VOLUNTARY REMEDIATION PROGRAM (VRP)
INVESTIGATION WORK PLAN
FREEPORT-MCMORAN SIERRITA INC.
GREEN VALLEY, ARIZONA

VOLUME I OF II

TEXT, TABLES & FIGURES

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TABLE OF ACRONYMS

Acronym	Definition
µg/L	micrograms per liter
ADEQ	Arizona Department of Environmental Quality
AGP	Acid Generating Potential
ANP	Acid Neutralizing Potential
APP	Aquifer Protection Permit
ARCH	air rotary casing hammer
ARS	Arizona Revised Statutes
As	Arsenic
asl	above sea level
ASTM	American Society for Testing and Materials
AWQS	Aquifer Water Quality Standards
BADCT	Best Available Demonstrated Control Technology
bgs	below ground surface
CLEAR	Copper Leach Electrowinning and Regeneration
CME	Central Mine Equipment Company
COI	Constituents of Interest
Cu	Copper
DO	dissolved oxygen
DPT	direct pulse technology
DQO	data quality objective
ELMA	Errol L. Montgomery & Associates
EPA	U.S. Environmental Protection Agency
FCX	Freeport-McMoRan Copper & Gold Inc.
GPL	Groundwater Protection Level
gpm	gallons per minute
HDPE	high density polyethylene
ID	inner diameter
IDW	investigation derived waste
mg/Kg	milligrams per kilograms
mg/L	milligrams per liter
MO	Mitigation Order
MS/MD	Matrix Spike/Matrix Duplincate

Acronym	Definition
mV	millivolts
nr-SRL	non-residential Soil Remediation Level
NTU	nephelometric turbidity unit
NGVD	National Geodetic Vertical Datum
OD	outside diameter
ORP	oxygen reduction potential
PLS	Pregnant Leach Solution
POC	Point of Compliance
PPE	personal protective equipment
PVC	polyvinyl chloride
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
Ra	Radium
RBSL	Risk Based Screening Level
SOP	Standard Operating Procedure
SPLP	Synthetic Precipitation Leaching Procedure
SX	solution extraction
SX/EW	solution extraction/electrowinning
TDS	total dissolved solids
U	Uranium
U mass	measured mass concentration of uranium
URS	URS Corporation
USC	Upper Santa Cruz
USCS	Unified Soil Classification System
VOC	volatile organic compounds
VRP	Voluntary Remediation Program

1.0 INTRODUCTION

URS Corporation (URS) was retained by Freeport-McMoRan Sierrita Inc., (Sierrita), a business unit of Freeport-McMoRan Copper & Gold Inc. (FCX), to prepare a site characterization work plan for the Sierrita Mine located near Green Valley, Arizona. The site characterization is to be performed under the Arizona Department of Environmental Quality's (ADEQ) Voluntary Remediation Program (VRP). ADEQ's VRP program is defined by Arizona Revised Statutes Title 49, Sections 49-171 through 49-188.

On June 19, 2007, Sierrita submitted an application to enter into ADEQ's VRP program to evaluate certain operations and constituents that are not considered by other regulatory programs such as the Mitigation Order On Consent, Docket No. P-50-06, and the Sierrita area-wide Aquifer Protection Permit (APP) No. P-101679. Those operations include:

- Facilities that ceased operation and/or were closed prior to implementation of the Sierrita APP (historical operations).
- Selected operations exempt from regulation under the APP.
- Operations "to be closed" under the APP.
- Active operations with the potential to release mining related constituents to groundwater.

Additionally, uranium impacts to groundwater will be evaluated site-wide.

The primary objectives of this work plan are to:

1. Assess potential impacts to soil, groundwater, and sediment from past releases and historical Sierrita operations for constituents of interest (COIs). COIs will include uranium, radionuclides and other mining-related metals (aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, molybdenum, nickel, potassium, selenium, sodium, thallium, and zinc). The COI list for the VRP investigation was selected based on a review of the list of groundwater constituents currently monitored or regulated at Sierrita under its APP permit, historical groundwater quality data for the Sierrita Mine, and current and historical mining processes and operations. These constituents also naturally occur in soils, rock, and groundwater common to mineralized mining areas.

2. Assess potential impacts to sediment and groundwater for COIs at areas downgradient of active Sierrita operations.

3. Evaluate background uranium concentrations in groundwater through the installation of monitor wells at background locations in mineralized bedrock formations.
4. Refine the preliminary site conceptual model for uranium in groundwater with respect to sources and migration pathways, including consideration of background conditions.

The scope presented in this work plan is intended to be the first phase of the site characterization to be completed under the VRP. The primary focus of this phase of the work will be to assess potential releases from former areas of operation, and to develop a concise conceptual site model and background conditions for uranium in groundwater. Subsequent phases of work will include follow-up investigation of operations where releases to soil, sediment, or groundwater have been identified in the first phase of the characterization, and, if needed, a further refinement of the groundwater conceptual site model through additional groundwater monitor well installation and/or sampling.

For purposes of this work plan, the Sierrita property is divided into the following five geographically defined areas:

- Demetrie Wash which contains the historical operations Former CLEAR Plant, Former E Pond, Former Evaporation Pond, Old D Pond, Former Esperanza Mill, Former C Seepage Pond, Former C Seepage Spoils, and Former Raffinate Pond.
- Amargosa Wash which contains the historical operations Precipitation Plant and Launders Facility; Former A Pond and B Pond; and active operations Headwall No. 1, Bailey Lake, Raffinate Pond No. 2, and Amargosa Pond.
- Esperanza Wash which contains active operations Headwall No. 2, Channel No. 2, Headwall No. 3, Raffinate Pond No. 3, SX Plant No. 3, and Headwall No. 4 (SX-3 Stormwater Pond).
- Tinaja and Unnamed Wash which contains the historical operation Tinaja Pond, and the active operation Headwall No. 5.
- The Esperanza and Sierrita Tailing Impoundments which contain the historical operation Rhenium Ponds.

Section 2.0 of this work plan provides a description of Sierrita, including an overview of process operations, and a physical description of the site including topography, hydrology, geology, and hydrogeology. Section 3.0 provides a summary of the existing information for the proposed operations to be investigated, and a summary of the existing information pertaining to uranium in groundwater. Section 4.0 presents a sampling approach for operations to be investigated and for uranium in groundwater.

The proposed field activities are described in Section 5.0, a Community Involvement Plan is presented in Section 6.0, and references are listed in Section 7.0. The project-specific Quality Assurance Project Plan is provided in Appendix B.

2.0 FACILITY DESCRIPTION AND PHYSICAL SETTING

2.1 GENERAL FACILITY DESCRIPTION

Sierrita operates an open pit mine and mineral processing facilities that are located approximately 6 miles northwest of Green Valley, Arizona (**Figure 2-1**). Sierrita produces copper, molybdenum, and rhenium products. Copper and molybdenum sulfides are produced through conventional milling and froth flotation. Copper cathodes are produced through solution extraction/electrowinning (SX/EW). Copper sulfate is produced through solution extraction and crystallization. Molybdenum trioxide is produced through roasting. Rhenium is also produced as a byproduct of the molybdenum roasting operations.

Sierrita consists of three open pits, a 112,000 ton-per-day concentrator, two molybdenum roasters, a rhenium plant, an oxide and low-grade sulfide ore stockpile leaching operation, and a copper sulfate plant. **Figure 2-2** presents the mine and various operation areas. The current mine operations are described briefly in the following paragraphs.

Ore Excavation, Crushing, Milling, and Grinding – The ore excavation operations include exploration, drilling, blasting, haul truck loading, and placement of blasted material. Sulfide ore is transported to the primary crusher where the ore is initially reduced in size to less than 6 inches. This crushed or “coarse” ore is then transported to the Sierrita coarse ore stockpile via an overland conveyor system. The coarse ore is processed through secondary and tertiary crushing systems. The resulting minus 5/8-inch material is transferred by a conveyor belt system into the Sierrita fine ore bin where it is stored as feed into ball mills. The milling and grinding circuit is the final size reduction process; reducing the ore to sand-size particles.

Flotation – The final grind derived from the crushing and grinding process is advanced to primary flotation, which uses a mix of reagents to physically separate copper and molybdenum-bearing particles from the remaining rock particles, called tailing. The resulting tailing slurry is thickened through settling and gravity discharged to the Sierrita Tailing Impoundment. A second flotation process is then used to separate the molybdenum disulfide-bearing particles from the copper-bearing particles, producing a molybdenum disulfide concentrate and a copper concentrate. The copper concentrate is stored in a covered outdoor storage area for loading and shipment to a smelter. The molybdenum disulfide is upgraded and filtered to enable further refining in the Molybdenum Processing Plant.

Molybdenum Processing – The filtered molybdenum disulfide is transferred from the flotation process to the Molybdenum Processing Plant where it is dried and stored in bins for further processing, including leaching and roasting. The molybdenum disulfide contains some copper and lead sulfide residuals which are reduced by hydro-metallurgical process involving hot ferric chloride leaching. The liquid is then separated from the solids, followed by recovery of the dissolved copper as cement copper, and regeneration of the leach liquor through chlorination. The leached molybdenum disulfide is dried and stored in bins prior to roasting. Roasting occurs in two multi-hearth roasters to yield molybdenum trioxide. The roasted molybdenum trioxide is placed in storage bins and packaged.

Rhenium Recovery – The molybdenum roasting operations include a rhenium recovery circuit where off-gassed steam containing rhenium oxide is condensed, collected, concentrated, and pumped to an ion exchange process for refining and shipment.

Leaching – Low-grade oxide and sulfide ores are hauled by truck and placed onto leach stockpiles located immediately south of the Sierrita Pit. A solution of dilute sulfuric acid is applied to the leach stockpile by either drip emitters or sprinklers. The sulfuric acid is allowed to leach through the stockpiles. As the sulfuric acid comes into contact with the ore, it dissolves the acid-soluble copper producing a solution called pregnant leach solution (PLS). This PLS flows to the less porous bedrock surface and along the natural topography; eventually discharging into headwalls where the PLS is collected.

Solution Extraction/Electrowinning (SX/EW) Process – The PLS produced during leaching is processed by solution extraction (SX) to produce copper sulfate or SX/EW to produce copper cathode. In the SX process, an organic phase diluent, containing an extraction reagent is used to transfer the copper in PLS to electrolyte. The electrolyte is pumped to either the EW tank-house located on the Twin Buttes Mine property or the Copper Sulfate Plant. At the EW tank-house, electrolyte flows through cells containing a submerged array of cathode and anode plates. Electric current is applied to the conductive solution and metallic copper is plated on the cathode plates by reduction/oxidation reaction. At the Copper Sulfate Plant, electrolyte solution is chilled to precipitate copper sulfate pentahydrate crystals which are then collected, dried, and packaged.

In addition to the currently active operations, a variety of other historical operations have occurred over the past 50 years, including:

- Former Copper Leach Electrowinning and Regeneration (CLEAR) Plant, a historical process that leached copper using sodium hydroxide.
- Former Esperanza Mill, a former process mill
- Launders Facility, a former precipitation plant
- Former C, D, and E ponds, process solution and seepage ponds

- Evaporation Pond, a pond associated with the CLEAR Plant operations
- Former Raffinate Pond, used to contain copper depleted process solutions

2.2 REGULATORY HISTORY AND FRAMEWORK

Open pit mining operations began in the Esperanza Pit in 1959. The Esperanza mining and milling operations and associated tailing impoundment were operated by Duval Corporation from 1959 through 1971, and from 1973 through 1978. Mining operations in the Sierrita Pit began in 1970. Intermittent operation occurred from 1970 through 1982. Cyprus Minerals Company (Cyprus) acquired the property in 1986. In 1993 Cyprus Amax Minerals Company was created by the merger of Cyprus Minerals Company and Amax, Inc. Subsequently, the property was acquired by Phelps Dodge in 1999, and then Phelps Dodge Corporation was acquired by FCX in 2007.

Sierrita initially operated under a Notice of Disposal approved by ADEQ in 1985. In 1994 Cyprus submitted an Aquifer Protection Permit (APP) application. Addenda and revisions to the APP application were submitted to ADEQ in 1997, 1999, and 2005. The APP was issued by ADEQ and became effective on June 29, 2007.

Sierrita is subject to numerous environmental regulations and permits. This section presents a discussion of the relevant regulatory requirements applicable to the operations, and the relationship of those programs and permits to the work addressed under the VRP.

Relevant environmental regulatory programs include the following:

Aquifer Protection Permit No. P-101679

The APP application was initially submitted in 1994 by Cyprus Sierrita Corporation. The application, addendums, and supplements are as follows:

- April 7, 1989: *Hydrogeologic Report in Support of Groundwater Quality Protection Permit Application, Sierrita Operation, Cyprus Sierrita Corporation,* Errol L. Montgomery & Associates, Inc.
- July 9, 1991: *Supplemental Hydrogeologic Report in Support of Groundwater Quality Protection Permit Application, Sierrita Operation, Cyprus Sierrita Corporation*, Errol L. Montgomery & Associates, Inc.
- September 7, 1994: *Aquifer Protection Permit Application Sierrita Operation, Cyprus Sierrita Corporation*, Errol L. Montgomery & Associates, Inc.

- August 1997: *Best Available Demonstrated Control Technology (BADCT) Demonstration, Supplement to Cyprus Sierrita Mine APP Application,* TerraMatrix/Montgomery Watson.
- August 1999: *Supplement to Aquifer Protection Permit Application BADCT Demonstration*, Montgomery Watson.
- July 4, 2001: *Additional Characterization of Hydrogeologic Conditions, Aquifer Protection Permit Application No. 101679,* Errol L. Montgomery & Associates, Inc.
- March 2005: *Supplement to the Aquifer Protection Permit Application BADCT Demonstration Addendum,* MWH Americas, Inc.

The APP (Permit No. P-101679*)* was signed by ADEQ and became effective on June 29, 2007. The APP clearly defines the specific facilities that are subject to regulation under the APP program. Specific constituents are monitored at Points of Compliance (POC) for those facilities regulated under the APP. Constituents that are not required for analysis generally include those that do not have Aquifer Water Quality Standards (AWQS) such as aluminum, cobalt, copper, molybdenum, sulfate, magnesium, zinc, uranium, and uranium isotopes. Certain constituents that do not have numeric AWQS are required for monitoring under the APP as either indicator parameters or to ensure compliance with narrative AWQS. Additionally, several facilities have been determined as exempt from the APP including the Solid Waste Landfill, Tire Disposal Cells, Ferric Regeneration, SX Plant Tank Farms, and the Tinaja Pond. Other facilities have been included in the APP as "to be closed under compliance schedule and/or to cease operation without intent to resume activities." These facilities include A Pond, B Pond, Old D Pond, Rhenium Ponds, and Launders Facility. Many of the permitted facilities were constructed as unlined containment areas or impoundments prior to initiation of the APP process and have subsequently been upgraded as part of the Best Available Demonstrated Control Technology (BADCT) requirements.

Sulfate Mitigation Order, Docket No. P-50-06

On June 8, 2006, Sierrita entered into Mitigation Order (MO) on Consent Docket No. P-50-06. The MO requires Sierrita to summarize existing information regarding the characterization of the sulfate concentrations in groundwater downgradient of the Sierrita Tailing Impoundment, characterize the horizontal and vertical extent of the sulfate plume as defined by concentrations in excess of 250 milligrams per liter (mg/L), evaluate the fate and transport of sulfate in groundwater, inventory existing registered private wells used as a drinking water source or public drinking water systems wells located within 1 mile of the sulfate plume, and identify and evaluate alternatives that practically and cost effectively meet the applicable water quality standard for sulfate (i.e., 250 mg/L) at the point of groundwater use for drinking water.

The MO is discussed in this work plan because the site characterization results and ongoing groundwater monitoring being conducted under the mitigation order could provide support to the VRP investigation.

2.3 PHYSICAL SETTING

2.3.1 Climate

Climate in the Sierrita area is typical of the arid southwestern desert. Average temperatures range from average summer highs in July of 101.1 degrees Fahrenheit to average winter lows in December of 40 degrees Fahrenheit (Western Regional Climate Center, 2003). According to the National Oceanic and Atmospheric Administration (NOAA, 2003) Tucson area has an annual average of 193 clear, sunny days.

Monthly average pan evaporation rates range from 3.25 inches in January to 14.9 inches in June (WRCC, 2005). The average annual precipitation for the Tucson basin is 12.80 inches. Meteorological data recorder at Sierrita in 2006 recorded total precipitation of 17.36 inches with 10.21 inches recorded during the months of July, August, and September. More than one third of the annual precipitation occurs during the months of July and August when moisture-bearing winds move into Arizona from the Gulf of Mexico. Summer rains occur in the form of thunderstorms, which can produce short, intense downpours, strong winds, and flash floods. Winter storm systems typically originate in the Pacific Ocean and occur between November and March.

Wind data recorded by Sierrita, between 2002 and 2006, show that winds are predominately from the west and southwest with wind speeds ranging from 4 to 19 miles per hour.

2.3.2 Hydrology

The surface water regime of the Sierrita mine is divided into 4 major drainage basins, each associated with one of the 4 major washes that drain the mine site: Demetrie, Amargosa, Esperanza, and Tinaja washes (**Figure 2-2**). Demetrie Wash trends south-southeast from the northeastern portion of the mill area, Amargosa Wash trends east from the leach stockpiles, Esperanza Wash trends southeast from the leach stockpiles, and Tinaja Wash trends southeast from the Sierrita Mountains across the southwest corner of the mine to the confluence of

Esperanza Wash. Three of these washes (Amargosa, Esperanza, Tinaja) discharge into Demetrie Wash which itself is an ephemeral tributary to the Santa Cruz River.

Demetrie Wash is an ephemeral wash originating in the Sierrita Mountains west-northwest of Sierrita. The wash flows along the northern boundary of the mine and turns south near the northeastern portion of the Sierrita mill area. Demetrie Wash then flows south along the eastern side of the mill area and trends south-southeast along the southwestern edge of the Sierrita Tailing Impoundment towards the Santa Cruz River. The elevation of Demetrie Wash ranges from 3,700 feet above sea level (asl) at the northeast corner of the mill area to 3,200 feet asl at the southwest corner of the Sierrita Tailing Impoundment. The average gradient of Demetrie Wash over this segment is approximately 116 feet per mile.

Historically, Demetrie Wash received all runoff from the mill area and Amargosa Wash. However, with the construction of Duval Canal Extension, a majority of the surface water runoff is captured by this extension, then diverted into Duval Canal and ultimately to the Sierrita Tailing Impoundment. Duval Canal existed as an unlined channel extending from B Pond into the tailing until 1992. Between 1992 and 1994 upgrades were made to the Duval Canal including lining and extending the channel upstream to the mill area. Sierrita is currently constructing a lined pond to capture Duval Canal discharges before they reach the Sierrita Tailing Impoundment.

Amargosa Wash is an ephemeral wash currently originating at the base of the leach stockpiles near Headwall No. 1. The Amargosa watershed flows approximately 6,000 feet east along a narrow corridor to its confluence with Demetrie Wash. A narrow, steeply sloping ridge flanks the wash to the south with more gently sloping terrain to the north. Approximately 17 to 20 feet of alluvium fills the wash throughout its length. The bedrock surface is deepest in the center of the wash and becomes more shallow to the north and south.

Esperanza Wash is an ephemeral wash currently originating at the base of the leach stockpiles near Headwall No. 3. The wash flows approximately 6 miles south-southeast to its confluence with Demetrie Wash. Esperanza Wash is filled with 11 to 30 feet of alluvium. In the vicinity of the PLS facilities, the bedrock surface forms an approximate “U” shape with the bedrock sides sloping 4:1 (Montgomery Watson, 2005).

Tinaja Wash is an ephemeral drainage located downgradient of the leach stockpiles. Tinaja Wash originates southwest of Cat Pond 2 and flows northeast for approximately 1.3 miles to its confluence with Esperanza Wash. An unnamed drainage, also flowing east, is present between the Tinaja and Esperanza washes. The unnamed drainage connects with the Tinaja Wash about

0.25 mile south of the Esperanza Wash. No additional information has been found, regarding alluvial thickness in the Tinaja Wash area.

2.3.3 Hydrogeology

This section presents a brief overview of the regional hydrogeology of the Sierrita area and a description of the site-specific hydrogeology and groundwater conditions at the mine property.

2.3.3.1 Regional Hydrogeology

The hydrogeologic conditions in the vicinity of Sierrita have been described by Lynch (1966), Cooper (1973), West and Aiken (1982), Errol L. Montgomery & Associates (ELMA) (1987, 1989, 1991, and 1997d), ELMA and Dames & Moore (1994), and Hydro Geo Chem (2006). A geologic map of the immediate Sierrita vicinity is presented on **Figure 2-3a** and **b**.

Sierrita is located in the southwest end of the Upper Santa Cruz (USC) groundwater sub-basin of the Tucson Active Management Area. The USC sub-basin is bounded on the southwest by the Sierrita Mountains in the area of Sierrita. The mountains are a contributing source of mountain-front recharge to the basin. The Santa Cruz River, entering the sub-basin from the south, is the main surface water drainage. Groundwater in the USC sub-basin occurs in three generalized hydrogeologic units: bedrock complex, alluvial deposits, and basin-fill deposits.

2.3.3.2 Local Hydrogeology

Generally, the principal hydrogeologic units in the Sierrita area are the *bedrock complex* which includes the Demetrie Volcanics, Harris Ranch Quartz Monzonite, and Ox Frame Volcanics; the *alluvial deposits* associated with modern drainage channels; and the *basin-fill deposits* including undifferentiated Tertiary sediments, the Pantano Formation, and Tertiary intrusive rocks. Brief lithologic descriptions are provided below; bedrock lithologies are summarized from West and Aiken (1982), ELMA (1989 and 2001), and from Hydro Geo Chem (2006).

Figure 2-3 is a geologic map prepared by the Arizona Geological Survey in 2007 and presents the locations of Sierrita monitor wells and piezometers. Appendix A contains stratigraphic cross sections prepared by ELMA as part of the *Additional Characterization of Hydrogeologic Conditions, Aquifer Protection Permit Application No. 101679* (ELMA, 2001). Monitor wells and piezometers constructed at the Sierrita property and the formations intersected by the wells and pizometers are summarized on **Table 2-1**.

Bedrock Complex

The bedrock complex throughout the Sierrita area has been characterized by the Arizona Geological Survey in 2007 and lithologic descriptions from monitor wells and piezometers constructed throughout the Sierrita property (**Figure 2-3**). The predominant geologic formations present in the Sierrita area include Ruby Star Granodiorite, Demetrie Volcanics, Harris Ranch Quartz Monzonite, and Ox Frame Volcanics.

Ruby Star Granodiorite. Tertiary intrusive rocks occur throughout the northern and eastern portions of the Sierrita Mill and mine area as illustrated on **Figure 2-3**. Tertiary intrusive rocks include the Ruby Star Granodiorite, Ruby Star quartz monzonite porphyry, dacite porphyry, and quartz diorite porphyry (West and Aiken, 1982). Ruby Star intrusives were encountered in monitor well MH-21 and in piezometers BW-03, PZ-03, PZ-04, PZ-05, PZ-06 indicating that the Ruby Star Granodiorite is the predominate surface bedrock formation in the mill area and northeast of the mill area. Monitor wells PZ-07 and PZ-09 were constructed further to the east and encountered between 110 to 160 feet of basin fill deposits underlain by the Ruby Star Granodiorite.

Groundwater yield to wells and piezometers completed in the Ruby Star Granodiorite is very low due to the low permeability of the rocks (ELMA, 2001). Calculated hydraulic conductivity using the Bouwer-Rice Method from slug tests conducted at MH-21, PZ-03, PZ-05, and PZ-06 ranged from 1.07×10^{-2} to 9.4×10^{-3} cubic feet per day per square foot (ELMA, 2001). These four wells are all screened in the upper 70 to 100 feet of the Ruby Star Granodiorite.

According to a research report prepared by Conoco Inc., in 1981, it was determined that the Ruby Star Granodiorite could be subdivided into a biotite granodiorite and a hornblende-biotite granodiorite, with the hornblende-biotite phase predominant in the southern portions of the batholith (Conoco, 1981). Aiken and Baugh (2007) report that the biotite granodiorite composition is more characteristic in the west and central portions of the batholith while the hornblende-biotite granodiorite phase occurs on the southeast side of the intrusion, cropping out to the north and east of the Sierrita Mill. The Conoco report states that the hornblende-biotite granodiorite contains relatively elevated concentrations of uranium with respect to the rest of the batholith (Conoco, 1981). This may be reflected in the elevated background concentration of uranium detected in background well MH-21 which was constructed in the hornblende rich granodiorite.

Demetrie Volcanics. Outcrops of the Demetrie Volcanics are visible in a large area south and east from the Sierrita and Esperanza pits. The Demetrie Volcanics underlie much of the southern part of the sulfide leach stockpile (**Figure 2-3**). The Demetrie Volcanics are upper Cretaceous in age and comprise a sequence of andesitic and dacitic breccias and flows. Demetrie Volcanics were encountered in monitor wells MH-20 and MH-23 and in piezometers PZ-02, PZ-08, PZ-13, PZ-14, PZ-15, and PZ-16. Piezometers PZ-13, PZ-14, and PZ-15 were formerly located in Esperanza Wash upstream of Headwall No. 3.

Groundwater yield to wells and piezometers completed in the Demetrie Volcanics is generally very low due to the low permeability of the rocks (ELMA, 2001). Calculated hydraulic conductivity using the Bouwer-Rice Method from slug tests conducted at MH-20, MH-23, PZ-02, PZ-13, PZ-15, and PZ-16 ranged from $1.70x10^{-3}$ to $1.3x10^{-5}$ cubic feet per day per square foot (ELMA, 2001). Two of these wells, MH-20 and PZ-15, are screened relatively deep in the formation (100 to 170 feet). These two wells have a lower calculated hydraulic conductivity than the shallow wells screened in the Demetrie Volcanics. The lower calculated hydraulic conductivity in the deeper wells may be due to decreased weathering and fracturing at greater depth.

Harris Ranch Quartz Monzonite. The Harris Ranch Quartz Monzonite is exposed in an area west and southwest from the Sierrita pit and occurs under the west edge of the sulfide leach stockpile (**Figure 2-3**). The Harris Ranch Quartz Monzonite is Triassic to Jurassic in age. The Harris Ranch Quartz Monzonite was encountered in upgradient monitor well MH-17 over the depth interval of 0 to 110 feet. Calculated hydraulic conductivity for this well using the Bouwer-Rice Method, was $1.47x10^{-2}$ cubic feet per day per square foot (ELMA, 2001).

Tinaja Peak. The Tinaja Peak Formation occurs in the southwest part of the Sierrita property and partially underlies the southeastern part of the sulfide leach stockpile (**Figure 2-3**). The formation was encountered in monitor wells MH-18 and MH-19, and in piezometer PZ-01. At these locations, the formation consists of tuffaceous sandy gravelly conglomerate and tuffaceous sandstone. At PZ-01 and MH-18, the formation has low permeability and groundwater yields are low (ELMA, 2001). At MH-19, the formation is substantially more permeable and groundwater yield is moderate (ELMA, 2001) This zone of higher permeability at MH-19 is of limited areal extent as indicated by substantial dewatering of the aquifer during hydraulic testing and by considerable fluctuations in observed groundwater levels during subsequent monitoring (ELMA, 2001).

Ox Frame Volcanics. Outcrops of the Ox Frame Volcanics near the southern parts of the Sierrita and Esperanza pits extend over a large area south and east of the open pits. The Ox Frame Volcanics also underlie much of the northern part of the sulfide leach stockpile (**Figure 2-3**). The Ox Frame Volcanics are Triassic in age and consist chiefly of rhyolite flows, tuffs, and tuff breccias with some minor sandstone/quartzite beds and andesite/dacite flows. Piezometers PZ-10 and PZ-12 were completed in Ox Frame Volcanics. Groundwater yield to these wells and piezometers completed in the Ox Frame Volcanics is unknown. Tests to determine the hydraulic conductivity for this formation have not been performed.

Alluvial Deposits

The surficial alluvial deposits are composed of gravels, sands, and silty sands; and include alluvial fan, terrace, and stream channel deposits. The surficial deposits are not hydro-geologically significant except for the stream channel deposits, which are referred to in this report as recent alluvium.

Occurrence of alluvial deposits in the Sierrita area is generally limited to natural drainage channels, including Demetrie Wash, Amargosa Wash, Esperanza Wash, and Tinaja Wash. The thickness of the alluvium penetrated by monitor wells and piezometers ranges from zero to 30 feet. The alluvium throughout most of the mill and mine areas is underlain by intrusive granitic bedrock, however, Demetrie Wash alluvium extends over the basin-fill deposits as it flows to the southeast.

Generally, the alluvial deposits are unsaturated and flow seasonally during recharge events. However, the presence of interceptor trenches and sumps located along Amargosa Wash suggest ongoing alluvial groundwater flow in Amargosa Wash. Additionally, historical water level measurements in monitor well MH-22 indicate continuous saturated alluvial flow in Demetrie Wash.

In Demetrie Wash, monitor well MH-22, located downstream from the confluence of Demetrie and Amargosa washes, is the only monitor well screened in alluvial deposits. Monitor well MH-22 is 20 feet deep and the recorded lithologic log reports approximately 17 feet of alluvium. The alluvium is described as consisting of 60 to 65 percent sand, 35 percent gravel, and trace to 5 percent silt and clay (ELMA, 1997). Since 1997, water levels have been measured quarterly (33 measurements). During this period the depth to groundwater in monitor well MH-22 has ranged from 9 to 15 feet, demonstrating alluvial groundwater is present throughout most of the year in this portion of Demetrie Wash.

No monitor wells are located directly in the channel of Amargosa Wash. Most monitor wells in the vicinity of Amargosa Wash are located beyond direct influence of the wash. A geotechnical investigation at Bailey Lake identified up to 19 feet of alluvium in the westernmost portion of Amargosa Wash. In 1993, B and C Sumps were constructed immediately downgradient of the Former B Pond and C Seepage Pond to serve as a hydraulic barrier to potentially impacted alluvial groundwater. The sumps were constructed in cutoff trenches excavated through the alluvium and into bedrock. The reported depth to water in these sumps ranges from approximately 10 to 13 feet. B and C Sumps currently collect alluvial water which is pumped to the Duval Canal. These sumps operate continuously, also indicating alluvial water is present in Amargosa Wash.

Currently, monitor wells BW-02 and MH-20 are the only monitor wells constructed in Esperanza Wash. Both of these monitor wells are screened in the underlying bedrock. The lithologic log for monitor well BW-03 reports that approximately 25 feet of alluvium was encountered at this location. The lithologic log for MH-20 reports approximately 7 feet of alluvium consisting of 70 percent gravel, 25 percent sand, and 5 percent silt and clay (ELMA, 1997). Static water levels in these two wells range from 10 to 16 feet below ground surface (bgs) at BW-03 and BW-14 to 160 feet bgs at MH-20. The static water level measurements for MH-20 are highly variable, possibly due to low recharge rates of the screened bedrock formation and inconsistent measurement.

Alluvium in Headwall No. 5 Wash is characterized by monitor well MH-19 which encountered the Tinaja Peak Formation at the surface. The upper 40 feet of the Tinaja Peak Formation at this location was described as silty and clayey sandy gravel (ELMA, 1997). Static water levels in well MH-19 range from 2 to 60 feet bgs. The APP BADCT demonstration describes this wash as containing up to 7 feet of alluvium (Montgomery Watson, 1999).

Basin-Fill Deposits

The basin-fill deposits comprise a sequence of sedimentary rocks of Quaternary and Tertiary age. The deposits consist of poorly consolidated gravel, sand, silt, and clay. The basin-fill aquifer is the principal source of groundwater to nearly all large-capacity water wells in the area, including wells used for providing water for mining operations at Sierrita.

The basin-fill has been divided into a lower basin-fill unit and an upper basin-fill unit based on regional hydrogeologic characteristics, and further subdivided into stratigraphic units based on lithology and depositional environment by Davidson (1973), and Anderson (1987). The upper basin-fill unit consists mostly of semi-consolidated to unconsolidated gravel, sands, and clayey silt. The upper basin fill has been generally correlated to the upper Tinaja Beds, the Fort Lowell Formation, and the surficial alluvium deposits as described by Anderson (1987) and Davidson (1973). In the vicinity of Sierrita, these units are typically undifferentiated (ELMA, 2001).

Basin-fill deposits generally occur east of Demetrie Wash and are not present in the mine and mill areas; however, basin-fill underlies most of the tailing impoundments. Thickness of basin-fill deposits ranges from zero in the vicinity of the mill increasing to approximately 110 to 165 feet in the Esperanza Tailing area, as indicated in drill logs for piezometers PZ-07 and PZ-09. At these locations the basin-fill deposits are unsaturated. Further east, near the toe of the Sierrita Tailing Impoundment, the basin-fill deposits range in thickness from approximately 500 feet at well MH-14 to 1,300 feet at well MH-09.

2.3.3.3 Groundwater Characteristics

Numerous investigations have previously been conducted to monitor groundwater quality and to collect additional groundwater characterization data in the areas of Sierrita and the Sierrita Tailing Impoundment. A significant amount of hydrogeologic data, including water levels, is available for the mine area as well as the tailing impoundment area.

Groundwater in the vicinity of Sierrita generally occurs in three principal formations:

1. Bedrock groundwater contained in the bedrock complex underlying a majority of the Sierrita mill and mine area.
2. Alluvial groundwater contained in alluvial channels of the Demetrie, Amargosa, Esperanza, and Tinaja washes.
3. Basin-fill deposits underlying the tailing impoundments east of the mine and mill complex.

The alluvium is hydrologically important in the Sierrita area because it serves as a conduit for flood flow recharge that infiltrates into the underlying bedrock complex aquifer. In the study area, alluvium occurs along the stream channels within each of the drainage areas.

The surficial alluvial deposits are composed of gravels, sands, and silty sands; and include alluvial fan, terrace, and stream channel deposits. The recent alluvium is very permeable and up to 100 feet thick in the Santa Cruz Basin (Davidson, 1973). However, in the Sierrita area no wells or excavations have indicated alluvial thickness more than 22 feet.

Where this unit overlies bedrock, infiltration to the lower part of the recent alluvium often occurs after ephemeral streamflow from periods of precipitation. As previously described, several locations along Amargosa Wash and at least one location in Demetrie Wash contain saturated alluvial flow. General groundwater flow direction in the alluvial aquifers is to the southeast following the washes into the basin toward the Santa Cruz River.

Groundwater, where present in the bedrock complex, occurs mainly within fractures. Small-scale fracturing in the bedrock complex is present within the Sierrita area. Where alluvium is present, alluvial groundwater flow may infiltrate into the underlying bedrock complex aquifer.

In general, the igneous rock types which comprise the bedrock complex have very low permeability and yield only small amounts of groundwater. Yields from bedrock wells and piezometers installed during investigations in the west half of the mine area ranged from approximately 0.001 gallon per minute (gpm) at monitor well MH-20 to 2.5 gpm at piezometer PZ-04. One exception is monitor well MH-19, which is believed to tap a limited zone of comparably higher permeability (ELMA, 2001).

Many lithologic well logs have indicated the presence of highly weathered zones and iron stained fractures in the upper 40 feet of the bedrock complex. This suggests that the hydraulic conductivities may decrease with depth. Slug tests performed on several wells and piezometers supports this hypothesis with conductivities ranging from 1.07×10^{-2} at well MH-21 screened from 28 to 79 feet bgs to 1.3×10^{-5} in well MH-20 screened from 120 to 176 feet bgs. Weathered zones and fracturing are spatially variable throughout the formations and across the property. In addition, the extent of fractures associated with faulting has not been characterized and may affect local groundwater flow.

Groundwater flow direction in the bedrock complex is generally to the east-southeast as illustrated on **Figure 2-4**. **Figure 2-4** reflects general flow direction for late 2007 and does not consider more localized flow directions that may be controlled by faulting or fracture patterns.

The basin-fill aquifer is the source of water supply to nearly all large-capacity wells in the area, including water for mining operations at Sierrita. Groundwater conditions in the basin-fill were previously described in ELMA (1987, 1989, 1991 and 2001), ELMA and Dames & Moore (1994), Hydro Geo Chem (2006).

South and southeast of the Sierrita Tailings Impoundment, the direction of groundwater flow has changed substantially since 1976 (Reed & Associates, 1986 and ELMA, 1989). In this area, the groundwater flow direction changed from east in 1976 to generally northeast at present. This change in flow direction is limited to the basin-fill deposits aquifer south and east of the tailing impoundment and is primarily the result of increased groundwater pumping from the Sierrita interceptor wells. In 1978, Duval Corporation initiated development of the interceptor well field to capture seepage from the Sierrita Tailing Impoundment. Currently, 23 interceptor wells are being operated by Sierrita at the eastern toe of the Sierrita Tailing Impoundment (**Figure 2-2**).

Sierrita Tailing Impoundment seepage and groundwater in the basin-fill deposits are the principal sources of water pumped from the interceptor wells.

Hydraulic conductivities in the basin-fill deposits generally range from 20 to 93 feet per day for the Fort Lowell Formation, 1.3 to 54 feet per day for the Tinaja beds, and 0.7 to 13 feet per day for the Pantano Formation (Davidson, 1973). Saturated thickness of the basin-fill deposits is greatest in the southern portion of the interceptor well field (>1,000 feet) and decreases to the north (<500 feet) with decreasing depth to bedrock.

Regionally, groundwater flow in the basin is generally to the north, roughly in the direction of flow in the Santa Cruz River. In the vicinity of Sierrita, groundwater flows eastward from the Sierrita Mountains through alluvium and the bedrock complex and into the basin-fill deposits. Within the basin-fill deposits, groundwater flow continues eastward until intercepting the main regional basin flow to the north. General groundwater flow directions for July 2007 are illustrated on **Figure 2-4**.

3.0 AREAS OF INTEREST

As described in Section 1.0, this work plan focuses on selected operations, COIs, and media that are not already addressed by other regulatory programs. COIs include: aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, molybdenum, nickel, potassium, selenium, sodium, thallium, zinc, and uranuim. The COI list for the VRP investigation was selected based on a review of the list of groundwater constituents currently monitored or regulated at Sierrita under its APP permit, historical groundwater quality data for the Sierrita Mine, and current and historical mining processes and operations. These constituents also naturally occur in soils, rock, and groundwater common to mineralized mining areas.

Operations to be considered include:

- Facilities that ceased operation and/or were closed prior to implementation of the Sierrita APP (historical operations).
- Selected operations exempt from regulation under the APP.
- Operations "to be closed" under the APP.
- Active operations with the potential to release mining related constituents to groundwater.

Additionally, uranium impacts to groundwater will be evaluated site-wide.

For descriptive purposes, the property is divided into five geographically distinct areas based on general drainage areas listed below. The geographic areas are illustrated on **Figure 3-1**.

1. Demetrie Wash
2. Amargosa Wash
3. Esperanza Wash
4. Tinaja Wash and Unnamed washes
5. Tailing Impoundments

The following sections describe the known information regarding operations within each geographic area and how those operations could impact the environment.

3.1 DEMETRIE WASH

Demetrie Wash is an ephemeral wash originating in the Sierrita Mountains west-northwest of Sierrita (**Figure 3-2**). The wash flows along the northern boundary of the mine and turns south near the northeastern portion of the mill area. Demetrie Wash then flows south along the eastern side of the mill area and trends south-southeast along the southwestern edge of the Sierrita Tailing Impoundment towards the Santa Cruz River.

Historical documents dating from 1987 indicate that Demetrie Wash has received releases of process fluids and tailing reclaim water. One such event occurred in 1992 after a storm event resulted in flow down the wash. Once the flow subsided, localized ponds of blue water were observed. Laboratory testing of this water indicated elevated levels of copper and a low pH (Dames & Moore, 1994). The data from this sampling event have not been located and the source of this low pH water was not determined. In 1993, B and C Sumps were constructed across Amargosa Wash alluvial sediments in an effort to intercept potential underflow that could discharge to Demetrie Wash (Dames & Moore, 1994).

Historical and currently operating facilities located in the Demetrie Wash area include:

- Former Copper Leach Electrowinning and Regeneration (CLEAR) Plant, a closed historical operation not regulated under the APP.
- Former E Pond, a closed historical operation associated with the Former CLEAR Plant and not regulated under the APP.
- Former Evaporation Pond, a closed historical operation associated with the Former CLEAR Plant and not regulated under the APP.
- Old D Pond, regulated under the APP as a facility "to be closed."
- Former Esperanza Mill, a closed historical operation not regulated under the APP.
- Former C Pond, a closed historical operation not regulated under the APP.
- Former Raffinate Pond, a closed historical operation not regulated under the APP.

These facilities are illustrated on **Figure 3-2**. The following sections present the known history and available analytical data for each facility.

3.1.1 Former Clear Plant

The Former CLEAR Plant produced metallic copper from 1977 to 1983 (**Figure 3-3**). The Former CLEAR Plant process leached copper from a slurry of copper concentrate using sodium and potassium chloride brines and a reagent of sodium hydroxide and ferric chloride. The leach solution was processed through two mixed reactors and a thickener before a slurry of cement copper was added to the leach solution to produce a pregnant solution. The pregnant solution was circulated in electrolytic tanks with anode and cathode arrays. Copper precipitated in the electrolytic tank was then filtered, washed, dried, and stored for market. The cooling towers associated with the Former CLEAR Plant operations are still standing, and are located south of the Former CLEAR Plant building (Hydro Geo Chem, 2008). Process flow diagrams for the Former CLEAR Plant indicate that waste solutions were minimized through recycling. The APP indicates that the operation also included a former Evaporation Pond and Old D Pond.

The main Former CLEAR Plant building and cooling towers remain on the process site; however, the process equipment and a majority of the building's interior contents have been dismantled and salvaged. Historical aerial photographs depict a number of above ground process tanks that were associated with the facility. Currently, no trace of the above ground process tanks is evident. **Figure 3-3** illustrates the locations of former above ground process tanks.

Information regarding the Former CLEAR Plant was obtained though interviews conducted in 2007 by URS with various Sierrita staff. The Former CLEAR Plant was commissioned in 1975, and a number of impoundments were associated with the plant, including the Former Evaporation Pond, the Old D Pond, and the Former E Pond. The Former Evaporation Pond was a lined impoundment located immediately north of the New D Pond, which is a currently operating facility. The Former Evaporation Pond received spent copper solution containing elevated concentrations of chloride. It was reported that the Former E Pond was located immediately east of the Former Evaporation Pond, in a location designated as "Old D Pond" in the APP application documents. The Former E Pond contained overflow from the Former CLEAR Plant. Therefore, based upon the 2007 interviews, the facility designated in the APP application documents as Old D Pond was actually the Former E Pond. The actual Old D Pond was apparently located south of the Former CLEAR Plant facilities.

In 1995, Cyprus Sierrita Corporation demolished the Former CLEAR Plant. When the Former Evaporation Pond was removed, the excavated soils were placed immediately south of the pond. During construction of New D Pond, these soils were removed and used to grade the area so surface drainage would flow to New D Pond (**Figure 3-3**).

Hydro Geo Chem performed an investigation at the Former CLEAR Plant site collecting surface soil, subsurface soil, and groundwater samples. Sample locations are illustrated on **Figure 3-3**. Results of the investigation are summarized on **Table 3-1** and can be found in the *Soil, Surface*

Water, and Groundwater Sampling in the Clear Plant and Esperanza Mill Areas, Hydro Geo Chem, 2008. The following is a summary of the analytical results:

- **Surface Soil**: Twelve samples were collected from the top 2 to 3 inches of soil (**Table 3-1**). Eight samples exceeded the 2007 Arizona non-residential Soil Remediation Level (nr-SRL) of 10 milligrams per kilogram (mg/Kg) for arsenic, with concentrations ranging from 17.1 to 166 mg/Kg. Two samples exceed the 2007 nr-SRL of 800 mg/Kg for lead, with concentrations ranging from 950 to 1,820 mg/Kg. One sample exceeded the 2007 nr-SRL of 63,000 mg/Kg for copper, having a concentration of 109,000 mg/Kg. Two samples exceeded the Groundwater Protection Level (GPL) of 35 mg/Kg for antimony, at concentrations of 52 and 66 mg/Kg. Three samples exceeded the GPL of 290 mg/Kg for lead, with concentrations ranging from 638 to 1,820 mg/Kg.
- **Subsurface Soil**: Twenty-four samples were collected from six trenches; with four trenches being 6 feet deep, two trenches being 8 feet deep, and one trench being 14 feet deep (**Table 3-1**). Nine samples, collected from depths ranging from 1 to 14 feet bgs, exceeded the nr-SRL of 10 mg/Kg for arsenic, with concentrations ranging from 10.4 to 37.1 mg/Kg. Two samples exceeded the GPL of 290 mg/Kg for lead, having a concentration of 293 and 488 mg/Kg. These samples were collected at 6 feet and 8 feet bgs, respectively.
- **Groundwater**: Grab samples were collected from two trenches (CP-T-5 and CP-T6) and borehole (CP-B-1). Cadmium was detected at a concentration of 0.014 mg/L, which exceeded the AWQS of 0.005 mg/L. Manganese was detected at a concentration of 2.8 mg/L, which exceeded the Risk Based Screening Level (RBSL) of 1.6 mg/L. Molybdenum was detected at concentrations 2.9, 15, and 0.88 mg/L, which exceeded the RBSL of 0.04 mg/L. Selenium was detected at a concentration of 0.21 mg/L, which exceeded the AWQS of 0.05 mg/L.

In December 2001, five soil samples were collected from a 5-foot deep test pit along the southern side of the Old D Pond, now termed the Former E Pond (MWH Americas, Inc., 2005). It was reported that none of these sample results for metals exceeded the nr-SRLs. This report did not reference the documents from which this information was obtained.

During the Hydro Geo Chem environmental study three surface soil samples, three subsurface soil samples, and one groundwater sample were collected in the vicinity of the Old D Pond (Hydro Geo Chem, 2008), which is now the Former E Pond. The investigation reported that stained soils were identified in the footprint of the former pond. Metals analysis of these soils detected arsenic at concentrations greater than 10 mg/kg.

The Former CLEAR Plant and associated historical ponds (Former Evaporation Pond and E Pond) are not APP regulated facilities and will be investigated through the VRP.

3.1.2 Old D Pond

APP application documents show the Old D Pond located in the southern portion of the Former Clear Plant area; however, a recent interview, inspection of an aerial photograph dated 1979, and a visual site inspection indicates that the Old D Pond was actually located approximately 1,000 feet south of the Former CLEAR Plant (**Figure 3-4**). During the site reconnaissance, URS noted a large depression with a sump south of the Former CLEAR Plant. It was reported that this pond was used into the 1990s, and is assumed to be the actual Old D Pond.

Very little process history is available; however, the Old D Pond, constructed in 1974, reportedly received process solutions from the Former CLEAR Plant operation. As described in Section 3.1.1 these solutions were recycled and possibly concentrated various constituents including metals and radionuclides.

Old D Pond listed in the APP as a facility “to be closed” at final mine closure, has been determined to be the Former E Pond, as described in Section 3.1.1. It is Sierrita’s intent to maintain the terminology of “Old D Pond” and adjust its location to what is now believed to be the actual location of Old D Pond. Potential discharges from Old D Pond will be investigated through the VRP.

3.1.3 Former Esperanza Mill

The Former Esperanza Mill processed sulfide ore from 1959 through 1981 (Hydro Geo Chem, 2008). No information has been found regarding specific processing methods, however it is known that the facility operated a mill, two thickeners, and a raw water pond (**Figure 3-5**). An aerial photograph from 1959 shows the mill location, thickeners, and pond that were associated with the facility. Tailing from the Former Esperanza Mill were conveyed via pipeline to the Esperanza Tailing Impoundment.

Hydro Geo Chem performed an investigation at the Former Esperanza Mill site, collecting 12 surface soil, 12 subsurface soil, 3 surface water, and 3 groundwater samples from an area much larger than the mill (**Figure 3-5**). The Hydro Geo Chem investigation encompasses an area of approximately 80 acres including Former C Pond and the Former Raffinate Pond which are discussed in the following sections. Results of the investigation are summarized on **Table 3-2** and can be found in the *Soil, Surface Water, and Groundwater Sampling in the CLEAR Plant* *and Esperanza Mill Areas, Hydro Geo Chem, 2008.* Results of the investigation are summarized below.

- **Surface Soil**: Twelve samples were collected from the top 2 to 3 inches of soil (**Table 3-2**, **Figure 3-5**). Seven samples exceeded the nr-SRL of 10 mg/Kg for arsenic, with concentrations ranging from 10.4 to 101 mg/Kg.
- **Subsurface Soil**: Twelve samples were collected from four trenches, with the trenches being 10, 12, 13, and 18 feet deep (**Table 3-2**, **Figure 3-5**). Three samples exceeded the nr-SRL of 10 mg/Kg for arsenic, with concentrations ranging from 23 to 38.8 mg/Kg.
- **Groundwater**: Groundwater samples were collected from two trenches (EM-UD and EM-T-4) and borehole (EM-B-1) (**Table 3-2**, **Figure 3-5**). The samples were filtered in the field and represent dissolved concentrations. Beryllium was detected at a concentration of 0.046 mg/L, which exceeded the AWQS of 0.004 mg/L. Cadmium was detected at concentrations of 0.2 and 0.0054 mg/L, which exceeded the AWQS of 0.005 mg/L. Manganese was detected at concentrations of 71, 6.8, and 18 mg/L, which exceeded the RBSL of 1.6 mg/L. Molybdenum was detected at concentrations 0.18, 2.4 and 0.05 mg/L, which exceeded the RBSL of 0.04 mg/L. Nickel was detected at a concentration of 0.15 mg/L, which exceeded the AWQS of 0.10 mg/L. Zinc was detected at a concentration of 3.7 mg/L, which exceeded the RBSL of 2 mg/L. URS was unable to locate the analytical data for EM-B-2.
- **Surface Water**: Grab samples were collected from three locations (EM-UP, EM-MID, and EM-LOW) along a surface drainage that was flowing from northwest to southeast across the Esperanza Mill area and discharging to Duval Canal (**Table 3-2**, **Figure 3-5**). Beryllium was detected at a concentration of 0.010 mg/L, which exceeded the AWQS of 0.004 mg/L. Cadmium was detected at concentrations of 0.069 and 0.0083 mg/L, which exceeded the AWQS of 0.005 mg/L. Copper was detected at a concentration of 170 mg/L, which exceeded the RBSL of 1.3 mg/L. Manganese was detected at concentrations of 12 and 4 mg/L, which exceeded the RBSL of 1.6 mg/L. Molybdenum was detected at concentrations 0.041, 1.5 and 0.73 mg/L, which exceeded the RBSL of 0.04 mg/L. Nickel was detected at a concentration of 0.18 mg/L, which exceeded the AWQS of 0.10 mg/L. Zinc was detected at a concentration of 6.5 mg/L, which exceeded the RBSL of 2 mg/L.

The Former Esperanza Mill is not regulated under the APP and will be investigated through the VRP.

3.1.4 Former C Pond

The Former C Pond was reportedly located near the northwest corner of the confluence of Demetrie and Amargosa washes (**Figure 3-5**). The Former C Pond was reportedly associated with the Esperanza Mill; however, recent interviews have indicated this pond was not associated with Esperanza Mill but was instead used to collect surface runoff from the Sierrita Mill area. According to the 1994 APP application, the Former C Pond has never been used as an operations pond nor has it ever been used to contain fluids from leaching operations (ELMA, 1994). The Former C Pond received runoff from the Sierrita crusher dust collector system. It was reported that the material was very fine and contained a relatively high concentration of copper. Sumps were located in the pond; however, the sediment was so fine that it would clog the pumps. Staff reported that the pond would fill up with sediment very quickly and would need to be "mucked out" on a regular basis. The excavated sediment was routinely placed on the ground surface immediately east of the impoundment, in an area (C Spoils area) just west of the current Duval Canal Extension (**Figure 3-5**).

The construction of the Duval Canal Extension in 1994 eliminated the need for surface water collection in the Former C Pond. In 1993, C Sump was installed downgradient of C Pond and west of Demetrie Wash (Dames & Moore, 1994). The intent of C Sump was to serve as a subsurface hydraulic collecting system for potentially impacted shallow groundwater flow before it entered Demetrie Wash.

Hydro Geo Chem environmental study of Esperanza Mill, five surface soil samples (EM-23, EM-24, EM-25, EM-26, and EM-27) and two subsurface soil samples from one location (EM-B-2) were collected in the vicinity of the Former C Pond (**Table 3-2**, **Figure 3-5**) (Hydro Geo Chem, 2008). Analysis of these soils did not detect any metals at concentrations greater than nr-SRLs.

The Former C Pond is not regulated under the APP and will be investigated under the VRP.

3.1.5 Former Raffinate Pond

A 1979 aerial photograph depicts a large pond immediately southeast of the Esperanza Mill (**Figure 3-5**). The pond is not visible in a 1994 aerial photograph of the same area. This pond was a former raffinate pond used for the Precipitation Plant. Its use was terminated when the current raffinate pond (APP Facility No. D-04) was constructed. No additional information regarding the years of operation or construction specifics referring to the Former Raffinate Pond have been located.

Hydro Geo Chem environmental studies of Esperanza Mill, three surface soil samples (EM-8, EM-9 and Em-10) were collected in the vicinity of the Former Raffinate Pond (**Table 3-2**, **Figure 3-5**) (Hydro Geo Chem, 2008). The analysis did not detect any metals at concentrations exceeding the nr-SRLs.

Former Raffinate Pond is not regulated under the APP and will be investigated under the VRP.

3.2 AMARGOSA WASH

Amargosa Wash is located in the southern portion of the Sierrita Mill area (**Figure 3-6**). Amargosa Wash is an ephemeral wash currently originating at the base of the leach stockpiles near Headwall No. 1. The Amargosa watershed flows approximately 6,000 feet east along a narrow corridor to its confluence with Demetrie Wash.

Amargosa Wash flows through the solution extraction process pond area. Since the early 1960s, Amargosa Wash has contained various process ponds, stormwater impoundments, and sumps over its 6,000 foot length between the leach stockpiles and Demetrie Wash. More recently, portions of the wash have been lined to redirect overflows from Headwall No. 1 and Bailey Lake to Amargosa Pond. The Amargosa Spillway is a lined channel directing overflow from Amargosa Pond and upgradient stormwater into Duval Canal.

A series of sumps and interceptor trenches are located along Amargosa Wash to collect potential underflow from the various impoundments. Interceptors No. 1 is located immediately downstream of Bailey Lake and No. 2 is located immediately downstream of Raffinate Pond No. 2 and upstream of Amargosa Pond. Subsurface flow captured at Interceptor No. 1 is pumped downstream to Raffinate Pond No. 2. Interceptor No. 2 collects subsurface flow that may pass Interceptor No. 1 or that may leak from Raffinate Pond No. 2. Subsurface flow captured by Interceptor No. 2 is also pumped to Raffinate Pond No. 2. Amargosa Sump is located immediately downstream of Amargosa Pond and intercepts subsurface flows that pass Interceptors Nos. 1 and 2. B Sump is the sump located furthest east and immediately upstream of the confluence of Amargosa and Demetrie Washes. B Sump was installed in 1993 as a hydraulic barrier and is keyed into the underlying bedrock.

Historical and currently operating facilities that may drain into Amargosa Wash include:

- Leach stockpiles and solution extraction facilities that are used to collect and hold process solutions. All of these facilities are active and regulated under the APP. Solutions in these facilities contain constituents for which groundwater is monitored under the APP, but for which numeric AWQSs have not been adopted. The VRP will be used determine whether or not there have been releases of COIs to groundwater from these facilities.

- Historical impoundments (A Pond and B Pond). These impoundments are regulated as "to be closed" facilities under the APP. The VRP will be used determine whether there have been releases of COIs from these facilities.
- Launders Facility is a "to be closed" facility in the APP; however, the APP reports that the facility is to be closed upon mine closure under the Mine Closure Reclamation Plan. The VRP will be used determine whether there have been releases of COIs from this facility, in advance of final mine closure.

In general, the potential impact to the environment from historical activities and potential impacts to groundwater at existing facilities located along Amargosa Wash and regulated under the APP will be investigated.

The following sections present the known history and available analytical data for facilities located in Amargosa Wash.

3.2.1 Headwall No. 1 and Bailey Lake

The easternmost portion of the leach stockpiles drain into the former Amargosa Wash channel and to Headwall No. 1 (**Figure 3-6**). Headwall No. 1 is an earthen berm that crosses Amargosa Wash at the base of the oxide leach area to form a small unlined retention pond. The headwall is designed to collect both surface runoff and shallow subsurface flow. PLS collected at Headwall No. 1 is conveyed via a lined channel into a concrete collection box from which it flows by gravity to the SX Plant No. 2. Bailey Lake is designed to contain overflow and subsurface flow from Headwall No. 1.

Headwall No. 1 and Bailey Lake
Details

	Headwall No. 1 Details	Bailey Lake Details
Location	Headwaters of Amargosa Wash	On Amargosa Wash immediately downgradient of Headwall No. 1
Purpose	Collect pregnant leach solution (PLS) from base of leach stockpile	Secondary headwall collecting subsurface flow from active leach stockpiles. Accepts overflow from Headwall No. 1
Date of construction	1957	Dam constructed in 1964 and upgraded in 1989
Construction	Earthen berm and unlined retention pond	Earthen dam and unlined reservoir
Capacity	3 acre feet	135 acre feet

Lithology	Alluvium and Demetrie Volcanics	Alluvium and Demetrie Volcanics
Discharge	Gravity flow over a lined discharge channel into concrete collection box then to SX Plant No. 2	No discharge
Overflow	Spillway into Bailey Lake	Lined spillway to Amargosa Pond

The Headwall No. 1 and Bailey Lake area is underlain by a thin layer of Quaternary alluvium which overlies the Demetrie Volcanics. The most recent groundwater elevations show that the direction of groundwater flow in the vicinity of Headwall No. 1 is to the east. The nearest monitor well is PZ-02 which is located southeast and hydraulically cross-gradient of the impoundments. Monitor well PZ-02 is sampled routinely and results show an average uranium concentration of 13.5 micrograms per liter (µg/L), which is similar to other monitor wells screened in Demetrie Volcanics.

PLS samples from Headwall No. 1 and Bailey Lake were collected in 1998 and analyzed for uranium, major cations/anions, and trace metals. The PLS had a low pH and contained elevated concentrations of radionuclides, sulfate, and a variety of trace metals.

Headwall No. 1 and Bailey Lake
PLS Analytical Data Summary
(mg/L)

	Total Uranium	**Arsenic**	**Beryllium**	**Cadmium**	**Chromium**	**Cobalt**	**Lead**	**Manganese**	**Molybdenum**	**Nickel**	**Selenium**
Headwall No. 1	13	0.15	1.080	1.050	1.4	10.5	0.012	486	1.2	6.3	0.05
Bailey Lake	4.37	0.13	1.06	1.17	1.1	10.7	0.023	501	1.0	6.1	0.06

PLS – pregnant leach solution
mg/l – milligrams per liter
Source: ELMA, 2001

Potential discharge of regulated constituents from these operational facilities is regulated under the APP. The VRP investigation will determine whether metals and radionuclides have been released into groundwater or Amargosa Wash.

3.2.2 Raffinate Pond No. 2

Raffinate Pond No. 2 is located in Amargosa Wash approximately 300 feet upstream of Amargosa Pond and immediately south of SX Plants Nos. 1 and 2. Raffinate Pond No. 2 was constructed in 1983 as a replacement to the former unlined raffinate pond (**Figure 3-6**). The current pond consists of a double lined below grade reservoir excavated into the native alluvium. Raffinate Pond is used to temporarily store copper-depleted leachate solution from SX Plants No. 1 and No. 2. The stripped PLS, also called raffinate, is pumped to the Raffinate Pond, immediately south of the SX Plant and is then recycled back to the active leach stockpiles.

Any overflows from Raffinate Pond No. 2 enter a lined channel and flow to Amargosa Pond.

No samples have been collected from this pond; however, a raffinate sample collected in 1998 is representative of solutions at this facility. The raffinate is dilute sulfuric acid with elevated concentrations of dissolved metals. Results of this analysis are summarized below.

Raffinate
Analytical Data Summary
(mg/L)

	Total Uranium	Arsenic	Beryllium	Cadmium	Chromium	Cobalt	Lead	Manganese	Molybdenum	Nickel	Selenium	Arsenic
Raffinate	0.29	0.3	0.03	0.06	<1	125	1.50	25.5	4	<1	2.45	11

mg/l – milligrams per liter
Source: ELMA, 2001

Potential discharge of regulated constituents from this facility is regulated under the APP. The VRP investigation will determine whether metals and radionuclides have been released into groundwater or Amargosa Wash.

3.2.3 Amargosa Pond

Amargosa Pond is located approximately 1,000 feet downstream of Bailey Lake and immediately downstream of Raffinate Pond No. 2. Amargosa Pond previously served as the old raffinate pond until approximately 1993 (Montgomery Watson, 1999). In 1994 the pond was upgraded and expanded into a single lined pond capable of containing a 100-year, 24-hour storm event. Currently, Amargosa Pond provides containment for stormwater runoff and upset conditions from Headwall No. 1, Bailey Lake, and Raffinate Pond No. 2. Stormwater runoff and overflow from upstream facilities flow through a lined channel in Amargosa Wash to Amargosa Pond.

To minimize subsurface flows in Amargosa Wash, Interceptor No. 1 and Interceptor No. 2 have been constructed immediately upstream and downstream of Amargosa Pond, respectively.

Subsurface flow upstream of Amargosa pond is captured at Interceptor No. 1 and pumped back to Raffinate Pond No.2. Flows passing Interceptor No. 1 are captured at Interceptor No. 2. Overflow from upset conditions at Amargosa Pond flow through a spillway and into Duval Canal eventually discharging into the Sierrita Tailing Impoundment.

3.2.4 Former A Pond

Former A Pond is a small unlined pond located in Amargosa Wash between Amargosa Pond and Former B Pond (**Figure 3-6**). Its purpose was to retain stormwater or leach solutions that overflow Amargosa Pond as a result of storm events. Overflow from Former A Pond was directed to Former B Pond.

Because Former A Pond was no longer needed following completion of improvements to Amargosa Pond in 1995, the dam was razed. At a later date, the earthen berm material was used to backfill the pond footprint. The sediments which had accumulated in Former A Pond were excavated and stockpiled on an active leach stockpile (MWH, 2005).

In 2001, soil samples were collected from a 7-foot deep test pit. Water seeped into the test pit and filled the pit to within 4 feet of ground surface. A 3-inch thick dark layer was noted at approximately 2 feet bgs. Results of this sampling event are reported in *Supplement to the Aquifer Protection Permit Application BADCT Demonstration Addendum, MWH, 2005.* In general, the analysis of the samples collected from the trench detected elevated levels of arsenic. Additionally, uranium was detected in the sample collected from the dark layer at a concentration of 38 mg/kg. Synthetic Precipitation Leaching Procedure (SPLP) analysis showed that the concentrations of all detected metals in the leachate were below the AWQS and uranium was detected at 0.02550 mg/L.

The 1999 *Supplement to Aquifer Protection Permit Application BADCT Demonstration* and the 2005 addendum prepared by Montgomery Watson state that final closure of A Pond will be completed in accordance with the Reclamation Plan during mine closure. Although this facility is scheduled for closure under the APP, it will be investigated under the VRP for potential releases of metals and radionuclides to groundwater.

3.2.5 Former B Pond

Former B Pond was constructed in 1960. It is an unlined pond located in Amargosa Wash immediately upstream of the confluence of Amargosa and Demetrie washes (**Figure 3-6**). According to the BADCT it is a non-stormwater pond intended to contain potentially impacted water flowing down Amargosa Wash (MWH Americas, 2005). The upgrade to Duval Canal was intended to collect and divert to the Sierrita Tailing Impoundment all stormwater runoff previously collected in Pond B.

A water sample was collected from B Pond in 1999. Results of the analysis showed a low pH, high conductivity, and elevated sulfate suggesting the water had characteristics of PLS (Montgomery Watson, 1999). The *1999 Supplement to Aquifer Protection Permit Application BADCT Demonstration* and the 2005 addendum prepared by Montgomery Watson state the appropriate BADCT for B Pond is closure. This facility is scheduled for closure under the APP; however, the potential for releases from Former B Pond to groundwater containing metals and radionuclides will be investigated under the VRP.

3.2.6 Launders Facility

The Launders Facility was constructed in 1958 as part of the Precipitation Plant (**Figure 3-6**). The former facility consisted of 22 concrete bins filled with iron cans and scrap iron. PLS was pumped into the bins and copper was precipitated onto the iron surfaces. As part of this process, the iron dissolved and was entrained into the leach solution. The copper precipitate was then transported off site for further processing. This operation was discontinued in 1987 when the SX/EW operations commenced.

The Launders Facility is listed as a “to be closed” facility in the APP; however, the APP reports that the facility will be closed during mine closure at the end of mine life. The facility will be investigated and possibly closed in advance of final mine closure under the VRP.

3.3 ESPERANZA WASH

Esperanza Wash is an ephemeral wash located in the southern portion of the Sierrita property, originating at the base of the leach stockpiles near Headwall No. 3 (**Figure 3-7**). The wash flows approximately 6 miles south-southeast to its confluence with Demetrie Wash.

Historical discharges have been documented in Esperanza Wash. In 1987 the U.S. Environmental Protection Agency (EPA) cited a Finding of Violation and issued an Order of Compliance for discharges from Headwall No. 4 to the Esperanza Wash. A subsequent EPA compliance inspection determined compliance with the Order.

Current operating facilities located in the Esperanza Wash include leach stockpiles and SX facilities regulated under the APP, including:

- Headwall No. 2 and Channel No. 2
- Headwall No. 3
- Raffinate Pond No. 3
- SX Plant No. 3
- Headwall No. 4

The following sections present the known history and available analytical data for facilities located in Esperanza Wash.

3.3.1 Headwall No. 2

Headwall No. 2 is a lined impoundment located in an unnamed wash that collects PLS from the leach stockpiles (**Figure 3-7**). PLS collected at Headwall No. 2 is pumped to Raffinate Pond No. 3. During heavy storm events, PLS may overflow from Headwall No. 2 into a lined channel and into the SX-3 Stormwater Pond.

Headwall No. 2 is located in an ephemeral wash that flows southeast to Demetrie Wash. The headwall is underlain by Demetrie Volcanics. Monitor well MH-27 is located approximately 1000 feet down gradient of Headwall No. 2. Based on recent data, groundwater flow in the vicinity of Headwall No. 2 is to the southeast.

Headwall No. 2
Details

	Headwall No. 2 Details	Channel No. 2 Details
Location	Unnamed wash draining leach stockpile	Immediately downgradient of Headwall No. 2
Purpose	Collect pregnant leach solution (PLS) from base of leach stockpile	Carries stormwater and overflow from Headwall No. 2 into SX-3 Stormwater Pond
Date of construction	Unknown	Unknown
Construction	Earthen berm with lined dam face	Lined channel
Capacity	3 acre feet	Measures 2,500 feet long by 10 feet wide
Lithology	Alluvium and Demetrie Volcanics	Alluvium and Demetrie Volcanics
Discharge	Pumped to Raffinate Pond No. 3	Drains into SX-3 Pond
Overflow	Into lined Headwall No. 2 Channel	No overflow
Downgradient monitor well	No downgradient wells	No immediate downgradient wells

A PLS sample from the headwall was collected in 1998 for uranium, major cation/anion, and trace metal analysis. Results of this analysis are summarized in the following table. The PLS contained elevated concentrations of radionuclides and selected metals. No soil samples have been collected from Drainage Channel No. 2.

Headwall No. 2
PLS Analytical Data Summary
(mg/L)

PLS Sample 1998	Total Uranium	Arsenic	Beryllium	Cadmium	Chromium	Cobalt	Lead	Manganese	Molybdenum	Nickel	Selenium	Arsenic
Headwall No. 2	8.3	0.11	0.882	1.110	1.0	10.1	<0.01	576	0.7	6.0	<0.01	0.014

PLS – pregnant leach solution
mg/l – milligrams per liter
Source: ELMA, 2001

Potential releases of constituents from this Headwall are regulated under the APP. The VRP investigation will determine whether metals and radionuclide constituents have been released into groundwater or the Esperanza Wash that flows to Demetrie Wash.

3.3.2 Headwall No. 3

Headwall No. 3 is a lined impoundment that collects PLS seepage from the base of the leach stockpiles in the former channel of Esperanza Wash. Headwall No. 3 is located approximately 500 feet downgradient of the leach stockpile. Accumulated PLS is pumped to Raffinate Pond No. 3 (**Figure 3-7**).

Headwall No. 3
Details

	Headwall No. 3 Details
Location	Esperanza Wash immediately downgradient of leach stockpile
Purpose	Collect pregnant leach solution (PLS) from base of leach stockpile
Date of construction	1993
Construction	Earthen berm with lined dam face
Capacity	15 acre feet
Underlying lithology	Alluvium and Demetrie Volcanics
Discharge	Pumped to Raffinate Pond No. 3
Overflow	Into lined channel which discharges to Headwall No. 4
Downgradient monitor well	BW-02

Headwall No. 3 is underlain by a thin layer of alluvium deposited in Esperanza Wash. Esperanza Wash flows south to the confluence of Demetrie Wash. The nearest downgradient monitor well is BW-02 which is screened from 19 to 95 feet bgs. In July 2007 10.4 ug/L total uranium was detected in monitor well BW-02. The depth to groundwater in BW-02 ranges from 2 to 15 feet bgs. The variability over time in the depth to groundwater measurements is likely due to seasonal influx from infiltration of surface water runoff along Esperanza Wash. Groundwater flow in the area of Headwall No. 3 is to the southeast, generally parallel with Esperanza Wash.

A sample of PLS collected from upstream of the headwall in 1998 was analyzed for uranium, major cation/anions, and trace metals. Results of this analysis are summarized in the following table. The PLS contained elevated concentrations of radionuclides, sulfate, and a variety of trace metals.

Headwall No. 3
PLS Analytical Data Summary
(mg/L)

PLS Sample 1998	Total Uranium	Arsenic	Beryllium	Cadmium	Chromium	Cobalt	Lead	Manganese	Molybdenum	Nickel	Selenium	Arsenic
Headwall No. 3	13	0.08	0.980	1.020	0.9	9.5	0.021	465	0.8	5.6	<0.004	0.06

PLS – pregnant leach solution
mg/l – milligrams per liter
Source: ELMA, 2001

Potential discharge of constituents from this Headwall is regulated under the APP. The VRP investigation will determine whether metals and radionuclides have been released into groundwater or Esperanza Wash.

3.3.3 Raffinate Pond No. 3

Raffinate Pond No. 3 is located in Esperanza Wash downgradient of Headwall No. 3 and SX-3 Stormwater Pond (**Figure 3-7**). Raffinate Pond No. 3 was a process solution pond originally designed to store raffinate. Raffinate Pond No. 3 now receives solutions from Headwall No. 3. Because the SX-3 Plant is no longer in operation, Raffinate Pond No. 3 currently accepts solutions from Headwall No. 3 through a concrete vault and pump system, allowing solution transfer between the two ponds. PLS is also pumped from Headwall No. 5 to Raffinate Pond No. 3.

Raffinate Pond No. 3
Details

	Raffinate No. 3 Details
Location	Esperanza Wash immediately downgradient of Headwall No. 3
Purpose	Originally constructed to store copper-depleted solution from SX-3 Plant. Currently receives pregnant leach solution (PLS) from Headwalls No. 3 and No. 5
Date of Construction	1993
Construction	Double lined basin with leak detection system
Capacity	16 acre feet
Underlying lithology	Alluvium and Demetrie Volcanics
Discharge	Pumped to Bailey Lake
Overflow	Into lined channel which discharges to SX-3 Stormwater Pond
Downgradient monitor well	BW-02

Raffinate Pond No. 3 is underlain by approximately 11 feet of alluvium and Demetrie Volcanics. Groundwater flow in the vicinity of the facility is to the southeast, generally parallel with Esperanza Wash.

No analytical data have been collected for Raffinate Pond No. 3.

Potential discharge of constituents from this pond is regulated under the APP. The VRP investigation will determine whether metals and radionuclides have been released into groundwater or Esperanza Wash.

3.3.4 Headwall No. 4 (SX-3 Stormwater Pond)

Headwall No. 4 is located in Esperanza Wash approximately 500 feet downstream of Headwall No. 3 (**Figure 3-7**). The *1999 Supplement to Aquifer Protection Permit Application BADCT Demonstration* renamed Headwall No. 4 as SX-3 Stormwater Pond. Headwall No. 4 was an unlined pond originally used to contain potential overflows from Headwall No. 3 and Raffinate Pond No. 3 (ELMA, 1994). This impoundment was redesigned in 1994 as a single-lined reservoir (Montgomery Watson, 1999). No samples for laboratory analysis have been collected from this impoundment. Sierrita intends to maintain this facility as a stormwater retention pond after closure.

Headwall No. 4
Details

	Headwall No. 4 (SX-3 Stormwater Pond) Details
Location	Esperanza Wash 500 feet downgradient of Headwall No. 3

Purpose	Originally constructed to contain overflows from Headwall No. 3 and Raffinate Pond No. 3. Currently, stormwater containment pond.
Date of construction	Pre-1994
Construction	Single-lined high density polyethylene (HDPE)
Capacity	52 acre feet
Underlying lithology	Alluvium and Demetrie Volcanics
Discharge	Pumped back to Raffinate Pond No. 3
Downgradient monitor well	BW-02 and MH-20

Potential discharge of constituents from this facility is regulated under the APP. The VRP investigation will determine whether metals and radionuclide constituents have been released into groundwater or Esperanza Wash.

3.3.5 SX Plant No. 3

SX Plant No. 3 was constructed in 1994 to handle PLS from the sulfide leach stockpiles on the eastern side of the Sierrita property (**Figure 3-7**). The plant was located on Esperanza Wash (**Figure 3-7**). The plant operated for 30 days in late 1994, and has not operated since. The former SX-3 tank farm was an exempt APP discharging facility according to the 1999 BADCT supplement. The remaining equipment is used to gather the PLS from the existing leach stockpiles and transfer the solution to SX Plant No. 2.

Potential discharge of regulated constituents from this facility is regulated under the APP. The VRP investigation will determine whether metals and radionuclide constituents have been released into groundwater or Esperanza Wash.

3.4 TINAJA AND UNNAMED WASH

Tinaja Wash is an ephemeral drainage located downgradient of the leach stockpiles (**Figure 3-7**). Tinaja Wash originates southwest of Cat Pond 2 and flows northeast for approximately 1.3 miles to its confluence with Esperanza Wash. An unnamed drainage referred to as Unnamed Wash flows east, and is present between Tinaja and Esperanza washes. Unnamed Wash discharges into Tinaja Wash about 0.25 mile south of Esperanza Wash.

Currently, operating facilities that may drain into the Unnamed and Tinaja washes include Headwall No. 5, a leach solution collection facility regulated under the APP and, and the non-regulated Tinaja Pond. Tinaja Pond is a stormwater and runoff catchment pond and is not regulated under the APP.

The following sections present the known history and available analytical data for facilities located in Tinaja and Unnamed washes.

3.4.1 Headwall No. 5

The western portion of the active sulfide leach stockpile drains into an unnamed wash and into Headwall No. 5, where it is contained (**Figure 3-8**). Headwall No. 5 was constructed in 1992 to contain primarily stormwater and redirect it for use as mine operations make-up water. Solutions collected at Headwall No. 5 are currently pumped to Headwall No. 3.

Headwall No. 5 is underlain by a thin layer of sandy to silty clay which is likely weathered bedrock, and Demetrie Volcanics (Montgomery Watson, 1999). The nearest downgradient monitor well is PZ-16. Monitor Well MH-19 is located downgradient of PZ-16 (**Figure 3-8**). The groundwater level in the bedrock has been measured at approximately 33 feet bgs (Montgomery Watson, 1999). Groundwater in the vicinity of Headwall No. 5 generally flows to the southeast parallel with Unnamed Wash. Immediately downgradient of Headwall No.5 is an interceptor system that collects subsurface flows and pumps these solutions into Headwall No. 5.

Headwall No. 5
Details

	Headwall No. 5 Details
Location	South of leach stockpile and east of Tinaja Wash
Purpose	Collect potentially impacted stormwater and pregnant leach solution (PLS)
Date of construction	1992
Construction	Earthen berm with lined dam face
Capacity	15 acre feet
Underlying lithology	Alluvium and Demetrie Volcanics
Discharge	Pumped to Headwall No. 3
Overflow	Unknown
Downgradient monitor well	MH-19

A sample of PLS from upstream of the Headwall No. 5 was collected in 1998 for uranium, major cation/anion, and trace metal analysis. Results of this analysis are summarized in the following table. The PLS contained elevated concentrations of radionuclides, sulfate, and a variety of trace metals.

Headwall No. 5
PLS Analytical Data Summary
(mg/L)

PLS Sample 1998	Total Uranium	Arsenic	Beryllium	Cadmium	Chromium	Cobalt	Lead	Manganese	Molybdenum	Nickel	Selenium	Arsenic
Headwall No. 5	0.91	<0.02	0.081	0.133	<0.05	1.47	0.006	60.6	0.25	0.82	<0.004	0.012

PLS – pregnant leach solution
mg/l – milligrams per liter
Source: ELMA, 2001

Potential discharge of constituents from this facility is regulated under the APP. The VRP investigation will determine whether metals and radionuclides have been released into groundwater or Tinaja Wash.

3.5 TAILING IMPOUNDMENTS

The tailing impoundment area consists of the Esperanza Tailing Impoundment, former Rhenium Ponds, and the Sierrita Tailing Impoundment (**Figure 3-9**).

3.5.1 Esperanza Tailing Impoundment

The Esperanza Tailing Impoundment was operated continuously from October 1959 through December 1971 and from January 1973 through December 1978. The tailing impoundment was operated intermittently from January 1979 through December 1981, when it was closed. The surface of the Esperanza Tailing Impoundment was subsequently capped with a layer of alluvial material (Reed & Associates, 1986). During 1991 and 1992, tailing from the Twin Buttes Mine was deposited in the west half of the Esperanza Tailing Impoundment. Currently, the impoundment is used for tailing deposition on a limited basis only during emergency clean outs or when blockages occur in the Sierrita tailing slurry pipeline.

3.5.2 Rhenium Ponds

The Rhenium Ponds were constructed in 1981 and consisted of three cells excavated into the surface of the Esperanza Tailing Impoundment. The cells were used for the storage and evaporation of process solutions from the Rhenium Plant (Montgomery Watson, 1999). Each cell measured 250 feet long, 65 feet wide, and 10 to 12 feet deep and was lined with geosynthetic. (MWH, 2005).

Two solution samples were collected from the cells in 1986 for laboratory analysis. Results of these analyses are summarized in the following table.

Rhenium Ponds
Analytical Data Summary
(mg/L)

Constituent	South Pond	North Pond
Total Dissolved Solids (TDS)	57,200	156,800
Electrical Conductance	160,000	477,926
pH	1.0	0.5
Calcium	36	55
Magnesium	13	87
Sodium	40	328
Potassium	6.3	96
Chloride	269	287
Sulfate	42,500	210,000
Nitrate (as NO3)	ND	ND
Fluoride	2.3	3.9
Antimony	<0.1	<0.1
Arsenic	<0.01	12.7
Barium	<0.5	<0.5
Beryllium	<0.01	0.03
Boron	1-	27.6
Cadmium	<0.005	0.012
Chromium	0.35	17.5
Copper	0.46	4.4
Iron	28	187
Lead	0.10	0.2
Manganese	1.1	5.6
Mercury	0.0002	<0.0002
Molybdenum	80	400
Nickel	0.30	9.4
Selenium	72.5	274
Silver	<0.01	<0.01
Strontium	0.1	0.3
Thallium	<0.5	<0.5
Zinc	0.52	6.2

Use of the Rhenium Ponds was discontinued in 1998. Closure of these ponds consisted of excavating sediments from the cells and placement of the removed sediment in the leach area. The ponds were then backfilled with tailing and graded.

As part of the investigation to support the *1999 Supplement to Aquifer Protection Permit Application BADCT Demonstration*, a test pit was excavated into the tailing where the former Rhenium Ponds were located and soil samples were collected. The samples were composited into one sample and analyzed for total metals and subjected to SPLP testing. No metals were detected at concentrations exceeding the 1997 nr-SRLs and none of the SPLP results exceeded the AWQS (MWH, 2005).

The Rhenium Ponds are listed as a “to be closed” facility in the APP; however, the APP reports that the facility will be closed upon mine closure under the Mine Closure Reclamation Plan. The VRP will provide the process to investigate and close this facility in advance of final mine closure.

3.5.3 Sierrita Tailing Impoundment

The Sierrita Tailing Impoundment began operation in 1970 and is currently in use. The impoundment covers an area of approximately 3,600 acres with a 2,500 foot divider dam to separate it into north and south sections. The impoundment measures approximately 300 feet thick and rests directly on the underlying basin-fill deposits.

Characterization of Sierrita Tailing Impoundment and underlying alluvium has been performed as described in the APP (ELMA, 1994). Two boreholes were drilled through the STI into the underlying alluvium: boreholes AGP-1 and AGP-2. Samples of tailing and alluvium were collected and static acid-base tests were performed to determine the acid generating potential (AGP) and acid neutralizing potential (ANP) of the samples. Results from these tests indicate that the tailing samples are not potentially acid generating. Synthetic Precipitation Leaching Procedures (SPLP) tests were also performed on samples of the tailing and underlying alluvium. The resulting SPLP extract was analyzed for common and trace constituent, including arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silver and zinc. Concentrations of trace constituents in excess of AWQS were not identified in the SPLP extract for tailing samples, indicating that substantial amounts of these trace elements would not be mobilized through the infiltration of natural precipitation. Uranium activity was detected in one of the tailing SPLP extract samples at a concentration 13.23 pCi/L. However, the uranium activity results for the remaining eight tailing SPLP extract samples ranged from 0.0 to 1.2 pCi/L (ELMA, 1994), indicating the single elevated uranium result to be of questionable validity.

Potential discharge of regulated constituents from the Sierrita Tailing Impoundment is regulated under the APP; sulfate originating from the impoundment is regulated under the MO. The VRP investigation will focus on characterization of metals and radionuclides in the tailing.

3.6 CONCEPTUAL UNDERSTANDING OF URANIUM IN GROUNDWATER

The purpose of this section of the work plan is to summarize and evaluate the available information pertaining to uranium in groundwater, and to present the current conceptual understanding of the presence of uranium in groundwater at Sierrita. Sierrita has sampled and analyzed groundwater for uranium and other radionuclides in monitor wells since 1997. Sierrita has monitored a selection of radionuclide parameters, including gross alpha, gross beta, radium-226, radium-228, U-234, U-235, U-238 and radon-222. The data evaluation presented in this section focuses primarily on measured mass concentration of uranium (U mass) in groundwater.

3.6.1 Available Data

The concentrations of U mass in samples collected in 1997 and 1998 were determined using the ASTM Fluorometric Method 2907 for Uranium in Water, while the USEPA ICP-MS Method 200.8 was utilized for measurement of uranium beginning in 1999 through the present. Results from the earlier testing where the Fluorometric Method should be used with caution, since the most up-to-date method for U mass analyses is the USEPA Method 200.8.

Table 3-3 provides a summary of the available U mass data for groundwater collected from monitor wells. In this table, the geological formation (in which each of the monitor wells is screened) is provided in parenthesis following the monitor or interceptor well identification. For wells screened entirely in alluvium a “Q” is listed, and for bedrock wells the type of rock that the well is screened in is listed (e.g., “HR” represents Harris Ranch Monzonite, “TP” represents Formation of Tinaja Peak, “DV” represents Demetrie Volcanics, and “RS” represents Ruby Star Granodiorite). Two monitor wells (PZ-07 and PZ-09) are screened within both alluvium and Ruby Star Granodiorite and are represented by “Q/RS.” Monitor wells that are used as POC wells for the Sierrita APP are marked with an asterisk.

In **Table 3-3**, the average U mass concentration in micrograms per liter (µg/L) for each well is provided. The average U mass value for each monitor well is the mathematical mean of all U mass analytical results measured for that well during the time period 1997-2007. **Table 3-3** presents the maximum and minimum measured concentrations, the total number of analytical results extracted from the Sierrita analytical database for the specified time period, and the dates of the earliest data evaluated. For ease of comparison, the order in which the monitor wells are listed on **Table 3-3** corresponds to their location on the Sierrita property. The first well listed, monitor well MH-17, is the westernmost well on the property. Subsequent wells are listed in approximately the same order in which the wells are geographically located west to east across the property. Monitor wells located east of the Sierrita Tailing Impoundment are listed in order from north to south. **Figure 2-2** presents the locations of each of the wells listed on **Table 3-3**.

3.6.2 Uranium in Bedrock Groundwater

As described in Section 2.3.3, the predominant bedrock formations present in the Sierrita area are the mineralized formations of Ruby Star Granodiorite, Harris Ranch Monzonite, and Ox Frame Volcanics; and the non-mineralized formations of Demetrie Volcanics and Tinaja Peak.

Monitor wells located in the western half (Demetrie Wash west) of the Sierrita property, with the exception of the alluvial monitor well MH-22, are screened in bedrock formations as summarized below:

- Ruby Star Granodiorite – Monitor wells PZ-03, PZ-04, PZ-05, PZ-06, BW-03, and MH-21. PZ-07 and PZ-09, which are slightly east of Demetrie Wash, are screened across basin-fill and Ruby Star Granodiorite
- Harris Ranch Monzonite – Monitor well MH-17
- Demetrie Volcanics – Monitor wells PZ-02, PZ-08, PZ-16, BW-02, MH-20, MH-23, and MH-27
- Formation of Tinaja Peak – Monitor wells PZ-01, MH-18, and MH-19

Monitor wells located hydraulically upgradient of Sierrita are screened in bedrock formations as summarized below:

- Harris Ranch Quartz Monzonite - Monitor well MH-17 is located on the western property boundary
- Tinaja Peak - Monitor well PZ-01 is located in the southwestern corner of the Sierrita property
- Ruby Star Granodiorite - Monitor well MH-21 is located northeast of the mill area

The highest concentrations of U mass are detected in wells screened within the Ruby Star Granodiorite formation, with concentrations of U mass as high as 1,600 μg/L in MH-21. Monitor well MH-21 is located hydraulically cross-gradient and likely outside the influence of Sierrita. Monitor well MH-21 is a background POC well for the APP and the groundwater quality at the MW-21 location may be representative of groundwater quality upgradient of Sierrita. The majority of the remaining wells screened within the Ruby Star Granodiorite (PZ-03, BW-03, PZ-

04, PZ-05, and PZ-09) also exhibit elevated levels of U mass, with the average U mass concentrations ranging from 63 µg/L to 450 µg/L.

As described in Section 2.0, background research relating to the Ruby Star Granodiorite has identified two phases of the formation: a biotite granodiorite and a hornblende-biotite granodiorite. Research conducted by Conoco, discussed in Section 2.0, indicates that the hornblende-biotite granodiorite crops out to the north and east of the Sierrita Mill. As described in Section 2.0, the hornblende-biotite granodiorite contains higher concentrations of U mass than other portions of the Ruby Star Granodiorite. Higher U concentrations detected in groundwater at MH-21 and possibly in the Sierrita Mill area are consistent with the location of the hornblende-biotite granodiorite. Other wells screened in the Ruby Star Granodiorite are located within or downgradient of Sierrita process areas. Therefore, based upon available data it cannot be determined whether the elevated levels of U mass are the result of releases from Sierrita process areas or are the result of U mass mobilized from the naturally occurring, mineralized rock.

Monitor well MH-17 is a bedrock well screened within the Harris Ranch Monzonite formation. Analysis of groundwater samples collected from MH-17 detected concentrations of U mass, as high as 150 µg/L. This monitor well is located within a mineralized rock formation upgradient of Sierrita process areas, and is considered to be representative of groundwater background conditions for the Sierrita Mine. Monitor well MW-17 is the only well on the Sierrita property screened in the Harris Ranch Monzonite.

Groundwater in bedrock wells screened within the non-mineralized Formation of Tinaja Peak and Demetrie Volcanics, with the exception of monitor well MH-23, generally exhibit average U mass concentrations less than 25 µg/L. Monitor well MH-23 is screened within the fractured upper portions of the Demetrie Volcanics and exhibits an average U mass concentration of 59.2 µg/L. Monitor well MH-23 is located near the confluence of Amargosa and Demetrie washes and adjacent to alluvial monitor well MH-22. Alluvial monitor well MH-22 exhibits an average U mass concentration of 319 µg/L.

3.6.3 Uranium in Alluvial Groundwater

Uranium in alluvial groundwater is characterized through sampling of only monitor well MH-22. Monitor well MH-22 is screened in the upper 17 feet of alluvium in Demetrie Wash, downgradient of the confluence of Amargosa Wash (**Figure 2-2**). The depth to groundwater in monitor well MH-22 ranges from 9 to 15 feet bgs, suggesting alluvial groundwater is present throughout most of the year in this portion of Demetrie Wash.

U mass concentrations in monitor well MH-22 range from 133 to 509 μg/L with an average concentration of 319 μg/L. The source of the alluvial groundwater is currently unknown, and will be investigated during the site characterization.

3.6.4 Uranium in Basin-Fill Groundwater

Monitor wells near the Esperanza Tailing Impoundment (PZ-07, PZ-08 and PZ-09) show average U mass concentrations ranging from 12.3 μg/L in PZ-07 to 190 μg/L in PZ-09. Data from PZ-09 are available only from two sampling events in 1997, conducted immediately following the installation of the well. Since that time, the well has not been sampled due to low water levels. Wells PZ-08 and PZ-09 are screened across the basin fill and Ruby Star contact penetrating the Ruby Star Granodiorite over an interval of 40 feet and 20 feet, respectively.

The eastern, downgradient edge of the Sierrita Tailing Impoundment trends north-south. A series of monitor are installed in an approximate north-south line parallel to the downgradient edge of the impoundment. These monitor wells are screened in the basin-fill sediments. The six monitor wells downgradient of the impoundment are shown on **Figure 2-2**. Average concentrations of U mass in the monitor wells downgradient of the impoundment are listed on **Table 3-3**. The highest concentrations of U mass in monitor wells downgradient of the impoundment are observed in MH-15W, downgradient of the center of the impoundment. The lowest U mass concentrations are observed in MH-16W near the south end of the impoundment.

3.6.5 Conceptual Understanding

As described in the preceding sections, localized elevated concentrations of U mass in groundwater have been measured in various areas on the Sierrita property. Existing data indicate that uranium occurs naturally in the mineralized bedrock formations of the Sierrita batholith that underlies most of the Sierrita Mine. Concentrations of U mass measured in process solutions are elevated above levels observed in groundwater samples. The role and extent to which each of these factors contributes to the observed U mass concentrations identified in groundwater of the basin-fill deposits is unknown.

Groundwater flow in the Sierrita area is complex, involving three primary aquifers: (1) alluvial aquifer, (2) bedrock aquifer, and (3) basin-fill aquifer. Each aquifer is in hydraulic connection with one or more of the others to varying degrees. The alluvial aquifer flows across bedrock and may infiltrate into the underlying bedrock. Where alluvium overlies basin-fill deposits, alluvial groundwater may percolate into the underlying regional basin-fill deposit. Groundwater in the bedrock complex flows to the east and discharges into the basin-fill deposits somewhere in the vicinity of the eastern edge of the Esperanza Tailing Impoundment.

Possible scenarios that could explain the elevated U mass observed in the bedrock, alluvial and basin-fill aquifers downgradient of the Sierrita Tailing Impoundment include:

1. Bedrock containing naturally occurring concentrations of uranium may release uranium to groundwater through natural weathering and dissolution processes. Groundwater in the bedrock complex flows eastward into the basin-fill deposits.
2. Seepage from historical or current mining operations may have occurred, potentially releasing solutions with elevated uranium concentrations to the underlying alluvial aquifer. Impacted groundwater may flow through the alluvial aquifer to the southeast where the alluvium directly overlies the basin-fill deposits. Percolation from alluvial groundwater downward into the basin-fill aquifer, primarily through Demetrie Wash along the southwestern edge of the Sierrita Tailing Impoundment, may impact the basin-fill aquifer.
3. Seepage from historical or current mining operations may have released solutions with elevated uranium concentrations to the underlying alluvial aquifer. The alluvial aquifer and bedrock aquifer are in hydraulic communication in areas where the bedrock complex is fractured. Impacted groundwater in the alluvial aquifer may migrate through the fractured bedrock, eventually discharging into the basin-fill deposits.
4. Impacted stormwater discharged from historical or current mining operations may have contained uranium from process solutions. This impacted stormwater is conveyed via the Duval Canal onto the Sierrita Tailing Impoundment where it mixes with reclaim water and is eventually recycled to the mill. Some water that collected on the top surface of the Sierrita Tailing Impoundment percolates through the impoundment into the underlying basin-fill deposits, and is captured by the interceptor wells downgradient of the impoundment.

One of these four scenarios, any combination of these scenarios, or some other unidentified scenario could contribute to elevated U mass observed in the bedrock, alluvial, or basin fill aquifers in the Sierrita vicinity. Various scenarios will be evaluated during the site characterization.

4.0 SAMPLING AND ANALYSIS PLAN

This section presents the Sampling and Analysis Plans (SAP) for the VRP site characterization. The purpose of the SAP is to present the objectives of the sampling; identify sample types, locations, and frequency; and provide procedures on equipment, documentation, sample handling, and analysis.

This section presents the sampling approach that will be implemented at each facility. The specific sampling rationale for each facility is presented on **Table 4-1**. Section 5.0 describes specific sampling procedures that will be implemented during the site characterization, and Appendix B provides the Quality Assurance Project Plan (QAPP).

Soil and sediment samples collected from areas of investigation as described in Sections 4.1 through 4.5 of this work plan will be analyzed for total uranium, COI metals, and radionuclides. Specific constituents for each analytical category are as follows:

- Radionuclides to include total uranium, isotopic radium (Ra-226 and Ra-228), and isotopic uranium (U-234, U-235 and U-238)
- COI metals to include total analyses for antimony, arsenic, barium, beryllium, cadmium, cobalt, copper, lead, manganese, mercury, molybdenum, nickel, selenium, thallium, and zinc

Analyses proposed for groundwater samples to be collected from existing, proposed, and alluvial monitor wells are described in Section 4.6, Groundwater Sampling and Analyses Plan.

4.1 DEMETRIE WASH

The Demetrie Wash area primarily consists of historical facilities that Sierrita is planning to close. Historical facilities located in the Demetrie Wash area include:

- Former CLEAR Plant, a closed historical operation not regulated under the APP
- Former E Pond, a closed historical pond associated with the Former CLEAR Plant and not regulated under the APP
- Former Evaporation Pond, a closed historical pond associated with the Former CLEAR Plant and not regulated under the APP
- Old D Pond, regulated under the APP as a facility “to be closed”
- Former Esperanza Mill, a closed historical operation not regulated under the APP

- Former C Pond, a closed historical pond not regulated under the APP
- Former Raffinate Pond, a closed historical pond not regulated under the APP

These facilities are illustrated on **Figure 4-1**. The following sections present the proposed sampling approach for each facility.

4.1.1 Former CLEAR Plant

The Former CLEAR Plant is an inactive, historic operation that is not an APP regulated facility. The Former CLEAR Plant comprises an area of roughly 59 acres encompassing the Former Evaporation Pond and Former E Pond. Section 3.1.1 describes the results of past sampling and analysis of soils and groundwater collected at the CLEAR Plant by Hydro Geo Chem. This sampling event included 12 surface soil samples, 24 subsurface soil samples, and two groundwater samples. The surface soil samples were collected from the top 3 inches of soil and may represent fill material which is known to have been placed over portions of the CLEAR Plant area.

To provide additional data representing in-place soil, a sampling grid with 200-foot centers will be established over the approximate 59 acre site. Soil samples will be collected to bedrock or tool refusal from 10 randomly selected grid nodes on the systematic sampling grid. In addition, three judgmental sampling locations have been selected at locations representing the highest detected arsenic and lead concentrations identified during the Hydro Geo Chem characterization. Sediment samples will be collected from each drainage originating at the CLEAR Plant area. Groundwater will be characterized through the installation of one upgradient (MW-2008-01) and one downgradient (MW-2008-02) monitor well as noted on **Figure 4-2**. The following is a summary of the proposed CLEAR Plant samples.

Grid Samples

At 10 randomly selected grid nodes illustrated on **Figure 4-2**, soil samples will be collected from multiple depth intervals using Geoprobe® direct push techniques. At each random sampling location, the boring will be advanced to bedrock or tool refusal, estimated at 22 feet bgs. The soil borings will be advanced using Geoprobe direct push techniques. Attempts will be made to collect one composite sample from each of the following intervals:

Former CLEAR Plant
Grid Sample Summary

Frequency and Depth of Samples				
Area	**Interval (ft bgs)**	**Media**	**Analyses**	
			Radionuclide	**COI Total Metals**
Former CLEAR Plant	0 to 1.5	Soil	10	10
	1.5 to 3	Soil	10	10
	5 to 7	Soil	10	10
	10 to 12	Soil	10	10
	15 to 17	Soil	10	10
	20 to 22	Soil	10	10
Total			**60**	**60**

ft bgs = feet below ground surface
COI = constituents of interest

Judgmental Samples

Judgmental sampling locations have been selected based on previous sampling results (**Figure 4-2**). Three locations were selected representing the highest detected arsenic and lead concentrations identified during the Hydro Geo Chem characterization (Hydro Geo Chem, 2008). At each judgmental sampling location, the boring will be advanced to bedrock or tool refusal, estimated at 22 feet bgs. The soil borings will be advanced using Geoprobe direct push techniques. Attempts will be made to collect one composite sample from each of the following intervals:

Former CLEAR Plant
Judgmental Sample Summary

Frequency and Depth of Samples				
Area	**Interval (ft bgs)**	**Media**	**Analyses**	
			Radionuclide	**COI Total Metals**
Former CLEAR Plant	0 to 1.5	Soil	3	3
	1.5 to 3	Soil	3	3
	5 to 7	Soil	3	3
	10 to 12	Soil	3	3
	15 to 17	Soil	3	3
	20 to 22	Soil	3	3
Total			**18**	**18**

ft bgs = feet below ground surface
COI = constituents of interest

Sediment Samples

Five shallow surface drainages originate and flow from the CLEAR Plant area eastward to Demetrie Wash and one drainage flows south towards Old D Pond. To evaluate potential sediment impacts, two sediment samples will be collected from each of the five drainage areas illustrated on **Figure 4-2**. One composite sediment sample will be collected from each of the following intervals using Geoprobe direct push techniques.

Former CLEAR Plant
Sediment Sample Summary

Frequency and Depth of Samples				
Area	**Interval (ft bgs)**	**Media**	**Analyses**	
			Radionuclide	**COI Total Metals**
Former CLEAR Plant	0 to 1.5	Soil	10	10
	1.5 to 3	Soil	10	10
Total			**20**	**20**

ft bgs = feet below ground surface
COI = constituents of interest

Groundwater Samples

Groundwater underlying the CLEAR Plant will be characterized by installing one monitor well immediately upgradient to the west-northwest direction and one monitor well immediately downgradient of the CLEAR Plant location to the east. The monitor wells will be installed using air rotary methods. The locations of the proposed monitor wells are shown on **Figure 4-2**. The proposed monitor wells will be constructed in the alluvial and shallow fractured bedrock aquifer. It is anticipated that the wells will be approximately 20 to 30 feet deep. Groundwater samples will be collected from these wells for four consecutive quarters.

Former CLEAR Plant
Groundwater Sample Summary

Monitor Wells				
Area	**Well Depth**	**Media**	**Analyses**	
			Radionuclide	**COI Dissolved Metals**
MW-2008-01 Upgradient	20-30 feet	Groundwater	4	4
MW-2008-02 Downgradient	20-30 feet	Groundwater	4	4
Total			**8**	**8**

COI = constituents of interest

4.1.2 Former E Pond

The Former E Pond is an inactive, backfilled pond located near the southeast corner of the Former CLEAR Plant. This pond was historically used to contain surface water runoff and possibly process solutions from upset conditions at the Former CLEAR Plant, as described in Section 3.1.1.

Characterization of the Former E Pond will be performed through collection of soil samples from two judgmental locations and the installation and sampling of one monitor well immediately downgradient of the Former E pond as shown on **Figure 4-2**. The following is a summary of the proposed Former E Pond sampling.

Judgmental Samples

Judgmental sampling locations will focus on the pond area since it is not included in the CLEAR Plant random sample area grid. One location on the western portion and one location on the eastern portion of the former pond will be sampled (**Figure 4-2**). At each judgmental sampling location, the boring will be advanced to bedrock or tool refusal, estimated at roughly 22 feet bgs. The soil borings will be advanced using Geoprobe direct push techniques. Attempts will be made to collect one composite sample from each of the following intervals:

Former E Pond
Judgmental Sample Summary

Frequency and Depth of Samples				
Area	**Interval (ft bgs)**	**Media**	**Analyses**	
			Radionuclide	**COI Total Metals**
Former E Pond	0 to 1.5	Soil	2	2
	1.5 to 3	Soil	2	2
	5 to 7	Soil	2	2
	10 to 12	Soil	2	2
	15 to 17	Soil	2	2
	20 to 22	Soil	2	2
Total			**12**	**12**

ft bgs = feet below ground surface
COI = constituents of interest

Groundwater Samples

Groundwater will be evaluated at Former E Pond by installing one monitor well (MW-2008-03) immediately downgradient of the former pond using air rotary drilling methods (**Figure 4-2**). Groundwater observations made during the soils investigation will be used for monitor well depth and screen placement. This monitor well will be used to evaluate potential impacts from the Former E Pond. The proposed monitor well will be constructed in the alluvial and shallow fractured bedrock aquifer. It is anticipated that the well will be approximately 20 to 30 feet deep. Upgradient groundwater conditions will be evaluated using analytical data collected from monitor well MW-2008-01, installed upgradient of the CLEAR Plant (Section 4.1.1). Groundwater samples will be collected from this well for four consecutive quarters.

Former E Pond
Groundwater Sample Summary

Monitor Wells				
			Analyses	
Area	Well Depth	Media	Radionuclide	COI Dissolved Metals
MW-2008-03 Downgradient	20-30 feet	Groundwater	4	4
Total			**4**	**4**

COI = constituents of interest

4.1.3 Former Evaporation Pond

The Former Evaporation Pond is an inactive pond located at the south end of Clear Plant. This pond was historically used to contain process solutions from the Former CLEAR Plant operations as described in Section 3.1.1.

Characterization of the Former Evaporation Pond will be performed using the systematic sampling grid for CLEAR Plant, as shown on **Figure 4-2**. One monitor well will be constructed immediately downgradient of the former pond. The following is a summary of the proposed Former Evaporation Pond samples.

Judgmental Samples

Two grid nodes from the CLEAR Plant grid are located within the boundaries of the Former Evaporation Pond (**Figure 4-2**). One judgmental soil boring at each grid node will be advanced to bedrock or tool refusal, estimated at 22 feet bgs. The soil borings will be advanced using Geoprobe direct push techniques. Attempts will be made to collect one composite sample from each of the following intervals:

Former Evaporation Pond
Soil Sample Summary

Frequency and Depth of Samples				
			Analyses	
Area	Interval (ft bgs)	Media	Radionuclide	COI Total Metals
Evap. Pond	0 to 1.5	Soil	2	2
Evap. Pond	1.5 to 3	Soil	2	2
Evap. Pond	5 to 7	Soil	2	2
Evap. Pond	10 to 12	Soil	2	2
Evap. Pond	15 to 17	Soil	2	2
Evap. Pond	20 to 22	Soil	2	2
Total			**12**	**12**

ft bgs = feet below ground surface
COI = constituents of interest

Groundwater Samples

Groundwater will be evaluated by installing one monitor well (MW-2008-04) immediately downgradient of the Former Evaporation Pond (**Figure 4-2**). Groundwater observations made during the soils investigation will be evaluated for possible monitor well depth and screen placement. The proposed monitor well will be constructed in the alluvial and shallow fractured bedrock aquifer. It is anticipated that the well will be approximately 20 to 30 feet deep. Upgradient groundwater conditions will be evaluated using analytical data collected from monitor well MW-2008-01, installed upgradient of the CLEAR Plant (Section 4.1.1). Groundwater samples will be collected from this well for four consecutive quarters.

Former Evaporation Pond
Groundwater Sample Summary

Monitor Wells				
			Analyses	
Area	**Well Depth**	**Media**	**Radionuclide**	**COI Dissolved Metals**
MW-2008-04	20-30 feet	Groundwater	4	4
Total			**4**	**4**

COI = constituents of interest

4.1.4 Old D Pond

Old D Pond is an inactive pond located approximately 0.25 mile south of CLEAR Plant. Old D Pond is an APP regulated facility designated for closure. Old D Pond will be characterized by drilling and collecting soil samples from soil borings within the former impoundment, collecting sediment samples from unnamed washes upgradient and downgradient of the former pond, and the installation and sampling of two monitor wells in the shallow alluvial and fractured bedrock aquifer. Proposed sampling locations are illustrated on **Figure 4-3**. The following is a summary of the proposed Old D Pond samples.

Soil Samples

Two soil borings will be drilled within the Old D Pond using Geoprobe direct push techniques (**Figure 4-3**). At each location, the boring will be advanced to bedrock or tool refusal, estimate at 22 feet bgs. An attempt to collect one composite sample from the each of the following intervals:

Old D Pond
Soil Sample Summary

Frequency and Depth of Samples				
Area	**Interval (ft bgs)**	**Media**	**Analyses**	
			Radionuclide	**COI Total Metals**
D Pond	0 to 1.5	Soil	2	2
D Pond	1.5 to 3	Soil	2	2
D Pond	5 to 7	Soil	2	2
D Pond	10 to 12	Soil	2	2
D Pond	15 to 17	Soil	2	2
D Pond	20 to 22	Soil	2	2
Total			**12**	**12**

ft bgs = feet below ground surface
COI = constituents of interest

Sediment Samples

Sediment samples will be collected from four locations in the unnamed wash flowing from the north through the Old D Pond (**Figure 4-3**). Sediment samples will be collected from two locations in the wash downstream of Old D Pond, flowing east to Demetrie Wash. One composite sediment sample will be collected from each of the following depth intervals using Geoprobe™ direct push techniques.

Old D Pond
Sediment Sample Summary

Frequency and Depth of Samples				
Area	**Interval (ft bgs)**	**Media**	**Analyses**	
			Radionuclide	**COI Total Metals**
D Pond Wash	0 to 1.5	Soil	6	6
D Pond Wash	1.5 to 3	Soil	6	6
Total			**12**	**12**

ft bgs = feet below ground surface
COI = constituents of interest

Groundwater Samples

Groundwater will be evaluated at Old D Pond by installing two monitor wells using air rotary methods (**Figure 4-3**). The exact locations of the monitor wells will be dependant upon physical access restrictions. Groundwater observations made during the soils investigation will be used to determine final monitor well depth and screen placement. The proposed monitor wells will be constructed in the alluvial and shallow fractured bedrock aquifer. It is anticipated the monitor wells will be approximately 20 to 30 feet deep. Groundwater samples will be collected from these wells for four consecutive quarters.

Old D Pond
Groundwater Sample Summary

Monitor Wells				
Area	**Well Depth**	**Media**	**Analyses**	
			Radionuclide	**COI Dissolved Metals**
MW-2008-05 Downgradient	20-30 feet	Groundwater	4	4
MW-2008-06 Upgradient	20-30 feet	Groundwater	4	4
Total			**8**	**8**

COI = constituents of interest

4.1.5 Former Esperanza Mill

The Former Esperanza Mill is an inactive, historic mill operation that is not an APP regulated facility. The Esperanza Mill comprises an area of roughly 80 acres encompassing the former mill, two thickeners, raw water pond, the Former Raffinate Pond, and Former C Pond.

Figure 4-4 illustrates a sampling grid with 200-foot centers that will be established over the site area. Soil samples will be collected from 10 randomly selected grid nodes on the systematic sampling grid. The following is a summary of the proposed Esperanza Mill samples.

Grid Samples

At 10 randomly selected grid nodes illustrated on **Figure 4-4**, soil samples will be collected from multiple depth intervals using Geoprobe direct push techniques. At each random sampling location, the boring will be advanced to bedrock or tool refusal, estimated at 22 feet bgs. Attempts will be made to collect one composite sample from each of the following intervals:

Former Esperanza Mill
Soil Sampling Summary

Frequency and Depth of Samples				
Area	**Interval (ft bgs)**	**Media**	**Analyses**	
			Radionuclide	**COI Total Metals**
Former Esperanza Mill	0 to 1.5	Soil	10	10
	1.5 to 3	Soil	10	10
	5 to 7	Soil	10	10
	10 to 12	Soil	10	10
	15 to 17	Soil	10	10
	20 to 22	Soil	10	10
Total			**60**	**60**

ft bgs = feet below ground surface
COI = constituents of interest

4.1.6 Former C Pond

Former C Pond is an inactive, backfilled pond located within the Esperanza Mill area. This former pond measured roughly 600 feet by 600 feet or 8.3 acres and is located in the eastern most portion of the Esperanza Mill area. This pond was periodically mucked-out using a dredge line, with the spoils placed on the east side of Duval Canal.

Characterization of the Former C Pond will be performed using the Esperanza Mill area systematic sampling grid as illustrated on **Figure 4-4**. The pond area will be investigated by drilling and collecting soil samples from five soil borings within the former impoundment. Two groundwater monitor wells will be installed, one upgradient and one downgradient of the former pond. The following is a summary of the proposed Former C Pond samples.

Judgmental Soil Samples

At 5 designated grid nodes illustrated on **Figure 4-4**, judgmental soil samples will be collected from multiple depth intervals using Geoprobe direct push techniques. At each grid node, the boring will be advanced to bedrock or tool refusal, estimated at 22 feet bgs. Attempts will be made to collect one composite sample from each of the following intervals.

Former C Pond
Soil Sampling Summary

Frequency and Depth of Samples				
Area	**Interval (ft bgs)**	**Media**	**Analyses**	
			Radionuclide	**COI Total Metals**
Former C Pond	0 to 1	Soil	5	5
	1 to 3	Soil	5	5
	5 to 7	Soil	5	5
	10 to 12	Soil	5	5
	15 to 17	Soil	5	5
	20 to 22	Soil	5	5
Total			**30**	**30**

ft bgs = feet below ground surface
COI = constituents of interest

Groundwater Samples

Groundwater will be evaluated at the Former C Pond area by installing one upgradient monitor well (MW-2008-07) and one downgradient monitor well (MW-2008-08) as shown on **Figure 4-4**. Groundwater observations made during the soils investigation will be considered for monitor well depth and screen placement. The proposed monitor wells will be constructed in the alluvial and shallow fractured bedrock aquifer. It is anticipated that the wells will be approximately 20 to

30 feet deep. Groundwater samples will be collected from these wells for four consecutive quarters.

Former C Pond
Groundwater Sampling Summary

Monitor Wells				
			Analyses	
Area	Well Depth	Media	Radionuclide	COI Dissolved Metals
MW-2008-07 Upgradient	20-30 feet	Groundwater	4	4
MW-2008-08 Downgradient	20-30 feet	Groundwater	4	4
Total			**8**	**8**

COI = constituents of interest

4.1.7 Former C Spoils

Dredged material from the Former C Pond was reportedly placed in an area located between Duval Canal and Demetrie Wash, as described in Section 3.1.4. The area measures roughly 300 feet by 700 feet. This area appears to have been re-vegetated with grass and trees, and overlaps the 404 mitigation area as shown on **Figure 4-4**.

Characterization of this area will be performed through the completion of four soil borings at designated grid nodes within the area of dredged spoil. At each designated grid node, the boring will be advanced to bedrock or tool refusal, estimated at 22 feet bgs. Prior to bedrock or refusal, an attempt will be made to collect one composite sample from each of the following intervals:

Former C Pond Spoils
Soil Sampling Summary

Frequency and Depth of Samples				
Area	Interval (ft bgs)	Media	Analyses	
			Radionuclide	COI Total Metals
Former C Pond Spoils	0 to 1.5	Soil	4	4
	1.5 to 3	Soil	4	4
	5 to 7	Soil	4	4
	10 to 12	Soil	4	4
	15 to 17	Soil	4	4
	20 to 22	Soil	4	4
Total			**24**	**24**

ft bgs = feet below ground surface
COI = constituents of interest

4.1.8 Former Raffinate Pond

Former Raffinate Pond is an inactive, unlined and backfilled pond located within the Esperanza Mill area as described in Section 3.1.5. This former pond measured roughly 400 feet by 800 feet.

Characterization of the Former Raffinate Pond will be performed using the sampling grid for Esperanza Mill area as illustrated on **Figure 4-4**. Soils from five grid locations will be sampled to either a maximum depth of 22 feet bgs, to bedrock, or to groundwater. Two judgmental samples will be collected from soils/sediments visually noted to be impacted. Two groundwater monitor wells will be installed, one upgradient and one downgradient of the former pond. The following is a summary of the proposed Former Raffinate pond sampling.

Judgmental Soil Samples

At 5 designated grid nodes illustrated on **Figure 4-4**, judgmental soil samples will be collected from multiple depth intervals using Geoprobe direct push techniques. At each grid node, the boring will be advanced to bedrock or tool refusal, estimated at 22 feet bgs. Attempts will be made to collect one composite sample from each of the following intervals:

Former Raffinate Pond
Soil Sampling Summary

Frequency and Depth of Samples				
Area	**Interval (ft bgs)**	**Media**	**Analyses**	
			Radionuclide	**COI Total Metals**
Former Raffinate Pond	0 to 1	Soil	5	5
	1 to 3	Soil	5	5
	5 to 7	Soil	5	5
	10 to 12	Soil	5	5
	15 to 17	Soil	5	5
	20 to 22	Soil	5	5
Total			30	30

ft bgs = feet below ground surface
COI = constituents of interest

Judgmental Sediment Samples

Judgmental sampling locations have been selected based on visible stained sediments. At each judgmental sampling location, the boring will be advanced to 3 feet bgs. One composite sample will be collected from each of the following intervals.

Former Raffinate Pond
Judgmental Sediment Sampling Summary

Frequency and Depth of Samples				
Area	**Interval (ft bgs)**	**Media**	**Analyses**	
			Radionuclide	**COI Total Metals**
Former Raffinate Pond	0 to 1	Sediment	2	2
	1 to 3	Sediment	2	2
Total			**6**	**6**

ft bgs = feet below ground surface
COI = constituents of interest

Groundwater Samples

Groundwater will be evaluated by installing one upgradient monitor well (MW-2008-11) and two downgradient monitor wells MW-2008-09 and MW-2008-10 to characterize downgradient groundwater quality as shown on **Figure 4-4**. Groundwater observations made during the soils investigation will be considered for monitor well depth and screen placement. Groundwater samples will be collected from these wells for four consecutive quarters.

Former Raffinate Pond
Groundwater Sampling Summary

Monitor Wells				
			Analyses	
Area	Well Depth	Media	Radionuclide	COI Dissolved Metals
MW-2008-09 Downgradient	40-60 feet	Groundwater	4	4
MW-2008-10 Downgradient	40-60 feet	Groundwater	4	4
MW-2008-11 Upgradient	40-60 feet	Groundwater	4	4
Total			**12**	**12**

ft bgs = feet below ground surface
COI = constituents of interest

4.2 AMARGOSA WASH

The primary objective of the site characterization activities in Amargosa Wash are to confirm that the existing solution impoundments have not impacted the alluvial groundwater. Characterization of facilities in Amargosa Wash will consist of collecting samples from the active SX ponds and collection of alluvial groundwater samples downgradient of each impoundment. Facilities of interest in Amargosa Wash include:

- Leach stockpiles and SX facilities that are used to collect and hold process solutions. All of these facilities are active and regulated under the APP. The VRP will be used to confirm that releases of COIs have not occurred from these facilities.
- Historical impoundments (A Pond and B Pond). These impoundments are regulated as “to be closed” facilities under the APP. As with the active APP regulated facilities, these facilities are potential sources of COIs. The VRP will be used to confirm that releases of COIs have not occurred from these facilities.
- Launders Facility is a “to be closed” facility in the APP; however, the APP reports that the facility is to be closed upon mine closure under the Mine Closure Reclamation Plan.

The VRP will be used to confirm that releases of COIs have not occurred from this facility, in advance of final mine closure.

In general, the potential impact to the environment from historical activities at existing facilities located along Amargosa Wash and regulated under the APP will be investigated. The following sections present the proposed samples that will be collected at facilities located in Amargosa Wash. **Figure 4-4** illustrates sample locations and **Table 4-2** summarizes the proposed samples and analysis.

4.2.1 Headwall No. 1 and Bailey Lake

Headwall No. 1 and Bailey Lake are APP facilities used to collect PLS from the active sulfide leach stockpiles. To profile the solutions contained in these impoundments one PLS sample from each impoundment will be collected for four consecutive quarters.

To confirm that releases of COIs to the Amargosa Wash alluvial aquifer have not occurred, two temporary alluvial groundwater monitor wells will be installed immediately downgradient of Bailey Lake (**Figure 4-5**). The temporary wells will be installed using Geoprobe direct push techniques. The temporary wells will remain in place for 1 year and alluvial groundwater samples will be collected for four consecutive quarters.

4.2.2 Raffinate Pond No. 2

Raffinate Pond No. 2 is used to contain copper depleted solutions discharged from SX Plants No. 1 and No. 2. To profile the solutions contained in this impoundment one solution sample will be collected for four consecutive quarters.

To confirm that releases of COIs to the Amargosa Wash alluvial aquifer have not occurred, one temporary alluvial groundwater monitor well will be installed immediately downgradient of the impoundment (**Figure 4-5**). The temporary well will be installed using Geoprobe direct push techniques. The temporary well will remain in place for 1 year and alluvial groundwater samples will be collected for four consecutive quarters.

4.2.3 Former A Pond

Former A Pond was an unlined pond located between Amargosa Pond and Former B Pond. Former A Pond was used to retain stormwater or leach solutions that would overflow Amargosa Pond. The pond has been razed; however, no analytical data has been collected to determine potential impacts this pond may have on the underlying alluvial aquifer.

To confirm that releases of COIs to the Amargosa Wash alluvial aquifer have not occurred, one temporary groundwater monitor well will be installed immediately downgradient of Former A Pond (**Figure 4-5**). The temporary well will be installed using Geoprobe direct push techniques. The temporary well will remain in place for 1 year and alluvial groundwater samples will be collected for four consecutive quarters.

4.2.4 Former B Pond

Former B Pond is an unlined impoundment located in Amargosa Wash immediately upgradient of the confluence of Amargosa and Demetrie washes. The impoundment was historically used to retain potentially impacted stormwater or leach solutions that would overflow Amargosa Pond.

If the impoundment contains water at the time of sampling, one surface water sample will be collected.

To confirm that releases of COIs to the Amargosa Wash alluvial aquifer have not occurred, one temporary groundwater monitor well will be installed immediately downgradient of Former B Pond (**Figure 4-5**). The temporary well will be installed using Geoprobe direct push techniques. The temporary well will remain in place for 1 year and alluvial groundwater samples will be collected for four consecutive quarters.

4.2.5 Launders Facility

The Launders Facility consists of concrete bins where PLS was pumped to precipitate copper onto iron surfaces. The facility and operation was abandoned in 1987; however, the concrete bins remain in place.

To confirm that releases of COIs to the Amargosa Wash alluvial aquifer have not occurred, one temporary groundwater monitor well will be installed immediately downgradient of the Launders Facility. The temporary well will be installed using Geoprobe direct push techniques. The temporary well will remain in place for 1 year and alluvial groundwater samples will be collected for four consecutive quarters.

4.3 ESPERANZA WASH

The primary objective of the site characterization activities in Esperanza Wash is to confirm that releases of COIs to the Esperanza Wash alluvial aquifer have not occurred. Characterization of facilities in Esperanza Wash will consist of collecting samples from the active SX ponds and collection of alluvial groundwater samples downgradient of each impoundment. Current operating facilities located in the Esperanza Wash include leach stockpiles and SX facilities regulated under the APP, including:

- Headwall No. 2
- Headwall No. 3
- Raffinate Pond No.3
- Headwall No. 4 (SX-3 Stormwater Pond)

In general, the potential impact to the environment from historical activities at existing facilities located along Esperanza Wash will be investigated. The following sections present the proposed samples that will be collected at facilities located in Esperanza Wash. **Figure 4-6** illustrates sample locations and **Table 4-2** summarizes the proposed samples and analysis.

4.3.1 Headwall No. 2

Headwall No. 2 is an APP facility used to collect PLS from the active sulfide leach stockpiles. To profile the solutions contained in this impoundment one PLS sample from the impoundment will be collected for four consecutive quarters.

To confirm that releases of COIs to the Esperanza Wash alluvial aquifer have not occurred, one temporary alluvial groundwater monitor well will be installed immediately downgradient of the impoundment, adjacent to Channel No. 2 (**Figure 4-6**). The temporary well will be installed using Geoprobe direct push techniques. The temporary well will remain in place for 1 year and alluvial groundwater samples will be collected for four consecutive quarters.

4.3.2 Headwall No. 3

Headwall No. 3 is an APP facility used to collect PLS from the active sulfide leach stockpiles. To profile the solutions contained in this impoundment one PLS sample from the impoundment will be collected for four consecutive quarters.

To confirm that releases of COIs to the Esperanza Wash alluvial aquifer have not occurred, one temporary alluvial groundwater monitor well will be installed immediately downgradient of the impoundment (**Figure 4-6**). The temporary well will be installed using Geoprobe direct push techniques. The temporary well will remain in place for 1 year and alluvial groundwater samples will be collected for four consecutive quarters.

4.3.3 Raffinate Pond No. 3

Raffinate Pond No. 3 is an APP facility historically used to contain raffinate from SX Plant No. 3. The pond is currently used to collect PLS from Headwalls No. 3 and No. 5. To profile the solutions contained in this impoundment one PLS sample from the impoundment will be collected for four consecutive quarters.

To confirm that releases of COIs to the Esperanza Wash alluvial aquifer have not occurred, one temporary alluvial groundwater monitor well will be installed immediately downgradient of the impoundment (**Figure 4-6**). The temporary well will be installed using Geoprobe direct push techniques. The temporary well will remain in place for 1 year and alluvial groundwater samples will be collected for four consecutive quarters.

4.3.4 Headwall No. 4 (SX-3 Stormwater Pond)

Headwall No. 4 was formerly used to contain potential overflows from Headwall No. 3 and is currently a stormwater pond. To profile the solutions contained in this impoundment one water sample from the impoundment will be collected for four consecutive quarters.

To confirm that releases of COIs to the Esperanza Wash alluvial aquifer have not occurred, one temporary alluvial groundwater monitor well will be installed immediately downgradient of the impoundment (**Figure 4-6**). The temporary well will be installed using Geoprobe direct push techniques. The temporary well will remain in place for 1 year and alluvial groundwater samples will be collected for four consecutive quarters.

4.4 TINAJA AND UNNAMED WASHES

The primary objective of the site characterization activities in Tinaja and Unnamed washes are to confirm that the existing operations have not impacted the alluvial groundwater. Characterization of facilities in Tinaja and Unnamed washes will consist of collecting samples from the active SX ponds and collection of alluvial groundwater samples downgradient of each impoundment. The facility of interest in Tinaja and Unnamed washes include Headwall No. 5.

4.4.1 Headwall No. 5

Headwall No. 5 is an APP impoundment used to collect PLS from the active sulfide leach stockpiles near the headwaters of an unnamed tributary to Tinaja Wash. To profile the solutions contained in this impoundment one PLS sample from the impoundment will be collected for four consecutive quarters.

To confirm that releases of COIs to the Esperanza Wash alluvial aquifer have not occurred, one temporary alluvial groundwater monitor well will be installed immediately downgradient of Headwall No. 5 (**Figure 4-7**). The temporary well will be installed using Geoprobe direct push techniques. The temporary well will remain in place for 1 year and alluvial groundwater samples will be collected for four consecutive quarters.

4.5 TAILING IMPOUNDMENTS

4.5.1 Rhenium Ponds

The Rhenium Ponds consisted of three cells excavated into the surface of the Esperanza Tailing Impoundment. The cells were used for the storage and evaporation of process solutions from the Rhenium Plant (Montgomery Watson, 1999). Each cell measured 250 feet long, 65 feet wide, and 10 to 12 feet deep and were lined with geosynthetic; however, the integrity of the lining was uncertain (MWH, 2005).

Characterization of this area will be performed using judgmental sampling locations. Soil samples will be collected to a total depth of 7 feet bgs from two locations at the former pond location. Approximate sampling locations are illustrated on **Figure 4-8**.

Judgmental Samples

Judgmental sampling locations have been randomly selected within the footprint of the former ponds. At each judgmental sampling location, one composite sample will be collected from each of the following intervals:

Frequency and Depth of Samples				
Area	**Interval (ft bgs)**	**Media**	**Analyses**	
			Radionuclide	**COI Total Metals**
Rhenium	0 to 1	Sediment	2	2
	1 to 3	Sediment	2	2
	5 to 7	Sediment	2	2
Total			**6**	**6**

ft bgs = feet below ground surface
COI = constituents of interest

4.5.2 Esperanza Tailing Impoundment

The Esperanza Tailing Impoundment is the older of the two tailing impoundments and operated over a time span of approximately 23 years receiving tailing from both the Esperanza Mill and Twin Buttes operations. This impoundment overlies the basin fill deposits where the analysis of groundwater has detected radionuclides. However, insufficient data exist to determine if groundwater radionuclides are a result of leaching from the tailing or due to naturally occurring conditions.

To assist with this evaluation, URS proposes to drill and sample two borings through the Esperanza Tailing Impoundment, and collect and analyze tailing and soil samples through the entire depth of the boring. One boring will be drilled on the south-central side of the impoundment at the approximate location of the Twin Buttes tailing placement and one boring will be drilled on the north-central side of the impoundment as illustrated on **Figure 4-8**.

Lithology of the borings will be recorded in the field by the site geologist. The composite samples will be analyzed for metals and radionuclides. The borings will be drilled with hollow stem augers, collecting samples on 5-foot intervals as described in Section 5.3. One composite samples will be collected at the following each of the following intervals using procedures described in Section 5.3.

Frequency and Depth of Samples				
			Analyses	
Area	**Interval (ft bgs)**	**Media**	**Radionuclide**	**COI Total Metals**
Esperanza Tailing	0 to 20	Composite Soil	2	2
	20 to 40	Composite Soil	2	2
	40 to 60	Composite Soil	2	2
	60 to 80	Composite Soil	2	2
	80 to 100	Composite Soil	2	2
Total			**10**	**10**

ft bgs = feet below ground surface
COI = constituents of interest

4.5.3 Sierrita Tailing Impoundment

The Sierrita Tailing Impoundment is the most recent impoundment used since approximately 1970. The Sierrita Tailing Impoundment also overlies basin fill deposits where the analysis of groundwater has detected radionuclides. However, insufficient data exist to confirm that radionuclides in groundwater are not a result of leaching from the tailing and may be due to naturally occurring conditions, or other source(s).

To assist with this evaluation, URS proposes to drill and sample four borings through the Sierrita Tailing Impoundment and collect and analyze tailing and soil samples through the entire depth of the boring. Approximate boring locations are illustrated on **Figure 4-8**. Lithology of the borings will be recorded in the field by the site geologist. The composite samples will be analyzed for metals and radionuclides. Proposed analyses are summarized on **Table 4-2**.

The borings will be drilled with hollow stem augers, collecting samples on 5-foot intervals as described in Section 5.4. One composite sample will be collected from each of the following intervals using procedures described in Section 5.4.

Frequency and Depth of Samples				
			Analyses	
Area	Interval (ft bgs)	Media	Radionuclide	COI Total Metals
Sierrita Tailing	0 to 20	Composite Soil	4	4
	20 to 40	Composite Soil	4	4
	40 to 60	Composite Soil	4	4
	60 to 80	Composite Soil	4	4
	80 to 100	Composite Soil	4	4
	100 to 120	Composite Soil	4	4
	120 to 140	Composite Soil	4	4
	140 to 160	Composite Soil	4	4
	160 to 180	Composite Soil	4	4
	180 to 200	Composite Soil	4	4
	200 to 220	Composite Soil	4	4
Total			**44**	**44**

ft bgs = feet below ground surface
COI = constituents of interest

Monthly sampling of reclaim pond water, and tailing decant solution and analyses for U mass and COI metals will be conducted for one year. The monthly sampling is recommended to assess temporal and seasonal variation of the solution quality, with the goal of providing a more complete characterization of the solutions. Once per quarter, the reclaim pond water and tailing decant solution samples will be analyzed for the following parameters.

- Radionuclides; including gross alpha, gross beta, isotopic radium (Ra-226 and Ra-228), isotopic uranium (U-234, U-235, and U-238), and dissolved U mass
- Dissolved metals including aluminum, antimony, arsenic, barium, beryllium, cadmium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, thallium, and zinc
- Field analyses; including pH, conductivity, temperature, dissolved oxygen, turbidity and redox potential
- General chemical parameters; including total dissolved solids, major cations (calcium, magnesium, sodium, and potassium) and major anions (sulfate, nitrate, nitrite, chloride, bicarbonate, and carbonate)

4.6 GROUNDWATER SAMPLING AND ANALYSIS PLAN

As described in Section 3.6, localized elevated concentrations of uranium and certain metals in groundwater have been measured in various areas on the Sierrita property. Existing data indicate that uranium and metals occur naturally in the mineralized bedrock formations of the Sierrita batholith which underlies most of the Sierrita Mine, and areas to the north and northeast of the mine. Elevated concentrations of U mass and various metals have been measured in various process solutions. Uranium and metals concentrations in various process solutions will be obtained as presented in Sections 4.1 through 4.5 for each area to be evaluated. The objective of the proposed groundwater characterization presented in this section is to obtain and evaluate hydrogeologic and groundwater analytical data that will allow an assessment of potential impacts to groundwater from natural and anthropogenic sources, and to improve the understanding of U and metals in site groundwater.

The initial phase of this groundwater characterization program will include:

1. sampling and analysis of groundwater from 27 existing monitor wells for four consecutive quarters
2. sampling and analysis of groundwater for four consecutive quarters from 11 new monitor wells to be constructed in the former CLEAR Plant and Esperanza Mill areas
3. Installation of 4 background monitor wells followed by sampling and analyses of groundwater from these monitor wells for four consecutive quarters
4. Installation of temporary alluvial wells downgradient of process solution impoundments, and sampling of groundwater from these temporary alluvial wells for four consecutive quarters
5. Evaluation of resulting data and refinement of the conceptual site model for groundwater pathway

4.6.1 Sampling of Existing and Proposed Groundwater Monitoring Wells

Currently, Sierrita collects groundwater samples from 24 existing groundwater monitor wells for analyses of radionuclides and dissolved metals as part of ongoing monitoring programs. Sampling of these wells will continue on a quarterly basis for four consecutive quarters. These wells include:

- BW-02 and BW-03
- PZ-02, PZ-03, PZ-04, PZ-05, PZ-06, PZ-07, and PZ-08

- PZ-16
- MH-14, MH-15W, and MH-16W
- MH-17, MH-18, MH-19, MH-20, MH-21, MH-22, and MH-23
- MH-27, MH-28, MH-29, and MH-30

In addition to these existing APP and other monitoring program wells, groundwater sampling will also be attempted from three existing wells, if access to the wells is readily available. These three wells are being proposed for sampling because of their location with respect to local geology and/or to specific upgradient facilities. These wells are:

- BW-04 – Located in Amargosa Wash immediately downgradient of Former B Pond and immediately upgradient of the Demetrie Wash confluence. This well is screened in the Ruby Star Granodiorite.
- PZ-2007-05 – Located at the eastern edge of the Esperanza Tailing Impoundment.
- PZ-01 – Located in the southwest corner of the Sierrita property screened in the Tinaja Peak Formation and hydraulically upgradient of Sierrita facilities. This well represents background groundwater conditions for the Tinaja Peak Formation and has only been sampled and analyzed twice for U mass with the last event occurring in 1997.

Eleven additional monitor wells will be constructed in the Former CLEAR Plant and Esperanza Mill areas as described in this section. These wells will also be sampled and analyzed for four consecutive quarters. The geologic and analytical data obtained during installation and sampling of these wells will be used to further refine the site conceptual model for groundwater pathway.

In summary, thirty-eight existing and newly installed monitor wells will be sampled for four consecutive quarters to identify any seasonal or temporal trends in groundwater quality. Upon completion of the four quarters of groundwater sampling and evaluation of the analytical data, the need to continue quarterly sampling of all listed wells will be evaluated, and plans for any subsequent sampling will be developed.

Table 4-3 lists the monitor wells that will be sampled, and the justification for sampling at each location. For the existing monitor wells, the depth of the screened interval and the geologic formation in which each well is screened are also listed. Groundwater samples collected from each well will be analyzed for:

- Radionuclides; including gross alpha, gross beta, isotopic radium (Ra-226 and Ra-228), isotopic uranium (U-234, U-235, and U-238), and dissolved U mass

- Dissolved metals including aluminum, antimony, arsenic, barium, beryllium, cadmium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, thallium, and zinc
- Field analyses; including pH, conductivity, temperature, dissolved oxygen, turbidity and redox potential
- General chemical parameters; including total dissolved solids, major cations (calcium, magnesium, sodium, and potassium) and major anions (sulfate, nitrate, nitrite, chloride, bicarbonate, and carbonate)

4.6.2 Installation and Sampling of Background Wells

Additional background bedrock monitor wells will be installed to further assess natural conditions of groundwater within two primary mineralized geologic units. As described in Sections 2.3 and 3.6, analytical results for background monitor wells MH-21 and MH-17 have shown consistently greater concentrations of U mass than many of the downgradient wells. Monitor wells, MH-21 and MH-17, are screened in the Ruby Star Granodiorite and Harris Ranch Quartz Monzonite formations, respectively.

A review of geologic research conducted by Conoco in 1978 demonstrates that well MH-21 is screened within the hornblende-rich Ruby Star Granodiorite, containing naturally elevated levels of uranium. **Figure 4-9** illustrates the approximate location of Conoco sampling locations and delineates the approximate area of the hornblende rich Ruby Star Granodiorite.

To further characterize background groundwater conditions within the Ruby Star Granodiorite, two monitoring wells (MW-2008-12 and MW-2008-13) will be constructed at the approximate locations illustrated on **Figure 4-9**. Analytical results from the sampling of groundwater in these two wells will be used to assess if the U mass concentrations associated with MH-21 are a result of naturally occurring uranium. Two monitor wells are recommended in the Ruby Star Granodiorite because the presence of hornblende is highly variable. These proposed locations for the two new wells are within the area identified by Conoco as having naturally elevated concentrations of uranium. The exact locations of the new wells will be dependant upon physical access restrictions.

A second existing background well, MH-17, is located in the southwestern corner of the Sierrita property and is screened in the Harris Ranch Quartz Monzonite. As discussed in Section 2.0, the Harris Ranch Quartz Monzonite has similar characteristics as the Ruby Star Granodiorite with elevated uranium concentrations compared to other plutonic rocks in the district and the presence of hornblende which contains uranium. Analyses of groundwater samples collected from MH-17 indicate elevated concentrations of U mass.

To further characterize the background groundwater conditions of the Harris Ranch Quartz Monzonite and to determine if the U mass concentrations in MH-17 are a result of naturally occurring uranium, one additional monitor well (MW-2008-15) will be constructed and sampled at the location illustrated on **Figure 4-9**.

A third existing background well, PZ-01, is located in the southwestern corner of the Sierrita property and is screened in the Tinaja Peak Formation. To further characterize the background groundwater conditions within the Tinaja Peak Formation and to determine if the U mass concentrations associated with PZ-01 are a result of naturally occurring uranium, one additional monitor well (MW-2008-14) will be constructed at the location illustrated on **Figure 4-9** and sampled.

Samples of rock from at least three intervals in each new bedrock boring will be collected and analyzed for radionuclides including isotopic radium (Ra-226 and Ra-228), isotopic uranium (U-234, U-235, and U-238), and U mass. Samples will be collected from representative portions of the formations encountered and from any mineralized vein deposit noted below groundwater elevation.

Monitor wells will be installed and developed following borehole drilling. Following well installation and development, samples of groundwater from each well will be collected. Samples collected from each well will be analyzed for:

- Radionuclides; including gross alpha, gross beta, isotopic radium (Ra-226 and Ra-228), isotopic uranium (U-234, U-235, and U-238), and dissolved U mass
- Dissolved metals including aluminum, antimony, arsenic, barium, beryllium, cadmium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, thallium, and zinc
- Field analyses; including pH, conductivity, temperature, dissolved oxygen, turbidity, and redox potential
- General chemical parameters; including total dissolved solids, major cations (calcium, magnesium, sodium, and potassium) and major anions (sulfate, nitrate, nitrite, chloride, bicarbonate, and carbonate)

Sampling and analyses of the new background monitor wells over four consecutive quarters is proposed to assess any seasonal or temporal trends in groundwater quality.

4.6.3 Alluvial Groundwater Sampling

Currently, only one monitor well, MH-22, is constructed and screened in alluvial materials at the Sierrita property. Well MH-22 is located in Demetrie Wash and is 20 feet deep, screened entirely in alluvium. This well has been sampled 37 times between 1997 and 2007. Measureable levels of groundwater have been present in the well during every sampling event. Analytical results for U mass range from 133 to 509 micrograms per liter (µg/L).

Installation of twelve temporary alluvial monitor wells is proposed in Sections 4.1 through 4.5 at locations adjacent to active and inactive process impoundments. The depth to groundwater and surface elevation will be recorded at each location, and groundwater samples will be collected from each of the twelve temporary wells for four consecutive quarters. Samples collected from each well will be analyzed for:

- Radionuclides including gross alpha, gross beta, isotopic radium (Ra-226 and Ra-228), isotopic uranium (U-234, U-235, and U-238), and dissolved U mass
- Dissolved metals including aluminum, antimony, arsenic, barium, beryllium, cadmium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, thallium, and zinc
- Field analyses including pH, conductivity, temperature, dissolved oxygen, turbidity, and redox potential
- General chemical parameters including total dissolved solids, major cations (calcium, magnesium, sodium, and potassium) and major anions (sulfate, nitrate, nitrite, chloride, bicarbonate, and carbonate)

4.6.4 Data Analysis and Refining of the Conceptual Site Model for Groundwater Pathway

Following the installation of proposed groundwater monitor wells and the collection and analyses of groundwater as described in the preceding sections, the resulting data will be summarized and evaluated. The outcome of this data evaluation will be further refinement of the groundwater conceptual site model for groundwater.

Geochemical data obtained from background and existing groundwater monitor wells, alluvial groundwater wells, and process solutions as described in this section will be used collectively to assess potential sources of suspected uranium, radionuclides, and metals in groundwater beneath the site.

These data will be used to evaluate inherent relationships, if any, of potential source media geochemistry to the groundwater compositions found beneath the source area and in groundwater downgradient of the source area. Hydrogeochemical data will be used to determine if mixing of soil leachate or process solutions releases with the underlying groundwater results in the observed groundwater compositions and constituent distributions, or whether the suspected radionuclide and metal constituents detected in groundwater are sourced from the natural mineralization present in the area. These hydrogeochemical relationships will be assessed using a variety of approaches including as appropriate: major and trace element chemistry fingerprints, element ratios such as Cu/U, U-234/U-238; Piper and Stiff diagrams; simple mixing relations; and geochemical modeling. Multivariate statistics may be used.

Following data evaluation and refinement of the groundwater conceptual site model for groundwater pathway, remaining data gaps will be identified. If necessary, subsequent groundwater monitor well installation and/or sampling will be recommended to further refine the conceptual site model.

5.0 FIELD ACTIVITIES

5.1 SITE RECONNAISSANCE

An initial reconnaissance and characterization will be performed and will include (1) surveying site and surrounding features including land use and access, (2) evaluating the condition of existing on-site monitor wells, and (3) identifying collection points for pond sampling.

5.1.1 Conducting the Survey

A land surveyor registered in Arizona will survey the sampling grids, sample locations, and other areas as needed. A map of the area of investigation indicating the features to be included in the survey will be provided to the surveyor. The survey will include:

- Identifying or establishing on-site benchmarks for future surveying reference
- Locations of pertinent structures and appurtenances
- Locations and surface water elevations of water bodies (Amargosa Wash)
- Location and identification of above and below ground utility lines, if applicable
- Coordinates and elevations of existing monitor wells and piezometers
- Coordinates and elevations of soil sample locations

The surveyor will permanently notch and survey the north side of the top of monitor well and piezometer casings, including existing wells if not marked and those installed during the field investigation, for consistency in measuring water levels and preparing potentiometric maps. The surveyor will provide a survey data file to URS for the preparation of report graphics.

5.1.2 Evaluating Existing Monitor wells

As part of site reconnaissance, this work will consist of locating and evaluating the condition of existing monitor wells including (1) inspecting the surface seal, well vault, protective casing, bollards, and well cap; (2) measuring the depth to water; and (3) measuring the total depth of each monitor well. If the surface seal needs repair, the repairs will be carried out during the monitor well installation by the drilling contractor. If excessive sediments are measured in a monitor well, the well will be redeveloped.

5.2 MOBILIZATION

Initial field activities will include obtaining utility clearances and mobilizing to the site. These activities are described in Sections 5.2.1 through 5.2.2.

5.2.1 Clearing Utilities

Prior to and during mobilization activities, reasonable measures will be undertaken to locate above ground and underground utilities before work begins in accordance with Sierrita policies. A locator service may be used to locate utilities. If utilities are identified in an area to be excavated or drilled, the utilities will be clearly marked with paint, plumes, stakes, flagging, or other appropriate marker. Intrusive work will not begin until utility locations are identified and marked, and clearance is issued by Sierrita, if applicable.

5.2.2 Mobilization

Appropriate personnel, equipment, and materials will be identified for mobilizing and demobilizing to and from the site to conduct each task of the field investigation. The mobilization will include URS personnel, utility locating subcontractor(s), Geoprobe® subcontractor(s), drilling subcontractor(s), and state of Arizona registered land surveyors.

5.3 SAMPLING PROCEDURES

This section describes the equipment and procedures that will be used during the sampling activities, including brief descriptions of Geoprobe soil and sediment sampling, soil boring sampling, geophysical logging, groundwater sampling, and process water sampling.

5.3.1 Geoprobe Soil and Sediment Sampling

Subsurface soil sampling equipment will be advanced to various depths using direct push Geoprobe technology. Soil samples will be collected at the intervals specified in Section 4. One composite sample will be collected from each interval. The composite sample collected from each interval and will be homogenized prior to filling the sample container. At each location, the penetration will be filled to ground surface with granular bentonite after sampling is completed.

The Geoprobe sampling method consists of advancing the sample rods by hydraulically pushing or driving the rods to the desired sample collection depth. URS will collect soil samples with a Macro-core® sampling device to maximize sample volume. The Macro-core sampler collects a soil core in a non-reactive plastic or acetate liner that is 4 feet long and 1.5 inches in diameter.

The Geoprobe stainless steel tube will be lined with a clear acetate sleeve and driven to a target depth or refusal. The exterior of the acetate sleeves will be labeled with a permanent marker; to indicate sample station number, top and bottom, and depth intervals bgs. The Geoprobe unit will be moved to the next sample location, and the procedure repeated. Sleeves containing soil samples will be transported to a centralized sample preparation area, where they will be logged and processed for analysis.

Acetate sleeves will either be cut into sections (i.e., sample intervals) with a hacksaw, or cut open lengthwise. Using the interval markings as a guide, soil samples will be placed into 2-gallon bags, then sealed and labeled with the sample number; which includes the sample medium, station number, depth interval, and date and time collected. When a sample portion is selected for laboratory analysis, the soil will be transferred into laboratory containers using disposable spatulas or spoons. Sample station number, depth interval, date and time, and analyses requested will be noted on the boring logs and in the field logbook. Chain-of-custody forms will be completed in accordance with standard industry protocols.

A field geologist will describe and identify the soil samples using ASTM D 2488, the visual manual procedure, according to the Unified Soil Classification System (USCS). The following information will be recorded on the lithologic logs:

- Grain size distribution (percent by visual estimation)
- Angularity of coarse grained particles
- Consistency
- Cementation
- Plasticity
- Moisture conditions
- Color using the Munsell Color charts

5.3.2 Soil Boring Sampling

Soil borings within the tailing impoundments will be advanced using a CME 1250 track-mounted drilling rig equipped with hollow stem augers. Soil samples will be collected on 5-foot intervals and composited every 20 feet. URS will use the following general sampling procedures, which may be modified at the site depending on actual site conditions.

- The borings will be drilled using 4 1/4-inch inner diameter (ID) hollow stem augers, creating a borehole of approximately 8 7/8 inches in diameter. The borings will be drilled to depths of approximately 100 feet bgs in the Esperanza tailing impoundment and 220 feet bgs in the Sierrita tailing impoundment.
- Soil samples will be collected from each boring on 5-foot intervals, beginning at ground surface. The soil samples will be collected using a California modified split spoon sampler. Upon removal from the split spoon, the soil samples will be placed into a 2-gallon bag, sealed, and homogenized; and labeled with the sample number which includes the sample medium, boring number, and depth interval.
- Every 20 feet, a 4-part composite will be homogenized into a separate 2-gallon bag using a clean or disposable spatula or spoon, and then placed into a laboratory container for shipment to the laboratory.
- Water generated during the decontamination will be contained in 55-gallon drums and labeled as investigation derived waste (IDW). The drums will be stored at each boring until approval is received to empty them onto the tailing impoundment.
- Upon completing each boring, the soil cuttings will be backfilled into the borehole. Non-shrink bentonite grout will be placed in the upper 2 feet of the borehole and hydrated with water. The drilling contractor will restore the work area to a reasonable condition and remove any trash generated during the work. Excess cuttings will be spread out on the tailing impoundment.

A field geologist will describe the soil samples using ASTM D 2488, the visual manual procedure, according to the USCS. Although tailing is expected to be relatively homogeneous, the following information will be recorded on the lithologic logs:

- Grain size distribution (percent by visual estimation)
- Angularity of coarse grained particles
- Consistency
- Cementation
- Plasticity
- Moisture conditions
- Color using the Munsell Color charts

5.3.3 Groundwater Sampling

Monitor wells will be sampled after well development using low-flow purging and sampling procedures (Section 5.4.6).

5.3.4 Process Water Sampling

Process fluids from the ponds will be sampled. Grab samples will be collected from a sampling port or other point in the system to obtain representative samples. If not available, URS will collect grab samples from the ponds using a pole sampler.

5.4 MONITOR WELL ACTIVITIES

This section describes the equipment and procedures that will be used for monitor well installation, development, purging, and sampling. Monitor wells will be installed in accordance with Standard Operating Procedure (SOP)-002a.

5.4.1 Geoprobe Monitor Well Installation

Geoprobe direct push technology (DPT) will be used to create a borehole for installing temporary wells downgradient of active and inactive process solution ponds. Temporary well screens will be set in selected boreholes that encounter alluvial groundwater and the installation consists of the following steps:

- Prepacked screens will consist of a standard, slotted polyvinyl chloride (PVC) well screen pipe surrounded by a stainless steel mesh. Sand will be factory-packed between the slotted PVC and the stainless steel mesh. A 2.5-inch outer diameter (OD) prepack well assembly with a 1-inch Schedule 40 PVC riser will be used. This well assembly will be installed with 3.25-inch OD probe rods. All casing and screen material will be received in original factory packaging.
- The bottom of each screen will be sealed with a flush-threaded end cap.
- The annulus around the well screens will be filled with a sand pack consisting of size 20/40 sand. In addition, 20/40 sand will be used above the screen as a barrier. With the barrier in place, granular bentonite will be installed in the annulus to form the well seal.

5.4.2 Permanent Monitor Well Installation

Boreholes for monitor wells within the mill areas will be advanced using a CME 1250 track-mounted drilling rig equipped with air rotary casing hammer (ARCH) technology. These wells will be collocated with judgmental boring locations. URS will use the following general sampling and well installation procedures, which may be modified at the site depending on actual site conditions:

- The monitor well borings will be drilled using a 9 5/8-inch diameter downhole hammer bit, creating a borehole of approximately 8 7/8-inches in diameter. The ARCH drill rig will use steel drive casing to create and stabilize the borehole. This method uses a casing hammer to advance steel casing concurrently with drilling. Compressed air will be used to lift cuttings from the borehole, which will be discharged through a cyclone and into a portable hopper. ARCH drilling reduces the potential for cross contamination of the aquifer and allows for direct placement of annular well materials during well construction.
- A field geologist will collect cuttings on 5-foot intervals from the cyclone. The cuttings will be logged in accordance with the USCS. Disturbed cuttings will be logged to establish basic borehole lithology, and cannot be relied upon alone for correlating or establishing stratigraphy. The following information will be noted on the lithologic logs:
  - Grain size distribution (percent by visual estimation)
  - Angularity of coarse grained particles
  - Consistency
  - Cementation
  - Plasticity
  - Moisture conditions
  - Color using the Munsell Color charts
- Well riser and screen material will be 4-inch, Schedule 80 PVC with flush-threaded joints. Well screen material will be 10 feet long and factory slotted with a slot size of 0.020 inches. All casing and screen material will be received in original factory packaging.
- The bottom of each well will be sealed with a flush-threaded end cap. Casing and screen materials will be installed to ensure that the wells are plumb and correctly aligned.
- The annulus around the well screens will be filled with a sand pack consisting of size 8/12 sand extending from the bottom of the boring to about 5 feet above the screen section. The filter pack will be placed into the borehole through a tremie pipe. The

drilling subcontractor will continuously monitor the depth of the filter pack with a weighted measuring tape.

- A 3-foot thick bentonite seal will be placed directly above the filter pack. The seal will be composed of commercially manufactured bentonite pellets or chips (0.25-inch diameter). The bentonite pellets will be placed into the borehole and hydrated before the rest of the well annulus is sealed. The drilling subcontractor will confirm the proper depth of the seal with a weighted measuring tape.
- An annular seal will be placed above the 3-foot bentonite seal. The annular seal will be a cement grout consisting of a mixture of Portland cement, bentonite, and water. The grout ratio will consist of about 7.5 gallons of water mixed with 4 pounds of bentonite, then mixed with one 94-pound bag of cement. The cement grout will be tremied into the borehole. The tremie pipe will be placed no more than 3 feet above the top of the bentonite seal. The grout will be conveyed via tremie pipe into the borehole and will continue until undiluted grout returns to the top of the borehole (at the ground surface). The quantity of grout used will be recorded on the well log.
- Monitor wells will be completed above grade with a locking steel shroud. The top of the PVC well riser pipe will be surrounded by an oversized diameter steel casing set in 3,000-pound-per-square-inch concrete at least 3 feet above ground surface. A vented well cap will be installed on each well casing. Locks will be brass and will be keyed alike. If requested, locks provided by Sierrita will be installed.
- A concrete apron (5 feet by 5 feet by 4 inches thick) will be constructed, with the concrete surface sloped away from the well.
- Protective bollards will be concreted outside of the concrete apron. Four, 3-inch diameter, 6-foot long bollard posts will be set in concrete, and spaced equally around the concrete pad. The bollards will set at 36 inches high, and will be painted with yellow reflective paint.
- A well completion diagram form will be completed for each well. All well materials and quantities used will be described in the field logbooks.

5.4.3 Well Development

Monitor wells will be developed in accordance with SOP-0023. The well development process will include surging and bailing to remove fines from the filter pack material, followed by pumping to remove suspended solids. The wells will be further developed after completion using a Smeal development rig or equivalent. Well development will be conducted after the well has been allowed to stabilize for a minimum of 72 hours.

Temperature, pH, specific conductivity, dissolved oxygen (DO), and turbidity will be monitored during surging and pumping. Surging and pumping will continue until these parameters stabilize (less than 0.2 pH units or a 10 percent change for the other parameters between three consecutive readings), and the water exhibits a nephelometric turbidity unit (NTU) reading of 10 or less. If the parameters have not stabilized after 3 hours, development will cease with the well being recorded as developed. Well development information will be recorded on a well development form.

Development water will be containerized in portable tanks for proper characterization and disposal. Development water will be treated as IDW.

5.4.4 Pumps

After well development is complete, URS will install dedicated micropurge bladder pumps in each monitor well. The pumps will be stainless steel with Dura-Flex Teflon® bladders, 316 stainless steel intakes, 3/8-inch Teflon-lined polyethylene tubing for discharge, and 1/4-inch polyethylene tubing for supply air. The pump intakes will be set at mid-screen in each of the wells.

5.4.5 Surveying

The monitor wells will be surveyed by an Arizona registered land surveyor following pump installation. For each well, the coordinates and elevation of the north side of the top of the well casing and the rim of the well vault will be surveyed. The vertical data will be referenced to mean sea level using the National Geodetic Vertical Datum (NGVD) 29 reference system.

5.4.6 Well Purging and Sampling

Newly installed monitor wells, temporary wells, and existing monitor wells will be purged and sampled in accordance with SOP-005. Low-flow sampling methodology will be used for newly installed wells. Existing monitor wells with dedicated (submersible) pumps will be sampled using existing equipment and the total well volume methodology.

5.4.6.1 Low-Flow Purge Methodology

For the low-flow purging methodology, the well will be purged until field parameters (pH, temperature, turbidity, DO, oxygen reduction potential [ORP], and conductivity) have stabilized.

Readings will be taken at a rate commensurate for the flow involved, but no sooner than every 3 minutes. Low-flow purging rates on the order of 0.1 to 1.0 liter per minute will be used depending on the site-specific hydrogeology. The maximum allowable drawdown during low-flow purging is 0.3 feet. If the maximum allowable drawdown limit of 0.3 feet is exceeded and cannot be achieved, then the Total Volume Purge Method described in Section 5.4.6.2 will be followed. Background wells being sampled for metals must attain a turbidity of 10 NTUs or less before sample collection unless a written variance (on a well-specific basis) is acquired. The turbidity goal for non-background samples is 15 NTU, but samples with higher turbidity are acceptable if turbidity readings are stabilized and the other conditions of low-flow purging have been met.

Low-flow purging is complete only when all required field parameters have stabilized (temperature, pH, turbidity, conductivity, DO, and ORP). Stabilization is achieved when two consecutive readings show temperature is within $\pm$ one degree Celsius, pH values are within $\pm$ 0.1 pH unit, turbidity is less than or equal to 10 NTUs or within $\pm$ 10 percent, conductivity is within $\pm$ 5 percent, DO is within $\pm$ 10 percent, and ORP is within $\pm$ 10 millivolts (mV). The Site Manager/Field Task Leader will determine if redevelopment of any monitoring well is necessary and appropriate.

5.4.6.2 Total Well Volume Purge Methodology

If a water level drawdown greater that 0.3 feet occurs at a purge rate of 0.1 liter per minute or less, or if it is deemed necessary due to an existing dedicated pump, the total well volume purge methodology will be used. Using the total well volume purging methodology, the well will be purged until a minimum of three total well casing volumes have been removed and field parameters (pH, temperature, turbidity, conductivity, DO, and ORP) have stabilized. A pumping rate will be established to minimize drawdown and will not exceed 2 liters per minute. When purging by this methodology, if parameters have not stabilized after six well casing volumes, then purging will cease and samples will be collected. Background wells being sampled for metals must attain 10 or less NTUs before sample collection unless a written variance (on a well-specific basis) is acquired. The turbidity goal for non-background samples is 15 NTU, but samples with higher turbidity are acceptable if turbidity readings are stabilized and the other conditions of total well volume purging have been met.

The volume of water in the well will be calculated based on the length of the saturated thickness in the well and the screen diameter (see below for calculation of volumes). The well volume will be calculated in gallons using the following equation:

Well Volume (V) (in gallons) = H x F

where V = one well volume

H = the difference between the depth of the well and depth of water (feet)

F = factor for volume of one foot section of casing (gallons) from the table below

Diameter of Casing (inches)	F Factor (gallons)
1.5	0.09
2.0	0.16
3.0	0.37
4.0	0.65
6.0	1.47

F can also be calculated from the following equation:

$$\mathbf{F=H\ (D/2)^2\ X\ 7.48\ gal/ft^3}$$

where D = the inside diameter of the well casing (feet)

The well will be sampled immediately following purging without moving or adjusting the position of the pump. Necessary precautions will be taken to prevent spilling potentially contaminated water. The water will need to be containerized and appropriately disposed of or treated prior to discharge.

If the well is purged dry with a flow rate of less than 2 liters per minute, it will be sampled as soon as possible after the minimum sample volume of groundwater has recharged the well. The requirements of a minimum of three well volumes purged and stabilization of field parameters will not be applied to sampling a well that has been purged dry if the pumping rate was less than 2 liters per minute.

Total well volume purging is complete only when all required field parameters have stabilized (temperature, pH, turbidity, conductivity, DO, and ORP) or six well casing volumes have been removed, whichever comes first. Water parameters will be measured after removal of each volume and approximately every 5 minutes after the first two well casing volumes. Stabilization is achieved when two consecutive readings show temperature is within ± 1 degree Celsius, pH values are within ± 0.1 pH unit, turbidity is less than or equal to 10 NTUs or within ± 10 percent, conductivity is within ± 5 percent, DO is within ± 10 percent, and ORP is within ± 10 mV. The

Site Manager/Field Task Leader will determine if redevelopment of any monitoring well is necessary and appropriate.

5.4.6.3 Records

Field notes will be kept in a bound field logbook and on a Monitoring Well Purging Form as required by SOP-019, *Field Activity Records*. The following information will be recorded using waterproof ink:

- Names of sampling personnel
- Weather conditions
- Project title
- Location and well number
- Date and time of sampling
- Condition of the well
- Decontamination information
- Initial and final static water level, total well depth
- Equipment calibration information
- Method of purging
- Volume of water purged before sampling
- Purge start/stop times
- Pumping rate, if applicable
- Field parameter measurements during purging
- Method of sample collection
- Sample identification numbers
- Photo documentation, if applicable
- Quality Assurance/Quality Control (QA/QC) samples collected
- Irregularities or problems

5.5 DECONTAMINATION

Equipment decontamination will be conducted in accordance with SOP-021. Before undertaking any sampling activities, the Geoprobe and drilling subcontractors will construct decontamination pads for the equipment used at the site. Down-hole drilling, sampling, and geophysical logging equipment will be decontaminated.

Reuseable equipment used to collect, handle, or measure samples will be decontaminated in accordance with SOP-021. The decontamination procedure will match the degree of contamination on the sampling equipment. All items that will come in contact with potentially contaminated media will be decontaminated before each use. If decontaminated sampling equipment is not used immediately, it will be covered with plastic. Decontamination episodes and deviations from decontamination procedures will be recorded in the designated field logbook. The general decontamination procedures for equipment includes (1) an Alconox® and water solution wash, (2) thorough tap water rinse, and (3) final deionized water rinse.

5.6 INVESTIGATION-DERIVED WASTE MANAGEMENT

IDW will be managed in accordance with SOP-020. A waste accumulation area will be used for the temporary storage of field generated waste, such as soil cuttings, drilling and well development fluids, purge water, decontamination fluids, and personal protective equipment (PPE). Other wastes will include discarded materials resulting from field activities that, in their present form, possess no inherent value such as disposable sampling tools, bags, paper towels, etc. Waste materials generated during the investigation activities will be managed and tracked. The wastes will be divided into soil, water, and PPE.

To ensure the appropriate disposal of IDW, a tracking system will document the information necessary to determine the amount of contamination present in the waste. Waste tracking will be performed by a field manager and includes the following activities: segregation by waste type, waste container labeling, waste container movement, waste container storage, and waste disposal.

Soil cuttings and potentially contaminated water will be contained in 55-gallon drums, roll-off bins, and portable water tanks on site near each sampling location. Disposable PPE, including Tyvek™ coveralls, gloves, and booties will be decontaminated and disposed of as non-hazardous waste.

URS and its subcontractors will contain small quantities of soil and potentially-contaminated water in 55-gallon drums. Roll off bins may be used for containing soil cuttings. Samples of solid and liquid IDW will be collected and submitted to an analytical laboratory for analysis. Based on analytical results received, soils and sediments may be re-used if concentrations are below residential SRLs or recycled if the material has legitimate copper or molybdenum values. Liquid IDW may be re-used or recycled through mine operations if the liquid is free of excess contaminantion or if the liquid has legitimate copper of molybdenum values, respectively. IDW that is not recycled or re-used by Sierrita will be transported to an approved disposal.

5.7 SAMPLE HANDLING AND ANALYSIS

This section describes sample handling, sample analysis, QC requirements, field instrumentation, and data management.

5.7.1 Sample Designation

Each sampling location will be identified with an alphanumeric designation according to the following sample classifications:

- **Grid Sample Designation** – Grid samples include soil and sediment samples collected at grid nodes from grid systems of 200-foot-square grid units. The grid sample designation will include three fields that are separated by dashes; consider the following example: **B03-0.0-0.5**.

    The first field, "**B03**," identifies the grid node numbering. The single-digit alpha character (B) represents the vertical grid lines, and double-digit numeric character (03) represents the horizontal grid lines. The grid node is the point where the grid lines intersect.

    The second field "**0.0**," represents the top of the sample interval measured in feet bgs.

    The third field "**0.5**," represents the bottom of the sample interval measured in feet bgs.

- **Judgmental Sample Designation** – Judgmental samples include soil and sediment samples that are not considered grid samples. The judgmental sample designation will include three fields that are separated by dashes; consider the following example: **JS04-2.0-4.0**.

    The first field, "**JS04,**" identifies the judgmental sample number. The first two alpha characters are the designation for judgmental sample (JS). The numerical characters (04) that follow JS are the distinct number for that judgmental sample location.

The second field "**2.0**," represents the top of the sample interval measured in feet bgs.

The third field "**4.0**," represents the bottom of the sample interval measured in feet bgs.

- **Sediment Sample Designation** – Sediment samples include only those samples that are collected from the channels of washes or pond bottoms. The sediment sample designation will include three fields that are separated by dashes; consider the following example: **SD01-0.5-1.0**.

  The first field, "**SD01,**" identifies the sediment sample number. The first two alpha characters are the designation for sediment sample (SD). The numerical characters (01) that follow SD are the distinct number for that judgmental sample location.

  The second field "**0.5**," represents the top of the sample interval measured in feet bgs.

  The third field "**1.0**," represents the bottom of the sample interval measured in feet bgs.

- **Soil Boring Sample Designation** – Soil boring samples include the (5 part) composite samples collected at the tailing impoundments. The soil boring sample designation will include three fields that are separated by dashes; consider the following example: **SB01-50-100**.

  The first field, "**SB01**," identifies the soil boring.

  The second field "**50**," represents the top of the sample interval measured in feet bgs.

  The third field "**100**," represents the bottom of the sample interval measured in feet bgs.

- **Groundwater Sample Designation** – Groundwater samples include groundwater samples from temporary and permanent monitor wells. The groundwater sample designations will include two fields that are separated by a dash; consider the following examples: **MW2008-01** and **TW2008-01**.

  The two alpha characters in the first field, "**MW**," or "**TW**" identifies whether the sample came from a permanent monitor well (MW) or a temporary monitor well (TW) followed by the year, 2008.

  The second field "**01**," represents the numerical designation of the MW or TW.

- **Field Duplicate Sample Designation** – Field duplicate samples will be identified by adding a "**D**" to the end of the sample designations described above; for example **MW-01D** and **SD01-0.5-1.0D**.
- **Matrix Spike/Matrix Spike Duplicate Sample Designation** – Matrix spike/matrix spike duplicate will be identified by adding an "**MSD**" to the end of the sample designations described above; for example **MW-01MSD** and **SD01-0.5-1.0MSD**.
- **Trip and Field Blank Sample Designations** – Trip and field blank samples will be identified sequentially beginning with **Trip-1** and **Field-1**, respectively.

5.7.2 Sample Container, Volume, Preservatives, and Holding Time Requirements

Table 5-1 specifies the required sample volume, container type, preservation technique, and holding time for analysis. This table includes aqueous and solid sample matrices, and includes information for organic, inorganic, and general chemistry parameters in each matrix. Required containers, preservation techniques, and holding times for field QC samples (such as duplicates, field blanks, trip blanks, and matrix spike/matrix duplicates) are the same as for investigative samples.

5.7.3 Sample Management and Tracking

Each sample will be traceable from the point of collection through analysis and final disposition to ensure sample integrity. URS will use standard EPA procedures to identify, track, monitor, and maintain chain-of-custody for all samples. These procedures are discussed further in the generic QAPP and include the following:

- Field chain-of-custody procedures
    - Field Procedures
    - Field logbooks
- Laboratory chain-of-custody procedures

5.7.4 Sample Analysis

This section describes analytical procedures for samples collected during field activities. **Table 5-1** lists the laboratory analytical methods and more details are provided in the attached QAPP. In all cases, appropriate methods of sample preparation, cleanup, and analysis are based on specific analytical parameters of interest, sample matrices, and required detection limits.

- Radionuclides; including gross alpha, gross beta, isotopic radium (Ra-226 and Ra-228), isotopic uranium (U-234, U-235, and U-238), and dissolved U mass
- Dissolved metals including aluminum, antimony, arsenic, barium, beryllium, cadmium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, thallium, and zinc
- Field analyses including pH, conductivity, temperature, DO, turbidity, and redox potential
- General chemical parameters including total dissolved solids, major cations (calcium, magnesium, sodium, and potassium) and major anions (sulfate, nitrate, nitrite, chloride, bicarbonate, and carbonate)

5.7.5 Quality Control

Field and laboratory QC samples and measurements will be used to verify that data meet the QA objectives. Field QC samples are collected to assess how sampling activities influence data quality. Similarly, laboratory QC samples will be used to assess how a laboratory's analytical program influences data quality.

Field QC samples will be collected and analyzed to assess the influence of sampling activities on data quality, and will include field duplicate and equipment rinsate samples. Trip blanks and field blanks will not be collected since the COIs do not include volatile organic compounds (VOCs).

Laboratory QC samples will include Matrix Spike/Matrix Duplicate (MS/MD) samples. Matrix Spike/Matrix Spike Duplicate (MS/MSD) samples will not be collected since the COIs do not include VOCs.

Field Duplicate – Samples are independent samples collected as close as possible, in space and time, to a sample. Field duplicate samples can measure the influence of sampling and field procedures on the precision of an environmental instrument. They can also provide information on the heterogeneity of a sampling location. Immediately after a sample is collected, the field duplicate sample is collected using the same collection method. Field duplicates are collected at a frequency of one for every 20 investigative samples of the same matrix type and are analyzed for the same analytes as the original sample.

Equipment Rinsate – Blanks are collected when devices, such as trowels and split spoons, are used to collect samples. These data are used to assess the cleanliness of the sampling equipment and the effectiveness of equipment decontamination. Equipment rinsate blanks are collected by pouring analyte-free water over the surfaces of sampling equipment that contacts sampling media. Equipment rinsate blanks are collected after sampling equipment has been decontaminated but before the equipment is reused for sampling. Equipment rinsate blanks are typically collected at a frequency of one for every 20 or fewer samples and are analyzed for all total analytes. Equipment rinsate blanks will not be used when disposable or dedicated sampling equipment is used.

Matrix Spike/Matrix Duplicate (MS/MD) – Samples will be used to measure the accuracy and precision of laboratory analyses of inorganic and general chemistry parameters. MS samples will be used to measure accuracy, while MS/MD samples will be used to measure precision. Each of these QC samples will be collected and analyzed at a frequency of one for every 20 investigative samples per matrix.

Frequency of Field Quality Control Samples

Field Quality Control Sample	Frequency	
	Aqueous Matrix	**Solid Matrix**
Field Duplicate	1 per 20 samples (all analyses)	1 per 20 samples (all analyses)
Equipment rinsate blank	1 per 20 samples (all analyses)	None
Matrix spike/matrix duplicate (inorganics only)	1 per 20 samples (inorganics and general chemistry)	1 per 20 samples (inorganics and general chemistry)

QC checks for field measurements will consist mainly of initial and continuing calibration checks of field equipment. When applicable, QC check standards independent of the calibration standards may be used to check equipment performance. For example, to check the accuracy of field equipment such as a pH meter, standard buffer solutions independent of the calibration standards may be used. Precision of field measurements will usually be checked by taking replicate measurements. The types and frequencies of field QC measurements and the QC limits for these measurements will follow EPA-approved methods.

5.8 FIELD INSTRUMENTATION

This section outlines procedures and guidelines that will be followed to ensure equipment and instruments function accurately and consistently.

5.8.1 Field Instrument and Equipment Testing, Inspection, and Maintenance Requirements

The following summarizes testing, inspection, and maintenance procedures for field equipment and instruments. Instrument testing, inspection, and maintenance procedures are based on the following:

- The type of instrument
- The instruments' stability characteristics
- The required accuracy, sensitivity, and precision of the instrument
- The instrument's intended use, considering project-specific data quality objectives (DQOs)
- The instrument manufacturer's recommendations
- Other conditions affecting measurement or operational control

For most instruments, preventative maintenance is performed in accordance with procedures and schedules recommended in (1) the instrument manufacturer's literature or operating manual, or (2) SOPs associated with particular applications of the instrument.

In some cases, testing, inspection, and maintenance procedures and schedules will differ from the manufacturer's specifications or SOPs. Procedures or schedules can differ, for example, when a field instrument is used to make critical measurements or when the analytical methods associated with a laboratory instrument require more frequent testing, inspection, and maintenance.

Once arrived at the site, field equipment and instruments will be inspected for damage. Damaged equipment and instruments will be replaced or repaired immediately. Battery-operated equipment will be checked to assure full operating capacity; if needed, batteries will be recharged or replaced. Critical spare parts—such as tape, paper, pH probes, electrodes, and batteries—will be kept on site to minimize equipment downtime.

Following use, field equipment will be properly decontaminated before being returned to its source. When equipment is returned, copies of any field notes regarding equipment problems will be included so that necessary repairs are carried out.

5.8.2 Field Calibration and Frequency

Field sampling and measurement equipment will be examined upon arrival by the URS Field Team Leader to verify that it is in good working condition by checking the instrument with calibration standards, or testing the operation or function of the equipment. The manufacturer's operating manual and instructions that accompany the equipment will be consulted to ensure that calibration procedures and user directions are followed. The precision of field measurements will be checked by taking replicate measurements. Field measuring equipment will be calibrated daily.

6.0 COMMUNITY INVOLVEMENT PLAN

In accordance with ARS Article 49-176 Sierrita will provide to the public reasonable notice and information regarding remediation. Sierrita will follow requirements of Article 49-176 including:

- Identifying a primary contact and phone number
- Providing general public notice
- Establishing a document repository

The primary contacts for this VRP project will be:

Ned Hall
Sierrita Chief Environmental Engineer
6200 West Duval Mine Road
P.O. Box 527
Green Valley, AZ 85622-0527
Telephone: (520) 648-8857

and

Joey Pace
Arizona Department of Environmental Quality
1110 West Washington Street
Phoenix, AZ 85007

Telephone: (602) 771-4574

Sierrita anticipates providing public notice through local media (e.g., newspaper) and through existing forums, such as the Green Valley Community Coordinating Council's Environment Committee monthly meetings.

To fulfill Sierrita's obligation to maintain a record of materials and to make certain records are available to the public, Sierrita will maintain a document repository at Joyner-Green Valley Branch Library in Green Valley. The project filing structure will parallel the flow of the planning and investigation process. The repository will contain all documents and information required to be prepared or maintained by the VRP. The document repository at the Joyner-Green Valley Branch Library is accessible during normal business hours.

Sierrita will also establish an internet web site that will make available published documents in PDF format. The web site will be hosted by Freeport-McMoRan Copper & Gold Inc.

7.0 REFERENCES

Anderson, S.R. 1987. Cenozoic Stratigraphy and Geologic History of the Tucson Basin, PimaCounty, Arizona, USGS Water-Resources Investigations Report 87-4190.

Conoco 1981. Rock Geochemistry in Mineral Exploration: Study Area 1. Sierrita Batholith, Pima Co., Arizona-Progress Report 2, Research Report 1240-3-2-81.

Cooper, J.R. 1973. Geologic Map of the Twin Buttes Quadrangle, Southwest of Tucson, Pima County, Arizona. U.S.G.S. Miscellaneous Investigation Map I-745.

Dames & Moore, April 7, 1994, memorandum to Mike Shinn, Cyprus Sierrita Corporation, Dames & Moore Job # 15847-016-108.

Davidson, E.S. 1973. Geohydrology and Water Resources of the Tucson Basin, Arizona, USGS Water-Supply Paper 1939-E, 81p.

Errol L. Montgomery & Associates (ELMA), Inc. 1986. Evaluation of Pumping Test Data for Interceptor Wells. June 16, 1986.

_____ 1987. Investigation For Assured Water Supply, Las Quintas Serenas Water Company Franchise Area and "Adjacent Lands", Pima County, Arizona: prepared for Las Quintas Serenas Water Company, Sahuarita, Arizona, December 21, 1987.

_____ 1989. Hydrogeologic Report in Support of Groundwater Quality Protection Permit Application, Sierrita Operation, Cyprus Sierrita Corporation, Pima County, Arizona, April 7, 1989.

_____ 1991. Supplemental Hydrologic Report in Support of Aquifer Protection Permit Application, Sierrita Operation, Cyprus Sierrita Corporation. July 9, 1991.

_____1997d. Additional Characterization of Hydrogeologic Conditions, Sierrita Operation Aquifer Protection Permit Application, Cyprus Sierrita Corporation, Pima County, Arizona: draft report prepared for Cyprus Sierrita Corporation, November 13, 1997.

_____ 2001. Additional Characterization of Hydrogeologic Conditions Aquifer Protection Permit Application No. 101679 Sierrita Mine, Phelps Dodge Sierrita, Inc. Pima County, Arizona. January 4, 2001.

Errol L. Montgomery & Associates and Dames & Moore (ELMA & DM). 1994. Aquifer Protection Permit Application, Sierrita Operation, Cyprus Sierrita Corporation, Pima County, Arizona. Volumes I and II. September 7, 1994.

HydroGeoChem 2008. Soil, Surface Water, and Groundwater Sampling in the Clear Plant and Esperanza Mill Areas,.

Montgomery Watson, August 1999, Supplement to Aquifer Protection Permit Application, BADCT Demonstration.

_____ 2005. Supplement to the Aquifer Protection Permit Application BADCT Demonstration Addendum.

NOAA 2003, official website, http://www.noaa.gov/

Reed and Associates 1986, Draft permit application, Duval Sierrita. Prepared for Duval Corporation, Green Valley, Arizona. (unpublished)

West, R.J., and Aiken, D.M., 1982. Geology of the Sierrita-Esperanza deposit, Pima Mining District, Pima County, Arizona: in "Advances in geology of the porphyry copper deposits, southwestern North America", ed. S.R. Titley, University of Arizona Press, pp. 433-465.

WRCC 2005. Western Regional Climate Center, http://www.wrcc.dri.edu/

TABLES

Table 2-1
Existing Groundwater Monitor Well Summary
Sierrita Mine, Green Valley, AZ

		Location Data		Construction Details									Elevation Details (ft-asl)				
Well Identifier	Well Registration Number	Northing	Easting	Date Constructed	Total Depth Drilled (ft-bgs)	Borehole Diameter (inches)	Well Total Depth (feet)	Well Diameter (inches)	Well Casing Type	Length of Screen (feet)	Depth to Top of Screen (ft-bgs)	Depth to Bottom of Screen (ft-bgs)	Ground Surface Elevation	Measuring Point Elevation	Well Bottom Elevation	Top of Screen Elevation	Bottom of Screen Elevation
BW-02	55-528097	90500.835	102444.01	6/1/1990	300	6.75	123	4	steel	76	19	95	3636.47	3633.1	3513.47	3617.47	3541.47
BW-03	55-528095	98037.467	110374.528	6/5/1990	95	6.75	93	4	steel	63	30	93	3540.29	3540.29	3447.29	3510.29	3447.29
BW-04	55-537576	97863.814	110143.803	2/17/1994	20	9.0	20	4.0	pvc	14	6	20	3530.04	3530.04	3510.04	3524.04	3510.04
MH-14	55-528098	97052.9	130475.5	6/12/1990	561	9.875	501	6.0	pvc	125	376	501	3150.74	3150.74	2588.00	2773	2648
MH-15W	55-528093	90505.5	130502.9	6/15/1990	466	9.875	466	6.0	pvc	125	320	445	3116.12	3116.12	2650.12	2796.12	2671.12
MH-16W	55-528099	85893.2464	130472.2791	6/29/1990	460	9.875	450	6.0	steel	125	315	440	3098.37	3098.37	2648.37	2783.37	2658.37
MH-17	55-561873	93805.051	89072.3297	5/18/1997	110	6.0	109.6	4.0	pvc	50	58	108	4137.55	4137.29	4027.55	4079.55	4029.55
MH-18	55-561874	88966.356	94486.1403	5/20/1997	180	4	179	4	pvc	118	60	178	3784.09	3784.09	3605.09	3724.09	3606.09
MH-19	55-561878	89036.198	98134.137	5/22/1997	75	4	72.8	4	pvc	30	40	70	3689.09	3689.09	3533.29	3649.09	3619.09
MH-20	55-561880	89928.869	103016.579	5/23/1997	180	6.0	176	4.0	pvc	56	120	176	3609.39	3609.39	3433.39	3489.39	3433.39
MH-21	55-561881	104132.4978	109145.6563	6/3/1997	100	6.0	80	4	pvc	51	28	79	3693.67	3693.67	3613.67	3665.67	3614.67
MH-22	55-561872	97273.887	110754.09	6/6/1997	20	12.0	18.1	4	pvc	10	6.5	16.5	3511.65	3511.65	3493.55	3505.15	3495.15
MH-23	55-561871	97349.709	110764.699	6/17/1997	80.12	6.0	80.12	4.0	pvc	60	18	78	3515.28	3515.28	3435.16	3497.28	3437.28
MH-27	55-203702	92263.945	102880.34	7/27/2004	80	6.0	80.0	4.0	pvc	60	20	80	3700.14	3700.88	3620.14	3680.14	3620.14
MH-28	55-903648	94247.23	130281.214	12/15/2005	492	9.875	492	4.0	steel	130	355	485	3141.51	3142.18	2649.51	2786.51	2656.51
MH-29	55-903649	88328.12	130767.581	12/19/2005	480	9.875	480	4.0	steel	130	340	470	3122.24	3123.15	2642.24	2782.24	2652.24
MH-30	55-903884	99149.03	127671.524	NA	547	5	547	9.875	pvc	120	430	530	3231.92	3232.45	2684.92	2801.92	2701.92
PZ-01	55-561865	89570.8535	89436.6732	6/14/1997	255	6.0	190	4.0	PVC	50	140	190	3948.68	3949.32	3758.68	3808.68	3758.68
PZ-02	55-561861	96348.471	105394.701	5/28/1997	110	6.0	108.32	4.0	PVC	59.32	49	108.32	3758.53	3759.69	3650.21	3709.53	3650.21
PZ-03	55-561860	98010.786	108458.655	5/29/1997	100	6.0	81.22	4.0	PVC	60	20	80	3592.13	3592.89	3510.91	3572.13	3512.13
PZ-04	55-561869	99761.5347	107682.9011	6/30/1997	70	6.0	70	4.0	pvc	50	20	70	3612	3612.68	3542.00	3592	3542
PZ-05	55-561868	100568.0974	108648.5025	6/2/1997	70	6.0	69.5	4.0	pvc	50	19	69	3601.62	3602.31	3532.12	3582.62	3532.62
PZ-06	55-561867	100710.7934	104662.1053	6/4/1997	80	6.0	80	4.0	pvc	50	18	78	3764.9	3765.56	3684.90	3646.9	3596.9
PZ-07	55-561870	100613.5487	114108.0116	6/5/1997	155	6.0	155	4.0	pvc	51	100	150	3545.3	3546.22	3390.30	3443.3	3392.3
PZ-08	55-561866	93519.664	115554.2034	6/6/1997	280	6.0	275	4.0	pvc	92	185	275	3476.64	3477.14	3196.64	3291.64	3199.64
PZ-09*	55-561859	98025.3395	116234.2334	6/13/1997	230	6.0	230	4.0	pvc	100	128	228	3504.18	3504.66	3274.18	3376.18	3276.18
PZ-12*	55-561864	95227.7676	94897.4683	7/15/1997	200	5.0	200	2.0	Steel	50	150	200	4110.35	4110.79	3910.35	3960.35	3910.35
PZ-13*	55-561875	92304.183	101042.607	NA	30	6.0	30	4.0	pvc	20	10	30	3701.16	3701.75	3671.16	3691.16	3671.16
PZ-14*	55-561877	92327.17	101082.406	NA	84	8.0	84	4.0	pvc	30	54	84	3711.52	3711.81	3627.52	3657.52	3627.52
PZ-15*	55-561876	92342.6131	101136.7001	6/30/1997	130	8.0	130	4.0	pvc	30	100	130	3719.01	3719.32	3589.01	3619.01	3589.01
PZ-16	55-580712	90049.2112	97842.6662	5/31/2000	82	6.0	82	4.0	pvc	60	20	80	3723.6	3723.6	3641.60	3703.6	3643.6

Notes:
* - Abandoned
in. = inch(es)
ft = feet
bgs = below ground surface
asl = above sea level
NA = not available

Table 3-1
CLEAR Plant Area
2005 Analytical Summary

	Antimony	Arsenic	Cadmium	Copper	Lead	Manganese	Molybdenum	Selenium
Non-residential SRL	680	10	850	63,000	2,000	43,000	8,500	8,500
GPL	35	290	29	NAP	290	NAP	NAP	290
Surface Soil Samples (2-3 inch depth)				**(mg/Kg)**				
CP-1	**52**	**105**	3	45,600	**638**	156	1,440	40
CP-2	**66**	**166**	4	9,020	**1,820**	71	3,020	50
CP-3	4.5	**16.3**	3.23	21,700	51.7	317	1,900	13.4
CP-5	2	**17.1**	4.5	6,220	141	332	522	4
CP-7	4.5	**31.3**	5.01	20,000	152	295	2,820	10.3
CP-9	10.3	**40.1**	24.9	59,300	200	587	2,290	16.1
CP-13	0.6	5.44	0.48	1,090	15.4	177	273	0.7
CP-14	0.3	4.63	1.01	2,080	12.7	464	369	0.9
CP-15	1.9	**13.7**	7.38	8,260	116	335	456	3.2
CP-16	11	**34.9**	21.2	**109,000**	**950**	384	1,980	12
CP-19	1.6	9.1	5.95	23,800	45.0	273	2,430	28.4
CP-21	0.4	4.81	1.26	2,360	25.1	377	446	1
Subsurface Soil Samples/Depth				**(mg/Kg)**				
CP-T-1-1.5'	0.8	**18.1**	8.9	40,100	77.1	347	377	2.1
CP-T-1-2'	NA	8.64	NA	2,520	21.7	NA	368	NA
CP-T-1-4'	NA	**14.3**	NA	4,390	37.2	NA	182	NA
CP-T-1-8'	NA	4.2	NA	1,200	12.7	NA	114	NA
CP-T-2-2'	NA	3.6	NA	765	12.5	NA	38	NA
CP-T-2-7'	NA	5.63	NA	2,160	39.8	NA	135	NA
CP-T-2-7'BL	7.6	**37.1**	2.2	1,470	270	157	535	8.1
CP-T-2-10'	NA	5.43	NA	2,850	44.7	NA	99	NA
CP-T-2-15'	NA	3.62	NA	4,350	80.10	NA	72	NA
CP-T-2-B-6'	1.4	**11.8**	2.75	2,600	62.4	569	625	2.5
CP-T-2-C-6'	2.1	**14.8**	1.5	1,950	**293**	197	331	3.9
CP-T-3-0.5'	NA	5.6	NA	4,750	31.1	NA	62	NA
CP-T-3-0.75'	1.2	**20.9**	1.07	978	6.03	379	264	0.6
CP-T-3-8'	NA	**26.9**	NA	14,100	**488**	NA	615	NA
CP-T-4-1.5'C	0.5	4.88	1.74	2,790	14.4	244	347	2.6
CP-T-4-1.5'	0.4	1.1	18.1	57,300	4.1	759	60	3.7
CP-T-4-2.5'	NA	**16.4**	NA	998	7.26	NA	330	NA
CP-T-4-14'	NA	**10.4**	NA	1,570	3.66	NA	91	NA
CP-T-5-1.5'	0.4	4.7	0.62	839	13.9	235	115	0.8
CP-T-5-3'	NA	4.14	NA	1,050	12.4	NA	95	NA
CP-T-5-6'	NA	5.27	NA	746	3.98	NA	60	NA
CP-T-6-2'	NA	5.38	NA	1,900	29.2	NA	76	NA
CP-T-6-4'	NA	4.75	NA	2,150	45	NA	143	NA
CP-T-6-6'	NA	3.96	NA	1,410	28.1	NA	52	NA
AWQS	0.006	0.05[a]	0.005	NS	0.05	NS	NS	0.05
RBSL	NAP	NAP	NAP	1.3	NAP	1.6	0.04	NAP
Water Quality Sample				**(mg/Kg)**				
CP-T-5	< 0.0030	< 0.010	< 0.0030	0.058	< 0.010	0.029	**2.9**	**0.21**
CP-T-6	< 0.0030	< 0.010	**0.014**	0.96	< 0.010	**2.8**	**15**	0.038
CP-B-1	< 0.0030	< 0.010	< 0.0030	0.25	< 0.010	1.5	**0.88**	0.028

BOLD - concentration exceeds standard

[a] Federal maximum contaminant level of 0.01 milligrams per liter effective in 2006

Notes:
SRL = Soil Remediation Level
GPL = Groundwater Protection Level
AWQS = Aquifer Water Quality Standards
RBSL = Risk Based Screening Level
mg/Kg = milligrams per kilograms

Table 3-2
Esperanza Mill
2005 Analytical Summary

	Arsenic	Beryllium	Cadmium	Copper	Manganese	Molybdenum	Nickel	Zinc
Non-residential SRL	10	11	850	63,000	43,000	8,500	34,000	510,000
GPL	290	23	29	NAP	NAP	NAP	590	NAP
Surface Soil Samples (2-3 inch depth)				**(mg/Kg)**				
EM-3	**34.8**	1	5.65	11,600	715	1,570	11	824
EM-4	**10.8**	0.55	2.55	8,360	657	630	25	443
EM-5	3.62	0.37	0.59	1,880	323	122	8	195
EM-9	5.01	0.44	0.57	522	340	230	5	86
EM-10	9.52	0.93	1.78	814	538	239	8	256
EM-13	4.23	0.72	0.83	668	172	2,640	8	64
EM-14	**11.8**	0.26	0.85	409	30	471	< 5	29
EM-17	**101**	0.33	2.8	2,330	75.5	1,690	< 1	77
EM-18	**10.4**	0.48	2.31	3,560	173	1,470	4	67
EM-20	**13.7**	0.55	2.39	4,710	405	6,500	14	234
EM-21	4.09	0.17	0.32	514	110	151	< 1	25
EM-26	**23**	2.36	1.99	5,220	928	936	20	429
Subsurface Soil Samples/Depth				**(mg/Kg)**				
EM-T-1-1.5'	**28.3**	0.41	1.3	2,200	151	305	6	51
EM-T-1-2'	**23**	0.82	NA	9,850	NA	229	NA	NA
EM-T-1-6'	5.49	0.85	0.26	1,700	146	24	9	100
EM-T-1-13'	1.35	0.69	NA	159	NA	3	NA	NA
EM-T-2-2'	3.58	0.51	NA	533	NA	16	NA	NA
EM-T-2-2.5'	5.3	0.70	3.6	1,170	31	1050	< 5	40
EM-T-2-B-18"	6.4	0.90	0.5	1,400	198	103	< 5	169
EM-T-3-4	**38.8**	0.90	1.6	1,850	212	260	< 5	111
EM-T-3-6'	4.7	1.03	1.37	1,270	593	21	8	209
EM-T-3-12'	3.52	1.43	NA	733	NA	20	NA	NA
EM-T-4-6'	6.77	0.76	2.83	2,020	250	550	6	104
EM-T-4-10'	2.66	0.76	NA	643	NA	88	NA	NA
AWQS	0.05[a]	0.004	0.005	NS	NS	NS	0.10	NS
RBSL	NAP	NAP	NAP	1.3	1.6	0.04	NAP	2
Water Quality Sample				**(mg/Kg)**				
EM-UD	< 0.010	**0.046**	**0.2**	0.17	**71**	**0.18**	**0.15**	**3.7**
EM-T-4	< 0.010	< 0.0010	< 0.0030	< 0.010	**6.8**	**2.4**	< 0.010	0.078
EM-B-1	< 0.010	< 0.0010	**0.0054**	< 0.010	**18.0**	**0.05**	0.033	NA
C-Sump	< 0.010	0.0039	**0.016**	0.95	**3.7**	**0.63**	0.030	1.4
EM-UP	0.012	< 0.0010	< 0.0030	0.011	< 0.010	**0.041**	< 0.010	< 0.050
EM-MID	< 0.010	**0.010**	**0.069**	**170**	**12**	**1.5**	**0.18**	**6.5**
EM-LOW	< 0.010	< 0.0010	**0.0083**	0.81	**4.0**	**0.73**	0.019	0.54

BOLD - concentration exceeds standard

[a] Federal maximum contaminant level of 0.01 milligrams per liter effective in 2006

Notes:
SRL = Soil Remediation Level
GPL = Groundwater Protection Level
AWQS = Aquifer Water Quality Standards
RBSL = Risk Based Screening Level
mg/Kg = milligrams per kilograms

TABLE 3-3. SUMMARY OF URANIUM MASS IN GROUNDWATER
SIERRITA MINE, GREEN VALLEY, ARIZONA

MONITOR WELL OR LOCATION	AVERAGE URANIUM (µg/L)	MAXIMUM URANIUM (µg/L)	MINIMUM URANIUM (µg/L)	EARLIEST DATE	MOST RECENT DATE	NUMBER OF DATA POINTS
MONITOR WELLS						
MH-17 (HR)	105.4	150	23.1	6/26/1997	7/13/2007	34
PZ-01 (TP)	3.8	4.3	3.3	6/19/1997	8/12/1997	2
*MH-18 (TP)	16.2	23	10	6/19/1997	7/13/2007	30
PZ-16 (DV)	24.3	76	2.3	11/2/2000	7/23/2007	23
*MH-19 (TP)	25.5	96.5	12	9/22/1998	7/20/2007	39
*MH-27 (DV)	ND	ND	ND	3/30/2005	8/6/2007	23
BW-02 (DV)	9.5	154	ND	7/3/2000	7/23/2007	19
*MH-20 ((DV)	6.1	18.6	ND	12/23/1997	7/24/2007	36
PZ-02 (DV)	13.5	21	9.2	6/27/1997	7/23/2007	30
PZ-03 (RS)	63.3	99.6	32	6/26/1997	7/12/2007	25
BW-03 (RS)	77.1	198	ND	7/3/2000	7/23/2007	24
*MH-21 (RS)	1,132	1,600	560	6/27/1997	7/13/2007	34
PZ-04 (RS)	138	170	109	6/23/1997	7/12/2007	7
PZ-05 (RS)	450	767	81.2	6/26/1997	7/16/2007	31
PZ-06 (RS)	13	20	9	7/2/1997	7/12/2007	8
*MH-22 (Q)	319.4	509	133	6/24/1997	7/16/2007	37
*MH-23 (DV)	59.2	130	6.7	7/2/1997	7/16/2007	33
PZ-07 (Q/RS)	12.3	13	12	11/16/2006	7/24/2007	4
PZ-09 (Q/RS)	190	210	170	7/11/1997	8/26/1997	2
PZ-08 (DV)	14.3	15	14	11/14/2006	7/12/2007	4
MH-30 (Q)	26.8	27	26	11/9/2006	7/11/2007	4
*MH-14 (Q)	26.6	34	17	4/6/1998	7/10/2007	28
*MH-28 (Q)	28.8	33	25	1/24/2006	8/6/2007	19
*MH-15W (Q)	54.6	72	11	2/26/1998	7/11/2007	31
*MH-29 (Q)	28.3	32	26	1/24/2006	8/6/2007	22
*MH-16W (Q)	5.9	10	4	2/26/1998	7/11/2007	29

Notes: * - Denotes APP Point of Compliance (POC) Well
HR - Harris Ranch Monzonite
TP - Formation of Tinaja Peak
DV - Demetrie Volcanics
RS - Ruby Star Granodiorite
Q - Alluvium
Q/RS - Alluvium over Ruby Star Granodiorite

Table 4-1
Sierrita VRP
Sampling Rationale

Area of Interest	Problem Statement	Potentially Impacted Media	Objective	Proposed Sampling
Demetrie Wash				
Former CLEAR Plant	Former operations included process that used solutions containing COIs. Limited data exist to confirm that the CLEAR Plant has not adversely affected the environment.	Surface and subsurface soil	Gather data to confirm that there has not been a release of COIs from CLEAR Plant to soil.	Establish a systematic grid with 200 foot centers over the entire plant area. Collect soil samples from the surface to bedrock at 10 random grid locations.
	Historical soil sampling identified several locations with elevated levels of antimony, arsenic, copper, and lead.	Surface and subsurface soil	Gather data to further delineate the areas having highest concentrations of COIs.	Collect soil samples from the surface to bedrock at 3 judgmental locations having the highest concentrations of COIs.
	No data exist to confirm that overflows and/or runoff from the facility have not impacted drainage channels and sediment.	Sediment	Confirm that releases of COIs from the CLEAR Plant have not occurred to sediment in drainage channels.	Collect sediment samples from 2 locations in each of the five drainage paths.
	Facility managed large quantities of process solutions stored in above ground storage tanks and impoundments. Samples have not been collected to confirm that the facility has not adversely impacted underlying groundwater. There are no existing monitor wells in this area.	Groundwater	Confirm that releases of COIs to groundwater have not occurred from the CLEAR Plant.	Install one upgradient monitor well to characterize background groundwater quality. Install one monitor well immediately downgradient of the plant area to characterize groundwater quality. Collect groundwater samples for four consecutive quarters.
Former E Pond	Unlined impoundment reportedly collected surface runoff from CLEAR Plant. Samples have not been collected to confirm that the pond has not adversely impacted subsurface soils.	Subsurface Soil	Confirm that the pond did not release elevated concentrations of COIs from solutions to subsurface soil.	Collect soil samples from the surface to bedrock at 2 judgmental locations drilled within the pond area.
	Samples have not been collected to confirm that the pond has not adversely impacted underlying groundwater. There are no existing monitor wells to monitor this area.	Groundwater	Confirm that releases of COIs to groundwater have not occurred from the Former E Pond.	Install one monitor well immediately downgradient of the pond to characterize groundwater quality. Collect groundwater samples for four consecutive quarters.

Table 4-1
Sierrita VRP
Sampling Rationale

Area of Interest	Problem Statement	Potentially Impacted Media	Objective	Proposed Sampling
				Resulting groundwater data will be compared to CLEAR Plant upgradient well
Former Evaporation Pond	Process solutions were stored in this lined pond. Samples have not been collected to confirm that the pond has not adversely impacted subsurface soil.	Subsurface Soil	Confirm that the pond did not release elevated concentrations of COIs from process solutions to subsurface soils.	Collect soil samples from the surface to bedrock at 2 judgmental locations drilled within the pond area.
	Samples have not been collected to confirm that the pond has not adversely impacted underlying groundwater. There are no existing monitor wells to monitor this area.	Groundwater	Confirm that releases of COIs to groundwater have not occurred from the Former E Pond.	Install one monitor well immediately downgradient of the pond to characterize groundwater quality. Collect groundwater samples for four consecutive quarters. Resulting groundwater data will be compared to CLEAR Plant upgradient well.
Old D Pond	Process solutions were stored in this unlined pond. Samples have not been collected to confirm that the pond has not adversely impacted subsurface soil.	Subsurface Soil	Confirm that the pond did not release elevated concentrations of COIs from process solutions to subsurface soils.	Collect soil samples from the surface to bedrock at 2 judgmental locations drilled within the pond area.
	No data exist to confirm that overflows and/or runoff from the facility have not impacted drainage channels and sediment.	Sediment	Confirm that releases of COIs from the Old D Pond have not occurred to sediment in drainage channels.	Collected sediment samples from 4 locations upgradient and 2 locations downgradient of the pond.
	Samples have not been collected to confirm that the pond has not adversely impacted underlying groundwater. There are no existing monitor wells to monitor this area.	Groundwater	Confirm that releases of COIs to groundwater have not occurred from the Old D Pond.	Install one upgradient monitor well to characterize background groundwater quality. Install one monitor well immediately downgradient of the pond to characterize groundwater quality.

Table 4-1
Sierrita VRP
Sampling Rationale

Area of Interest	Problem Statement	Potentially Impacted Media	Objective	Proposed Sampling
				Collect groundwater samples for four consecutive quarters.
Former Esperanza Mill	Historic mill that separated copper using floatation process included mill, thickners, and raw water pond. Historical soil sampling identified several locations with elevated levels of arsenic.	Surface and subsurface soil	Gather data to confirm that there has not been a release of COIs from Former Esperanza Mill to soil.	Establish a systematic grid with 200-foot centers over the entire plant area. Collect soil samples from the surface to bedrock at 10 random grid locations.
Former C Pond	Historic unlined pond used to contain run-off from Sierrita Mill area. Limited data exist to confirm that the pond has not adversely impacted surface and subsurface soils.	Surface and subsurface soil	Gather data to confirm that there has not been a release of COIs from Former C Pond to soil.	Collect soil samples from the surface to bedrock at 5 judgmental locations drilled within the pond area.
	Samples have not been collected to confirm that the pond has not adversely impacted underlying groundwater. There are no existing monitor wells to monitor this area.	Groundwater	Confirm that releases of COIs to groundwater have not occurred from the Former C Pond.	Install one monitor well upgradient and one monitor well immediately downgradient of the pond to characterize groundwater quality. Collect groundwater samples for four consecutive quarters.
Former C Pond Spoils	Sediments dredged from Former C Pond were disposed to the ground surface immediately east of the Former C Pond. No data exist to confirm that the spoils have not adversely impacted surface and subsurface soils.	Surface and subsurface soil	Gather data to confirm that there has not been a release of COIs from Former C Pond Spoils to soil.	Collect soil samples from the surface to bedrock at 4 judgmental locations drilled within the spoils area.
Former Raffinate Pond	Historical unlined pond used to hold raffinate solution potentially containing COIs. Limited data exist to confirm that the pond has not adversely impacted surface and subsurface soils.	Surface and subsurface Soil	Gather data to confirm that there has not been a release of COIs from Former Raffinate Pond to soil.	Collect soil samples from the surface to bedrock at 5 judgmental locations drilled within the pond area.

Table 4-1
Sierrita VRP
Sampling Rationale

Area of Interest	Problem Statement	Potentially Impacted Media	Objective	Proposed Sampling
	Samples have not been collected to confirm that the pond has not adversely impacted underlying groundwater. There are no existing monitor wells to monitor this area.	Groundwater	Confirm that releases of COIs to groundwater have not occurred from the Former Raffinate Pond.	Install one upgradient monitor well to characterize background groundwater quality. Install two monitor wells immediately downgradient of the pond to characterize groundwater quality. Collect groundwater samples for four consecutive quarters.
Amargosa Wash				
Headwall No. 1 and Bailey Lake	Active ponds used to collect PLS. Headwall No. 1 and Bailey Lake were sampled once in 1998.	Not applicable	Characterize COIs in process solution.	Collect one sample from each Headwall No. 1 and Bailey Lake for four consecutive quarters.
	Samples have not been collected to confirm that the ponds have not adversely impacted groundwater.	Groundwater	Confirm that the ponds have not released elevated concentrations of COIs from process solutions to groundwater.	Install and sample two temporary alluvial wells immediately downgradient of the ponds. Collect groundwater samples from the wells for four quarterly sampling events.
Raffinate Pond No. 2	Active pond used to contain copper depleted solutions. Raffinate Pond No.2 was sampled once in 1998.	Not applicable	Characterize COIs in process solution.	Collect one sample from Raffinate Pond No. 2 for four consecutive quarters.
	Samples have not been collected to confirm that the pond has not adversely impacted groundwater.	Groundwater	Confirm that the pond has not released elevated concentrations of COIs from process solutions to groundwater.	Install and sample one temporary alluvial well immediately downgradient of Raffinate Pond No.2. Collect groundwater samples from the well for four quarterly sampling events.
Former A Pond	Former A Pond was used to retain stormwater or leach solutions that overflow Amargosa Pond. Samples have not been collected to confirm that the pond has not adversely	Groundwater	Confirm that the pond has not released elevated concentrations of COIs from process solutions to groundwater.	Install and sample one temporary alluvial well immediately downgradient of Former A Pond. Collect groundwater samples from the well for four quarterly sampling events.

Table 4-1
Sierrita VRP
Sampling Rationale

Area of Interest	Problem Statement	Potentially Impacted Media	Objective	Proposed Sampling
	impacted groundwater.			
Former B Pond	Former B Pond was used to retain stormwater or leach solutions that overflow Amargosa Pond. Samples have not been collected to confirm that the pond has not adversely impacted groundwater.	Groundwater	Confirm that the pond has not released elevated concentrations of COIs from process solutions to groundwater.	Install and sample one temporary alluvial well immediately downgradient of Former B Pond. Collect groundwater samples from the well for four quarterly sampling events.
Launders Facility	Inactive facility where concrete bins were used to contain PLS. Samples have not been collected to confirm that the pond has not adversely impacted groundwater.	Groundwater	Confirm that the pond has not released elevated concentrations of COIs from process solutions to groundwater.	Install and sample one temporary alluvial well immediately downgradient of the Launders Facility. Collect groundwater samples from the well for four quarterly sampling events.
Esperanza Wash				
Headwall No. 2	Active pond used to collect PLS. Headwall No. 2 was sampled once in 1998.	Not applicable	Characterize COIs in process solution.	Collect one sample from Headwall No. 2 for four consecutive quarters.
	Samples have not been collected to confirm that the pond has not adversely impacted groundwater.	Groundwater	Confirm that the pond has not released elevated concentrations of COIs from process solutions to groundwater.	Install and sample one temporary alluvial well immediately downgradient of Headwall No. 2. Collect groundwater samples from the well for four quarterly sampling events.
Headwall No. 3	Active pond used to collect PLS. Headwall No. 3 was sampled once in 1998.	Not applicable	Characterize COIs in process solution.	Collect one sample from Headwall No. 3 for four consecutive quarters.
	Samples have not been collected to confirm that the pond has not adversely impacted groundwater.	Groundwater	Confirm that the pond has not released elevated concentrations of COIs from process solutions to groundwater.	Install and sample one temporary alluvial well immediately downgradient of the pond. Collect groundwater samples from the well for four quarterly sampling events.
Raffinate Pond No. 3	Active pond used to contain copper depleted solutions. Raffinate Pond No. 3 was sampled once in 1998.	Not applicable	Characterize COIs in process solution.	Collect one sample from Raffinate Pond No. 3 for four consecutive quarters.

Table 4-1
Sierrita VRP
Sampling Rationale

Area of Interest	Problem Statement	Potentially Impacted Media	Objective	Proposed Sampling
	Samples have not been collected to confirm that the pond has not adversely impacted groundwater.	Groundwater	Confirm that the pond has not released elevated concentrations of COIs from process solutions to groundwater.	Install and sample one temporary alluvial well immediately downgradient of Raffinate Pond No. 3. Collect groundwater samples from the well for four quarterly sampling events.
SX Plant No. 3	Samples have not been collected to confirm that the plant has not adversely impacted groundwater.	Groundwater	Confirm that the plant has not released elevated concentrations of COIs from process solutions to groundwater.	Install and sample one temporary alluvial well immediately downgradient of SX Plant No. 3. Collect groundwater samples from the well for four quarterly sampling events.
Headwall No. 4	Active pond used to collect PLS. Headwall No. 4 was sampled once in 1998.	Not applicable	Characterize COIs in process solution.	Collect one sample from Headwall No. 4 for four consecutive quarters.
	Samples have not been collected to confirm that the pond has not adversely impacted groundwater.	Groundwater	Confirm that the pond has not released elevated concentrations of COIs from process solutions to groundwater.	Install and sample one temporary alluvial well immediately downgradient of Headwall No. 4. Collect groundwater samples from the well for four quarterly sampling events.
Tinaja and Unnamed Washes				
Headwall No. 5	Active pond used to collect PLS. Headwall No. 5 was sampled once in 1998.	Not applicable	Characterize COIs in process solution.	Collect one sample from Headwall No. 5 for four consecutive quarters.
	Samples have not been collected to confirm that the pond has not adversely impacted groundwater.	Groundwater	Characterize immediately underlying alluvial groundwater	Install and sample one temporary alluvial well immediately downgradient of Headwall No. 5. Collect groundwater samples from the well for four quarterly sampling events.
Tailing Impoundments				
Rhenium Ponds	Historical lined pond used to hold rhenium process solutions. Limited data exist to confirm that the Rhenium Ponds have not adversely impacted surface and subsurface soils.	Surface and subsurface soil	Gather data to confirm that there has not been a release of COIs from Rhenium Ponds to soil.	Collect soil samples from the surface to bedrock at 5 judgmental locations drilled within the footprint of the former Rhenium Ponds.

Table 4-1
Sierrita VRP
Sampling Rationale

Area of Interest	Problem Statement	Potentially Impacted Media	Objective	Proposed Sampling
Esperanza Tailing Impoundment	No data exist on the constituent make up of the tailing or the potential for leaching of COIs to groundwater.	Groundwater	Gather data to characterize COI concentrations and leachability of the tailing constituents.	Collect tailing samples every 10 feet (composite 2 samples each 20 foot) from 2 soil borings drilled through the Esperanza Tailing Impoundment into underlying basin and fill deposits.
Sierrita Tailing Impoundment	Limited data exist on COI concentrations in the reclaim pond.	Not applicable	Gather data to characterize COI concentrations in reclaim water.	Collect samples from the reclaim pond and tailing decant solution monthly to evaluate temporal and seasonal variation of solution quality.
	Only limited data on the constituent make up of the tailing or the potential for leaching of COIs.	Groundwater	Gather data to characterize COI concentrations and leachability of the tailing constituents.	Collect tailing samples every 10 feet (composite 5 samples each 50 foot) from 4 soil borings drilled through the Sierrita Tailing Impoundment into underlying basin and fill deposits.

TABLE 4-2
SIERRITA VRP
SUMMARY OF FREQUENCIES AND LOCATIONS OF SAMPLES

Sample Location Area	Interval (ft bgs)	Media	ANALYSES						
			SOIL / SEDIMENT		GROUNDWATER/SOLUTION				
			Metals(1) (SW-7000 Series)	Radiochemistry(2)	Dissolved Metals(3) (E200 Series)	Radiochemistry(4)	Major Anions (SW-846 9056 or EPA 300.0)	TDS (Method 160.1)	Field Water Quality Parameters(5)
Former CLEAR Plant	0 to 1	Soil	13	13					
	1 to 3	Soil	13	13					
	5 to 7	Soil	13	13					
	10 to 12	Soil	13	13					
	15 to 17	Soil	13	13					
	20 to 22	Soil	13	13					
	0 to 1	Sediment	20	20					
	1 to 3	Sediment	20	20					
	20 to 40	Groundwater			8	8	8	8	8
Former E Pond	0 to 1	Soil	2	2					
	1 to 3	Soil	2	2					
	5 to 7	Soil	2	2					
	10 to 12	Soil	2	2					
	15 to 17	Soil	2	2					
	20 to 22	Soil	2	2					
	20 to 40	Groundwater			4	4	4	4	4
Former Evap. Pond	0 to 1	Soil	2	2					
	1 to 3	Soil	2	2					
	5 to 7	Soil	2	2					
	10 to 12	Soil	2	2					
	15 to 17	Soil	2	2					
	20 to 22	Soil	2	2					
	20-40	Groundwater			4	4	4	4	4
Former D Pond	0 to 1	Soil	2	2					
	1 to 3	Soil	2	2					
	5 to 7	Soil	2	2					
	10 to 12	Soil	2	2					
	15 to 17	Soil	2	2					
	20 to 22	Soil	2	2					
	0 to 1	Sediment	6	6					
	1 to 3	Sediment	6	6					
	20-40	Groundwater			8	8	8	8	8
Former Esperanza Mill	0 to 1	Soil	10	10					
	1 to 3	Soil	10	10					
	5 to 7	Soil	10	10					
	10 to 12	Soil	10	10					
	15 to 17	Soil	10	10					
	20 to 22	Soil	10	10					
Former C Pond	0 to 1	Soil	5	5					
	1 to 3	Soil	5	5					
	5 to 7	Soil	5	5					
	10 to 12	Soil	5	5					
	15 to 17	Soil	5	5					
	20 to 22	Soil	5	5					
	20 to 40	Groundwater			8	8	8	8	8

TABLE 4-2
SIERRITA VRP
SUMMARY OF FREQUENCIES AND LOCATIONS OF SAMPLES

Sample Location Area	Interval (ft bgs)	Media	ANALYSES						
			SOIL / SEDIMENT		GROUNDWATER/SOLUTION				
			Metals(1) (SW-7000 Series)	Radiochemistry(2)	Dissolved Metals(3) (E200 Series)	Radiochemistry(4)	Major Anions (SW-846 9056 or EPA 300.0)	TDS (Method 160.1)	Field Water Quality Parameters(5)
C Pond Spoils	0 to 1	Soil	4	4					
	1 to 3	Soil	4	4					
	5 to 7	Soil	4	4					
	10 to 12	Soil	4	4					
	15 to 17	Soil	4	4					
	20 to 22	Soil	4	4					
Former Raffinate Pond	0 to 1	Soil	5	5					
	1 to 3	Soil	5	5					
	5 to 7	Soil	5	5					
	10 to 12	Soil	5	5					
	15 to 17	Soil	5	5					
	20 to 22	Soil	5	5					
	0 to 1	Sediment	2	2					
	1 to 3	Sediment	2	2					
	20 to 40	Groundwater			12	12	12	12	12
Headwall No. 1	NA	Process Solution			4	4	4	4	4
	10 to 20	Alluvial Groundwater			4	4	4	4	4
Bailey Lake	NA	Process Solution			4	4	4	4	4
	10 to 20	Alluvial Groundwater			4	4	4	4	4
Raffinate Pond	NA	Process Solution			4	4	4	4	4
	10 to 20	Alluvial Groundwater			4	4	4	4	4
Headwall No. 3	NA	Process Solution			4	4	4	4	4
	10 to 20	Alluvial Groundwater			4	4	4	4	4
Raffinate Pond No. 3	NA	Process Solution			4	4	4	4	4
	10 to 20	Alluvial Groundwater			4	4	4	4	4
Headwall No. 4	NA	Process Solution			4	4	4	4	4
	10 to 20	Alluvial Groundwater			4	4	4	4	4
SX Plant No. 3	NA	Process Solution			4	4	4	4	4
Headwall No. 2	NA	Process Solution			4	4	4	4	4
	10 to 20	Alluvial Groundwater			4	4	4	4	4
Rhenium Ponds	0 to 1	Soil	2	2					
	1 to 3	Soil	2	2					
	5 to 7	Soil	2	2					
	10 to 12	Soil	2	2					
	15 to 17	Soil	2	2					
	20 to 22	Soil	2	2					
Esperanza Tailing Impoundment	0-20	Sediment/Tailing	2	2					
	20-40	Sediment/Tailing	2	2					
	40-60	Sediment/Tailing	2	2					
	60-80	Sediment/Tailing	2	2					
	80-100	Sediment/Tailing	2	2					

TABLE 4-2
SIERRITA VRP
SUMMARY OF FREQUENCIES AND LOCATIONS OF SAMPLES

Sample Location Area	Interval (ft bgs)	Media	ANALYSES						
			SOIL / SEDIMENT		GROUNDWATER/SOLUTION				
			Metals(1) (SW-7000 Series)	Radiochemistry(2)	Dissolved Metals(3) (E200 Series)	Radiochemistry(4)	Major Anions (SW-846 9056 or EPA 300.0)	TDS (Method 160.1)	Field Water Quality Parameters(5)
Sierrita Tailing Impoundment	0-20	Sediment/Tailing	4	4					
	20-40	Sediment/Tailing	4	4					
	40-60	Sediment/Tailing	4	4					
	60-80	Sediment/Tailing	4	4					
	80-100	Sediment/Tailing	4	4					
	100-120	Sediment/Tailing	4	4					
	120-140	Sediment/Tailing	4	4					
	140-160	Sediment/Tailing	4	4					
	160-180	Sediment/Tailing	4	4					
	180-200	Sediment/Tailing	4	4					
	200-220	Sediment/Tailing	4	4					
Subtotal for Soil/Sediment Samples			380	380					
Field Duplicate	NA	Soil/Sediment	38	38					
QA/QC MS/MD	NA	Soil/Sediment	19	19					
Total for Soil/Sediment Samples			437	437					
Existing Monitor Wells(6)	NA	Groundwater			108	108	108	108	108
Proposed Background Wells(7)	NA	Groundwater			12	12	12	12	12
Sump B	NA	Groundwater			4	4	4	4	4
Sump C	NA	Groundwater			4	4	4	4	4
Reclaim Pond	Surface	Pond			12	12	4	4	12
Decant Solution	NA	Solution			12	12	4	4	12
Subtotal for Water Samples					256	256	240	240	256
QA/QC MS/MD	NA	Water			13	13	0	0	0
QA/QC Rinsate	NA	Water			13	13	0	0	0
QA/QC Field Duplicate	NA	Water			26	26	24	24	0
Total for Water Samples					307	307	264	264	256
TOTAL SAMPLES FOR ALL MEDIA			**437**	**418**	**307**	**307**	**264**	**142**	**256**

NOTES:

NA Not Applicable

(1) Metals: antimony, arsenic, barium, beryllium, cadmium, cobalt, copper, lead, manganese, mercury, molybdenum, nickel, selenium, thallium, and zinc

(2) ^{226}radium, ^{228}radium ,uranium isotopes ^{234}U, ^{235}U, ^{238}U, uranium mass

(3) Metals: aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, cobalt, copper, iron, lead, magnesium, manganese, mercury, molybdenum, nickel, potassium, selenium, sodium. thallium, and zinc

(4) 226 radium, 228 radium, uranium isotopes 234U, 235U, 238U , gross apha and gross beta, dissolved uranium mass

(5) Temperature, pH, specific conductivity, dissolved oxygen, turbidity, Eh

(6) BW-02, BW-03, BW-04, PZ-01, PZ-02, PZ-03, PZ-04, PZ-05, PZ-06, PZ-07, PZ-08, PZ-16, MH-14, MH-15W, MH-16W, MH-17, MH-18, MH-19, MH-20, MH-21, MH-22, MH-23, MH-27, MH-28, MH-29, MH-30, PZ-2007-05

(7) MW-2008-12, MW-2008-13, MW-2008-14, MW-2008-15

bgs below ground surface

MS/MD Matrix spike/matrix duplicate

QA/QC Quality assurance/quality control

Table 4-3
Sierrita VRP
Groundwater Sampling Justification

Well Identifier	Location	Screened Formation	Depth to Top of Screen (ft-bgs)	Depth to Bottom of Screen (ft-bgs)	Justification
Exisiting Monitor Wells					
BW-02	Esperanza Wash downgradient of Headwall No. 3, Raffinate Pond No. 3, SX-3 Drain Pond and Stormwater Pond	Demetrie Volcanics	19	95	Confirm no releases have occurred from process solution ponds located in Esperanza Wash.
BW-03	East bank of Demetrie Wash downgradient of the Amargosa Wash confluence	Ruby Star Granodiorite	30	93	Evaluate potential releases from upgradient process areas along the west side of Demetrie Wash and potential influence from Amargosa Wash.
BW-04	Amargosa Wash downgradient of B Pond and B Sump		6	20	Evaluate potential releases from B pond and Amargosa Wash area in general. May assist with determining effectiveness of B Sump.
MH-10	Southern edge of STI, east of Demetrie Wash	Clay/arkosic bedrock	280	600	Evaluate groundwater quality on southern edge of STI in vicinity of Demetrie Wash.
MH-14	Downgradient of STI in northern portion of well field	basin fill	376	501	Evaluate basin fill groundwater quality in northern portion of well field.
MH-15W	Downgradient of STI in central protion of well field	basin fill	320	445	Evaluate basin fill groundwater quality in central portion of well field.
MH-16W	Downgradient fo STI in southern portion of well field	basin fill	315	440	Evaluate basin fill groundwater quality in southern portion of well field.
MH-17	Background well located in the southwest corner of the Sierrita property	Harris Ranch Quartz Monzonite	58	108	Represents background groundwater conditions in the Harris Ranch Quartz Monzonite.
MH-18	Near Tinaja Wash downgradient of the waste rock stockpile	Tinaja Peak Formation	60	178	Evalulate impacts from waste rock stockpile and possibly represents groundwater conditions generally upgradient of Sierrita.
MH-19	Unnamed Wash downgradient of the active leach areas and Headwall No. 5	Tinaja Peak Formation	40	70	This well is screened at a shallower elevation than well PZ-15. Evalulate shallower aquifer impacts from sulfide leach area and Headwall No. 5.
MH-20	Esperanza Wash downgradient of Headwall No. 3, Raffinate Pond No. 3, SX-3 Drain Pond and Stormwater Pond. Further downgradient of well BW-02	Demetrie Volcanics	120	176	This well is screened at a deeper elevation than well BW-02. Evalulate deeper aquifer impacts.
MH-21	Upgradient well located on the east bank of Demetie Wash upgradient of the mill area	Ruby Star Granodiorite	28	79	Verify background COI concentrations in the Ruby Star Granodiorite and compare results to newly installed background wells.
MH-22	Alluvial well located in Demetrie Wash downgradient of the Amargosa Wash confluence	Alluvium	6.5	16.5	Evaluate alluvial groundwater in Demetrie Wash to identify potential releases from Demetrie and Amargosa washes.

Table 4-3
Sierrita VRP
Groundwater Sampling Justification

Well Identifier	Location	Screened Formation	Depth to Top of Screen (ft-bgs)	Depth to Bottom of Screen (ft-bgs)	Justification
MH-23	Bedrock well collocated with MH-22 in Demetrie Wash. Will compare a	Ruby Star Granodiorite	18	78	Evaluate potential influence of alluvial water with underlying bedrock groundwater.
MH-27	East of the sulfide leach stockpile and east of Headwall No. 2	Demetrie Volcanics	20	80	Evaluate quality of bedrock groundwater in vicinity of Headwall No. 2.
MH-28	Downgradient of STI in northern portion of well field	basin fill	355	485	Evaluate basin fill groundwater quality in northern portion of well field.
MH-29	Downgradient of STI in southern portion of well field	basin fill	340	470	Evaluate basin fill groundwater quality in southern portion of well field.
MH-30	Downgradient of STI in northern portion of well field	basin fill	430	530	Evaluate basin fill groundwater quality in northern portion of well field.
PZ-01	Background well located in the southwest corner of the Sierrita property	Tinaja Peak Formation	140	190	Represents background conditions in the Tinaja Peak Formation.
PZ-02	East of the sulfide leach area and southeast of Headwall #1 and Bailey Lake	Demetrie Volcanics	49	108.32	Evaluate quality of bedrock groundwater downgradient of sulfide leach stockpile and in vicinity of Headwall No. 1 and Bailey Lake.
PZ-03	Southern portion of the mill area downgradient of the SX circuit	Ruby Star Granodiorite	20	80	Evaluate bedrock groundwater quality in Amargosa Wash and possibly part of the Esperanza Mill area. Provides an additional Ruby Star Granodiorite monitoring point.
PZ-04	Center of the mill area downgradient of Sierrita Mill	Ruby Star Granodiorite	20	70	Evaluate bedrock groundwater quality in the general mill area and provides an additional Ruby Star Granodiorite monitoring point.
PZ-05	East central mill area generally downgradient of most operations in mill area	Ruby Star Granodiorite	19	69	Evaluate bedrock groundwater quality in the general mill area and provides an additional Ruby Star Granodiorite monitoring point.
PZ-06	Upgradient of the mill area and downgradient of waste rock stockpiles	Ruby Star Granodiorite	18	78	Evaluate bedrock groundwater quality upgradient of the mill area.
PZ-07	North of Esperanza Tailing Impoundment	basin fill/Ruby Star Granodiorite	100	150	Evaluate groundwater quality at northern edge of basin fill and northern Sierrita property boundary.
PZ-08	South of Esperanza Tailing Impoundment	Demetrie Volcanics	185	275	Evaluate southern portion Sierrita property boundary and groundwater quality before it flows beneath Sierrita Tailing Impoundment.
PZ-16	Unnamed Wash downgradient of the active leach areas and Headwall No. 5	Demetrie Volcanics	20	80	Evaluate quality of bedrock groundwater in vicinity of Headwall No. 5.
PZ-2007-05	Eastern edge of the Esperanza Tailing Impoundment	Tailing and basin fill	232	288	Evaluate basin fill groundwater quality immediately downgradient of the Esperanza Tailing Impoundment and near the Sierrita Tailing Impoundment reclaim pond.

Table 4-3
Sierrita VRP
Groundwater Sampling Justification

Well Identifier	Location	Screened Formation	Depth to Top of Screen (ft-bgs)	Depth to Bottom of Screen (ft-bgs)	Justification
Proposed Monitor Wells					
CLEAR Plant Wells					
MW-2008-01	Background well west of Former CLEAR Plant	Ruby Star Granodiorite	20	40	Evaluate groundwater quality upgradient of the Former CLEAR Plant Area.
MW-2008-02	West of Former CLEAR Plant	Ruby Star Granodiorite	20	40	Evaluate groundwater quality immediately downgradient of the Former CLEAR Plant.
MW-2008-03	East of the Former E Pond	Ruby Star Granodiorite	20	40	Evaluate groundwater quality immediately downgradient of the Former E Pond.
MW-2008-04	East of the Former Evaporation Pond	Ruby Star Granodiorite	20	40	Evaluate groundwater quality immediately downgradient of the Former Evaporation Pond.
MW-2008-05	East of Old D Pond	Ruby Star Granodiorite	20	40	Evaluate groundwater quality immediately downgradient of the Old D Pond.
MW-2008-06	West of Old D Pond	Ruby Star Granodiorite	20	40	Evaluate groundwater quality upgradient of the Old D Pond.
Esperanza Area Wells					.
MW-2008-07	West of Former C Pond	Ruby Star Granodiorite	20	40	Evaluate groundwater quality immediately upgradient of the Former C Pond.
MW-2008-08	East of Former C Pond	Ruby Star Granodiorite	20	40	Evaluate groundwater quality immediately downgradient of the Former C Pond.
MW-2008-09	East of Former Raffinate Pond	Ruby Star Granodiorite	20	40	Evaluate groundwater quality immediately downgradient of the Former Raffinate Pond.
MW-2008-10	East of Former Raffinate Pond	Ruby Star Granodiorite	20	40	Evaluate groundwater quality immediately downgradient of the Former Raffinate Pond.
MW-2008-11	West of Former Raffinate Pond	Ruby Star Granodiorite	20	40	Evaluate groundwater quality upgradient of the Former Raffinate Pond.
Background Wells					
MW-2008-12	Northeast of mill area and north of MH-21	Ruby Star Granodiorite	NA	NA	Evaluate background concentrations in hornblende-rich Ruby Star Granodiorite.
MW-2008-13	Northeast of mill area and north of MH-21	Ruby Star Granodiorite	NA	NA	Evaluate background concentrations in hornblende-rich Ruby Star Granodiorite.
MW-2008-15	Southwest Corner of property	Harris Ranch Quartz Monzonite	NA	NA	Evaluate background concentrations in Harris Ranch Quartz Monzonite.
MW-2008-14	Southwest Corner of property	Tinaja Peak Formation	NA	NA	Evaluate background concentrations in Tinaja Peak Formation.

Notes:
ft bgs = feet below ground surface
NA = Not Applicable
STI = Sierrita Tailing Impoundment

TABLE 5-1
SAMPLE SUMMARY, CONTAINERS, AND METHODS

Analytical Paramter	Extraction/Method	Sample Matirx	Preservation	Number/Minimum Volume of Container(s)	Sample Hold Time (from collection)
Ra 226	SW3050/E903.0	Soil/Sediment	None	4oz Glass	6 months
Ra 228	SW3050/E904.0	Soil/Sediment	None	4oz Glass	6 months
U-234, U-236, U-238	SW3050/E907.0	Soil/Sediment	None	4oz Glass	6 months
Uranium	SW3050/E908.0	Soil/Sediment	None	4oz Glass	6 months
Total Metals (GFAA)	SW7000 Series	Soil/Sediment	None	4oz Glass	6 months
Ra 226	E903.0	Water	pH < 2 with HNO_3	1000 mL plastic	6 months
Ra 228	E904.0	Water	pH < 2 with HNO_3	1000 mL plastic	6 months
U-234, U-236, U-238	E907.0	Water	pH < 2 with HNO_3	1000 mL plastic	6 months
Uranium	E200.8	Water	pH < 2 with HNO_3	1000 mL plastic	6 months
Gross Alpha & Gross Beta	E900.0	Water	pH < 2 with HNO_3	1000 mL plastic	6 months
Total Metals[1] (GFAA)	E200 Series	Water	pH < 2 with HNO_3	250 mL poly	180 days
Major Anions	Sw-846 9056 or EPA 300.0	Water	Cool to 4°C	250 mL poly	48 hours for $N0_2$, 28 days for all else
Eh	ADTM 1498	Water	NA	1 100-mL poly or glass	Analyze Immediately
TDS	EPA 160.1	Water	Cool to 4°C	1 100-mL poly or glass	7 days
pH	SW 846-940B	Water	NA	1 100-mL poly or glass	Analyze Immediately
Temperature	EPA 170.1	Water	NA	1 100-mL poly or glass	Analyze Immediately
Specific Conductance	EPA 120.1	Water	NA	1 100-mL poly or glass	Analyze Immediately
Turbidity	EPA 180.1	Water	NA	1 100-mL poly or glass	Analyze Immediately
Dissolved Oxygen	Field Instrument	Water	NA	1 100-mL poly or glass	Analyze Immediately

Notes: [1]Filtered in the field
Ra - Radium
mL - milliter
TDS - Total Dissolved Solids
Eh - oxidation reduction potential
pH - negative log hydrogen ion activity

FIGURES