing as the blank (i.e., not screened) portion of the well. Approximately three feet of the steel surface casing will stick up above the ground surface to protect the plastic tubing of the monitor well.

A 20-foot, 0.020-inch slotted screen constructed of schedule 40 PVC will be installed at the design interval. A 2-inch flush-threaded PVC end cap will be placed at the bottom of the screened interval. Where necessary, beneath the water table, the borehole beneath the screen and bottom cap will be filled with fully hydrated bentonite grout (nominally 0.375-inch pellets) to three feet below the bottom of the well. Bentonite will be installed via tremmie pipe. Filter pack will begin at the top of the bentonite.

A filter pack consisting of 10/20 silica sand will be placed against the well screen and will extend approximately 3 feet above the top of the screen interval (i.e., 23 feet of filter pack placed in the annulus). Filter pack will be installed via tremmie pipe. A minimum one-foot thick layer of finer filter-pack sand material will be placed on top of the coarser filter pack to limit cement grout intrusion. A cement seal will then be placed in the annular space from the top of the filter pack to ground surface.

A locking 6-inch diameter well monument will be installed with a stick-up of approximately three feet above ground surface. A nominal 6-inch thick, 2-foot by 2-foot concrete slab will be placed around the surface casing. The well monument will contain the name of the monitor well with designations for shallow, intermediate or deep completions (e.g., B/W-10S and B/W-4D). A permanent measurement point will be marked on the PVC well casing inside the monument.

A Nevada-registered surveyor will be employed to survey the horizontal and vertical locations of each new monitor well, including the ground surface and top-of-casing elevations. The reference measurement point for taking depth-to-water measurements will be permanently marked on the top of the interior PVC well casing, and surveyed within +/-0.01 foot in relation to mean sea level and within +/- 0.05 foot relative to Nevada State Plane West Zone coordinates (NAD 27).

Well Development Methods

After the bentonite grout and cement surface seal has cured, each monitor well will be developed to remove fine-grained material from the well and to improve the hydraulic connection to the screened portion of the alluvial aquifer. Development procedures will include surging the well and periodically pumping or bailing fine grained material until the turbidity of the discharge water is less than or equal to 10 NTUs or has stabilized (i.e., varies less than +/- 10% over three successive casing volumes).

Well Sampling Methods

Groundwater samples will be collected from the new monitor wells installed in accordance with this Process Areas RI Work Plan using low-flow (minimal drawdown) sampling procedures that are consistent with EPA guidance (EPA 1996 and 2002), per the following procedures:

- The pumping system would be prepared for operation by connecting the tubing to the in-line water quality meter and lowering the pump and tubing into the well, with the intake positioned at the approximate middle of the well screen.
- Commence well purging by low-flow pumping from the well at a flow rate not to exceed 500 ml/min. Initially a flow rate between 200 and 500 ml/min will be used. Efforts will be made to minimize air bubbles in the sampling tubing by either increasing the flow rate as appropriate, or restricting the flow by clamping the tube. The purge rate would be recorded in the field logbook or field sampling form. Purging will continue until parameters have stabilized and a minimum of one screen volume of water is removed.
- Ideally, drawdown in the well should not exceed 0.3 feet. Pumping rates should, if needed, be reduced to the minimum capabilities of the pump to help allow parameter stabilization.
- During purging, field parameters would be monitored and recorded including pH, conductivity, temperature, ORP and dissolved oxygen at time intervals sufficient to evacuate the volume of the flow-through cell, which would be calculated by dividing the volume of the flow-through cell by the pumping rate.
- Well sampling can commence after equilibration of water quality parameters. Equilibrated trends are generally obvious and usually follow either an exponential decay or asymptotic trend during purging.
- If the indicator field parameters have not stabilized after one hour of purging, then discontinue purging and collect the groundwater samples.
- At a minimum, at least two screen volumes should be purged prior to collecting a sample.

Equilibration is defined as three consecutive water quality parameter readings that meet the following EPA guidelines:

- Temperature is ± 3 percent RPD
- pH is ± 0.1 standard pH unit
- Conductivity is ± 3 percent RPD
- ORP is ± 10 mV
- DO is ± 10 percent RPD
- Turbidity is ± 10 percent RPD when turbidity exceeds 10 NTUs.

Additional procedures to address high turbidity and improve the reliability of field stabilization data include:

- 1) Prior to connection to the flow cell, purge one screen volume from well.
- 2) Collect a water sample and measure and record its turbidity. If turbidity is <30 NTU, connect to flow cell and begin measuring and recording stabilization parameters. If turbidity is >30 NTU, install an in-line pre-filter(s) prior to connection to flow cell and begin measuring and recording stabilization parameters.
- 3) Following purging of a second screen volume and achievement of well stabilization according to field parameter readings, disconnect from flow cell and disconnect pre-filter(s). Collect a water sample and measure and record its turbidity.
- 4) Collect unfiltered and filtered water samples according to requirements for laboratory analyses.

After the initial sampling event conducted at these nine new monitor wells, these wells would then be included in the quarterly monitoring program performed by ARC. The constituent list to be analyzed for during subsequent quarterly sampling events will, initially, be consistent with the analytes currently being monitored. This list may be modified pursuant to the *Draft Site-Wide Groundwater Monitoring Plan* (Brown and Caldwell, 2007e), currently under review by EPA.

6.3.7 Collection and Analysis of Monitor Well Samples

Following installation and development, monitor wells will be sampled and groundwater analyzed in conjunction with the subsequent quarterly site-wide monitoring event. Sampling

activities and analysis will be conducted in accordance with the approved procedures presented in the Second-Step HFA and the revised QAPP. Groundwater will be analyzed for the constituents presented in Table 6-6.

Table 6-6. Proposed Analyte List for Monitor Well Sampling				
Parameter or Analyte	Total/ Dissolved	Method ⁽¹⁾	Reporting Limit ⁽¹⁾	Units
Physical Parameters and Major Anions/Cations				
Alkalinity (Total as CaCO ₃)	Total	2320 B	2.0	mg/L (as CaCO ₃)
Chloride	Total	EPA 300.0	0.5	mg/L
Fluoride	Total	EPA 300.0	0.5	mg/L
Nitrate	Total	EPA 300.0	0.15	mg/L as N
Nitrite	Total	EPA 300.0	0.15	mg/L as N
Phosphorus, Total	Total	EPA 365.3	0.05	mg/L
Sulfate	Total	EPA 300.0	0.5	mg/L
pH	Total	EPA 150.1	0.01	pH Units
Total Dissolved Solids (TDS)	Total	EPA 160.1	10	mg/L
Total Organic Carbon (TOC)	Total	EPA 415.1	1.0	mg/L
Metals				
Aluminum	Total + Dissolved	EPA 6010B	0.05	mg/L
Antimony	Total + Dissolved	EPA 6020	0.002	mg/L
Arsenic	Total + Dissolved	EPA 6020	0.001	mg/L
Barium	Total + Dissolved	EPA 6020	0.001	mg/L
Beryllium	Total + Dissolved	EPA 6020	0.0005	mg/L
Boron	Total + Dissolved	EPA 6010B	0.05	mg/L
Cadmium	Total + Dissolved	EPA 6020	0.001	mg/L
Calcium	Total + Dissolved	EPA 6010B	0.1	mg/L
Chromium	Total + Dissolved	EPA 6020	0.002	mg/L
Cobalt	Total + Dissolved	EPA 6020	0.001	mg/L
Copper	Total + Dissolved	EPA 6020	0.001	mg/L
Iron	Total + Dissolved	EPA 6010B	0.04	mg/L
Lead	Total + Dissolved	EPA 6020	0.001	mg/L
Lithium	Total + Dissolved	EPA 6010B	0.05	mg/L
Magnesium	Total + Dissolved	EPA 6010B	0.02	mg/L
Manganese	Total + Dissolved	EPA 6020	0.001	mg/L
Mercury	Total + Dissolved	EPA 7470A	0.0002	mg/L
Molybdenum	Total + Dissolved	EPA 6020	0.02	mg/L

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Table 6-6. Proposed Analyte List for Monitor Well Sampling -- Continued				
Parameter or Analyte	Total/ Dissolved	Method ⁽¹⁾	Reporting Limit ⁽¹⁾	Units
Metals - Continued				
Nickel	Total + Dissolved	EPA 6020	0.002	mg/L
Potassium	Total + Dissolved	EPA 6010B	0.5	mg/L
Selenium	Total + Dissolved	EPA 6020	0.002	mg/L
Silicon	Total + Dissolved	EPA 6010B	0.05	mg/L
Silver	Total + Dissolved	EPA 6020	0.001	mg/L
Sodium	Total + Dissolved	EPA 6010B	0.5	mg/L
Strontium	Total + Dissolved	EPA 6010B	0.02	mg/L
Thallium	Total + Dissolved	EPA 6010B	0.01	mg/L
Tin	Total + Dissolved	EPA 6010B	0.1	mg/L
Titanium	Total + Dissolved	EPA 6010B	0.001	mg/L
Uranium, Total	Total + Dissolved	EPA 6020	0.001	mg/L
Vanadium	Total + Dissolved	EPA 6020	0.002	mg/L
Zinc	Total + Dissolved	EPA 6020	0.01	mg/L
Radiochemicals				
Gross Alpha	Total + Dissolved	EPA 900.0	3.0	pCi/L
Gross Beta	Total + Dissolved	EPA 900.0	4.0	pCi/L
Radium-226	Total + Dissolved	EPA 903.0	1.0	pCi/L
Radium-228	Total + Dissolved	EPA 904.0	1.0	pCi/L
Thorium-228	Total + Dissolved	EPA 907.0	1.0	pCi/L
Thorium-230	Total + Dissolved	EPA 907.0	1.0	pCi/L
Uranium-234	Total + Dissolved	EPA 907.0	1.0	pCi/L
Uranium-235	Total + Dissolved	EPA 907.0	1.0	pCi/L
Uranium-238	Total + Dissolved	EPA 907.0	1.0	pCi/L

Notes: (1) EPA laboratory analytical methods and method detection limits are consistent with those provided in the revised QAPP; alternative analytical methods identified in the QAPP may also be used.

6.3.8 Sample Handling, Labeling, and Preservation

Preparation of groundwater samples in the field for transport to the laboratory (including handling, labeling, packaging, documentation, shipment preparation and custodial quality control) would be conducted in accordance with the revised QAPP.

Sample Identification and Labeling

Each sample will be tracked according to the well location identification (e.g. the sample identification will be PA-MW4). The unique attributes of sample collection date and time will be marked on the chain of custody and will be tracked in the sample database. Sample labels would be completed with a permanent marker and attached to each sample container prior to ground water collection. The labels would include the following information:

- Sample identification and type
- Sample date and time
- Sample preparation and preservative
- Analyses to be performed
- Person who collected sample

Sample Preservation

For all non-metal analytes except nitrate, samples would be collected in 1,000-mL bottles with out acid preservative. Samples for nitrate will be collected in 1,000-mL bottles and acidified to pH<2 with sulfuric acid. Immediately following collection, samples would be placed into an insulated cooler chilled with ice to an approximate temperature of four degrees centigrade. The samples would then be transported to the analytical laboratory via overnight mail or personal delivery. Sample containers, preservation methods and filtering methods are listed in Table 6-7.

Parameter	Amount for Analysis	Container	Filtering	Maximum Hold Time	Storage Conditions	Preservatives
Total Dissolved Solids (TDS)	1,000 mL	1,000 mL HDPE	None	7 days	4°C	None
Sulfate	500 mL	1,000 mL HDPE	None	28 days	4°C	None
Nitrate	100 mL	1,000 mL HDPE	None	48 hours	4°C	H ₂ SO ₄ to pH<2
Total Metals	Varies per metal	500 mL HDPE	None	6 months	4°C	HNO ₃ to pH<2
Dissolved Metals	Varies per metal	500 mL HDPE	0.45 µm	6 months	4°C	HNO ₃ to pH<2
Acidity/Alkalinity	100/200 mL	500 mL HDPE	None	14 days	4°C	None
Total Organic Carbon (TOC)	25-50 mL	40 ml amber glass vial/screw cap with thick silicone rubber-backed TFE septa	None	28 days	4°C	H ₂ SO ₄ to pH<2

Notes: HDPE = High-density polyethylene HNO₃ = Nitric acid mL = milliliters H₂SO₄ = Sulfuric Acid

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6.4 Vadose Zone Investigations

The vadose zone investigation will be conducted in a phased approach, as indicated above, and is based on the conceptual model described in Section 2.2.4 for the fate and transport of any residual mine-related chemicals within the vadose zone underlying the Process Areas. Important OU-specific CSM factors include: 1) the dry condition of the distal alluvial fan materials observed in sonic cores from borehole drilling; and 2) the relatively homogeneous grain size distribution (Appendix D) from core samples that were lithologically logged as variable soil types (silty sand [SM] and lean clay [CL]; Brown and Caldwell 2005a). The approximate 100-foot depth to the water table, combined with low annual precipitation and high potential evaporation rates suggests that: 1) the long-term annual rate of infiltration is likely to be very low; and 2) the potential for mine-related chemicals within vadose zone soils to migrate to the water table is also very low.

ARC anticipates that the proposed initial phase of vadose zone investigations (Phase 1-4), materials characterization and unsaturated zone hydraulic modeling, will be adequate for the RI. However, if required by EPA, a second phase of vadose zone investigations (Phase 2-3) would include detailed vadose zone monitoring, which may be implemented to support the hydraulic modeling results. ARC understands the importance of conducting a comprehensive vadose zone investigation in the Process Areas, given that the results may be applicable to Site-wide conditions and other OUs overlying similar alluvial fan materials with analogous unsaturated zone characteristics.

6.4.1 Materials Characterization and Flux Modeling

The initial phase of vadose zone investigations will include: 1) the collection of hydraulic and geotechnical data from representative alluvial fan materials; 2) the laboratory analysis and interpretation of the collected data; and 3) numerical modeling of the potential flux of meteoric water through the vadose zone under existing and anticipated precipitation and evaporation conditions at the Site. As shown in Figure 6-5, vadose zone materials will be collected from eight locations, including a sub-set of the borehole locations described in Section 6.3 to be used

for additional groundwater investigations and monitor well construction in the Process Areas. The rationale for the eight locations presented in Table 6-8 is based on the following aspects:

- Areas associated with known occurrences of mine-related groundwater and/or mine-related chemicals in Process Areas soils that may have been subjected to sufficient quantities of process solutions during historic operations;
- Areas with a moderate-to-high potential for meteoric water infiltration due to relatively permeable surface soil conditions, the likelihood of recent ponding and localized vegetation occurrences that would likely be supported by sufficient soil moisture content; and
- Areas that appear to have a low potential for infiltration due to both low permeability surface soil conditions and the absence of ponding.

The unsaturated hydraulic properties for these alluvial fan materials will be characterized by collecting a representative number of alluvial fan material types from the four vadose sub-zones (i.e., land surface, intermediate vadose, deep vadose and capillary sub-zones) at each location, and developing an estimate of the average net flux to the water table based on these results, as discussed below.

Location ID	Anticipated Number of Samples Per Subsurface Zone ⁽¹⁾				Rationale
	Land Surface Zone	Intermediate Vadose Zone	Deep Vadose Zone	Capillary Zone	
PA-VZ-1	1	1	1	1	Assess potential high infiltration area (i.e., a topographic low that would promote focused recharge) near the historic East Solution and Calcine Ditches.
PA-VZ-2	1	2	2	1	Asses potential high infiltration area along the lower portion of the Calcine Ditch, near soil sampling location PA-WW4 where the most negative Acid-Base Potential (ABP) result (i.e., -64 t/kt) and elevated metals/radiochemicals (e.g., iron, arsenic, calcium, etc.) were detected.
PA-VZ-3	1	2	2	1	Assess potential low infiltration area within OU-3 near a groundwater hot spot (PA-GW23); co-located with a monitor well proposed in this Process Areas RI Work Plan.
PA-VZ-4	1	2	2	1	Assess potential low infiltration area within OU-3 near a groundwater hot spot (PA-GW18); co-located with a monitor well proposed in the Site-Wide Groundwater RI Work Plan (OUI-ONMW-5).
PA-VZ-5	1	2	2	1	Assess potential high infiltration area associated with the former Dump Leach Solution Pond (KK).

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Location ID	Anticipated Number of Samples Per Subsurface Zone ⁽¹⁾				Rationale
	Land Surface Zone	Intermediate Vadose Zone	Deep Vadose Zone	Capillary Zone	
PA-VZ-6	1	1	1	1	Assess potential high infiltration area along the East Solution Ditch where elevated metals and radiochemicals have been detected in soil but not as an underlying groundwater hot spot.
PA-VZ-7	1	1	1	1	Assess an area of presumed high infiltration associated with the only vegetation (i.e., a large tree) within the Process Areas.
PA-VZ-8	1	1	1	1	Assess potential low infiltration area near a groundwater hot spot (PA-GW4); co-located with a monitor well proposed in this Process Areas RI Work Plan.

Notes: (1) Land Surface Zone = 0 to 0.5 meters; Intermediate Vadose Zone = 0.5 to ~5 meters; Deep Vadose Zone = ~5 meters to the capillary fringe; Capillary Fringe = ~2 centimeters to ~2 meters depending on material type..

The collected samples will be analyzed for the following parameters:

- Grain size distribution including hydrometer for clay percentage (ASTM D-422)
- Moisture content (ASTM D2216)
- Bulk density (ASTM D2937)
- Atterberg Limits (ASTM D4318)
- A seven point SWCC including the saturated hydraulic conductivity (ASTM D2355)

The field and laboratory results will be compared to the SoilVision database of unsaturated soil properties with the objective of reducing the uncertainty associated with vadose zone hydraulic modeling. The two-dimensional modeling software, SVFLUX 2D, is proposed for use for the Process Areas. SVFLUX 2D is a SoilVision product that represents the state-of-the-art for such models. The specific approach and objectives for hydraulic modeling of the vadose zone underlying the Process Areas will be developed with EPA once the field and laboratory data have been compiled and compared to the SoilVision database. The model will evaluate vadose zone infiltration flux and seasonal moisture movement under climatic scenarios that may represent existing or anticipated conditions, and a “worst-case” scenario that describes what conditions would be required for meteoric water to reach groundwater. Additional scenarios may be run during the FS phase of the project to evaluate potential flux for cover conditions that do not currently exist (e.g., an engineered soils cap).

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6.4.2 Vadose Zone Monitoring

As described above, as a second phase of the investigations, vadose zone monitoring may be performed to verify modeling results under ambient climate and soils conditions at select locations in the Process Areas. ARC anticipates that such monitoring may serve to obviate the need for extensive vadose zone characterization activities at other Site locations, including many of the remaining OUs. This expectation would be based on: 1) the apparent homogeneity of the distal alluvial fan materials underlying the Process Areas, and the Site in general; and 2) the results of limited confirmatory drilling, sampling and hydraulic analysis of the vadose zone materials underlying the remaining OUs at the Site.

Specific details of the vadose zone monitoring phase of the FSAP would, if implemented, be developed in conjunction with EPA after the unsaturated zone modeling results become available. Possible monitoring approaches include direct field measurement, indirect field measurements, direct laboratory measurements, indirect laboratory measurements, and analog material or sites per the following examples:

- Direct field measurement - fluxmeter
- Indirect field measurements - soil water content (e.g., time domain reflectometry and neutron probes), and/or matric suction measurements (tensiometers, heat dissipation sensors)
- Direct laboratory measurements – column tensiometers or pressure plate
- Indirect laboratory measurements – determination of the soil-water characteristic curve, i.e., measurement of soil water retention under varying levels of suctions
- Analog material or sites – using soil texture and/or grain size distribution information from the project site and finding field or laboratory measured properties from similar soil types.

In effort to collect information at the correct scale and at a satisfactory density, a multi-approach and multi-scale series of tasks may be implemented, and could include one or more of the monitoring approaches listed above.

6.5 Potential Initial Building, Structures, and Process Components Assessment

ARC has developed this phase (Phase 1-5) of the FSAP in anticipation that EPA may require a preliminary assessment of buildings, structures and process components relative to soils investigations immediately adjacent to, or underlying, these features. The radiometric survey described in Section 6.1 includes the assessment of buildings and other features in the Process Areas, and would be conducted prior to any assessment of Process Areas features. ARC recognizes that the timing to complete the soils investigations described in Section 6.6 will be extended due to the iterative nature of potential demolition and removal of certain facilities followed by soils investigations under the facility footprints and, potentially further delineation sampling. ARC also recognizes that the timing of such activities is constrained by the following:

- Neither EPA nor ARC owns any buildings or structures in the Process Areas, and the final disposition of these facilities is unclear at the present time (ARC believes the Arimetco bankruptcy court owns all Process Areas buildings, structures and process components).
- Local governments and/or business interests for re-development of portions or all of the Process Areas from mining and/or commercial/light industrial re-use may influence the timing of the RI/FS, and eventual remedial actions, for existing Process Areas features.

Based on the uncertainties described above, ARC is uncertain which building and other structural features would be included in the remedial investigation for the Process Areas. The preliminary building assessment, if conducted, would consist of surveys for radiochemicals, asbestos-containing materials (“ACM”), and lead-based paint (“LBP”). The surveys for ACM and LBP are described below.

6.5.1 Asbestos Survey

An asbestos survey will be performed on buildings in the Process Areas to determine if ACM are present for only those buildings that need to be demolished in order to conduct soils investigations under those buildings. ACM materials within buildings that will remain in place are not subject to CERCLA. For any buildings that require demolition, approval to demolish those buildings will need to be obtained from the bankruptcy court before those buildings, which are the property of Arimetco’s bankruptcy estate, can be destroyed.

The survey would be performed according to guidelines set forth in the American Society for Testing and Materials (ASTM) *Standard Practice for Comprehensive Asbestos Building Surveys* (ASTM E 2356-04). The asbestos survey would be designed to meet the necessary requirements for use in providing agency notification of demolition and/or renovation activities under the Environmental Protection Agency's (EPA) Title 40 Code of Federal Regulations Title 40, Part 61, Subpart M, National Emission Standards for Hazardous Air Pollutants (40 CFR §61 et. seq., NESHAP).

Sampling and analysis methods used to determine asbestos containing materials in the structure(s) would be those generally provided in the Asbestos Hazard Emergency Response Act (AHERA), 40 CFR §763, et. seq. The results of the survey would confirm the presence or absence of Category I and Category II non-friable ACM and regulated asbestos containing material (RACM) in each building according to NESHAP requirements. The classification of the ACM will be based on the following definitions in the NESHAP regulations:

- Category I, Non-Friable ACM – Refers to asbestos-containing resilient floor coverings (vinyl asbestos floor tile [VAT]), gaskets, packing, and asphalt roofing materials containing greater than 1 percent asbestos, as determined using the method specified in Appendix D, subpart F, 40 CFR part 763, Section 1, polarized light microscopy (“PLM”). Removal of Category I materials from a structure is only required prior to demolition, renovation, or repair if they are in poor condition, friable, or subject to sanding, cutting, or abrading during demolition activities.
- Category II, Non-Friable ACM – Refers to any non-friable material, excluding Cat. I Non-Friable ACM, containing more than 1 percent asbestos, as determined using the method specified in Appendix D, subpart F, 40 CFR part 763, Section 1, PLM, that when dry, cannot be crumbled, pulverized, or reduced to powder by hand pressure. Category II may become RACM when demolition actions are applied to the materials.
- Regulated ACM – RACM include:
 - Friable asbestos material (defined by NESHAP as any material containing more than 1 percent asbestos that when dry, can be crumbled, pulverized, or reduced to powder by hand pressure);
 - Category I Non-Friable ACM that has become friable;
 - Category I Non-Friable ACM that will be or has been subject to sanding, grinding, cutting, or abrading; and

- Category II Non-Friable ACM that has a high probability of becoming or has become crumbled, pulverized, or reduced to a powder by forces expected to act on the material in the course of the demolition or renovation of the structure.

RACM would need to be removed from a structure prior to any demolition, renovation, or repair activity that might disturb the RACM if the quantity of the material exceeds the threshold limits under the NESHAP.

Representative bulk samples of suspect materials would be collected from all of the buildings in the Process Areas. Sample collection in occupied buildings will only be allowed if it does not threaten the health of workers or result in non-discrete damage. Suspect materials that are sampled shall be representative of homogeneous areas. A homogeneous area is defined by AHERA as a building material that is similar in color, texture, and age of construction. Homogeneous areas shall first be visually identified by a certified AHERA building inspector in each building. Sampling methods will be determined in the field and as recommended in ASTM E 2356-04 to adequately evaluate each assumed homogeneous area. Any limitations in the sampling (e.g., inaccessibility of materials in portions of a building) shall be identified in field notes. Field documentation will include drawings of each building, areas within the building sampled, and locations of ACM samples and homogeneous areas.

The bulk samples shall be analyzed for asbestos content by PLM according to the EPA methodology of visual estimation: *Interim Method for the Determination of Asbestos in Bulk Sample* (EPA, 1982). Point counting shall be performed on friable ACM with an asbestos content less than or equal to 1 percent to determine whether the material is RACM. Samples shall be analyzed by a laboratory with National Voluntary Laboratory Accreditation Program (“NVLAP”) accreditation. If material in certain portions of a building is inaccessible, limited non-destructive sampling or visual estimation will be performed according to ASTM E 2356-04. All materials not sampled shall be assumed ACM per the NESHAP requirements.

6.5.2 Lead-Based Paint Investigations

A preliminary survey may be performed on the exteriors of buildings in the Process Areas to determine if LBP is present. High-density sampling with x-ray fluorescence (“XRF”), and limited bulk sampling, may be conducted to obtain representative results in accordance with U.S. Department of Housing and Urban Development (“HUD”) LBP regulations: *Guidelines for the Evaluation and Control of Lead-Based Paint Hazards in Housing* (HUD, 24 CFR Parts 35, 36, 37).

XRF measurements of lead content in suspected LBP would be conducted with a portable XRF spectrum analyzer which will be calibrated prior to commencing the survey and at regular intervals according to manufacturer operating instructions. The instrument is equipped with a data logger to enable high density sampling of a surface (i.e., the collection of a larger quantity of samples than possible with chip sampling). Specifications for the instrument are provided in Appendix K (K-2). A minimum of five XRF direct readings would be taken at locations throughout each homogeneous area in a building (a homogeneous area is defined as a ‘painted surface that is similar in color, texture, and age of application’). Examples of homogenous areas include exterior trim and siding. Homogeneous areas would first be visually identified by a qualified building inspector in each building.

Limited bulk samples would be collected from homogenous areas that the field screening indicates are lead-contaminated. Samples would be collected according to the *ASTM Standard Guide for Sample Selection of Debris Waste from a Building Renovation or Lead Abatement Project for Toxicity Characteristic Leaching Procedure (TCLP) Testing for Leachable Lead (Pb)* (ASTM E 1908-97). Bulk samples would be collected by scraping a 2-inch by 2-inch sample from the surface with a putty knife (the putty knife would be decontaminated between samples). Samples would be analyzed for leachable lead by the Toxicity Characteristic Leaching Procedure (“TCLP”). The hazardous waste criterion for lead wastes is established under the Resource Conservation and Recovery Act (“RCRA”), Subtitle C, as 5.0 mg/L measured with the TCLP.

As with the asbestos survey, any limitations in the LBP sampling would be identified in field notes. Field documentation will include drawings of each building, areas within the building sampled, and locations of LBP samples and homogeneous areas.

6.6 Soil Investigations

As described in Section 3.0, the initial soils investigations conducted in 2004-2005 were designed on the basis of the 12 sub-areas listed in Table 2-1. Additional soil sampling activities (Phase 2-4) will result in a complete assessment of the distribution of mine-related chemicals in Process Areas soils. ARC anticipates that the soil investigations will require several iterations of drilling step-out borings, collecting and analyzing soil samples, and interpreting the results. The evaluation of soil chemical data will also include a statistical comparison with the preliminary and screening levels identified in this Process Areas RI Work Plan and background soils data collected pursuant to the *Background Soils Work Plan* (Brown and Caldwell 2006). Based on the results of the previous soils investigations in the Process Areas, the following three general types of data gaps to be addressed include:

- Areas/features with incomplete delineation sampling;
- Areas/features identified since the 2004-2005 investigation; and
- Quality control issues requiring corrective action.

Figure 6-6 presents a decision tree diagram for determining when no further sampling is required for these conditions.

6.6.1 Identification of Sample Locations

As described above, two types of samples are proposed: 1) delineation (e.g., step-out) samples based on previously collected soil samples that exceeded preliminary screening levels; and 2) samples to investigate areas/features identified since the 2004-2005 investigation. Delineation samples will be collected for specific chemicals with analytical results that exceed the

preliminary screening levels described in Section 3.0. If results from the 2004-2005 investigation did not exceed preliminary soil screening criteria, then the area/feature was determined to require no further sampling (i.e., a candidate for no further action).

Delineation sample locations are proposed in up to four directions and sample depths were limited to 5 feet beyond the depth of the deepest sample with a chemical concentration greater than a preliminary screening level, or the final screening level to be established based on the background soils investigation. Step-out boring locations will be approximately 20 feet in four principal directions from the original sample (or fewer directions if accessibility is limited) in order to determine the horizontal extent of impacted soils. In areas where there appears to be a continuity between adjacent sample locations, such as ditches or closely spaced samples, delineation samples would not be collected between the already identified impacted areas. In these areas, delineation samples will be collected from lateral locations (i.e., perpendicular to the ditch or radially from the closely spaced areas).

Additional soil sample locations are proposed in the areas listed below that have been identified since the 2004-2005 investigation:

- Area 1: Location of underground fuel tank (removed) northeast of the Administration Building.
- Area 5: Dump leach recirculation sump associated Precipitation Plant; and pump house northwest of the Precipitation Plant.
- Area 8: Southwest end of the Overflow Solution Ditch (FFF).
- Area 9: North end of the East Solution Ditch (EEE).

The samples for these areas/features target sumps, piping, access doors, and stained soils associated with the newly identified area/feature previously described.

6.6.2 Determination of Sample Depths

Samples will be collected at 5-foot depth intervals in to determine the vertical extent of potentially impacted soils. In general, the total depth of a proposed boring will be limited to five feet below the deepest sample with results above a preliminary soil screening level or to-be-established background value. Samples collected from surface soils (0-2 feet bgs) and subsurface soils (2-10 feet bgs) will also be used for the evaluation of human health and ecological risk. Given that the maximum depth of a buried feature is not expected to exceed 20 feet bgs, the maximum depth of sampling needed to evaluate the feature is 25 feet. Table 6-9 summarizes the proposed sample collection intervals for samples to be collected from each borehole.

Top Depth (feet bgs)	Bottom Depth (feet bgs)	Interval Length (feet)
0	2	2
4	5	1
9	10	1
14	15	1
19	20	1
24	25	1

6.6.3 Identification of Analytical Parameters

Table 6-10 summarizes the proposed list of analytes, and their respective reporting limits, for the Process Areas soil samples to be investigated under this FSAP. The five metals detected over preliminary soil screening levels from the 2004-2005 investigation include: arsenic, copper, iron, lead and thallium. In addition, antimony will remain on the analyte list to address specific quality control issues. Four radiochemicals (uranium, thorium-232, radium-226, and radium-228) and the three petroleum hydrocarbon carbon ranges (TPH-g, TPH-d, and TPH-mo) will also remain on the analyte list.

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Table 6-10. Proposed Analytical Methods and Reporting Limits		
Parameter	Analytical Method	Reporting Limit
Metals		
Antimony	6020	1000 µg/kg
Arsenic	6020	500 µg/kg
Copper	6020	1000 µg/kg
Iron	6010B	5.0 mg/kg
Lead	6020	500 µg/kg
Thallium	6020	500 µg/kg
Thorium	6020	0.5 mg/kg
Uranium	6020	0.5 mg/kg
Radiochemicals/Radioisotopes		
Radium-226	HASL 300	1.0 pCi/g
Radium-226	HASL 300	1.0 pCi/g
Thorium-228	HASL 300	1.0 pCi/g
Thorium-230	HASL 300	1.0 pCi/g
Thorium-232	HASL 300	1.0 pCi/g
Uranium-234	HASL 300	1.0 pCi/g
Uranium-235	HASL 300	1.0 pCi/g
Uranium-238	HASL 300	1.0 pCi/g
Total Petroleum Hydrocarbons		
Diesel (C12-C23)-TPH	8015B	5.0 mg/kg
Motor Oil (C23-C40)-TPH	8015B	5.0 mg/kg
Gasoline (C4-C12)-TPH	5035A-8015B	0.4 mg/kg
VOCs		
Benzene	5035A-8260B	1.0 µg/kg
Ethylbenzene	5035A-8260B	1.0 µg/kg
Toluene	5035A-8260B	1.0 µg/kg
Xylene (total)	5035A-8260B	4.0 µg/kg
Methyl tertiary-butyl ether (MTBE)	5035A-8260B	2.0 µg/kg
SVOCs		
Acenaphthene	8270C	330 µg/kg
Acenaphthylene	8270C	330 µg/kg
Anthracene	8270C	330 µg/kg
Benzo(a)anthracene	8270C	330 µg/kg
Benzo(a)pyrene	8270C	330 µg/kg
Benzo(b)fluoranthene	8270C	330 µg/kg
Benzo(g,h,i)perylene	8270C	330 µg/kg
Benzo(k)fluoranthene	8270C	330 µg/kg
Chrysene	8270C	330 µg/kg
Dibenzo(a,h)anthracene	8270C	420 µg/kg
Fluoranthene	8270C	330 µg/kg
Fluorene	8270C	330 µg/kg
Indeno(1,2,3-cd)pyrene	8270C	330 µg/kg
2-Methylnaphthalene	8270C	330 µg/kg
Naphthalene	8270C	330 µg/kg
Phenanthrene	8270C	330 µg/kg
Pyrene	8270C	330 µg/kg

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6.6.4 Sample Collection Method

Soil samples will be collected by sonic core, hollow-stem auger with split spoon or direct push methods in order to retrieve relatively undisturbed core sample. Sonic core method will not be used on samples that are to be submitted for analysis of any volatile compounds, such as VOCs, because of the heat generated from friction on the core barrel which could volatilize materials and negatively impact the results. The core sample retrieved should contain enough volume of material to allow for collection of all normal as well as duplicate samples.

Core samples from the desired sample interval will be homogenized thoroughly prior to distribution to sample containers. The exception is that samples for VOC analysis will be collected from the undisturbed core prior to homogenization to avoid loss of volatile compounds that may be in the sample. The sample may be homogenized either by placing the entire soil interval in a disposable plastic bag, which can be agitated and manipulated by hand to mix the soil, or in a reusable stainless steel mixing bowl and mixed with a gloved hand or stainless steel spoon. All reusable sampling and mixing tools will be washed between each use following standard decontamination procedures outlined in the revised QAPP (SOP-05; Brown and Caldwell 2007).

Pebbles or rocks greater than one-half inch in maximum dimension, and organic materials (e.g. roots, leaves), will be removed from the sample by picking them out by hand. These materials, if included in the sample, could impact the data results by causing a “nugget effect” (i.e., a higher- or lower-than-expected result due to non-typical concentrations of chemicals in the rock. Samples will not be subjected to grinding at the laboratory as this could potentially change the geochemistry of the soil. Grinding of the soil samples would increase the homogeneity of the sample, but could also potentially change the geochemistry of the soil by exposing minerals that are currently bound-up in the larger particles to acid leaching during sample preparation.

6.6.5 Soil Lithology Descriptions

Photographs will be taken at each sampling point including a general location photo and a close-up of the soil column. The photo location and number will be recorded on the field log sheets. The sample location coordinates will be recorded via GPS instruments at the time of sampling or at a marked location afterwards.

Lithologic descriptions of soil samples will be logged at the time of sample collection using the ASTM USCS Standard D 2487-92. Classification will include grain size, sorting, and plasticity among others and will be recorded on a separate log sheet. Observations of soil horizons or changes in soil characteristics as observed in the excavation will be recorded per the revised QAPP (SOP-12: "Soil and Rock Descriptions"), which lists the characteristics to be described.

6.6.6 Area Specific Sample Locations

Area 1 - Three sample locations exceeded screening levels in Area 1. Delineation samples will be collected around these areas and new sample locations have been identified to fill a data gap where historic evidence of a UST was found:

Administration Building (A) - Surface soil from 0.5 to 2.5 feet bgs near the garage area behind the Administration Building (PA-A1) exceeded screening levels for TPH-mo. Two sample locations are proposed around this original location to delineate the extent of impacted soils. The areas to the southwest and southeast have limited access due to electrical utilities and buildings, therefore no samples are proposed in these areas. Delineation samples will be drilled to a total depth of 10 feet and will be analyzed for TPH, VOC and SVOC. Historic information indicates that there was a underground fuel tank located off the northeast end of the Administration Building used for fueling non-mining road vehicles, and anecdotal information indicates that the fuel tanks were removed. Three sample locations are proposed in this area, which may be modified by geophysical surveys designed to locate the UST. The samples will be analyzed for the complete analytical suite including: metals, radiochemicals, TPH, VOCs and SVOCs. Because the tank was buried, impacted soils are likely to occur at the based of the buried tank rather than the surface, where samples will be collected.

Filling Station #2 (W) - Soils adjacent to the area of above-ground fuel pumps (PA-W1) exceeded screening levels for TPH-mo and TPH-d to a depth of 10 feet, the total depth previously sampled. Four sample locations are proposed and will be drilled to a total depth of 15 feet and will be analyzed for TPH, VOCs and SVOCs.

Filling Station #4 (Z) - Soils adjacent to the fuel pump island and underground piping (PA-Z1) exceeded screening levels for TPH-d in the surface sample. Three sample locations are proposed, and will be drilled to a total depth of 10 feet, and will be analyzed for TPH, VOCs and SVOCs. Two locations are proposed to investigate the lateral extent of hydrocarbon contamination with distance from the buried fuel pipeline and a third is proposed to determine the impact to soil underneath the concrete slab on which the pumps were located. Investigation of the area to the northeast will be completed as part of the utility pipeline UT-J as described in Section 6.6.7.

The proposed sample locations, depths and analytical parameters for Area 1 are summarized in Table 6-11 and shown in Figure 6-7.

Original Location ID	Max Depth of Chemicals (ft bgs)	Planned Location ID	Proposed Depth (ft bgs)	Analytical Suite				
				Metals	Rad	TPH	VOC	SVOC
PA-A1	2.5	PA-A2	10		X	X	X	X
		PA-A3	10		X	X	X	X
None	NA	PA-A4	20	X	X	X	X	X
None	NA	PA-A5	20	X	X	X	X	X
None	NA	PA-A6	20	X	X	X	X	X
PA-W1	10	PA-W2	15		X	X	X	X
		PA-W3	15		X	X	X	X
		PA-W4	15		X	X	X	X
		PA-W5	15		X	X	X	X
PA-Z1	2.5	PA-Z2	10		X	X	X	X
		PA-Z3	10		X	X	X	X
		PA-Z4	10		X	X	X	X

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Area 2 - Twelve sample locations exceeded screening levels in Area 2:

Equipment Wash (C) – Sample PA-C1, located at the edge of the concrete wash pad and adjacent to the drain sump, soil from 3.5 to 5 feet bgs exceeded screening levels for TPH diesel and motor oil. Two sample locations are proposed further off the concrete. None are planned on the concrete side of this location as previous samples collected under the concrete found no chemicals above screening levels. Delineation samples will be drilled to a total depth of 10 feet and will be analyzed for TPH, VOC and SVOC.

Tire Shop (I) - One sample location (PA-I1) was collected under the concrete apron in front of the Tire Shop, later used for Fire Engine Storage. The sample exceeded screening levels for TPH-diesel and the pesticide DDT at 0.5 to 2.5 feet bgs. There are three sample locations within 50 feet that do not exceed preliminary screening levels for any of these parameters. Therefore, no delineation samples will be collected.

Truck Shop (K) - Four locations around the perimeter of the Truck Shop (PA-K4, K5, K8 and K9) exceeded screening levels for TPH diesel and motor oil, all in the surface soils from 0.5 to 2.5 feet bgs. Each of these locations will have delineation samples collected to a depth of 10 feet and analyzed for TPH, VOCs and SVOCs.

Equipment Garage (L) - Two locations on the northeast side of the Equipment Garage (PA-L1 and L2) exceeded screening levels for TPH diesel and motor oil in surface samples from 0.5 to 2.5 feet. Three additional boreholes will be drilled and sampled to a depth of 10 feet and analyzed for TPH, VOCs and SVOCs.

Truck Wash and Paint Shop (M) - One location on the north corner of the Paint Shop (PA-M2) exceeded screening levels for THP diesel and motor oil and copper in the surface sample. Two delineation locations will be drilled to a depth of 10 feet and will be analyzed for metals, TPH, VOCs and SVOCs. The area to the north of this location is bounded by a small topographical

bench, less than three feet in height, and the area immediately north of the bench is the Upper Truck Sludge Pond (BBB) which is discussed in Area 11. Therefore, no samples are proposed in this direction.

Lead Shop (O) - One location near the south corner of the Lead Shop (PA-O2) exceeded screening levels for lead. Three delineation locations will be drilled to a depth of 10 feet and analyzed for metals.

Primary Crusher (CC) - One location near the Primary Crusher (PA-CC2) exceeded screening levels for arsenic and TPH motor oil at 10 feet bgs. Four additional locations will be drilled around this location to delineate to a depth of 15 feet and will be analyzed for metals, TPH, VOCs and SVOCs.

The proposed sample locations, depths and analytical parameters for Area 2 are summarized in Table 6-12 and shown in Figure 6-8.

Table 6-12. Area 2 Proposed Sample Locations and Analysis								
Original Location ID	Max Depth of Chemicals (ft bgs)	Planned Location ID	Proposed Depth (ft bgs)	Analytical Suite				
				Metals	Rad	TPH	VOC	SVOC
PA-C1	5	PA-C3	10		X	X	X	X
		PA-C4	10		X	X	X	X
PA-K4	2.5	PA-K16	10		X	X	X	X
		PA-K17	10		X	X	X	X
		PA-K18	10		X	X	X	X
PA-K5	2.5	PA-K13	10		X	X	X	X
		PA-K14	10		X	X	X	X
		PA-K15	10		X	X	X	X
PA-K8	2.5	PA-K11	10		X	X	X	X
		PA-K12	10		X	X	X	X
PA-K9	2.5	PA-K10	10		X	X	X	X
PA-L1	2.5	PA-L5	10		X	X	X	X
PA-L2	2.5	PA-L6	10		X	X	X	X
		PA-L7	10		X	X	X	X

Original Location ID	Max Depth of Chemicals (ft bgs)	Planned Location ID	Proposed Depth (ft bgs)	Analytical Suite				
				Metals	Rad	TPH	VOC	SVOC
PA-M2	2.5	PA-M4	10	X	X	X	X	X
		PA-M5	10	X	X	X	X	X
PA-O2	2.5	PA-O4	10	X	X			
		PA-O5	10	X	X			
		PA-O6	10	X	X			
PA-CC2	2.5	PA-CC3	10		X	X	X	X
		PA-CC4	10		X	X	X	X
		PA-CC5	10		X	X	X	X
		PA-CC6	10		X	X	X	X
PA-OO3	10	PA-OO5	15		X	X	X	X
		PA-OO6	15		X	X	X	X
		PA-OO7	15		X	X	X	X

Area 3 - One location in Area 3 exceeded screening levels:

Sulfide Ore Crusher and Stockpile (YY) - One location in the vicinity of the Sulfide Ore Crushing and Stockpiling area located at the northwest end of the Vat Leach Tanks (PA-YY2) exceeded preliminary screening levels for copper at the shallow depths. The boring for this sample drilled through 12 feet of crushed ore before encountering native soil. The collected soil samples started at 12 feet bgs to avoid collecting the crushed ore and are measured as if the contact with native soil is the actual land surface. Therefore the shallow and subsurface samples were actually collected at 12 to 14 feet bgs and 16.5 to 18 feet bgs. Three delineation locations will be drilled to a depth of 10 feet below the contact with native soil which is expected to be 10 to 15 feet below current topography. Samples will be analyzed for metals.

The proposed sample locations, depths and analytical parameters for Area 3 are summarized in Table 6-13 and shown in Figure 6-9.

Original Location ID	Max Depth of Chemicals (ft bgs)	Planned Location ID	Proposed Depth (ft bgs)	Analytical Suite				
				Metals	Rad	TPH	VOC	SVOC
PA-YY2	5 (measured at the start of native soil) 18 (actual)	PA-YY3	10 (23 actual)	x				
		PA-YY4	10 (23 actual)	x				
		PA-YY5	10 (23 actual)	x				

Area 4 – Twelve locations exceeded screening levels in Area 4 in the vicinity of the Solution Tanks and associated pumping station:

Solution Tanks (DD) – Nine sample locations around the Solution Tanks exceeded preliminary screening levels (PA-DD4, PA-DD5, PA-DD6, PA-DD7, PA-DD8, PA-DD9, PA-DD10, PA-DD11 and PA-DD13). Eight of these locations were surface grab samples collected at each corner of the Solution Tanks from a depth of 0.5 to 1 foot bgs and one location, PA-DD13, was a deep borehole drilled at the northwest end of the tanks. Only surface samples to a depth of 1 or 2.5 feet are impacted around these tanks. Most of the sample locations exceeded screening levels for one or more of the following metals: arsenic, copper, iron or thorium. Location PA-DD5 exceeded the screening level for radium-226, and all but one location, DD8, exceeded the screening level for TPH diesel and motor oil.

Because Area 4 has been identified as an area of elevated metal and radiochemical concentrations in the process solutions, it is proposed to analyze for metals and radiochemicals in all delineation samples regardless of the original sample. ARC recognizes that the original samples were surface grab samples and did not adequately characterize the subsurface. Samples will be collected to a depth of 10 feet and will be analyzed for metals, radiochemicals, TPH, VOCs and SVOCs.

Solution Tanks Pumphouse (FF) – Two locations on the southwest side of the pumphouse required further characterization (PA-FF2, FF3). Location FF2 exceeded for only TPH diesel and motor oil and FF3 exceeded for metals (arsenic, iron, thorium), radiochemicals (radium-226,

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-228) and TPH motor oil. Five additional locations will be drilled to a depth of 10 feet and analyzed for metals, radiochemicals, TPH, VOCs and SVOCs. Accessibility in this area is limited by an embankment to the southwest and numerous concrete structures and foundations. One additional sample location has been identified to evaluate a process feature not previously tested. One 20 foot deep borehole, PA-FF5, is proposed adjacent to Overflow Sump, a feature located on the southwest side of the Solution Tanks in which the process solution piping trench box likely collected leaked leach and wash solutions that were transferred between process tanks.

The proposed sample locations, depths and analytical parameters for Area 4 are summarized in Table 6-14 and shown in Figure 6-10.

Table 6-14. Area 4 Proposed Sample Locations and Analysis								
Original Location ID	Max Depth of Chemicals (ft bgs)	Planned Location ID	Proposed Depth (ft bgs)	Analytical Suite				
				Metals	Rad	TPH	VOC	SVOC
PA-DD4	1	PA-DD26	10	X	X	X	X	X
		PA-DD27	10	X	X	X	X	X
		PA-DD28	10	X	X	X	X	X
PA-DD5	1	PA-DD24	10	X	X	X	X	X
		PA-DD25	10	X	X	X	X	X
PA-DD6	1	PA-DD22	10	X	X	X	X	X
		PA-DD23	10	X	X	X	X	X
PA-DD7	1	PA-DD19	10	X	X	X	X	X
		PA-DD20	10	X	X	X	X	X
		PA-DD21	10	X	X	X	X	X
PA-DD8	1	PA-DD15	10	X	X			
		PA-DD16	10	X	X			
		PA-DD17	10	X	X			
PA-DD9	1	PA-FF9	10	X	X	X	X	X
PA-DD10 & PA-FF4	1	PA-DD32	10	X	X	X	X	X
		PA-DD33	10	X	X	X	X	X
PA-DD11	2.5	PA-DD29	10	X	X	X	X	X
		PA-DD30	10	X	X	X	X	X
		PA-DD31	10	X	X	X	X	X
PA-DD13	2.5	PA-DD18	10	X	X			
PA-FF2	2.5	PA-FF7	10	X	X	X	X	X
		PA-FF8	10	X	X	X	X	X
PA-FF3	5	PA-FF6	10	X	X	X	X	X
None		PA-FF5	20	X	X	X	X	X

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Area 5 – Eight locations in Area 5, the Precipitation Plant/Iron Launderers, exceeded screening levels in surface soils only (PA-EE1, PA-EE2, PA-EE4, PA-EE6, PA-EE8, PA-EE9, PA-EE11 and PA-EE17). Delineation sampling will be completed around the areas that exceed the screening criteria as well as around a few additional process components that were not previously sampled. Access is restricted on the northeast length of the plant due to a cement lined trench, approximately 20 feet wide and 8 to 10 feet deep and partially buried, and a concrete apron extending an additional 20 feet from the trench area. The concrete apron extends around the southeast side of the plant for a distance of approximately 120 feet.

All proposed samples will be collected from native soils off the concrete apron because this was an area where copper concentrate solids were handled on the northeast and southeast sides (i.e., process solutions with the potential to leach into soils were not present in this area). Access is restricted at the northwest corner in the location of sample PA-EE21 by concrete structures and piping between the pumphouse and re-circulation sump, preventing the collection of a delineation sample in this area. The proposed sample locations, depths and analytical parameters for Area 5 are summarized in Table 6-15 and shown in Figure 6-11.

Four new sampling locations have been identified to evaluate components where process solutions were handled including the Iron Launderers Pump House and the Vat Leach Dump Leach Re-circulation Sumps. All new locations will be analyzed for the full analyte suite and will be sampled to a depth of 10 feet except the locations next to the pump house, which will be sampled to a depth of 20 feet due to the depth of the basement area.

Original Location ID	Max Depth of Chemicals (ft bgs)	Planned Location ID	Proposed Depth (ft bgs)	Analytical Suite				
				Metals	Rad	TPH	VOC	SVOC
PA-EE1	1.5	PA-EE29	10	x	x			
		PA-EE30	10	x	x			
PA-EE2	1.5	PA-EE26	10	x	x	x	x	x
		PA-EE27	10	x	x	x	x	x
		PA-EE28	10	x	x	x	x	x

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Table 6-15. Area 5 Proposed Sample Locations and Analysis - Continued								
Original Location ID	Max Depth of Chemicals (ft bgs)	Planned Location ID	Proposed Depth (ft bgs)	Analytical Suite				
				Metals	Rad	TPH	VOC	SVOC
PA-EE4	1.5	PA-EE24	10	X	X			
		PA-EE25	10	X	X			
PA-EE6	1.5	PA-EE-22	10	X	X			
PA-EE8	1.5	PA-EE38	10	X	X	X	X	X
PA-EE9	2.5	PA-EE34	10	X	X	X	X	X
PA-EE11	2.5	PA-EE31	10	X	X			
		PA-EE32	10	X	X			
		PA-EE33	10	X	X			
PA-EE17	2.5	PA-EE35	10	X	X	X	X	X
		PA-EE36	10	X	X	X	X	X
		PA-EE37	10	X	X	X	X	X
None	NA	PA-EE21	20	X	X	X	X	X
None	NA	PA-EE23	20	X	X	X	X	X
None	NA	PA-EE39	10	X	X	X	X	X
None	NA	PA-EE40	20	X	X	X	X	X

Area 6 – The Sulfide Concentrator only had one initial sample that exceeded a preliminary screening level (PA-HH6). Therefore, delineation samples will be collected only around this one location. This sample was collected underneath the concrete floor slab of the area presumed to be the aeration/frother section of the floatation plant and exceeded screening levels for an SVOC compound in the shallow soils under the floor. Additional subsurface metal and concrete structures were also encountered in this bore hole at a depth of 8 feet bgs. Two delineation samples will be collected around this location to a depth of 10 feet and analyzed for TPH, VOCs and SVOCs. Access is significantly limited in this area due to the remnant concrete foundations and structures, therefore delineation samples will only be collected to the north of the primary sample.

The proposed sample locations, depths and analytical parameters for Area 6 are summarized in Table 6-16 and shown in Figure 6-12.

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Original Location ID	Max Depth of Chemicals (ft bgs)	Planned Location ID	Proposed Depth (ft bgs)	Analytical Suite				
				Metals	Rad	TPH	VOC	SVOC
PA-HH6	2.5	PA-HH14	10			X	X	X
		PA-HH15	10			X	X	X

Area 7 – Area 7 is the Calcine Ditch, which was sampled at 200-foot intervals along its accessible length and all but one sample exceeded preliminary screening levels. ARC assumes that intermediate samples along its length will yield results with similar chemical concentrations as seen from the previous soils investigations. Because of the proximity of the VLT pile on its north side, there is limited or no access to collect delineation samples in that direction. Therefore, delineation sampling is proposed to determine the width of impacted soils laterally from the ditch on its southeast side, with the assumption that similar results would result from sampling along its northwest margin. The proposed sample locations, depths and analytical parameters for Area 7 are summarized in Table 6-17 and shown in Figure 6-13.

Original Location ID	Max Depth of Chemicals (ft bgs)	Planned Location ID	Proposed Depth ^(a) (ft bgs)	Analytical Suite				
				Metals	Rad	TPH	VOC	SVOC
PA-WW1	10	PA-WW21	15	X	X			
PA-WW2	20	PA-WW20	25	X	X			
PA-WW3	20	PA-WW19	25	X	X			
PA-WW4	10	PA-WW18	15	X	X			
PA-WW5	20	PA-WW17	25	X	X			
PA-WW7	20	PA-WW16	25	X	X			
PA-WW8	20	PA-WW15	25	X	X			
PA-WW9	10	PA-WW14	15	X	X			
		PA-WW13	15	X	X			
PA-WW10	5	PA-WW12	10	X	X	X	X	X
		PA-WW11	10	X	X	X	X	X

Notes: ^(a) Proposed depth is based on elevation of original sample location; depth will need to be extended if proposed location is significantly higher than original location.

The depth of the lateral delineation samples is 25 feet bgs, as measured at the bottom of the ditch. Because of limited accessible width within the ditch itself, the proposed sample locations shown

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in Figure 6-13 will be drilled from the elevated roadway and the final drilled depth will be modified to account for the difference in elevation. Delineation sampling at the terminal ends of the ditch is not feasible because the south end is buried under a heap leach pile and the north end is at the point where the ditch enters the evaporation pond. This area will be evaluated in a separate RI Work Plan for the Evaporation Ponds and Sulfide Tailings OU.

Area 8 – This area consists of the Overflow Ditch (approximate 1,000-foot length), previously identified as the North Solution Ditch. Review of historical photos connects this ditch around the west and southwest sides of the Solution Tanks Pumphouse to the Overflow Sump. The type of solution that was conveyed in the Overflow Ditch is uncertain, but it is likely to have been a process waste or spent solution. Of the original samples collected along the exposed portion of this ditch, four locations exceeded screening levels for metals (arsenic and iron) and two of those four exceeded screening levels for TPH. Delineation samples will be collected around the locations that exceeded, primarily to identify lateral extent of impact from the ditch. An additional four locations have been added to the southwestern end of the ditch which was not previously sampled and is no longer visible as a surface feature. Because the exact location of the ditch is not identifiable on the surface, two samples are proposed side-by-side at a distance of 20 feet from each other. Proposed sample locations, depths and analytical parameters for Area 8 are listed in Table 6-18 and shown in Figure 6-14.

Table 6-18. Area 8 Proposed Sample Locations and Analysis								
Original Location ID	Max Depth of Chemicals (ft bgs)	Planned Location ID	Proposed Depth (ft bgs)	Analytical Suite				
				Metals	Rad	TPH	VOC	SVOC
PA-FFF1	2.5	PA-FFF22	10	x		x	x	x
PA-FFF8	2.5	PA-FFF21	10	x		x	x	x
PA-FFF16 PA-FFF17	25	PA-FFF20	25	x				
		PA-FFF19	25	x				
None	NA	PA-FFF23	10	x				
None	NA	PA-FFF24	10	x				
None	NA	PA-FFF25	10	x				
None	NA	PA-FFF26	10	x				

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Area 9 – Historic photos show a visible ditch traveling from a drain outflow area along the front of the sulfide tailings embankment and exiting through a culvert underneath the mine road towards the evaporation ponds. Most of this ditch is still visible today, and was sampled along approximately 1,200 feet of the total 1,800-foot length. Thirteen of the twenty-one sample locations exceeded screening levels for metals (arsenic, iron and thallium), radiochemicals (thorium, uranium and radium-226/-228) and TPH. Two locations on the southern end also exceeded screening levels for pesticides.

In general, along the central and southern portions of the ditch, the center samples exceeded preliminary screening levels to a depth of 10 feet bgs, and the peripheral samples did not exceed screening levels. No delineation samples are proposed around these peripheral locations because they adequately define the lateral extent of contamination away from the ditch. Additional samples are only proposed in areas where no previous samples were collected, such as the northern portion of the ditch. Based on the observed ditch geometry, solutions would have had greater potential to have leached into adjacent soils laterally from the central axis in the northern of the ditch (i.e., the occurrence of low areas where the ditch traveled through a culvert and ponding was likely). Four additional locations are proposed to characterize the northern portion of this ditch before it crosses under the haul road and intersects the Calcine Ditch. Proposed delineation sample locations are shown in Table 6-19 and Figure 6-15.

Original Location ID	Max Depth of Chemicals (ft bgs)	Planned Location ID	Proposed Depth (ft bgs)	Analytical Suite				
				Metals	Rad	TPH	VOC	SVOC
PA-EEE20	10	PA-EEE22	15	X	X	X	X	X
PA-EEE1	10	PA-EEE24	15	X	X	X	X	X
PA-EEE11	10	PA-EEE23	15	X	X	X	X	X
PA-EEE13	2.5	PA-EEE26	15	X	X	X	X	X
PA-EEE15	10	PA-EEE25	15	X	X	X	X	X
PA-EEE16	15	PA-EEE28	20	X	X	X	X	X
PA-EEE18	15	PA-EEE27	20	X	X	X	X	X
None	NA	PA-EEE29	20	X	X	X	X	X
None	NA	PA-EEE30	20	X	X	X	X	X
None	NA	PA-EEE31	20	X	X	X	X	X
None	NA	PA-EEE32	20	X	X	X	X	X

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Area 10 – Five sample locations exceeded preliminary screening levels in this area. Delineation sampling will be conducted around each of these areas:

BLM Low Area (HHH) – Sample locations in this area were laid out in a systematic grid since no obvious process components were identified. Three of the grid samples (PA-HHH1, PA-HHH8 and PA-HHH16) exceeded preliminary screening levels for arsenic and iron metals only. The metals in these soils were generally in shallow surface soils to 5 feet with the exception of PA-HHH8 which contained elevated metals to a depth of 20 feet bgs. The source of these metals at depth is uncertain. Delineation samples will be collected around each of locations. One additional location (PA-HHH-73) was added outside the southeast corner of the Surge Pond in area that was identified in EPA's July/August 2007 radiometric survey.

Concrete Ramps (II) – One sample located in the vicinity of small concrete pump or valve box exceeded screening levels for arsenic and copper. Four delineation samples will be located around this location and analyzed for metals.

Dump Leach Surge Pond (KK) – One sample location collected from the soils inside and underneath this pond feature exceeded screening levels for arsenic, thorium and radium-228. Two delineation samples will be collected around this location and a third sample will be collected in the northwest corner of the pond in an area identified with radiometric levels exceeding background by the EPA survey. All samples will be analyzed for metals and radiochemicals.

Proposed delineation sample locations are shown in Table 6-20 and Figure 6-16.

Table 6-20. Area 10 Proposed Sample Locations and Analysis								
Original Location ID	Max Depth of Chemicals (ft bgs)	Planned Location ID	Proposed Depth (ft bgs)	Analytical Suite				
				Metals	Rad	TPH	VOC	SVOC
PA-HHH1	2.5	PA-HHH39	10	X				
		PA-HHH40	10	X				
		PA-HHH41	10	X				
		PA-HHH42	10	X				
PA-HHH8	20	PA-HHH44	25	X				
		PA-HHH45	25	X				
		PA-HHH46	25	X				
		PA-HHH47	25	X				
PA-HHH16	5	PA-HHH48	10	X	X			
		PA-HHH49	10	X	X			
		PA-HHH50	10	X	X			
		PA-HHH51	10	X	X			
PA-II3	2.5	PA-II4	10	X				
		PA-II5	10	X				
		PA-II6	10	X				
		PA-II7	10	X				
PA-KK3	15	PA-KK4	20	X	X			
		PA-KK5	20	X	X			
None	NA	PA-KK6	20	X	X			
None	NA	PA-HHH43	10	X	X			

Area 11 – Eleven sample locations in Area 11 exceeded preliminary screening levels:

Lower Truck Sludge Pond (CCC) – The two angle boreholes that were drilled underneath the pond area exceeded preliminary screening levels for metals (arsenic, iron, thorium and uranium), TPH (gasoline, diesel and motor oil) and three VOC compounds. Two delineation sample locations will be drilled stepping out to the northwest, away from the pond area, and will be drilled in a vertical orientation.

Truck Sludge Pond Ditch (DDD) – One sample location along the ditch alignment exceeded screening levels for TPH-mo. Two delineation sample locations will step-out from this location towards the south and west. Access to the north and east is restricted by an embankment.

BLM Low Area (HHH) – Delineation samples will be collected from seven of the eight sample locations in the sampling grid that exceeded preliminary screening levels for metals, including

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arsenic and copper, and TPH. Location PA-HHH36 exceeded screening levels for pesticides at a depth of 10 feet bgs but exceed by only a very small margin. Initial evaluation of pesticide results, as discussed in Section 3.4.3, found a very small percentage of detection above screening levels and eliminated it as a potential concern at the Site and nearby sample locations detected no presence of pesticides. Therefore no delineation samples are proposed around this location. One additional location was added (PA-HHH72) in the vicinity of elevated radiometric readings measured by EPA during the July-August 2007 survey.

Proposed delineation sample locations are shown in Table 6-21 and Figure 6-17.

Original Location ID	Max Depth of Chemicals (ft bgs)	Planned Location ID	Proposed Depth (ft bgs)	Analytical Suite				
				Metals	Rad	TPH	VOC	SVOC
CCC4	25	PA-CCC5	25			x	x	x
CCC2	20	PA-CCC6	25	x		x	x	x
DDD3	2.5	PA-DDD4	10			x	x	x
		PA-DDD5	10			x	x	x
HHH19	5	PA-HHH53	10			x	x	x
		PA-HHH54	10			x	x	x
		PA-HHH55	10			x	x	x
		PA-HHH56	10			x	x	x
HHH21	5	PA-HHH61	10	x		x	x	x
HHH23	2.5	PA-HHH62	10			x	x	x
HHH25	2.5	PA-HHH57	10	x		x	x	x
		PA-HHH58	10	x		x	x	x
		PA-HHH59	10	x		x	x	x
		PA-HHH60	10	x		x	x	x
HHH27	2.5	PA-HHH63	10			x	x	x
		PA-HHH64	10			x	x	x
		PA-HHH65	10			x	x	x
HHH33	10	PA-HHH66	15			x	x	x
		PA-HHH67	15			x	x	x
		PA-HHH68	15			x	x	x
HHH34	25	PA-HHH69	25	x				
		PA-HHH70	25	x				
		PA-HHH71	25	x				
None	NA	PA-HHH52	10	x	x	x	x	x

This is a draft report and is not intended to be a final representation of the work done or recommendations made by Brown and Caldwell. It should not be relied upon, please consult the final report.

Area 12 – Nine Sample locations in Area 12 exceeded preliminary screening levels, as described below:

Arimetco Acid Tanks (PP) – Three locations exceeded screening levels for arsenic. These sample locations are at the top of the Vat Leach Tails material where Arimetco had established acid tanks and pumps. The material sampled was leached oxide ore and did not contain any native soil. The arsenic in the original sample is likely to be common to much of the VLT material, therefore delineation sampling around these points will do little to determine the extent of arsenic contamination in this area. No delineation samples are proposed for this location.

Crusher (UU) – Two sample location exceeded screening levels for copper in the vicinity of the crusher area. The copper in the original samples is likely to be related to the crushed ore material, therefore delineation sampling around these points will do little to determine the extent of copper contamination in this area. No delineation samples are recommended for this location.

Tailings Pumphouse (VV) – Two samples collected adjacent to the Tailings Pumphouse exceeded screening levels for metals (arsenic and copper), radium-226, and TPH motor oil. Five delineation samples will be collected around these locations and will be analyzed for metals, radiochemicals, TPH, VOCs and SVOCs.

Surface Pumps (ZZ) – One sample location exceeded screening levels for arsenic. Two delineation sample will be collected in this area and will be analyzed for metals.

Concrete Pump Tanks (AAA) – One sample located adjacent to the pump tank exceeded screening levels for arsenic. Three delineation sample locations will be drilled to a depth of 20 feet and analyzed for metals.

Proposed delineation sample locations are shown in Table 6-22 and Figures 6-18, 6-19 and 6-20.

Original Location ID	Max Depth of Chemicals (ft bgs)	Planned Location ID	Proposed Depth (ft bgs)	Analytical Suite				
				Metals	Rad	TPH	VOC	SVOC
VV1	10	PA-VV6	15	x	X	x	x	x
		PA-VV7	15	x	X	x	x	x
VV2	20	PA-VV4	25	x	X	x	x	x
		PA-VV5	25	x	X	x	x	x
		PA-VV8	25	x	X	x	x	x
ZZ1	10	PA-ZZ2	15	x				
		PA-ZZ3	15	x				
AAA1	15	PA-AAA2	20	x				
		PA-AAA3	20	x				
		PA-AAA4	20	x				

6.6.7 Pipeline and Conveyance Feature Sample Locations and Rationale

Additional sample locations have been identified to further delineate chemicals in soils that may be associated with solution conveyance features such as pipelines and ditches. Targeted locations are based on: 1) previous sample results associated with identified pipeline or conveyance features that exceeded preliminary screening levels; and 2) newly identified or previously un-sampled features.

Delineation sampling along pipelines is proposed only along the linear direction of the pipeline at distances of 200 feet or less from the original sample location that exceeded preliminary screening levels. Samples will be collected by backhoe excavation, similar to the collection method used during the original soils investigation.

Because some uncertainty remains as to the accuracy of the locations of the conveyance features, ARC proposes to use a backhoe to locate the target pipeline and determine the depth at the planned sample location. When piping is encountered, the backhoe will trench along the length of the pipe until a joint or seam is encountered, and a sample will be collected 6 to 12 inches below the pipe. In the case of surface piping and surface ditches, samples will be collected from surface soils (0 to 2 feet bgs) and subsurface soils (4 to 5 feet bgs).

Additional samples are proposed in the areas listed below that have been identified since the 2004-2005 investigation:

- UT-A/E/H: Trench box for the main pipeline between the Leach Tanks, Solution Tanks and Precipitation Plant.
- UT-B: Surface pipeline conveying pregnant dump leach solution to Precipitation Plant

Sample locations have been identified for the following conveyance features, and the rationale for the locations is provided below. Table 6-23 lists the planned samples for each conveyance feature. Each sample will be analyzed for the analytes listed in Table 6-6. Identified conveyance features have been subdivided into the following categories, locations of which are provided in Figures 6-21 through 6-26:

- Pregnant solution
- Spent solution
- Acid
- Fuel
- Drains
- Sewer

Pregnant Solution – Pregnant solutions are solutions that are expected to contain high concentrations of metals as the result of leaching of the ore material. Figure 6-21 shows the locations of the described conveyance features and sample locations.

Leach Vat Pregnant Process Solution (UT-A) – Two sample locations are proposed along this pipeline feature, which consists of a concrete ditch and tunnel with pipelines. The concrete structures served as containment for any spills from the pipeline which would have minimized potential impacts to the underlying soils. But because this was a main conveyance feature for pregnant and spent process solutions, two samples will be collected from soils adjacent to the concrete structure. These samples will also evaluate the other pipelines that are located in this area including the Precipitation Plant Spent Solution (UT-E) and Sulfuric Acid (UT-H).

Dump Leach Pregnant Solution (UT-B) – The underground portion of this pipeline was previously identified and sampled, with one sample that exceeded preliminary screening levels. One delineation sample is proposed along this underground portion approximately 75 feet east of this sample. A second sample is also proposed along this pipeline in the section southwest of the Pumphouse where the pipeline bends slightly. The aboveground portion of this pipeline was not adequately evaluated but one sample location collected in the vicinity of the pipeline did exceed screening levels for copper and TPH. Nine new samples are proposed along the 3,000 foot section that crosses the Process Areas. Much of the pipeline has been removed but remnants are still visible and the location is fairly well known. Samples will be collected at a spacing of 200 feet and at depths from 0 to 2 feet bgs and 4 to 5 feet bgs.

Sulfide Concentrate Slurry (UT-C) – This pipeline is has either been removed or is inaccessible, and no soil samples are proposed.

Spent Solution - Spent solutions may also contain high concentrations of select metals or other compounds, such as residual acid or other sulfates, but should be relatively depleted of copper following recover of copper product in the plant. Spent solutions generally refer to waste process solutions that are disposed to the on-site ponds. Figure 6-22 shows the locations of the described conveyance features and sample locations.

Precipitation Plant Spent Solution to Pond (UT-D) – Several samples along this feature exceeded preliminary screening levels, including three samples along the underground portion in the vicinity of the Recirculation Sump which exceeded screening levels for metals and two samples collected in an open ditch section of the feature which exceeded screening levels for metals and radiochemicals. One delineation sample is proposed along the underground section located on the north end of the ditch area. One additional sample is proposed along the underground portion northeast of the Precipitation Plant, and two samples are proposed along the underground portion that runs alongside the southwest side of the Precipitation Plant.

Precipitation Plant Spent Solution to Acid Plant (UT-E) – This feature will be evaluated by the samples listed in UT-A.

Sulfide Tails Slurry (UT-F) – One sample located at the point where the underground pipeline exits the ground to become a surface pipeline exceeded screening levels. One sample will be collected approximately 100 feet upstream from the original sample location point along the underground pipeline (avoiding a potential intersection with the UT-D feature at 75 feet), and one sample will be collected 75 feet downstream in the vicinity of the remnants of the above-ground pipeline. The above-ground section of this pipeline was located on top of a causeway constructed from VLT materials, and the proposed sample will be collected from the native soil.

Acid - Acid solutions refer to concentrated or dilute sulfuric acid produced in the Acid Plant and transferred to processing areas where acid was used for ore leaching, such as the Vat Leach Tanks or the Dump Leach. Figure 6-23 shows the locations of the described conveyance features and sample locations.

Strong Acid (UT-G) – This pipeline is no longer accessible and likely was removed prior to construction of the Phase III heap leach pad. No samples will be collected.

Sulfuric Acid to Dump Leach (UT-H) – This pipeline likely carried a diluted sulfuric acid solution to the Dump Leach piles located on the south side of Burch Drive. One sample collected along the underground portion of this pipeline exceeded screening levels for copper, likely caused by nearby processing activities rather than leaks from the pipeline. One additional sample will be collected along the underground portion of this pipeline, approximately 100 feet from a sample that exceeded screening levels, to fill a gap of greater than 200 feet between previous samples. The above-ground portion will be evaluated with the samples listed in UT-B.

Acid Line (UT-I) – This pipeline is shallow and exposed on the surface. The origin and destination of this pipeline is unknown because only a short portion is shown on Anaconda’s Site map. Four surface samples will be collected around the original sample that exceeded screening levels, 20 feet in each direction.

Fuel – Fuel pipelines are very limited at the Site but were used in the Process Areas to distribute fuel from storage tanks to fuel pumps. Figure 6-24 shows the locations of the described conveyance features and sample locations.

Fuel Distribution Pipeline (UT-J) – Two samples will be collected along this pipeline. These samples may be superseded by other UST investigation samples or removal actions.

Drains – Drains are the somewhat undefined category of conveyance features that were used for the transfer of relatively small quantities of solutions that were not directly related to process solutions. Drains occur as pipelines and ditches and were typically gravity drained from a higher elevation to a lower elevation and allowed to run off as un-reclaimed waste. Figure 6-25 shows the locations of the described drains and sample locations.

Truck Wash Sump Drain (UT-K) – This drain line was evaluated by borehole sample PA-C1 which was collected at the point where the drain line exits the sump box. The length of the drain line is short enough to preclude the need for additional sampling.

Grease Pit Drain (UT-L) – One sample location will be collected from a location approximately 100 feet from the sample that exceeded preliminary screening levels. Previous soil investigations attempted to locate this line, east of the proposed sampling location, and were not successful.

Fuel Tank Sump Drain (UT-M) – This drain line has not previously been sampled but is thought to have been removed when the fuel tanks and containment area was removed. No sample is proposed.

Assay Lab Drain (UT-N) – One sample is proposed at the terminus of this drain line to attempt to locate the “dry well” feature identified on Site maps and to determine if the drain actually discharges into it.

Secondary Crusher Dust Slurry Drain (UT-O) – Several samples located along or near this underground pipeline exceeded preliminary screening levels for metals and hydrocarbons. Three additional delineation sample locations are proposed at this location.

Vat Leach Pumphouse Drain (UT-P) – The pumphouse building has been removed and the location of the drain line thought to come from the building is unknown. Historical documents indicate a drain line draining to a dry well in the vicinity of this building. No samples are proposed for this area.

Sulfide Pumphouse Overflow Ditch (UT-Q) – There is no surface expression of this ditch, which is likely to be located very close to the currently active Weed Heights sewer line. No samples are proposed for this feature because of the uncertainty of its location and the potential risk of damaging the sewer line.

Sewer – Sewer pipelines were used throughout the site to collect wastewater from bathrooms, sinks, and showers and transfer the waste to the sewage settling tank and storage ponds. Sewer pipelines are not expected to have carried process related solutions but unknown materials may have been poured down the drains. Figure 6-26 shows the locations of the described sewer pipelines and sample locations.

Administration Sewer Line (UT-R) – No samples exceeded screening levels along this section of sewer line and the section of pipe that is suspected to connect to the Primary Crusher is not accessible. Therefore, no samples are proposed.

Acid Plant Sewer Line (UT-S) – One sample collected in the vicinity of the Secondary Crusher exceeded screening levels for hydrocarbons. This sample was likely impacted by other nearby activities rather than reflecting contamination caused by the pipeline. No delineation samples are proposed along this section of sewer line.

Leach Plant Sewer Line (UT-T) – One sample collected near the Solution Tanks Pumphouse exceeded preliminary screening levels for hydrocarbons and was likely caused by maintenance on the electrical transformers located inside the adjacent building. To confirm this, one sample is proposed at a location approximately 100 feet from this location along this sewer line.

Main Sewer Line (UT-U) – Two samples collected in the vicinity of the Wash Pad (C) exceeded preliminary screening levels for hydrocarbons and were likely to have been impacted by nearby vehicle maintenance and washing activities and the Truck Sludge Pond area rather than solutions leaked from the sewer pipeline. One sample will be collected downstream from the original sample at the area where the pipeline is expected to turn northwest. The second original sample located at the north end of the pipeline, near the Sewage Solids Tank, exceeded the preliminary screening level for thorium. Therefore, two delineation samples will be collected along this line, one sample 75 feet upstream and one sample downstream from this second original sample location.

ARC attempted to locate a large section of this line along the Precipitation Plant with several backhoe excavations during the 2004-2005 investigation, but was not successful. Either the pipeline is buried deeper than the backhoe could reach or it is not located as drawn in Site piping diagrams. Therefore, no samples are proposed along this stretch.

Weed Heights Sewer line (UT-V) – No samples exceeded screening levels and none are proposed.

Table 6-23. Area UT Proposed Sample Locations and Analysis						
Conveyance Feature ID	Planned Location ID	Analytical Suite				
		Metals	Rad	TPH	VOC	SVOC
UT-A	PA-UT61	x	x	x	x	x
	PA-UT62	x	x	x	x	x
UT-B	PA-UT63	x	x	x	x	x
	PA-UT64	x	x	x	x	x
	PA-UT65	x	x	x	x	x
	PA-UT66	x	x	x	x	x
	PA-UT67	x	x	x	x	x
	PA-UT68	x	x	x	x	x
	PA-UT69	x	x	x	x	x
	PA-UT70	x	x	x	x	x
	PA-UT71	x	x	x	x	x
	PA-UT72	x	x	x	x	x
	PA-UT73	x	x	x	x	x
UT-D	PA-UT74	x	x	x	x	x
	PA-UT75	x	x	x	x	x
	PA-UT76	x	x	x	x	x
	PA-UT77	x	x	x	x	x
UT-F	PA-UT78	x	x	x	x	x
	PA-UT79	x	x	x	x	x
UT-H	PA-UT80	x	x	x	x	x
UT-I	PA-UT81	x	x	x	x	x
	PA-UT82	x	x	x	x	x
	PA-UT83	x	x	x	x	x
	PA-UT84	x	x	x	x	x
UT-J	PA-UT85	x	x	x	x	x
	PA-UT86	x	x	x	x	x
UT-L	PA-UT87	x	x	x	x	x
UT-N	PA-UT88	x	x	x	x	x
UT-O	PA-UT89	x	x	x	x	x
	PA-UT90	x	x	x	x	x
	PA-UT91	x	x	x	x	x
UT-T	PA-UT92	x	x	x	x	x
UT-U	PA-UT93	x	x	x	x	x
	PA-UT94	x	x	x	x	x
	PA-UT95	x	x	x	x	x

6.7 Phase 3 and 4 Activities

Phase 3 and 4 activities that may be conducted following Phase 2 activities are briefly described below. A more detailed description of the activities in these subsequent phases, if determined to be necessary by project decision-makers, would be provided as an addendum to this Work Plan or provided in an alternative format that is acceptable to EPA. Phase 3 activities will follow the

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groundwater and vadose zone investigations in Phase 1 and the soils investigation in Phase 2, and are tentatively scheduled for Q2 through Q3 2009. A detailed schedule for the Phase 3 activities would be established after the completion of Phase 2 activities.

Note that the first iteration of soil and groundwater investigation was conducted in 2004-2005, the second iteration investigations are proposed in this Process Areas RI Work Plan, and Phase 3 investigations represent a third iteration. Examples of activities in Phases 3-1 and 3-2 include additional delineation borings for the collection of soil samples at depth or groundwater grab samples, and the collection of additional depth-specific groundwater samples from additional monitor wells that may be installed (beyond those listed in Section 6.3). As stated previously, the start and duration of Phase 4 activities is uncertain. ARC anticipates that: 1) Phase 4 activities will be iterative in nature, and are initiated when a building is identified for renovation or demolition/removal; and 2) a Responsible Party will prepare a building-specific, detailed work plan separate from this document, as required.

SECTION 7.0

QUALITY ASSURANCE PLAN

The investigations proposed in this Process Areas RI Work Plan will be conducted pursuant to the revised site-wide project QAPP (ESI and Brown and Caldwell, 2007). The program incorporates the following items: standard operating procedures, equipment calibration and maintenance, field and laboratory QC samples, data validation, corrective action, and data completeness. The goal of the quality assurance program is to produce data sets that are consistent, have little bias, high precision and that meet the project goals. Quality assurance procedures will be implemented on field data collection and sampling as well as laboratory analytical methods. A review of data results will be completed by a quality assurance oversight contractor in order to determine whether the project data goals have been met and if any data must be qualified or rejected due to data quality issues. The QA/QC issues for this Process Areas RI Work Plan include:

- Sample identification, handling, and transport;
- Equipment decontamination;
- The use of quality control samples such as blanks and duplicates;
- Field documentation; and
- Data review.

7.1 Sample Identification and Handling

Each sample will be placed in clean, unused wide mouth glass jars or other sample container provided by the laboratories and will be labeled with the sample identification number. The labels will be filled out with a permanent marker and will include the following information:

- Sample identification
- Date and time of sample collection
- Sampler's initials
- Analyses requested

- Preservation method (if required)
- Project name

Each sample will be tracked according to its unique sample field identification number assigned when the sample is collected and recorded clearly in the field notebook. The field identification number will include:

- Sample location name (e.g., Process Areas = PA)
- Process component (e.g., Administration Building = A)
- Sample location number (e.g., 01)
- Sample interval (e.g., -1, -5, -10)

For example, the sample collected from the five foot interval from location number 5 near the Administration Building would be labeled PA-A5-5. All final sample locations and designations will be presented in a Data Summary Report. Upon collection, samples will be placed in a cooler and chain of custody, sample preservation and shipping procedures will be followed as defined in SOP-01 “Environmental Sample Handling” and SOP-02 “Sample Preservation” (Appendix A).

7.2 Equipment Decontamination

As needed, with the exception of disposable equipment, all sample collection equipment will be decontaminated between each sample, including samples collected from shallow and deep intervals at the same location. SOP-05 “Equipment Decontamination” in Appendix A provides detailed procedures on project implementation of equipment decontamination. In general, sampling equipment will be hand-washed with a solution of tap water and Alconox detergent, rinsed with distilled or tap water, rinsed with a weak nitric acid solution, and a final rinse in clean distilled water. After use, gloves and other disposable PPE will be containerized and handled as investigation derived waste.

7.3 Quality Control Samples

The QA objectives for the sample-handling portion of the field activities are to verify that sample collection, packaging and shipping are not introducing variables into the sampling chain that could provide any basis to question the validity of the analytical results. In order to fulfill these QA objectives, QC samples will be prepared and submitted. If the analysis of the QC sample indicates that variables were introduced into the sampling chain, then the samples shipped with the questionable QC sample will be evaluated for the possibility of cross-contamination in the field or breach of laboratory QC. All blanks and duplicate samples will be labeled in the same manner as regular samples, with no indication that they are QC samples and will be submitted for the complete suite of analytes as described in Table 2-2.

Field Duplicates – Field duplicates are used to check for sampling and analytical error, reproducibility, and homogeneity. Duplicate samples will be collected at a frequency of one per every 20 investigation samples and each sample from a duplicate set will have a unique sample identification. Duplicate samples will be collected by gathering twice the sample volume in a plastic ziplock bag or stainless steel bowl, blending the entire volume to homogenize the soil, and splitting the blended soil into separate containers for the original and the duplicate samples. Splitting of the sample will be completed by alternately spooning portions of the blended sample into the original and duplicate sample containers.

Equipment Rinse Blanks – Analyses of equipment rinse blanks are used to assess the efficiency of field equipment decontamination procedures in preventing cross-contamination between samples. Equipment rinse blanks will be collected at a frequency of one per 20 samples, and at least once each day samples are collected, by pouring laboratory grade de-ionized water over the reusable sampling equipment and collecting in a clean container.

Field Blanks – Field blanks are used to assess possible contamination of samples during the sample collection process due to airborne contaminants. Field blanks are collected by pouring

laboratory grade dionized water into a sample container under the same field conditions as the original sample was collected. They will be collected at a frequency of one per 20 samples.

Matrix Spike/Matrix Spike Duplicate (MS/MSD) Samples – MS/MSD samples are investigative samples to which known amounts of analytes are added in the lab before analysis. The recoveries for spiked compounds can be used to assess how accurate the analytical method is for the site-specific sample matrix. MS/MSD samples for soils typically do not require submitting additional sample volume but should be listed on the chain-of-custody form as required for that sample. One MS/MSD sample should be analyzed for every 20 samples submitted to the lab.

7.4 Field Documentation

Summary of field measurements and sampling activities will be recorded in a bound field logbook or log sheets, and entries must contain accurate and inclusive documentation of project activities as described in SOP-03 “Field Notes and Documentation”. Entries will be made using permanent waterproof ink, and erasures are not permitted. Errors will be single-lined out, should not be obscured, and initialed and dated. The person making the entries will sign at the end of each day’s entry, and a new page will be started for each day of sampling. The following entries will be made:

- General descriptions of weather conditions
- Location of each sampling point
- Date and time of sample collection
- The type of QC sample collected and the method of collection
- Field measurements made, including the date and time of measurements
- Calibration and/or checks of field instruments
- Reference to GPS and photographs
- Date and time of equipment decontamination
- Field observations and descriptions of problems encountered

Photographs will be taken at each sampling point including a general location photo and a close-up of the soil column. The photo location and number will be recorded on the field log sheets. The sample location coordinates will be recorded via GPS instruments at the time of sampling.

Soil lithologies will be logged at the time of sample collection using the Unified Soil Classification System Standard D 2487-92, developed by ASTM. Classification will include grain size, sorting, and plasticity among others and will be recorded on a separate log sheet. Observations of soil horizons or changes in soil characteristics as observed in the excavation will be recorded. SOP-12 "Soil and Rock Descriptions" further defines the characteristics to be described during soil logging.

7.5 QA/QC Review

Final data reported by the laboratories will undergo review by a QA oversight contractor under the direction of ARC. The purpose of analytical data verification/validation is to review data for completeness and confirm that requested methods and procedures were followed as required by this Work Plan and the QAPP. The outcome of the verification/validation process is to qualify data results that may be inaccurate due to data quality limitations (e.g., contaminated blanks, exceedance of sample holding times, or lab control standards ("LCS") outside acceptable limits). Data verification will be completed on eighty percent (80%) of all project samples and includes review of the following measures:

- Sample holding times,
- Accuracy (by evaluating MS/MSD and LCS recovery),
- Precision (by evaluating field and lab duplicate results),
- Blank contamination,
- Surrogate compound recoveries,
- Chain-of-custody, and
- Case narrative.

Level IV data validation will be completed on the remaining 20 percent (20%) of samples that, in addition to the verification review listed above, will include a review of all raw laboratory data and calculations such as:

- Initial and continuing instrument calibration logs,
- Interference check samples,
- Reporting limits and sample recovery summaries, and
- Sample preparation and analytical run logs,

Analytical results will be evaluated during the verification/validation review of data received from the laboratories, and will also include a completeness check to ensure that all data has been properly loaded into the database used for report generation. Data that fail to meet the QA objectives for the characterization of background materials associated with the Yerington Mine Site will be qualified as to usability and potential low or high bias. The review of analytical data will follow the basic guidance provided in the National Functional Guidelines for Data Review (<http://www.epa.gov/superfund/programs/clp/guidance.htm>), unless specified otherwise.

SECTION 8.0 DATA MANAGEMENT PLAN

Data generated during implementation of the Process Areas RI Work Plan will be managed in accordance with the Data Management Plan for the Yerington Mine Site (Brown and Caldwell, 2007). The DMP is meant to supplement the requirements and specifications stated in the field sampling and analysis plan (Section 4.0) and the QAPP. The DMP provides the processes and guidelines for sample tracking, storage, access, delivery, and reporting of new chemical analytical, geologic, biologic and spatial data generated by investigation operations. Additionally, the DMP addresses the management of historical data. Key data management objectives are identified and listed below.

- Provide data users with tools that allow simple and rapid access to stored data of various types;
- Provide methods of data entry and data loading with known accuracy and efficiency;
- Apply well-documented data validation modifications to the electronic database;
- Manage sample data using a unique sample identification number;
- Establish a sample inventory of new data and provide methods of sample inventory reconciliation;
- Store and provide sample-specific attributes, including location identifier, sample type, sample media, depth, date, and target study area;
- Provide reporting and delivery formats from a single database source to support data analysis, site characterization, risk assessment, modeling, and spatial analysis;
- Provide the ability to electronically compare results to project-specific reference or screening criteria; and
- Identify needs for incorporating historical data and establish a database of this information when possible; otherwise, establish a data inventory plan that identifies and catalogues historical data not suited for database entry.

All borehole locations will be surveyed for X, Y, and Z coordinates using a Trimball GeoXT handheld GPS unit with an accuracy of one meter or less. The GPS unit has an integrated

receiver that uses WAAS (Wide Area Augmentation System) correction messages to improve GPS accuracy. All survey coordinates will be entered into the sample database and were used to develop all GIS map data for surface and subsurface representations of sample results.

SECTION 9.0 HEALTH AND SAFETY

All field activities will be conducted in accordance with the revised Health and Safety Plan (“HASP”) for the Site (Brown and Caldwell 2007b). The HASP identifies, evaluates and prescribes control measures for health and safety hazards, including radiological hazards, and describes emergency response procedures for the Site. HASP implementation and compliance is the responsibility of Brown and Caldwell, with ARC taking an oversight and compliance assurance role. Copies of the HASP are located at the Site, in ARC’s La Palma, California office, and in Brown and Caldwell’s Carson City, Nevada office. The HASP includes:

- Safety and health risk or hazard analysis;
- Employee training requirements;
- Personal protective equipment (PPE);
- Medical surveillance;
- Site control measures (including dust control);
- Decontamination procedures; and
- Emergency response.

The HASP includes a section for Site characterization and analysis that would identify specific Site hazards and aid in determining appropriate control procedures. Required information for Site characterization and analysis includes:

- Description of the response activity or job tasks to be performed;
- Duration of the planned employee activity;
- Identified safety and health hazards; and
- Emergency response capabilities.

9.1 Training

All contractors will receive applicable training, as outlined in 29 CFR 1910.120(e) and as stated in the HASP. Site-specific training will be covered at the pre-entry briefing, with an initial Site tour and review of Site conditions and hazards. Records of pre-entry briefings will be maintained at the project site.

Elements to be covered in site-specific training include:

- persons responsible for site-safety,
- site-specific safety and health hazards,
- use of PPE,
- work practices,
- engineering controls,
- major tasks,
- decontamination procedures and emergency response.

Other required training, depending on the particular activity or level of involvement, includes Occupational Safety and Health Administration (“OSHA”) 40-hour Hazardous Waste and Emergency Operations (“HAZWOPER”) training and annual 8-hour refresher courses. Other training may include, but is not limited to, competent personnel training for excavations and confined space. Copies of Site personnel OSHA certificates will be maintained at the project site or in employee personnel records that are available on short notice for review.

9.2 Personal Protective Equipment

Minimum PPE requirements while performing the sampling task or other field activities outlines in this Work Plan include:

- Hard hat
- Safety glasses
- Steel-toe boots
- High-visibility clothing or reflective vest

- Long sleeve shirts
- Nitrile and/or leather work gloves (as needed)

Additional PPE may be required depending on the work task and may include, but is not limited to, respirators, goggles, chemical protective suits, fall protection or hearing protection.

9.3 Respiratory Protection

The use of respiratory protection may be required during select activities of this Work Plan such as ground disturbance in areas of contaminated soils where the workers may be exposed to contaminant concentrations that exceed the OSHA permissible exposure limits (“PEL”) in airborne dust. Other situations that may require respiratory protection include working in the Radiological Control Area or conducting asbestos surveys or removal actions.

Prior to the initiation of any intrusive field activity, the Site Safety Officer, Project Manager and field personnel will evaluate the potential risk of exposure based on previous soil sample data, process history (e.g. known chemical spills), or other known or suspected hazards. If a potential risk is identified, field personnel will be required to monitor respirable particulate concentrations during dust generating activities or conditions and will calculate the area specific action level. Should total dust concentration in the work area exceed the action level, then fit tested respirators will be required by all personnel working in or near the disturbance. The following formula will be used to determine the area specific action level:

$$\text{Action Level (mg/m}^3\text{)} = \text{OSHA PEL (mg/m}^3\text{)} / (\text{soil conc. (mg/kg)} * 10^{-6} * \text{SF} * \text{CF})$$

Where OSHA PEL is the 8-hour Time Weighted Average (“TWA”), Short-Term Exposure Level (“STEL”), or other OSHA defined action level, whichever is lower. The action level is measured as total dust particles recorded by a real-time field meter such as the DustTrak or MIE Miniram. The soil concentration is based on previous analytical results for specific contaminants. A safety factor of 2 is applied to ensure that actual exposures remain well below the OSHA PEL for a

given contaminant, and a correction factor of 2 is also applied to correct for the fact that the real-time meter is not able to read all of the particulates but typically only reads PM10 sized particles. For example, the action level for arsenic in an area where soil concentrations are 300 mg/kg is 0.033 mg/m³ based on the following calculation:

$$\begin{aligned}\text{Action Level} &= \frac{0.01 \text{ mg/m}^3}{0.03 \%} \times \frac{1}{10} \\ &= 0.33 \text{ mg/m}^3 \times 0.1 \\ &= 0.033 \text{ mg/m}^3\end{aligned}$$

Additional quantitative sampling may be done using personal air sampling pumps worn by an individual in their breathing zone to determine actual exposure levels and respiratory requirements. The HASP should be consulted for guidance on selecting an appropriate respirator and other requirements as well as a listing of OSHA PEL levels for contaminants that may be encountered at the project site.

9.4 Radiation Safety

Field personnel working in the Process Areas for at least 30 days within a 90 day period, or if they must work around an area of elevated radiometric readings (i.e., the Radiological Control Area) for any duration of time, must wear a personal monitoring device such as an optically stimulated luminescent dosimeter (“OSL”). The OSL must be worn at all times while working in the Process Areas and will be stored in a non-impacted area, such as the Weed Heights office, during non-work hours. OSL badges will be submitted for laboratory analysis either monthly or quarterly. In addition to the OSL monitoring, all work areas will be monitored for gamma radiation levels using a uR meter or a Geiger-Muller meter. The gamma activity level will be recorded in the field notes and areas that exceed the RCA action level of 200 microrentgens per hour (uR/hr) will not be entered without the supervision of a radiation health physicist.

Work activities conducted within an RCA will establish restricted work zones (e.g. exclusion zone, contaminant reduction zone, and support zone) as specified in Section 7.0 of the HASP in

order to control the spread of contamination outside of the work area. Decontamination and testing procedures as specified in Section 8.0 of the HASP will be followed for all equipment and personnel who have entered the RCA.

9.5 Ground Disturbance Safety Requirements

All drilling, excavation or other activities that result in ground disturbance must be evaluated for potential buried utilities that could interfere or create a safety hazard. Utility Service Alert (USA North) is the public underground utility location service for northern Nevada, but does not provide locating services for privately owned utilities such as on the mine site. A private locating service should be used to physically survey the planned work area in order to identify buried utilities that may not be registered with the public service.

9.6 Job Safety Analysis

Job Safety Analysis (“JSA”) is a tool that is used to identify the hazards associated with all aspects of a specific task and to then identify the preventive actions that can be implemented to minimize the hazards. Control of the hazards can be accomplished by a) elimination of the task, b) use of engineering controls to reduce exposure to the hazard, or c) use of PPE to protect personnel from injury.

Comprehensive JSAs will be completed for all field tasks required in this Work Plan before the work is initiated and will be developed jointly by the field staff conducting the work and the Site Safety Officer. All field staff and sub-contractors will review the JSA prior to conducting the work and frequently throughout the task in order to identify new hazards or controls. Task-specific JSAs will be kept on-site at all times. A general summary of the potential hazards for the tasks listed in Section 4.0, Field Sampling and Analysis Plan, is provided in Table 7-1. Task specific JSAs for drilling, excavation and soil sampling are provided in Appendix L, and are subject to revision at any time before or during implementation of these field activities.

Table 9-1. Job Safety Analysis Summary	
Field Activities	Potential Hazards
1. Borehole drilling and lithologic logging	<ul style="list-style-type: none"> ▪ Drilling into underground utilities. ▪ Striking overhead lines or objects with drill mast. ▪ Injury to hearing from noise. ▪ Inhalation hazards from dust from drilling activities. ▪ Physical injury from moving parts of machinery, hydraulic fluids, handling drill pipe. ▪ Physical hazards to personnel on the ground in the vicinity of the heavy machinery ▪ Physical hazards associated with use of hand tools. ▪ Lifting and ergonomic hazard from handling soil cores.
2. Backhoe excavation	<ul style="list-style-type: none"> ▪ Pit wall collapse ▪ Underground Utilities
3. Monitor well installation and development	<ul style="list-style-type: none"> ▪ Inhalation of silica sand, bentonite, or concrete dust. ▪ Lifting and ergonomic hazard from handling heavy bags of sand, bentonite or concrete. ▪ Skin irritation from dermal or eye contact with purged groundwater. ▪ Slipping or falling on uneven or wet ground surface. ▪ Overhead hazard with pump truck mast and bailer
4. Soil Sampling	<ul style="list-style-type: none"> ▪ Radiation hazards in select areas ▪ Body positioning and lifting hazards
5. Groundwater sampling	<ul style="list-style-type: none"> ▪ Skin irritation from dermal or eye contact with groundwater. ▪ Slipping or falling on wet ground surface or drilling platform. ▪ Burn or corrosion from sample preservatives. ▪ Lifting and ergonomic hazards from lifting sample pump and sample cooler
6. Building evaluation and asbestos sampling	<ul style="list-style-type: none"> ▪ Inhalation hazards ▪ Unstable or damaged buildings; broken glass; unprotected fall hazards
7. General Activities	<ul style="list-style-type: none"> ▪ Heat stress due to high ambient temperature, improper clothing, lack of ventilation, lack of water, or lack of shade; or ▪ Hypothermia or frostbite due to low ambient temperature, improper clothing, damp or wet clothing, or lack of source for heat. ▪ Sunburn from lack of shade or improper clothing. ▪ Biological hazard from contact with spiders, insects or reptiles.
8. Unsafe conditions	<ul style="list-style-type: none"> ▪ Unexpected hazardous conditions such as wind, rain, snow, fire, earthquake, or other natural disaster can occur.

This is a draft report and is not intended to be a final representation of the work done or recommendations made by Brown and Caldwell. It should not be relied upon, please consult the final report.

SECTION 10.0 REPORTING

As specified in the SOW, a draft RI Report for the Process Areas will be prepared for EPA review that includes, but is not limited to: a description of the nature and extent of contamination, and physical and chemical properties of the OU, facility structures, investigation objectives, a description of the field investigations undertaken to meet the identified objectives, and an updated CSM. The draft RI Report will include a summary of all the data results, including original analytical reports (in electronic format), recommendations for additional phases of investigation where all the data gaps are not filled, and preliminary remedial action objectives (RAOs) and applicable, relevant and appropriate requirements (“ARARs”) for the remediation of the operable unit. The draft RI Report will present the results of any treatability studies conducted as part of the RI, as requested by EPA. If required the treatability study would include a description of the objectives, the parameters used to evaluate the success of the study, results and the conclusions of the treatability study. The draft RI Report will also contain the results of the HHRA.

Due to the phased approach for completing the extensive activities described in this Work Plan, the draft RI Report will be prepared in phases (e.g., draft Phase 1 RI Report). This reporting strategy will meet EPA’s desire to receive analytical results of field activities in a timely manner. Examples of the approaches and methods that will be used to evaluate the large amount of data anticipated to be summarized in the draft RI Report are provided below.

- Statistical evaluation of analytical results of background soil and groundwater samples and calculation of background concentrations of mine-related chemicals.
- Evaluation of radiometric survey data and comparison with soil analytical results.
- Evaluation of analytical results from soil samples taken from within the process areas will include visual inspection of tabulated data, preparation of graphs and figures (e.g., perspective views of subsurface analyte concentrations), and statistical analyses and charts (e.g., box plots, IVPs). Soil analytical results will be compared with background concentrations and preliminary soil screening levels.

- Evaluation of groundwater analytical data will include visual inspection of tabulated data, preparation of graphs and figures, statistical analyses (e.g., box plots, IVPs), water balance and groundwater flow calculations, and groundwater flow and geochemical modeling. Groundwater analytical results will be compared with background concentrations and MCLs.
- Geologic information will be compiled and used to develop maps, cross sections and other figures that illustrate the regional and local topography, geology, stratigraphy, structural geology, and depositional history of the alluvial groundwater flow systems in the study area.
- Lithologic information (material type, grain size, sorting, and degree of cementation), hydrogeologic information (water level measurements, hydraulic conductivity, porosity, and Darcy velocity) and geochemical information (chemical and isotopic compositions, apparent ages) will be used to classify and describe the saturated and unsaturated hydrogeologic units which may be part of the migration pathways, and make an interpretation of the degree of interconnections between saturated zones. Collectively, regional and local geologic and lithologic information will be used to assess structural geologic elements and construct hydrogeologic cross sections and fence diagrams showing the extent (depth, thickness, lateral extent) of hydrogeologic units which may be part of the migration pathways, and the presence or absence of impermeable units or confining layers.
- Water level monitoring data obtained from groundwater monitor wells and/or piezometers will be used to develop groundwater potentiometric surface maps and hydrologic cross sections. The maps and cross sections will illustrate the vertical and horizontal components of groundwater flow, and seasonal or temporal changes in groundwater elevations or hydraulic gradients, and hydraulic relationships between the groundwater and surface water flows. In addition, water level monitoring data, surface water flows and other information will be used to evaluate anthropogenic influences that may affect the hydrogeology in the vicinity of the Site. Hydraulic test results will be presented and used to determine the average rate of groundwater flow in the alluvial aquifer(s) and the degree to which that flow rate varies spatially and/or temporally.
- Groundwater quality data from zonal samples and monitoring wells will be used to construct maps and or block diagrams that illustrate the three dimensional distribution of chemicals in alluvial groundwater and contaminant migration pathways. Data associated with the testing of aquifer solids will be used to evaluate potential geochemical processes that affect the release and/or attenuation of chemicals from/to aquifer solids (in particular, contaminant partitioning to various operationally-defined mineral fractions), and the mobility and transport of chemicals in groundwater.

SECTION 11.0
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