Atlantic Richfield Company

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October 21, 2008

Mr. Kevin Mayer
SFD-7-2
US EPA Region 9
75 Hawthorne Street
San Francisco, CA 94105-3901

RE: Draft DQO Report
Leviathan Mine
Alpine County, California

Dear Mr. Mayer:

As required by Paragraph 51 of the Administrative Order for Remedial Investigation and Feasibility Study and the associated Statement of Work issued by U.S. EPA Region IX on June 23, 2008, Atlantic Richfield Company (Atlantic Richfield) is submitting this Draft Data Quality Objectives Report (DQO Report) for the Leviathan Mine Site.

If you have any questions regarding this DQO Report, please do not hesitate to contact us.

Sincerely,

Tony Brown for
Environmental Business Manager

cc: Gary Reilly, EPA Region 9
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Draft Data Quality Objectives Report: Remedial Investigation and Feasibility Study

Leviathan Mine

Alpine County, California

Prepared for:

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Prepared by:

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October 2008

Project 13091

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LIST OF ABBREVIATIONS AND ACRONYMS

µS/cm	microseimens per centimeter
AA	alternative action
AAA	administrative abatement actions
ACSA	Aspen Creek Study Area
AMEC	AMEC Geomatrix, Inc.
AMD	acid dine drainage
AO	administrative order
AOC	administrative order on consent
ARAR	applicable and/or relevant and appropriate requirement
ARD	acid rock drainage
ASB	Aspen Seep Bioreactor
ASTM	American Society for Testing Materials
Atlantic Richfield	Atlantic Richfield Company
bgs	below ground surface
BSA	Background Study Area
CAMU	Corrective Action Waste Management Units
CCR	California Code Regulations
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfs	cubic feet per second
cm/sec	centimeters per second
COPC	chemical of potential concern
CSM	conceptual site model
CUD	Channel Underdrain
CWA	Clean Water Act
cy	cubic yards
DFA	dynamic field activities
DQO	Data Quality Objectives
DR	decision rules
DS	decision statement
DM	Department of Interior, Department Manual
DTSC	California Department of Toxic Substances Control
EFCR	East Fork Carson River
ELAP	California Environmental Laboratory Accreditation Program
ESC	expedited site characterization
FS	Feasibility Study
FSP	Field Sampling Plan
ft.	feet
ft/day	feet per day
ft/ft	feet per foot
GIS	Geographic Information System
g/cm^3	grams per cubic centimeter
gpm	gallons per minute
HDPE	High-Density Polyethylene
HDS	High-Density Sludge
HHRA	Human Health Risk Assessment
HSSE	Health, Safety, Security, and Environment

IRM	interim remedial measure
kg	kilogram
LCSA	Leviathan Creek Study Area
LRWQCB	Lahontan Regional Water Quality Control Board
LTS	Lime Treatment System
MCLs	maximum contaminant levels
MCLGs	maximum contaminant level goals
mg	milligrams
mg/L	milligrams per liter
msl	mean sea level
MWH	Montgomery Watson Harza
NCP	National Contingency Plan
NDEP	Nevada Department of Environmental Protection
NOAA	National Oceanographic and Atmospheric Administration
NPL	National Priority List
NRDA	Natural Resource Damage Assessment
NTCRA	Non-Time-Critical Removal Action
O&M	operations and maintenance
OS	Overburden (Aspen) Seep
OSA	Off-Site Study Area
PID	Photoionization Detector
Pit SA	Pit Study Area
PLC	Programmable Logic Controller
PMF	Probable Maximum Food
PMP	Probable Maximum Precipitation
PPE	personal protective equipment
ppm	parts per million
PRG	preliminary remediation goals
PSQ	principle study question
PUD	Pit Underdrain
PVC	polyvinyl chloride
PWTF	Pond Water Treatment Facility
QA/QC	Quality Assurance/ Quality Control
QAPP	Quality Assurance Project Plan
RAGS	U.S. EPA Risk Assessment Guidelines for Superfund
RAM	Removal Action Memorandum
RAOs	remedial action objectives
RAWP	Remedial Action Work Plan
RCRA	Resource Conservation and Recovery Act
RCTS	Rotating Cylinder Treatment System
RI/FS	Remedial Investigation Feasibility Study
RME	reasonable maximum exposure
ROD	record of decision
RPM	Remedial Project Manager
RWQCB	Lahontan Regional Water Quality Control Board
SAP	Sampling and Analysis Plan
SDWA	Safe Drinking Water Act

Site	Leviathan Mine Site
SMP	Draft Leviathan Mine Site 2002 Site Management Plan
SMS	site management strategy
SNARLS	suggested non-adverse response levels
SPCC	Spill Prevention, Control, and Countermeasure
SPLP	Synthetic Precipitation Leaching Procedure
SOW	statement of work
SSHSP	Site-Specific Health and Safety Plan
State	State of California
STLC	soluble threshold limit concentration
SWRCB	State Water Resource Control Board
SWQC	surface water quality criteria
TAC	Technical Assistance Committee
TBC	to be considered
TCLP	Toxicity Characteristic Leaching Procedure
TDS	total dissolved solids
TSS	total suspended solids
TTLC	total threshold limit concentration
UAO	Unilateral Administrative Order
UNR	University of Nevada, Reno
UC Davis	University of California, Davis
U.S.	United States
U.S. ACOE	U.S. Army Corps of Engineers
U.S. DOE	U.S. Department of Energy
U.S. EPA	U.S. Environmental Protection Agency
USFS	U.S. Forest Service
USGS	U.S. Geological Survey

DRAFT
RI/FS
DATA QUALITY OBJECTIVES REPORT
Leviathan Mine Site
Alpine County, California

1.0 INTRODUCTION

This Draft Remedial Investigation/Feasibility Study (RI/FS) Data Quality Objectives Report (DQO Report or Report) has been prepared by AMEC Geomatrix, Inc. (AMEC), on behalf of Atlantic Richfield Company (Atlantic Richfield). The Report is a requirement of a Unilateral Administrative Order (UAO) issued to Atlantic Richfield on June 23, 2008, by the U.S. Environmental Protection Agency (U.S. EPA) for the Leviathan Mine Site (Leviathan Mine Site or Site) (See Figure 1). The Report follows the requirements for scoping a RI/FS as defined in the Guidance for Conducting Remedial Investigations and Feasibility Studies under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (OSWER 9335.3-01).

The Statement of Work (SOW) in the UAO defines the Leviathan Mine Site as "the area within the Mine property boundaries and adjacent areas outside the property boundary which have been disturbed by mining activities, such as mine wastes, excavations, landslides and runoff of surface water and groundwater." For the purpose of this Report the word "Site" is used generally to refer to this same on and off-property area described in the SOW. In order to facilitate the RI/FS work, the disturbed portion of the on-property area is also referred to as "on-site" and the downstream surface water area is referred to as "off-site."

1.1 ORDER REQUIREMENTS

This DQO Report is responsive to requirement 51 of the UAO, which states:

> *Within 90 days of the Effective Date, Respondent shall submit to EPA the Data Quality Objectives Report ("DQO Report") as described in the SOW. Within 60 days of EPA approval of the DQO Report, Respondent shall submit the Work Plan, as described in the SOW. If EPA disapproves of or requires revisions to the DQO Report or Work Plan, in whole or in part, Respondent shall amend and submit to EPA a revised DQO Report or Work Plan which is responsive to the directions in all EPA comments, within 30 days of receiving EPA's comments.*

The DQO Report was originally due to U.S. EPA by September 22, 2008, 90 days from the June 23, 2008, effective date of the UAO. U.S. EPA then agreed to extend the DQO Report submittal date to October 22, 2008, to allow stakeholder input prior to Report preparation.

1.2 PURPOSE AND OBJECTIVES

The process described in this DQO Report will meet the following objectives:

- facilitate systematic RI/FS project planning;
- assist in developing a RI/FS strategy to deal with project constraints (time, budget, weather, health and safety, etc.);
- assist in developing an understanding of how uncertainties may impact the RI/FS decision-making process;
- identify what the goals are and what the consequences may be if the decisions are made in error;
- assist in developing a strategy for determining the confidence level in the data collected;
- assist the team in identifying "data gaps."; and
- provide the framework for developing the RI/FS Work Plan.

1.3 RI/FS SCOPING PROCESS

Scoping is the initial planning phase of the RI/FS process and it involves developing a Site Management Strategy (SMS) to facilitate better planning and management of Site activities. The scoping process is divided into two steps. The first step begins with the collection and evaluation of existing Site data and the development of the Conceptual Site Models (CSMs) (Figure 2). From the data evaluation an SMS is developed that preliminarily identifies the types of actions that may be required to address the problems (such as whether interim actions may be taken to mitigate potential threats), the optimal sequence of Site actions and activities, and the procedures that may be used to streamline the RI/FS process.

Once the existing Site information has been analyzed and the CSM is developed, a preliminary range of remedial action alternatives is developed and associated technologies identified. The identification of these alternatives and technologies at this point in the process is not meant to be an exhaustive investigation of alternatives, but it is intended to be a more general classification of potential remedial actions based on the initially identified potential routes of exposure and associated receptors identified in the CSM. The identification of

technologies and alternatives is necessary to help ensure the data needed to evaluate these technologies are collected. Similarly, if treatability studies are contemplated, the data necessary to evaluate these studies need to be considered. Preliminary identification of potential Applicable and/or Relevant and Appropriate Requirements (ARARs) in the scoping phase assists in initially identifying remedial alternatives.

The most important part of the Scoping process is the identification of data needs to characterize the Site, complete the CSM, better define ARARs, and narrow the range of the preliminary remedial alternatives identified. This data needs step is accomplished via the DQO process and then with the preparation of work plans. In general, the RI/FS must obtain data to define the source areas of contamination, the potential pathways of migration, and the potential receptors and associated exposure pathways to the extent necessary to evaluate whether or not and to what extent a threat to human health or the environment exists now or in the future and to develop and evaluate remedial alternatives, including the No Action alternative (OSWER 1988).

1.4 DQO PROCESS

The U.S. EPA defines the DQO process as "a systematic, iterative, and flexible planning process based on the scientific method." U.S. EPA policy states that:

> *"before information or data are collected on Agency-funded or regulated environmental programs and projects, a systematic planning process must occur during which performance or acceptance criteria are developed for the collection, evaluation, or use of these data."*

This process was developed to provide a common structure and terminology to practitioners designing data generation programs. The DQO process produces quantitative and/or qualitative statements that express the project-specific decision goals.

Applying the DQO process to the data collection activities should assure that all necessary future needs for the data are considered. The process will also assist the team in developing a cost-efficient and environmentally and ecologically sound remedial solution. A summary of the seven steps U.S. EPA defines as the DQO process are presented below and shown on Figure 3.

> Step 1 – Statement of the Problem. Define the problem that necessitates the study; identify the planning team, examine budget, schedule.

Step 2 – Identify the Goal of the Study. State how environmental data will be used in meeting objectives and solving the problem, identify study questions, define alternative outcomes.

Step 3 – Identify Information Inputs. Identify data and information needed to answer study questions.

Step 4 – Define the Boundaries of the Study. Specify the target population and characteristics of interest; define special and temporal limits, scale of interference.

Step 5 – Develop an Analytic Approach. Define the parameter of interest, specify the type of inference, and develop the logic for drawing conclusions from findings.

- decision making;
- hypothesis testing;
- estimation; and
- other analytical approaches.

Step 6 – Specify Performance or Acceptance Criteria. Specify probability limits for false rejection and false acceptance decision errors; and develop performance criteria for new data being collected or acceptable criteria for existing data being considered for use.

Step 7 – Develop the Plan for Obtaining Data. Select the resource-effective sampling and analysis plan that meets the performance criteria.

1.5 CONTENT OF REPORT

Section 2 summarizes background information including the Site history, the primary data sources used to develop the DQOs and the work completed as part of the RI/FS scoping data evaluation in 2007. Section 3 presents both the human health and ecological CSMs. Section 4 presents a SMS for conducting the RI/FS. Section 5 describes Study Areas defined for completing the RI/FS. Section 6 provides a technology screening and proposes an initial evaluation of applicable technologies by study area. Section 7 presents State and Federal ARARs. The DQOs are described in Section 8 and Section 9 presents the references cited in the Report.

2.0 BACKGROUND

This section provides a Site history, presents the primary data sources considered in the DQO development process, and describes the scope and results of the data evaluation conducted as part of the scoping work that was used to prepare the CSMs presented in Section 3. The data sources considered in the scoping were those available in the current Site database.

2.1 SITE DESCRIPTION AND HISTORY

Leviathan Mine is an inactive open-pit mine on the eastern slopes of the Central Sierra Nevada Mountains at an elevation of approximately 7,000 feet (ft.) six miles east of Markleeville, in Alpine County, California (Figure 1). The Site property is located principally within Section 14, 15, 22, and 23 Township 10 North, Range 21 East of the Topaz Lake and Mt. Siegel U.S. Geological Survey (USGS) quadrangles.

The on-site property consists of 32 patented mineral claims and a patented mill site, which together total approximately 656 acres. The State of California owned portion of the property is approximately 479 acres. Disturbance from historical mining activities is evident on approximately 253 acres, most of which is State-owned property.

Access to the on-site area is dependent on the weather, but is provided by unpaved roads from State Highway 89 east through Markleeville, California from the west, and from U.S. Highway 395 from Gardnerville, Nevada, to the north. The California-Nevada border lies approximately three miles northeast of the on-site property.

Mining began on site in approximately 1863 and continued on an intermittent basis until 1962. Originally, the mine was opened to supply copper sulfate for refining silver ore at the Comstock mines in and near Virginia City, Nevada. From 1863 until the early 1870s, approximately 500 tons of copper-sulfate containing material were removed by the early miners. By 1870, at least two adits had been developed, blast furnaces and other mining machinery installed, and the mine was smelting up to six tons per day of copper.

Development of the large sulfur deposit began in earnest in the mid-1930s and continued through the early 1940s. Numerous adits, raises, drifts and stopes were excavated during this time period to explore and mine the sulfur. In 1933, there were four tunnels: Tunnel No. 1 at several hundred feet in length; a shorter Tunnel No. 2; Tunnel No. 3 at 760 feet, which discharged mine drainage water at a rate of 30 gallons per minute; and Tunnel No.4 at 300 feet in length. Tunnel No. 5 was constructed a short time later.

By 1934 the Leviathan Sulfur Company, a subsidiary of Western Clay and Metals Company, had acquired an interest in the mine and was producing approximately 100 tons of sulfur per

day. Between 1935 and 1941, the Calpine Corporation of Los Angeles, through a sublease from Texas Gulf Sulfur Company, constructed a mill and experimental plant for the recovery of sulfur; developed an extensive system of tunnels, drifts and rises; lengthened Tunnel No. 5 (the main adit) to 3,000 feet; and produced 5,000 long tons of sulfur. The Siskon Mining Corporation, a subsidiary of Texas Gulf Sulfur Company, acquired the mine in 1945 and continued to mine for and produce sulfur up through 1948.

In 1950, Siskon Mining Corporation patented the 32 mining claims and millsite claim comprising the Site and then sold its claims to the Calsul Mining Corporation.

Anaconda acquired the on-site property in 1951 from Calsul as a source of sulfur for processing copper ore at its mine near Yerington, Nevada. Between 1952 and 1953 Anaconda's contractor, Isbell Construction Company, further developed the underground mine into an open-pit mine by removing overburden material from above the sulfur orebody. Anaconda conducted open pit sulfur mining at the mine for a period of approximately eight years between 1954 and 1962.

In late 1962, Anaconda ceased all mining operations and closed the mine. In November 1962, Anaconda quitclaimed all of its property to William and Zella Mann. The Manns then formed Alpine Mining Enterprises, Inc., and transferred all of the mining claims and the millsite comprising the mine to the new company in May 1963. On or about December 19, 1983, Alpine Mining Enterprises, Inc. conveyed ownership of 465 acres of the Leviathan Mine property to the State of California by Corporation Grant Deed in consideration for payment of $54,500. The State Public Works Board authorized this acquisition by resolution dated January 31, 1984.

On or about August 20, 1984, the State Department of General Services transferred jurisdiction over the acquired Mine property to the State Board, which delegated jurisdiction over environmental cleanup activities at the Site to the Regional Board, effective as of January 3l, 1984.

2.2 REGULATORY HISTORY AND SITE LISTING

In May 1998, U.S. EPA issued an Administrative Order on Consent for Removal Action (1998 AOC) to Atlantic Richfield. Under the 1998 AOC, Atlantic Richfield agreed to remove certain quantities of liquids collected in the evaporation ponds, collect specific information on Site conditions, and reimburse U.S. EPA and other agencies for certain response costs. The 1998 AOC was modified in February 2000 to include a Riparian Conservation Project. On November 22, 2000, U.S. EPA issued an Administrative Order for Early Response Actions to Atlantic Richfield to submit work plans for a phased RI/FS for developing long-term responses

to releases from the Site. This Order also required Atlantic Richfield to plan and implement Early Response Actions to address known releases.

The U.S. EPA added the Site to the National Priorities List (NPL) on May 11, 2000.

In July 2000, U.S. EPA issued Administrative Abatement Action (AAA) under Section 106 of CERCLA to the Lahontan Regional Water Quality Control Board (RWQCB) to treat water in the evaporation ponds. The AAA was modified in each of the following years (2001, 2002, 2003, and 2004) to provide similar removal actions each summer which succeeded in eliminating overflow to the creek. U.S. EPA issued a new AAA in 2005 directing RWQCB to treat acid rock drainage/acid dine drainage (ARD/AMD) captured in the evaporation ponds each year until a final remedy is selected and implemented.

U.S. EPA signed a Non-time Critical Removal Action memorandum on July 12, 2005 (NTCRA) selecting a phased program for testing the effectiveness and reliability of on-site year-round ARD treatment. An additional objective of the NTCRA is to eliminate untreated ARD discharge to the watershed to provide an opportunity to evaluate the scope of subsequent phases of the RI/FS, given that such interception and treatment can be expected to substantially alter the nature and extent of threats posed by the Site.

On June 23, 2008, the U.S. EPA issued the RI/FS UAO to Atlantic Richfield. The UAO includes a SOW for conducting the RI/FS at the Site including completing this DQO Report.

The SOW included in the UAO requires collecting information to supplement and verify existing information on the environmental setting and pathway characterization, source characterization, receptor identification and risk assessments, geotechnical engineering evaluations and a Feasibility Study for the Site. Work conducted under the UAO is anticipated to lead to a final record of decision (ROD) for the entire Site.

On September 26, 2008 U.S. EPA modified the removal action NTCRA to include changes to the treatment approach and work conducted on the Site between 2005 and 2008.

2.3 DATA SOURCES

Multiple organizations have collected various environmental and ecological data at the Site. These data are presented in Table 1.

2.4 SCOPING DATA EVALUATION

Consistent with the RI/FS scoping process defined in the National Contingency Plan (NCP), 40 CFR Section 300.430(b), an evaluation of existing data was conducted in 2007 to form a basis

for development of the DQOs and the scope of the work to be performed that will be presented in the RI/FS Work Plan. A summary of that evaluation is provided here as a basis for the CSMs and DQOs presented in this Report. The scoping data evaluation was conducted in six parts:

1. site database upgrade;
2. initial water balance assessment;
3. assessment of the Site hydrogeology;
4. review of the geochemistry data;
5. human health and ecological risk exposure review in to create a CSM; and
6. review of available geotechnical studies.

The scoping data evaluation relied on data in the Site database and a number of references cited in Section 9.

The scope and general results of this data evaluation are presented below. Additional detail on the analysis of existing data will be presented in the RI/FS Work Plan.

2.4.1 Database Upgrade

As part of the scoping evaluation, the Site electronic database was reviewed for completeness, and then was supplemented and upgraded for future use in the RI/FS process. An inventory of data from various environmental media was prepared and an assessment of the data for usability in the RI/FS process was conducted. A review of completeness of the database and an assessment of the available documentation of the information contained in the database was completed. For data that is anticipated to be used in the RI and the risk assessment, data quality indicators were assigned such that the data can be used in the context of U.S. EPA Risk Assessment Guidelines for Superfund (RAGS) and other CERCLA data quality requirements. In addition to a completeness and data quality review, the database was upgraded with Site coordinates so that all data points can be located and incorporated on a consistent mapping system. A summary of the project database is shown on Figure 4 and the current content of the database is listed in Table 1. This database update was last provided to U.S. EPA and the stakeholders in June of 2008.

2.4.2 Water Balance

Previous studies have focused separately on general climate parameters, surface-water flow data, and groundwater elevation and discharge data. However, to date no synthesis of these

data has been presented. The general objectives of the water balance data evaluation were to:

- identify and characterize primary components of the Site water balance;
- assess long-term average and extreme climate conditions to assess available water for flow into the Site and direct precipitation to the Site;
- assess potential long-term flood frequency flows potentially entering the Site via the surface water pathways;
- develop estimates of the Probable Maximum Precipitation (PMP) and Probable Maximum Flood (PMF) to estimate the most extreme potential conditions on Site;
- estimate monthly average flows for the key water balance components at the Site; and
- identify and discuss key data gaps for the water balance.

2.4.2.1 Site Water Balance Components

Components of the water balance for the Site include sources of surface and groundwater flowing onto the Site, and surface and groundwater flow derived on-site from direct precipitation and recharge. Water discharges from the Site as surface water flow, groundwater flow, and evaporation/evapotranspiration from the surface. Site water balance components are shown on Figure 5 and summarized below.

INFLOWS TO THE SITE

1. Inflows to surface water from outside the Site are listed below.
    a. Inflows from within the Leviathan Creek Watershed include:
        i. Leviathan Creek upgradient of the Site;
        ii. Upper Tributary;
        iii. Lower Tributary;
        iv. 4L Creek; and
        v. Other small unnamed tributaries.
    b. Inflows from within the Aspen Creek drainage include:
        i. Aspen Creek upgradient of the Site; and
        ii. Unnamed Tributary.
2. Inflows to surface water derived on Site include:
    a. Runoff from precipitation falling directly on the surface; and

b. Groundwater discharges to streamflow.

3. Inflows to groundwater from outside the Site include:

    a. Flows from upgradient of the Site.

4. Inflows to groundwater derived on-site are listed below.

    a. Recharge to the groundwater from direct precipitation include:

        i. The open pit area;
        ii. Waste rock areas;
        iii. Leakage from the ponds and conveyance structures;
        iv. Undisturbed areas; and
        v. Other areas.

    b. Recharge to groundwater from stream losses.

OUTFLOWS FROM THE SITE

1. Surface water outflows off site including:

    a. Leviathan Creek downgradient of confluence with Aspen Creek.

2. Evaporation and evapotranspiration including:

    a. Open water evaporation from ponds;
    b. Open water evaporation from creeks; and
    c. Evapotranspiration from vegetation.

3. Groundwater outflows including:

    a. Groundwater discharges to streamflow; and
    b. Downgradient groundwater flow.

These components summarize the main sources and sinks of both surface water and groundwater flow at the Site. These components also account for general flow interactions on site, in that outflows from groundwater represent inflows to surface water, and vice versa.

The general goal of the Site water balance is to estimate long-term average flows for each component to understand where and how much water is flowing across the on-site area, and how much water is moving between the surface and groundwater domains. It is important to understand potential available water in terms of precipitation both incident on the Site and within the upper watersheds feeding the Site. In addition, it is important to understand maximum precipitation and flow events to be able to assess long-term remedial activities at the Site.

2.4.2.2 Precipitation

Precipitation falling both within the watersheds above the Site and directly on the Site provide the source of all water flowing at the Site. A meteorological station was developed on site and has been producing data since 2003. However, the data set is not complete in terms of daily precipitation totals, with data missing during 22 of the 42 months for which data are available. Because of the short period of record for on-site data and the significant amount of missing data within the period of record, other regional data sources and estimates were used to estimate potential precipitation at the Site during the scoping evaluation.

Brown and Caldwell (1983) developed isohyets of precipitation measured at various regional meteorological stations to develop an estimate of approximately 14.4 inches for mean annual precipitation at the Leviathan Mine Site. Monthly average precipitation was developed based on an assumed relationship between Leviathan and Woodfords, California. MWH did not update this analysis, but noted that the State's meteorological station was in the process of installation.

A review of the map of mean annual precipitation for California developed by Rantz (1969), based on precipitation measured between 1900 and 1960, shows the Leviathan Mine Site is falling between the 22.5 and 27.0 inches per year contours, suggesting a much higher mean annual precipitation than that estimated by Brown and Caldwell. This is likely due to the fact that simple interpolation methods such as the isohyetal method are not considered accurate for mountainous terrain because they do not account for the effects of topography, or the angle or direction of various facing slopes on precipitation (e.g, higher elevations within the watershed may receive significantly more precipitation, Phillips et al., 1992).

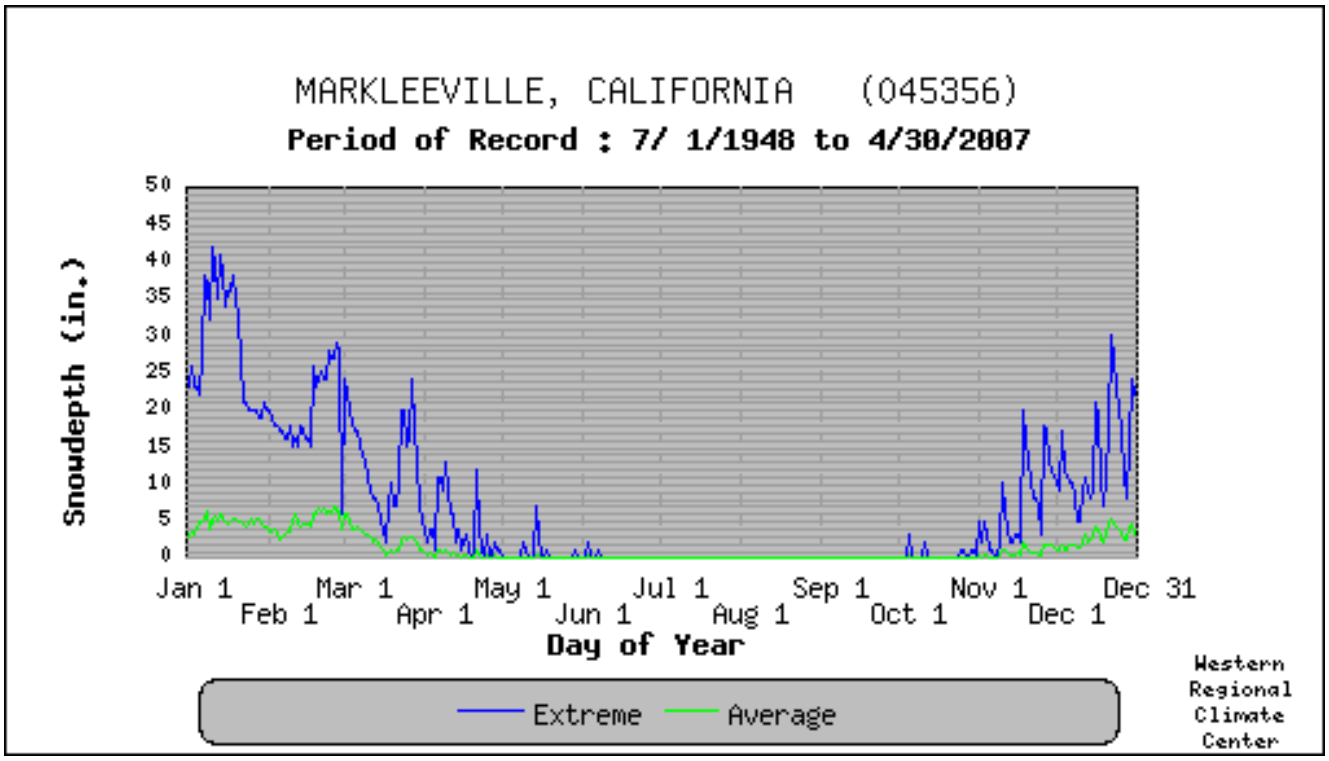
Techniques are available that attempt to account for variations in topography and other variables on climatic parameters. One widely used method is the PRISM (Parameter-Elevation Regressions on Independent Slopes Model) climate mapping system, developed by Dr. Christopher Daly (http://prism.oregonstate.edu/). PRISM is a unique knowledge-based system that uses point measurements of precipitation, temperature, and other climatic factors to produce continuous, digital grid estimates of monthly, yearly, and event-based climatic parameters. The PRISM model is continuously updated to incorporate point data, a digital elevation model, and expert knowledge of complex climatic extremes, including rain shadows, coastal effects, and temperature inversions.

PRISM produced precipitation estimates are available for any location in the United States, and come as data points on an 800-meter (30-arcsecond) grid of the United States. Annual precipitation estimates developed using the PRISM model were downloaded for the Leviathan Mine Site by entering the latitude and longitude of the current on-site meteorological station.

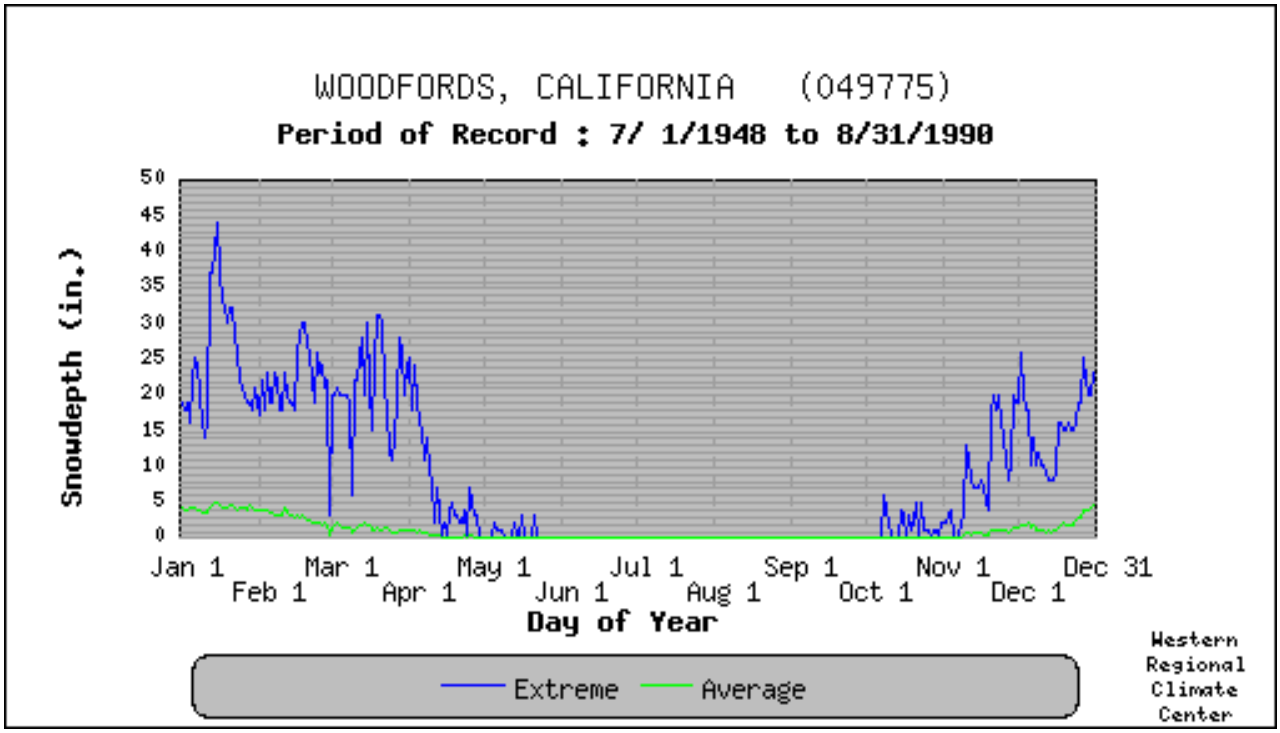
Mean monthly and annual precipitation estimates based on data from 1971 through 2000 (e.g., 30-year normals) are presented in Table 2. Contours of PRISM estimated mean annual precipitations within the broader watersheds are shown on Figure 6.

As shown in Table 2, the majority of precipitation in the watershed occurs in winter months from October through March (25 inches or 79.4 percent of the average annual precipitation). Precipitation during these months falls as snow, producing significant snow pack which routinely restricts access to the on-site property due to deep snow conditions followed by peak runoff periods in April and May.

In addition to the PRISM estimates for the Site, nearby meteorological stations with long periods of record were reviewed. The graph below shows the average and extreme snow depths measured at Markleeville, California. Under average conditions, snow stays on the ground until the end of April, and snow pack begins to develop again in early November. In extreme years, the snow pack has extended into late June and developed in early October. Snow depths of over 40 inches are evident in the period of record (snow depths are greater at Monitor Pass).



The graph below shows snow data from Woodfords, another nearby meteorological station. This data shows a very similar pattern of snow pack, with snow continuing into May and beginning again in October.



The estimated long-term mean annual precipitation for Leviathan was estimated by the PRISM model at 31.5 inches per year. This is slightly higher than the estimate by Rantz, 1969 and more than double the estimate developed by Brown and Caldwell. This illustrates the general uncertainty in understanding the actual amount of available water at the Site and within the broader Leviathan Creek watershed.

As noted, data from the meteorological station installed on-site are complete for only 20 months between 2003 and 2006. A comparison between precipitation measured during these months and estimates from the PRISM model is presented in Table 3. This comparison indicates that on average, PRISM estimates are approximately 59 percent higher than Site measurements.

With the limited available record at the Site, it is difficult to evaluate if Site measurements are significantly more accurate than regional estimates based on climate modeling. For the purposes of estimating the Site water balance, the higher (and potentially more conservative) PRISM estimates were used in the analysis.

2.4.2.3 Short-Term Precipitation Events

Another important consideration in understanding the Site water balance in relation to ongoing Site activities is the potential for short-term storm-related precipitation events and their impact on surface water flows. Twenty-four-hour precipitation return periods have been estimated for California by the National Oceanographic and Atmospheric Administration (NOAA) (NOAA Atlas 2, Precipitation Frequency Atlas of the Western United States, 1973). Maps containing (http://www.weather.gov/oh/hdsc/currentpf.htm) estimates of 24-hour precipitation return periods for the Leviathan Mine Site were reviewed. The Site and the broader watershed area were generally near several precipitation contours on the map, as shown on Figure 7, resulting in some uncertainty in accurately reading the maps for the Site. Therefore, estimates were made based on both observing which contour most closely crossed the general Site area, and on an estimate of the area-weighted average of contours within the Station 23 watershed. Results are presented in Table 4.

The 100-year 24-hour precipitation for the Site is estimated to range from 7.0 to 7.5 inches based on this method. The maximum daily precipitation total measured at the on-site meteorological station during 2003 through 2006 is 1.5 inches, which is significantly lower than the estimated 3.0 inches for the 2-year return period. As before, measurement error and biases make interpreting the short period of Site data difficult, and use of the 24-hour precipitation estimates from the NOAA Atlas is considered conservative.

The PMP is generally the maximum depth of precipitation that is physically possible for a particular geographic region, and has been estimated for the Site based on procedures described in Hydrometeorological Reports No. 58 and 59 (HMR 58 and 59, PMP for California, NWS, 1999). All-season 24-hour PMP maps for California were downloaded in Geographic Information System (GIS) format from the NOAA National Weather Service Hydrometeorological Design Studies Center Web page (http://www.weather.gov/oh/hdsc/studies/pmp.html). These PMP maps represent estimates for watersheds of 10 square miles or greater. The watershed estimated above USGS gauging station 23 is estimated at approximately 10 square miles, and was thus used in the calculation.

Estimates of the all-season PMP for various storm durations were developed for the Leviathan Mine Site based on procedures outlined in HMR 58, and are summarized in Table 5.

As shown on Table 5, the 24-hour all-season PMP for the Site is estimated at approximately 12.6 inches.

For the Site, peak stream flows are generally observed during snow melt occurring in spring. Therefore, the maximum available water for a peak event may not be the all-season PMP, but

may be derived from a rain-on-snow event during the spring. Estimates of the maximum rain-on-snow event were developed based on procedures outlined in U.S. Army Corps of Engineers Guidance EM-1110-2-1406, Runoff from Snowmelt. The method uses the 100-year 24-hour precipitation, an assumption of unlimited snow available for runoff, and temperature and wind speed parameters for the Site. Using 7.5 inches for the 24-hour precipitation, an average wind speed of 5 miles/hour (from Site data), and an assumed temperature of 60 degrees for the storm, the maximum snowmelt for the 24-hour storm was estimated at 3.3 inches. This results in a total available water of 10.8 inches for the maximum rain-on-snow event, which is below the all-season PMP of 12.6 inches. Therefore, the estimated all-season PMP of 12.6 inches is considered the maximum potential short-term event for the Site.

2.4.2.4 Stream Flow

A key component of the Site water balance is surface water flow entering the Site. The USGS established some short-term daily measurement stations in 1981 and 82, and established a number of permanent continuous monitoring stations in 1998. These stations are shown on Figure 7. Key stations near the Site that have had generally continuous monitoring since 1998 include Station 1 (Leviathan Creek above the Mine), Station 15 (Leviathan Creek above Aspen Creek) and Station 23 (Leviathan Creek above Mountaineer Creek). In addition, daily flow data have been collected at 4L Creek above Leviathan Creek and Station 22 (Aspen Creek above the Site) since October 2003. Monthly average flow rates measured at these stations are summarized in Table 6; monthly average stream flows are shown on Figure 8.

In addition to continuous monitoring stations at and near the Site, several one-time or short-term stream flow measurements have been made at the Site. These data are useful to provide a framework for assessing general Site conditions, but generally can not be used directly to develop Site water balance estimates.

While general average conditions may be estimated from the limited stream flow data set from continuous monitoring at the Site, the period of record is not extensive enough to accurately estimate extreme conditions. Extreme stream flow and flood conditions are important to understand to support remedial design activities and to understand changes in the Site water balance during extreme events. Rough estimates of flood frequency flows from the gauged locations were developed using regression techniques outlined in *Nationwide Summary of USGS Regional Regression Equations for Estimating Magnitude and Frequency of Floods for Ungaged Sites, 1993* (USGS, 1994). The Leviathan Mine Site falls within an area that has two different regression techniques; (1) the Sierra Region of the California Statewide Rural zones, and (2) the Eastern Sierra Region 5 of the Southwestern United States zone (USGS, 1994). Regression equations for various stream flow return periods are provided based on drainage

area, elevation, and latitude. Both sets of regression equations were used to estimate potential peak discharge return period flows, as summarized in Table 7.

As shown in Table 7, peak discharge return flows estimated using regression equations from the Eastern Sierra Region in the Southwestern United States were generally smaller than those estimated using the equations for the Sierra Region of rural California. Table 8 shows the peak discharges measured annually at stations with some period of record. As shown on the Table 8, peak discharges are generally similar for the period of record (e.g., over a 5 to 7 year period) as those anticipated by the return flow estimates.

The maximum event for stream flow is the PMF. There are many methods available for estimating the PMF (USCOE, EM 1110-2-1417). For simplicity, we have used the 24-hour PMP and have assumed 100 percent runoff over the catchment area during the period (e.g., precip times catchment area) and taken the average flow this would produce over the period. This method was chosen for use in the water balance assessment and may not be suitable for engineering design.

Estimates for the 24-hour PMF for the main Site drainages are presented in Table 9.

These flows are all higher than the estimated 100-year peak discharges, and are considered conservative estimates of the peak sustained 24-hour flows at the Site.

2.4.2.5 Groundwater Discharges

Groundwater discharges to the surface at the Site occur from the Aspen and Delta Seep the mine adit, and the pit and channel underdrains. Flow data from these sources (except for the Delta Seep) have been collected since 1999. Monthly average flows from these sources are summarized in Table 10. As shown on the table, peak groundwater discharges occur during April and May, similar to peak surface water flows.

2.4.2.6 Preliminary Site Water Balance Estimate

Based on the data analysis above, the net outflow (outflow-inflow) for the Site is 82 gallons per minutes (gpm). This difference represents approximately 17 percent of the total water balance flows as described above. The imbalance is likely due to uncertainties in groundwater inflows, variations in assumed runoff, and/or recharge to groundwater. Additional data needs in the RI/FS for the water balance are the following:

- minimal groundwater-related data to assess flow rates (gradients, hydraulic conductivity, etc.);

- minimal data on surface water/groundwater interactions (gaining and losing stream flows that could affect water chemistry);
- limited data and analysis of recharge to key source areas such as the pit and waste rock; and
- long-term precipitation and stream flow records to assess longer-term flow conditions.

2.4.3 Evaluation of the Hydrogeology

The following section presents the Site hydrogeology developed during the scoping evaluation.

2.4.3.1 Regional Setting

The Site is located near the eastern margin of the Sierra Nevada Mountain Range, approximately four miles west of the California/Nevada border. The Sierra Nevada Mountains are situated near the western margin of the Basin and Range Geologic Province. The region surrounding the Site is seismically active.

A circular caldera structure is apparent from the interpretation of aerial photographs in the region (Figure 10). The structure appears to be approximately 10 miles in diameter with the Leviathan Mine Site located at the approximate center of the structure. Regional hydrothermal alteration patterns are localized around the boundary of the structure where leaching and mineralization are present. Mineral exploration and production within the district have been focused within hydrothermally altered strata. Gold, silver, copper, lead, zinc, tungsten, and antimony were formally produced from a hydrothermal mineral deposit at the Zaca Mine, located approximately four miles southwest of the Site. Active hot springs are present along the banks of the East Fork of the Carson River, approximately 6 miles west of the Site (1.5 miles northeast of Markleeville), and at Grover Hot Springs State Park, approximately 11 miles west of the Site. Similar mineralization and alteration patterns are present where Bryant Creek enters the East Fork of the Carson River and also along Nevada Highway 395 to the southeast.

2.4.3.2 Site Stratigraphy

Geologic units at the Site generally consist of Tertiary (approximately mid-Miocene to Pliocene) age volcanic and volcaniclastic sedimentary rocks. Local rock unit nomenclature was established by Herbst and Sciacca (1982). A separate rock unit nomenclature was established for the altered and non-altered equivalents of rock strata. A geologic map of the Site, and surrounding area, is available in Herbst and Sciacca (1982) and shown on Figure 11. Geologic cross sections taken from Sciacca (1982) and Brown and Caldwell (1983) are shown on Figures 12 and 13. Note these figures were originally prepared before the Site Pollution Abatement Project.

Two sequences of volcaniclastic fine to coarse grained sandstones, conglomerate, breccias, and lahars, termed the Upper and Lower Sedimentary Sequences, were identified by Herbst and Sciacca (1982). Literature prior to the early 1980s may refer to unsilicified portions of the Upper Sedimentary Sequence strata as “tuff or acid leached tuff” and “agglomerate” in the vicinity of the open pit. Evans (1977) reports that these strata are similar to Pliocene age rocks of the Mehrten Formation, in the Western Sierra Nevada foothills. Evans reported a maximum combined thickness of approximately 220 ft. for the tuff and agglomerate. The thickness of the Lower Sedimentary Sequence is not known due to limited exposure; however, Sciacca (1984) reports that the formation thickness exceeds 163 ft. based on information from USGS piezometer boring 7.

Strata within the Upper and Lower Sedimentary Sequences are similar. The presence of a irregularly distributed, non-laterally continuous basalt was used to subdivide these strata within the rock formation nomenclature. The basalt has a thickness of approximately 80 ft. near the open pit area (Sciacca and Matthews, 1988). Induration within the Upper Sedimentary Sequence is reportedly weaker than within the Lower Sedimentary Sequence. These strata underlie, and comprise, much of the landslide present in the northern portion of the Site. The Upper Sedimentary Sequence reportedly dips to the north. The monitoring wells and piezometers that have been installed at the Site were largely drilled within these strata; and waste rock piles that are partly composed of the altered/unaltered Upper Sedimentary Sequence material.

Altered strata of the Upper Sedimentary Sequence are overlain by silicified strata of the Upper Sedimentary Sequence near the open pit. These rocks are known as the silicified iron stained breccia and silicified breccia by Herbst and Sciacca (1982). Evans (1977) reports a maximum silicified rock thickness of 160 ft. near the open pit, with substantial thinning away from the center of the ore body. Sciacca and Matthews (1988) report a silicified rock thickness range of 13 to 82 ft. These strata are also informally called “silicified cap rock.”

Five igneous rock units (quartz latite porphyry, leviathan peak andesite, biotite pyroxene hornblende andesite, hornblende pyroxene andesite, and the above-mentioned basalt) have been identified in the vicinity of the Site (Figure 11). The quartz latite porphyry outcrops near Leviathan Creek, immediately upstream of Pond 2 south of the former waste dump. The Biotite pyroxene hornblende andesite is encountered adjacent to Leviathan Creek near the Delta Slide/seep, and near the toe of the landslide in the northern portion of the Site. Southeast of the open pit, the hornblende pyroxene andesite is overlain by a conglomerate within the Upper Sedimentary Sequence.

2.4.3.3 Alteration and Mineralization

Hydrothermal alteration of the strata at the Site occurred from ascending silica rich solutions, likely from an unexposed magma source. During the alteration event, iron-copper-bearing, and hydrogen sulfide-charged fluids intruded the Site most likely as two separate events. Oxidation of the hydrogen sulfide gas resulted in the precipitation of sulfur. Mineralization initially occurred within relatively porous tuff material. Precipitation of sulfur caused a reduction of porosity and permeability, resulting in lateral and downward spreading of mineral-laden fluids (Evans, 1977).

Sulfur mineralization occurred in the area of the open pit, approximately 200 to 300 ft. below the former ground surface. The sulfur ore body occurs as a relatively flat, elliptical lens, with dimensions of approximately 2,400 ft. in length, 700 ft. in width, with a maximum thickness of 90 ft. and an average thickness of 58 ft. (Evans, 1977). Sulfur mineralization occurs within the tuff near the base of the Upper Sedimentary Sequence and an underlying “andesite.” Veins of pure sulfur, 1 to 2 ft. in thickness, were noted by Anaconda Company geologists within the tuff (Evans, 1977). Herbst and Sciacca (1982) reported that pyrite and marcasite are irregularly distributed through the ore bearing interval, at concentrations up to 30 percent of the rock mass.

Marcasite, pyrite, arsenopyrite and chalcopyrite occur within the strata above and below the ore body strata (Evans, 1977). These sulfide minerals are found throughout the silicified/altered overburden strata in the vicinity of the open pit. Jasperoid clasts within the silicified strata reportedly contain up to 15 percent disseminated sulfide minerals (Sciacca, 1984).

Based on information presented by Hammermeister and Walmsley (1985), smectite is the predominate clay mineral originating from alteration of the strata at the Site. Sciacca (1984) reported that x-ray diffraction of samples from the spoil piles and waste dump, which are predominately altered strata of the Upper Sedimentary Sequence, are predominately comprised of smectite. Lesser concentrations of kaolinite, chlorite, alunite, and illite were also reported using mineral analysis techniques. Visible kaolinite may also be observed in portions of the open pit. Chloritized breccia has also been observed and noted in the nomenclature of Herbst and Sciacca (1982).

2.4.3.4 Faulting and Bedding

The Site is faulted, particularly in the area west and northwest of the open pit. Landslides, alluvial cover and alteration obscure some of the faulting relationships. The following is summarized from Herbst and Sciacca (1982) and Sciacca (1984). Fault identification (A through G) is from nomenclature of Sciacca (1984) (See Figure 14).

At least three distinct periods of faulting are interpreted to be represented. Much of the faulting appears to predate the mineralization based on the alteration patterns. All faults are vertical or near vertical.

Fault A is a pair of normal faults that trend northeast-southwest. They pass on either side of a small sandstone knob on the west side of the pit. The northwest fault of the pair dips 83° to the southeast. The northwestern block of the fault is upthrown.

Fault B trends east-west. It vertically offsets sandstone and basalt (south block up thrown); a portion of this fault may extend west into the biotite-pyroxene hornblende andesite.

Faults A and B are offset by Fault C, which is the most significant fault in the area. Fault C is visible in a road-cut east of the landslide area. The fault passes through a swale between two hills on the northwest edge of the pit. No cap rock or sulfur mineralization has been noted north of Fault A or west of Fault C.

Fault D trends northwest-southeast with the northeast block upthrown. Because this fault offsets a silicified breccia-andesite contact, it appears to have a horizontal component of movement as well as a vertical component. At the southeast edge of the mapped fault trace there is a spring. The relationship of Fault D to Fault C is obscured by material in the pit.

Fault E is visible on the east side of the pit entrance. The fault extends along the headwall scarp of a large landslide east of the pit entrance. It offsets Faults A and B.

Fault F trends northeast-southwest near the south gate. The sense of movement on this fault is unclear.

Fault G is an east-west trending fault which cuts the andesite, appears to vertically offset the basalt unit, and may be related to the Aspen Seep discharge. The relationship between this fault and Fault D is concealed by overburden and landslide debris. This fault passes through the horseshoe-shaped main scarp of the landslide in the mine tailings. Fault G offsets Fault E.

Bedding

Only a few of the sedimentary units in the area are well enough exposed for bedding and sedimentary structures to be visible. The bedding, where measurable, varies in dip in response to the irregular paleotopography.

West and northwest of the waste dump, beds of coarse-to-fine-grained sandstone, pebbly sandstone, and laminated silt of the lower sedimentary sequence strike roughly east-west and

dip slightly to the south. At the pit entrance, altered sandstones and lahars of the upper sedimentary sequence strike roughly east-west and dip to the north. East and west of the landslide north of the pit, sandstone and pebbly sandstone beds dip to the north.

Joints and Fractures

Attitudes of joints and fractures vary widely within the study area. A common strike recorded during previous work is 70°-80° east of north. This general strike was noted on a small fracture on joints in silicified iron-stained breccia quartz latite prophyry, and biotite pyroxene hornblende andesite, and on bedding in unaltered and argillically altered sediments. The dips accompanying these strikes are dissimilar, ranging from shallow dips to the south to steep northerly dips.

2.4.3.5 Hydrogeology

The majority of groundwater migration would be through primary permeability of the reworked or more recent rock units as overburden and waste piles. Secondary permeability features such as joints, fractures and faults are not considered significant pathways due to clay and mineral replacement.

The Quaternary units are unconsolidated natural and artificial deposits of gravel, sand, silt, clay, and rock fragments. Depending on the composition of these units at a particular location, they may transmit water.

The landslides and debris flows in the pit appear to be the result of oversteepening of slopes underlain by poorly consolidated sedimentary rocks during mining. The slide material is broken and may be very permeable.

The large active composite landslide north of the pit appears to be in similar sedimentary rocks. The evidence of numerous seeps and springs are visible within the slides and at the toe of the lower slide.

Alluvium and ponded sediment are principally reworked artificial fill. The characteristics of each pile varies with the source material, but these units are generally thin and their overall storage capacity for groundwater is limited.

Artificial fill as waste rock or overburden overlies large sections of the study area. USGS holes 14, 15, and 16, opposite the pit entrance encountered between 25 to 60+ ft. of fill. Holes 3A, 3B, and 3C on the fill area north of the pit all encountered roughly 30 ft. of fill before

encountering sandstone. The fill is unconsolidated, and consists primarily of sandy clay with some boulders and occasional lenses of gravel-size material.

Where either the upper or lower sandstone is not covered by a cap of indurated rock such as basalt, the sandstone is susceptible to landsliding. The sandstones and pebbly sandstones of the upper sequence probably have some permeability. The more indurated lower sequence probably has lower permeability. Lahars of both sequences may have some matrix permeability.

The upper sedimentary unit has been altered in the pit area, resulting in an argillically altered sandstone and breccia and a chloritized breccia. The high clay content of these units indicate that water would probably be retained rather than discharged.

Water Levels and Gradients

Brown and Caldwell (1983), SRK (1988/89) and MWH (2001) prepared groundwater elevation contour maps for the entire Site using groundwater elevations observed at the USGS piezometers and the SRK monitoring wells. North-northwesterly groundwater flow (obliquely towards downstream Leviathan Creek) is depicted for the northern portion of the Site, and west-northwesterly groundwater flow (towards Leviathan Creek) in the southern portion of the Site (Figure 15). Groundwater elevations ranged from over 7,300 ft. mean sea level (msl) east of the open pit to below 6,700 ft. near the toe of the large landslide in the northern portion of the Site. A gradient of approximately 0.18 feet per foot (ft/ft) was calculated for the area beneath the landslide.

Southern Portion of Site

Groundwater within the southern portion of the Site (Figure 15) either flows towards the pit or towards Leviathan Creek (as noted above). At the Delta Seep, groundwater flows to the ground surface. MWH (2002) reported that the Delta Seep flowed at an average rate of 0.024 cubic feet per second (cfs) (10.77 gpm) between 1998 and 2000.

Clustered piezometers 9A/B/C, 10A/B/C, 11A/B/C, and 18A/B/C, located in close proximity to each other in the Delta area, were monitored during the 1982 USGS study. Periods of upward and downward vertical groundwater movement were observed by the USGS during these studies.

Between September 1998 and September 1999, groundwater elevations measured by SRK in shallow screened wells MW-2S and MW-10S were consistently higher than groundwater

elevations in deeper screened wells MW-2D and MW-10D, respectively. Groundwater elevation differences ranged from 0.03 to 2.11 ft. (MW-2S/D) and 0.21 to 1.74 ft. (MW-10S/D) during this monitoring period. Given these elevation differences, a vertical groundwater gradient appears to be present within this portion of the Site. Similar seasonal groundwater elevation fluctuations were observed at paired wells MW-2 (4.00 ft. at MW-2S and 4.39 ft. at MW-2D) and MW-10 (11.28 ft. at MW-10S and 12.81 ft. at MW-10D).

Faults identified at the Site appear to have minimal impact on overall (larger scale) groundwater flow patterns. Clayey fault gouge may have similar hydrogeological properties as clay altered strata in these areas.

The discharge from Tunnel 5 has been postulated to come wholly or in part from groundwater. Movement of water from the sandstone northeast of the waste dump is unlikely because of the dip of bedding. For the same reason, movement of water from the sandstone north of the pit also seems unlikely. Movement of water from fractured or jointed rock is possible but difficult to quantify. Percolation through the more permeable sides of the pit, especially the flattened landslide slopes, seems possible. Percolation from Leviathan Creek along the dip of beds of the lower sedimentary sequence (now buried by fill) is also possible. Water measurements by the USGS indicate no loss of water along Leviathan Creek in this area.

Northern Portion of Site

Groundwater appears to flow toward the confluence of Leviathan and Aspen Creek at a relatively steep gradient.

The waste rock piles comprise the upper portion of the landslide in the northern portion of the Site. Saturated finer-grained strata within the weakly indurated Upper Sedimentary Sequence provide the primary failure surface of the Leviathan Creek Basin Landslide (Herbst and Sciacca, 1982). Landslide movement is to the north-northwest, parallel to the direction of dipping beds and groundwater flow.

Movement of the landslide is influenced by the amount of water in the sliding mass; water increases the weight of the mass and lubricates the slip surface(s). USGS drillholes 3A/3B and 3C all encountered groundwater. With the exception of a perched table at a depth of 15 ft. in 3B, groundwater was encountered in materials beneath the fill at depths ranging from 35 to 106 ft. The data suggests a lack of a continuous groundwater surface within the fill materials.

No subsurface geologic or groundwater elevation data are available for drilling done on the lower landslide. Water meter measurements by the USGS indicate no loss of water along

Aspen Creek in this area. Groundwater moving downslope from the upper slide area could contribute groundwater to the lower landslide from the sandstone north of the pit also but this seems unlikely.

Hydraulic Conductivities

The USGS performed slug/bail tests on 44 of the piezometers to estimate the hydraulic conductivity of the subsurface materials. Using the data presented in Hammermeister and Walmsley (1985), the median and mean hydraulic conductivity values for the shallow subsurface are 1.0 ft/day and 2.73 ft/day, respectively. Only 8 of the 44 tests showed hydraulic conductivities exceeding 2.0 ft/day. Storage effects of groundwater within the filter pack material surrounding the piezometer screens may have resulted in an overestimation of actual hydraulic conductivity values of the shallow saturated strata.

Samples of "waste dump material" and "spoil tailings area" were submitted for constant-head permeability testing, during one of the studies completed in the early 1980s. Permeability values of 1.4×10^{-5} centimeters per second (cm/sec) (0.04 ft/day) and 2.3×10^{-5} cm/sec (0.065 ft/day), respectively, were reported (Brown and Caldwell, 1983). Brown and Caldwell (1983) summarize that "in general," permeability values for "the Spoil Tailings Area A" material ranged from 1×10^{-4} cm/sec to 8.5×10^{-4} cm/sec (0.28 ft/day to 2.4 ft/day) and permeability values for the "waste dump" material ranged from 4×10^{-4} cm/sec to 7×10^{-4} cm/sec (1.1 ft/day to 2.0 ft/day).

2.4.3.6 Overview of the Hydrogeologic Site Conceptual Model

Based on the hydrogeology evaluation data, the Site can be divided into two major areas divided along the topographic ridge east of the pit. The area north and east of the ridge, the overburden and landslide area, has relatively distinct hydrogeologic and alteration properties (see further description of this area below) where the groundwater flows to the east and north. The area to the west of the topographic high includes the pit, which is a groundwater sink and then the waste pile area to the west that drains to Leviathan Creek. Characteristics of the model include the following:

- groundwater flow mimics topography (with the exception of the pit area);
- bedding does not play a major factor in groundwater flow;
- faulting does not appear to play a major role (as a groundwater divide or secondary permeability features) in controlling groundwater flow, the clay in the faults acts similar to surrounding clay-altered bedrock;
- faulting likely occurred prior to sulfur mineralization;

- though it varies locally, the groundwater system consists of a shallow waste rock or tailings/colluvial zone, a clay-altered bedrock zone and possibly a weathered bedrock zone;

- in the northern overburden/landslide area, the slide plane influences groundwater flow, there are small grabens in the slide area;

- where groundwater monitoring well pairs are present, downward vertical gradients have been measured; and

- argillic alteration (smectite and illite) and replacement are widespread in the shallow bedrock, making hand identification of geologic units almost impossible. The primary groundwater transport zones are in the altered clay materials.

Based on the hydrogeological model and the data evaluation, data gaps include:

- better physical characterization (mine features, topography, structure and stratigraphy) of all source and recharge areas;

- additional insitu groundwater characterization data in source and discharge areas;

- water level monitoring of shallow groundwater flows and quality in selected areas;

- assessment of surface water groundwater interactions in selected areas;

- identification and characterization of ponds and springs;

- characterization of aquifer parameters in selected areas; and

- development of background groundwater data.

2.4.4 Evaluation of Geochemistry

A number of investigations pertaining to the geochemistry of the Site were conducted and reviewed as part of the scoping evaluation presented below.

2.4.4.1 Soils

Limited soil geochemical data exist at the Site. While SRK collected samples from 199 locations in 1998 (Figure 16), only paste pH and specific conductance were measured. No samples were sent to an analytical laboratory for trace metal or other constituent analysis. Soil pH values ranged from 1.85 to 8.85 with a median value of 4.5 (Figure 16). Conductivity values ranged from 10 microsiemens per centimeter (µS/cm) to 5,600 µS/cm, with a median conductivity of 40 µS/cm.

Sciacca and Matthews (1988) evaluated the distribution of pyrite at the Site. Their study showed that pyrite is present in soils at the Site and that low pH and metal-rich groundwater was associated with the localized presence of pyrite (Sciacca and Matthews, 1988).

2.4.4.2 Groundwater Geochemistry

Limited data on groundwater geochemistry have been collected at the Site. In 1982, the USGS installed 36 piezometers and collected groundwater samples that were analyzed for dissolved metals and major ion chemistry. The piezometers were installed upgradient of the Site area, within the Site area, and to the north of the Site in the Figure 17. As a result of the pollution abatement project conducted in 1984 and 1985, and the continued movement of the landslide, most of the piezometers either no longer exist or are currently inaccessible.

Groundwater conditions at the Site were reevaluated in 1998. SRK installed 15 new monitoring wells in the Site area (Figure 17), and also sampled two of the remaining USGS piezometers for their analysis. Two rounds of groundwater samples were collected from these wells in October and November 1998. Summary statistics for analytical results obtained during these two events are shown in Table 11.

The concentrations of many of the metals/metalloids range over several orders of magnitude with the highest concentration being associated with wells located within the Site area and generally associated with the open pit and the adit. The poorest water quality was observed at PZ-26, as noted in Brown and Caldwell (1983). They stated in that report that PZ-26 was in the southernmost part of the pit and suggested that the extent to which groundwater is degraded at this location may be due to the well intersecting saturated bedrock containing sulfur-rich ore and pyritic material. However, the location of this well, given the data currently in the database, indicates that it is outside of the pit and to the west (Figure 17), but possibly completed in an unmined, mineralized zone.

2.4.4.3 Surface Water Geochemistry

Anaconda began collecting surface water quality data in Leviathan Creek as early as 1954, concurrent with open pit mining operations. These data, summarized in Brown and Caldwell (1983), show that water quality in Leviathan Creek at sites within and below the Site was degraded compared to creek water collected above the Site at Station 1 (Figure 7). The changes observed in surface water chemistry from above to below the Site, decreasing pH and increasing SO_4 and metals concentrations, are consistent with the oxidation of sulfur and/or pyrite as described by the reactions shown below.

$$S^0 + 1.5O_2 + H_2O \rightarrow SO_4^{2-} + 2H^+$$

$$FeS_2 + 3.5O_2 + H_2O \rightarrow Fe^{2+} + 2SO_4^{2-} + 2H^+$$

Oxygen and sulfur isotopic data, however, indicated that the primary source of ARD at the Site is the oxidation of pyrite and not elemental sulfur (Taylor et al., 1984).

A mass balance approach has also been used to develop a clearer understanding of the geochemistry of the Site and region. Brown and Caldwell (1983) evaluated mass loading to Leviathan Creek, but they only considered total dissolved solids (TDS) from Stations 1 through 17 (Figure 18). Because TDS will predominantly reflect sulfate loading, this analysis does not provide a very accurate picture of what is happening with metals loading.

However, Webster et al. (1994) calculated mass loading and chemical attenuation rates for individual constituents at the Site. Chemical attenuation was defined as the loss of chemical mass of a dissolved constituent from a flowing body of water due by hydrobiogeochemical processes. The significant conclusions presented in the Webster et al. (1994) report are as follows:

- Eighty percent of the dissolved iron mass in Leviathan Creek immediately below the Site was removed before Station 25, which is located below the confluence with Mountaineer Creek.
- Almost 100 percent of the arsenic is removed over the same distance.
- Copper and zinc were removed to a significantly lesser extent, with copper being removed further upstream and at slightly lower pH values.
- Geochemical modeling with WATEQ4F and MINTEQA2 indicated that the iron was most likely removed as an oxyhydroxysulfate, and that arsenic, copper, and zinc were removed by adsorption to the iron mineral phase.
- Seasonal variations in attenuation of copper, zinc, and arsenic were directly related to the pH of the water. Iron, copper, zinc, and arsenic were each removed over different stretches of the creek and at different rates. Chemical attenuation rates for arsenic, copper, zinc, and iron were determined and are presented in Table 12, from data that were included in Table II of the Webster et al. (1994) report.

This concept of metal removal or attenuation can also be illustrated by comparing metals concentrations against that of a conservatively transported compound as shown on Figures 19 through 22, in which the concentrations of iron, arsenic, nickel, and zinc are plotted against the sulfate concentration, respectively.

Because sulfate is an oxyanion, it typically acts more conservatively than a divalent metal cation. Ideally, chloride would be a better constituent to compare to metals data, but there is insufficient major ion chemistry in the surface water database to use chloride. It is likely that sulfate is also being removed with iron and aluminum precipitating as an iron and/or an

aluminum oxyhydroxysulfate mineral phase, such as schwertmannite or basaluminite, respectively. However, because the concentration of sulfate is in great excess of the metals, it can function reasonably well as a “pseudo” conservative ion.

Figures 19 and 20 show that iron and arsenic are rapidly attenuated such that at Station 23 the concentrations of these constituents are essentially equivalent to those observed at Station 1. In contrast, nickel and zinc are removed from the stream more slowly. At Station 26, the concentration of nickel is slightly above the levels measured at Station 1 (Figure 21). The concentration of zinc measured at Station 25 approximates those observed at Station 1 (Figure 21).

Figures 19 through 22 show that iron and other metals are rapidly attenuated and removed from Leviathan Creek between Station 15 and Station 26. Metal concentrations measured at Station 25 and 26 are generally close to background levels. This is consistent rapid metals removed observe by Webster et al. (Webster, 1994).

For the scoping phase of the project we reevaluated mass loading using the most recent data set. Our analysis of mass loading includes both surface water quality data from the USGS and contained in the Leviathan database collected by Lahontan Regional Water Quality Control Board (LRWQCB). The median mass loading of select constituents calculated from 1998 to 2006 is shown in Table 13. These data show that there is a significant increase in mass loading to Leviathan Creek downstream from the Site as measured at Station 15, which is just above the confluence of Aspen Creek, as compared to upstream at Station 1. Other findings from a review of the mass balance data include the following:

- the mass of aluminum decreases by 87 percent from Station 15 to Station 23 and then increases by 111 percent from Station 23 to Station 26;
- the stream load of arsenic decreases by 54 percent from Station 15 to Station 23 and subsequently increases by 447 percent from Station 23 to Station 26;
- the mass of copper and zinc also decreases from Station 15 to Station 23 and then rebounds significantly when calculated at Station 26; and
- in contrast, the mass of nickel continues to decrease from Station 15 to Station 26.

In sum, this data would indicate that there is considerable mass loading of metals to Leviathan and Bryant creeks downstream of the Site. Webster et al. (Webster, 1994) also observed increases in the mass of copper, iron, sulfate and zinc below the confluence of Mountaineer Creek.

Because of these issues with data quality, mass loading for select constituents was compared for specific days when stream flow and geochemical data appeared to be consistent. Mass loading data from this analysis is shown in Table 14. This analysis shows that defining trends in mass loading for specific constituents downstream from the Site is more complicated, as trends are not consistent between sampling events. However, these data do show that additional mass loading of some constituents, most notably aluminum, arsenic, chromium, and copper, may occur downstream of the Site.

2.4.4.4 Sediments

There are very limited data on stream sediment geochemistry. However, data are available in the Leviathan database for samples collected primarily between 1998 and 2005 at several stream locations (USGS, 2005). Iron concentrations in Leviathan Creek increase about sixfold from Station 1 above the Site area to Station 15 below the Site and just above the confluence of Aspen Creek, and then decrease further downstream (Figure 23). Sources of metals loading to sediments are currently not fully understood, as unidentified sources not related to mining at Leviathan may also contribute significantly to downstream loading.

Sediment concentrations of arsenic also appear to increase significantly at Station 15 and then decrease further downstream (Figure 24). The sediment concentrations of nickel and zinc are higher upstream of the Site at Station 1 than they are at Station 15. Both nickel and zinc increase in concentration downstream of Station 15, with Nickel increasing to a greater extent. The distribution of the metals within the stream sediments is consistent with the predictions for metal adsorption to iron oxyhydroxides and/or oxyhydroxysulfates, as pH values increase downstream of the Site, as proposed by Webster et al. (1994).

2.4.4.5 Overview of Geochemical Site Conceptual Model

Degradation of Leviathan Creek water quality downstream of the Site results from the introduction of surface water and potentially groundwater discharges with low pH and elevated TDS, typical of ARD-impacted waters. Pyrite oxidation and the generation of ARD is a complex process that is often described by the three chemical reactions shown below (Figure 25).

$$FeS_2 + 3\tfrac{1}{2}O_2 + H_2O \rightarrow Fe^{2+} + 2SO_4^{2-} + 2H^+$$

$$Fe^{2+} + \tfrac{1}{4}O_2 + H^+ \rightarrow Fe^{3+} + \tfrac{1}{2}H_2O$$

$$FeS_2 + 14Fe^{3+} + 8H_2O \rightarrow 15Fe^{2+} + SO_4^{2-} + 16H^+$$

From these reaction equations, it is apparent that water and molecular oxygen are both required for pyrite oxidation to occur. Thus the primary sources of ARD and/or metals loading

to Leviathan Creek are areas within and around the Site area that contain adequate pyrite mass and where both water and oxygen are available.

Characteristics of the geochemistry CSM include:

- Previous reports have listed five known sources of ARD discharge to Leviathan Creek:
  - the PUD;
  - adit drainage (adit #5);
  - CUD;
  - Delta Seep; and
  - Aspen Seep, also known as the Overburden Seep (OS).
- The pit and adit are significant sources where the reactions associated with ARD production are known to occur.
- Other known "sources," the CUD, Delta Seep, and Aspen Seep, represent point discharges to Leviathan Creek, while the actual source of contaminants is the weathering/oxidation of the fine-grained pyrite that is disseminated upgradient of the discharge point.
- The location and extent of the primary sources of ARD to the five point discharges noted above are not clearly defined, but may include small to large recharge basins, recharge through waste and overburden, flows emanating from the adit and/or pit, leakage from evaporation ponds, and leakage from transfer piping.
- Background water quality (surface and groundwater) is currently poorly defined.
- Significant mass loading of metals and total dissolved solids to Leviathan Creek occurs downstream of the Site at Station 15. Metal loads are attenuated at various rates, which are primarily controlled by stream pH.
- Additional mass loading of some metals and sulfate from undefined sources occurs well downstream from the Site.
- Groundwater is likely anoxic, and therefore, addition of alkalinity prior to surface discharge may provide an alternative more passive approach to treatment.
- An increase in pH along the groundwater flow path in the eastern portion of the Site suggests the possible neutralization of groundwater in contact with calcite-bearing rocks.
- Source control (e.g., inhibition of pyrite oxidation) requires that the contact of disseminated pyrite with water and/or oxygen be minimized.

Based on the geochemistry data evaluation and model, data gaps include:

- better physical characterization of all source areas;
- additional soil and groundwater source characterization data in all areas;
- more current stream sediment sample data;
- selected surface soil data to evaluate selected exposure pathways; and
- development of background data for all media.

2.4.5 Human Health and Ecological Risk Evaluation

As part of the scoping data evaluation, existing data collected in the vicinity of the Site was assessed to identify chemicals of potential concern (COPCs) and evidence for potential impairment to human health and ecological receptions. The results of this evaluation were the CSMs described in Section 3.

2.4.6 Geotechnical Review

Based on the data available, the geotechnical conditions at the Site are presented below. Review of existing data indicates that from a geotechnical standpoint, there are two significant material classifications at the Site: waste rock and bedrock. Additional detail will be added to the geotechnical evaluation through the course of the RI Investigation. A brief description of the two major material classifications is presented below.

2.4.6.1 Waste Rock Material

The waste rock material at the Site is overburden soil and waste rock that was removed from above the ore bodies during mining operations and the early advancement of underground workings. The material is described as high-plasticity clayey sand with gravel, sandy and gravelly clay, and sandy silt. The fines content typically ranged from about 30 to 60 percent. The plasticity index of the material is typically above 70. Direct shear tests were also performed on the waste material in the Delta Slope area. The tests showed an undrained cohesion value between 600 and 3,327 pounds per square foot with undrained friction values between 0° and 44°.

2.4.6.2 Bedrock

A detailed description of the bedrock at the Site is presented in the hydrogeology section above. From a geotechnical standpoint, the most significant consideration of the bedrock is the large landslide on the northern portion of the Site, described below. It is important to note that the previous investigations have not included strength testing of the bedrock materials.

2.4.6.3 Geotechnical Aspects of the Conceptual Site Model

Based on the preliminary evaluation of the available data, preliminary geotechnical aspects of the CSM were developed for the Leviathan Creek Basin Landslide, the Delta Area waste rock slope, and for general Site development.

Leviathan Creek Basin Landslide

The Leviathan Creek Basin Landslide (landslide) is a large (180-acre) bedrock structure slide on the north end of Site. It is our understanding that there is not a current program to monitor the movements in the landslide, but it is assumed to be active. Previous work indicated that there is likely a threshold phreatic surface within the slide mass that will cause movement. Although regrading has been performed since the time of that work, it is assumed that the potential for movement is still significant.

From a geotechnical engineering standpoint, the landslide is significant because the Aspen Seep is located within the slide mass. Structures built on the landslide and pipelines crossing the landslide mass are subject to deformations caused by the landslide. Because of the scale of the landslide, stabilization of the entire slide mass is likely not a feasible mitigation alternative.

Surface water should be directed away from the landslide mass whenever possible. Surface water will seep into the slide mass, adding load to the head of the slide and acting to lubricate the slide planes. Additionally, the remedial measures should minimize the amount of water that is stored in open ponds in this area.

Delta Area Waste Rock Slope

The Delta slope is approximately 250 ft. long by 150 ft. wide and 80 ft. high and is composed of waste rock. The upper portion of the slope has been subject to rotational slope failures and the lower portion has been subject to debris flows. The Delta Seep is located at the toe of the Delta slope. The waste rock at the Delta slope was regraded after the 2004 slope failure. The current slope appears to be graded at about 3:1 (Horizontal to Vertical) with two relatively flat benches. Drainage trenches were installed in an attempt to reduce the infiltration of surface water into the slide mass. There is a large catchment area above the slope that likely still allows surface water to flow towards the toe of the slope and Delta Seep.

The slope has remained relatively stable since the repair work in 2005; however, the long-term stability has not been evaluated. It is possible that a high snow year or moderate-to-large

earthquake could destabilize the slope and cause damage to any collection or treatment equipment at the Delta Seep area.

2.4.6.4 Conclusion

The design and construction of remedial measures at the Site should account for the geotechnical considerations described above. Steep slopes may be subject to permanent deformation when groundwater is elevated or during an earthquake. Re-grading of these slopes may be necessary. Treatment facilities on active landslides should be designed to accommodate deformation of the landslides. Ponds and other water retention structures should be located where they will not adversely impact the active landslides or potentially create other stability and seepage issues. Thorough investigation and design will reduce the potential for these hazards at the Site.

3.0 CONCEPTUAL SITE MODELS

As described in U.S. EPA's "Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA" (U.S. EPA, 1988), the purpose of a CSM is to describe what is known about chemical sources, migration pathways, exposure routes and receptors at a Site. The CSM depicts the exposure pathways and the mechanisms by which a receptor may come into contact with COPCs in the environment. Using the U.S. EPA Risk Assessment Guidance for Superfund (U.S. EPA, 1989), potential exposure pathways applicable to the Site have been identified and addressed. An exposure pathway is defined by four elements (U.S. EPA, 1989):

- a source and mechanism of COPC release to the environment;
- an environmental medium of concern (e.g., air, soil, water) or transport mechanism (e.g., volatilization) for the released COPC;
- a point of potential contact with the medium of concern; and
- an exposure route (e.g., ingestion) at the contact point.

An exposure pathway is considered "complete" if all four of these elements are present. Only complete exposure pathways need to be evaluated for the purposes of a risk assessment. Separate CSMs have been developed for human and ecological receptors (Figures 26 and 27). Elements (e.g., sources, fate and transport mechanisms) common to both CSMs are discussed further in this section. Subsequent sections discuss the specific receptors, exposure routes, and exposure pathways for human and ecological risk assessment. Additional details on the CSMs will be presented in the RI/FS Work Plan.

3.1 SOURCES

The primary sources of chemicals at the Site are overburden, waste rock, and naturally occurring rock that are exposed to precipitation and generate ARD and ARD, respectively. The Site was underground and an open pit mine which exposed naturally occurring rock to oxygen and water. The high sulfur content of the waste rock and exposed rock results in acidic discharges (low pH of 2 to 3) as water percolates through the rock to groundwater or discharges to surface water. Groundwater and surface water with a low pH will result in the increased solubility of metals. The metals move with the surface water and can be deposited in sediments as pH increases. Specific sources of AMD/ARD at the Site include: underground sources, the CUD, the Aspen Seep, the ponds, the Delta Seep, the PUD, and the adit.

Waste rock and overburden was placed on Site and some was reportedly used for dust control and stabilization on access roads. An estimated 22 million tons of waste rock/overburden were distributed across the Site (Brown and Caldwell, 1983).

3.2 CHEMICALS OF POTENTIAL CONCERN

This section briefly summarizes the COPCs associated with the Site. U.S. EPA's SOW (U.S. EPA, 2008) identifies the following chemicals as potentially Site related:

- aluminum;
- arsenic;
- beryllium;
- cadmium;
- chromium;
- cobalt;
- copper;
- iron;
- lead;
- manganese;
- mercury;
- nickel;
- selenium;
- thallium;
- vanadium; and
- zinc.

U.S. EPA's selection of these COPCs was based on previous evaluations. This listing will serve as the basis for additional Site characterization during the RI/FS.

Because these chemicals are present in nature, an assessment will be conducted to evaluate whether the concentrations measured represent natural background conditions. Concentrations will be compared with concentrations from reference sites to assess whether the chemicals should be classified as COPCs or as naturally occurring.

3.3 FATE AND TRANSPORT

There are a number of mechanisms by which chemicals identified above can migrate to other areas or to other media. U.S. EPA (1989) has identified several of these mechanisms. Based on current information, the relevance of these mechanisms to the Site is discussed below.

Fugitive Dust Generation

Fugitive dusts may be generated from the waste rock/overburden at the Site and along Leviathan Mine Road and other access roads where this material was deposited.

Volatilization

None of the COPCs are considered volatile.

Leaching (percolation)

Percolation of precipitation and melted snow pack through the Site to groundwater is a potential release mechanism for COPCs to groundwater. Precipitation and snow melt in contact with the Site may become AMD/ARD.

Groundwater Transport

Based on the hydrogeologic model, the majority of groundwater from the Site ultimately discharges to Leviathan and Aspen creeks.

Surface Water Runoff

Surface water runoff is created when AMD/ARD is generated during precipitation events, contacts the Site, waste rock, or overburden and migrates to the local creeks. The low pH of AMD/ARD can result in dissolution of metals in water from rock and sediment. Increases in pH can result in deposition of metals transported by surface water to sediment. Also, sediment may be deposited along the banks of the creeks during high flow events and become accessible as soil.

Bioaccumulation

COPCs identified at the Site may bioaccumulate and may be found in plants, aquatic organisms, and wildlife that come in contact with soil, surface water and sediment affected by COPCs.

3.4 HUMAN HEALTH SITE CONCEPTUAL EXPOSURE MODEL

The characterization of the potential exposure pathways at the Site, based on existing information, is presented in the CSM (Figure 26). The remainder of this section identifies potential receptors, exposure routes and potentially complete exposure pathways. Insignificant and incomplete pathways are also identified and discussed.

3.4.1 Potential Receptors

The identification of potential human receptors is based on the characteristics of the Site, the surrounding land uses, and the probable future land uses. The Site, owned by the State of California, is currently fenced with gates at the entrances to the Site from the access roads from the north and south (Leviathan Mine Road), but the remainder of the area is not surrounded by fencing. During winter months potential access is further limited because of snow pack such that a standard 4-wheel drive vehicle could not reach the Site on the dirt access roads covered with snow. Access to the area including the Site during the winter months requires use of snow cats, snowmobiles, or other alternative transportation.

The land surrounding the Site, through which creeks downstream of the Site flow (e.g., Leviathan, Aspen, and Bryant creeks) and on which access roads to the Site have been constructed, is owned by the U.S. Forest Service (Brown and Caldwell, 1983). There are no physical or institutional controls limiting access to these areas such as fences or signs.

Future land use is not anticipated to change in the area surrounding the Site. Unrestricted future use of the Site is considered to be consistent with the surrounding U.S. Forest Service land is anticipated in the future (e.g., recreational).

The following receptors have been identified for the Site and surrounding areas:

- Current On-Site Trespasser – Although access to the Site is restricted by gates at the roadways, a trespasser could access the Site on foot since the Site is not completely surrounded by fencing nor is it always monitored or occupied. The trespasser would be anticipated to be at the Site for up to one week per year. The likelihood of this exposure scenario is limited by the restricted roadway access, the remote location, periodic Site activity, and unrestricted access to alternative areas outside the Site.

- Current Off-Site Recreational Visitor – The areas downstream of the Site could be assessed by a recreational visitor for hiking or camping. Based on previous assessments of a recreational visitor by the California Department of Health Services (CDHS, 2002) and Gradient (2002), these activities are limited to the summer months when access to the area is not limited by snow. We also anticipate that this scenario would address potential exposure for a U.S. Forest Service Park Ranger.

- Current Off-Site Rancher – During the agricultural growing season, water from Bryant Creek has been regularly diverted for irrigation purposes to the River Ranch. This diversion (River Ranch Irrigation Channel) is located immediately downstream of the Doud Springs inlet into Bryant Creek. The diversion is approximately 7.8 miles downstream from the Site and is located on the western side of Bryant Creek. This diversion channel, which appears to be unlined and runs for approximately 2 to 3 miles before reaching the River Ranch, has been used for agricultural irrigation and livestock consumption on the River Ranch. Livestock pastured on the River Ranch might consume the irrigation water and feed on crops grown with the diversion water. There is another diversion from Bryant Creek located about ¼ mile above the mouth of Bryant Creek as it enters the East Fork of the Carson River. This diversion is used to irrigate River Ranch pasture land to the north of Bryant Creek, along the Carson River East Fork (CDHS, 2002). During the Site walk in June 2007, water was not being diverted from Bryant Creek to irrigate the pasture or for livestock consumption. Further information on the potential for current/future diversion of water is required to identify whether exposure pathways for this scenario are complete.

- Current Off-Site Resident – Residences are located in the vicinity of Leviathan Mine Road where overburden and waste rock may have been used and could become airborne as windborne dust or from road traffic. The potential for exposure is related to the portion of the Leviathan Mine Road nearest the residences and Route 395. Potential effects from the Site or windblown dust from other portions of Leviathan Mine Road would be not significant for this residential area.

- Current Off-Site Washoe Tribe Member – The Washoe Indian tribe of California and Nevada (Washoe Tribe) historically has used the area in the vicinity of the Site for hunting, fishing, and gathering (Walker, 2003). Although current practices by the tribe members are not documented, a current tribe member could access the area periodically for these purposes. However, tribal members are not likely to be using the resources off-site in a manner consistent with historical subsistence lifestyles (Walker, 2003).

- Future On-Site Washoe Tribe Member – The scenario for this receptor assumes that unrestricted access to the Site becomes available in the future. The scenario is otherwise the same as for the current off-site Washoe Tribe member, specifically use of the Site for hunting, fishing, and gathering (Walker, 2003). Although current practices by the tribe members are not documented, a current tribe member could access the area periodically for these purposes.

- Future Off-Site Washoe Tribe Member – The Washoe Tribe has developed a hypothetical reasonable maximum exposure (RME) scenario for future use of the area surrounding the Site (Harper, 2005a, b). The hypothetical RME scenario assumes that a tribal member lives a subsistence lifestyle with family in a house in a sparsely populated riparian corridor near the Site (Walker, 2003). The location of the residence is in the farthest upstream available allotment. The subsistence lifestyle includes a home garden, wood for fuel, no paved areas, and a groundwater well or surface water source of drinking water. Subject to legal restrictions on access, potential exposure would be driven by media-specific concentrations in this

area for some exposure media (e.g., drinking water, plants), with periodic foraging to other areas nearer to the Site (e.g., wildlife, aquatic organisms).

- Future On-Site Recreational Visitor – Future land use is likely to be open space within a national forest area. Similar to the off-site recreational visitor, this receptor could be on Site for up to one week but these activities are limited to the summer months when access to the area is not limited by snow. Based on discussions with stakeholders, we will assume that the Site could be used for recreational vehicles in the future and will consider additional windblown dust raised by that activity. We also anticipate that this scenario would address potential exposure for a U.S. Forest Service Park Ranger.

3.4.2 Exposure Points and Routes

Based on the COPCs, affected media, and migration pathways discussed above, points of potential human contact with Site-related COPCs include soil, groundwater, surface water, sediment, air, plants, aquatic organisms, and wildlife.

- Potential exposure routes associated with COPCs in soil are incidental ingestion, dermal contact, and inhalation of resuspended particulates. Related potential exposure routes include ingestion of plants and wildlife. On-site and off-site soil will be evaluated independently. Additional data is required to assess whether off-site soil on access roads and adjacent to creeks (resulting from stream overflow) is related to Site activities and whether these areas have COPC concentrations greater than background.

- Potential exposure routes associated with use of on-site groundwater are based on designation of groundwater in the Markleeville Hydrologic Area as a potential municipal supply in the Lahontan Basin Plan (RWQCB, 1995) and the fact that groundwater discharges to surface waters that are designated as drinking water sources. Potential exposure routes consist of ingestion and dermal contact. At this time, only one exposure point (on-site groundwater) is anticipated for this medium because Site groundwater is believed to discharge to the nearby creeks.

- Potential exposure routes applicable to COPCs in surface water are incidental ingestion and dermal contact. Related potential exposure routes include ingestion of plants, aquatic organisms, wildlife and cattle. For the purpose of the risk assessment, off-site surface water exposure points may consist of several stream segments that are evaluated independently based on differences in concentrations, sample distribution and confluences with additional streams.

- Potential exposure routes applicable to COPCs in sediment are dermal contact and ingestion. Related potential exposure routes include ingestion of plants, aquatic organisms and wildlife. Similar to surface water, off-site sediment exposure points may consist of several stream segments that are evaluated independently based on differences in concentrations, sample distribution and confluences with additional streams.

3.4.3 Exposure Pathways

Given the characteristics of the COPCs of interest and release processes discussed above, this section describes the potential exposure pathways for current and future land use of the Site.

Current On-Site Trespasser

A current on-site trespasser potentially could be exposed to on-site soil via incidental ingestion, dermal contact and inhalation of resuspended particulates. Additionally, on-site surface water may be accessed while the trespasser is on-site, resulting in exposure via ingestion of surface water, aquatic organisms and wildlife. While off-site exposure pathways are also possible for this receptor, other receptors will address exposure to off-site media and this receptor will be limited to on-site exposure.

Current Off-Site Recreational Visitor

A current off-site recreational visitor potentially could be exposed to COPCs in surface water and sediment via dermal contact and incidental ingestion. This receptor may ingest aquatic organisms potentially affected by COPCs during the visit. This receptor potentially may be exposed to chemicals in off-site soil via ingestion, dermal contact and inhalation of resuspended particulates; however, off-site soil-related pathways are only considered potentially complete until additional data is collected. This receptor is anticipated to have a longer exposure duration than the on-site trespasser, but exposure is limited to off-site areas.

Current Off-Site Rancher

Water diverted from Bryant Creek has been used as a water supply for cattle and irrigation for pastures at the River Ranch. A rancher potentially could be exposed to COPCs that may bioaccumulate in the cattle, as well as to surface water itself and plants grown using the surface water for irrigation. This exposure scenario is associated with a specific medium location of water at the diversion and is not relevant to other areas off-site.

Current Off-Site Resident

Although it is unclear if related to Leviathan Mine, a current off-site resident may be exposed to windblown dust and dust from road traffic from the portion of Leviathan Mine Road nearest Route 395 where waste rock and overburden may have been used. If the windblown dust has deposited over time, the current off-site resident may be exposed via direct contact with soil and ingestion of homegrown produce.

Current Off-Site Washoe Tribe Member

A current off-site Washoe Tribe member potentially may be exposed to COPCs in surface water and sediment via dermal contact and incidental ingestion during periodic visits to the Site. The current tribe member also may ingest fish, plants and wildlife potentially affected by COPCs in surface water, sediment and soil. The current tribe member may potentially also be exposed to off-site soil via ingestion, dermal contact and resuspension of particulates; however, the off-site soil exposure pathways are considered only potentially complete until additional data are collected along roads and streambeds.

Future On-Site Washoe Tribe Member

As stated previously, the distinction between this receptor and the current off-site Washoe Tribe member is access to the Site. A future on-site Washoe Tribe member potentially may be exposed to COPCs in surface water and sediment via dermal contact and incidental ingestion during periodic visits to the Site. The current tribe member also may ingest fish, plants and wildlife potentially affected by COPCs in surface water, sediment and soil. The current tribe member may potentially also be exposed to on-site soil via ingestion, dermal contact and resuspension of particulates.

Future Off-Site Washoe Tribe Member

Based on the RME scenario, a future off-site Washoe Tribe member potentially may be exposed to COPCs in surface water and sediment via dermal contact and ingestion. If a well is installed in affected groundwater, then the future off-site tribe member potentially may be exposed to COPCs in groundwater via dermal contact and ingestion. The future off-site tribe member also may ingest fish, plants and wildlife potentially affected by COPCs in surface water, sediment and soil. The future tribe member also may potentially be exposed to on-site and off-site soil via ingestion, dermal contact, and resuspension of particulates; however, the off-site soil exposure pathways only are considered potentially complete pending further evaluation.

Future On-Site Recreational Visitor

Following completion of remedial activities, a future on-site recreational visitor potentially could be exposed to COPCs in surface water and sediment via dermal contact and incidental ingestion. This receptor may ingest aquatic organisms potentially affected by COPCs during the visit. This receptor potentially may be exposed to chemicals in on-site soil via ingestion, dermal contact, and inhalation of resuspended particulates. This receptor is expected to have the same exposure duration as the off-site recreational visitor. Exposure is limited to specific times of the year based on the inaccessibility of the area. To address stakeholder concerns,

the possibility of exposure to airborne dust resulting from off-road vehicles being ridden across the Site will be considered.

3.5 ECOLOGICAL SITE CONCEPTUAL MODEL

The characterization of the potential ecological exposure pathways at the Site, based on existing information, is presented in the CSM (Figure 27). This section identifies potential receptors, exposure routes, and complete pathways. Insignificant and incomplete pathways are also identified and discussed.

3.5.1 Potential Receptors

The identification of potential ecological receptors is based on the characteristics of the Site, surrounding habitats and the general categories of organisms that would be expected to occur within aquatic, riparian and upland habitats. The following receptors have been identified for the Site and surrounding areas:

- benthic macroinvertebrates (aquatic insects);
- fish;
- fish-eating mammals;
- fish-eating birds;
- aquatic plants;
- upland plants;
- soil invertebrates;
- herbivorous mammals;
- carnivorous mammals;
- upland birds other than raptors; and
- raptors.

With the exception of historical studies that have characterized benthic macroinvertebrates (ENSR, 1999; Thompson and Welsh, 1999; Herbst, 1995, 1997, 2000) and fish species (Lehr, 2000; Schoen et al., 1995) in the vicinity of the Site, surveys to quantify the habitats and other categories of ecological receptors found within these habitats have not been conducted.

3.5.2 Exposure Points and Routes

Based on the COPCs, affected media, and migration pathways available for the Site and surrounding areas, points of potential ecological receptor contact with COPCs include soil, surface water, sediment, air, plants and aquatic and terrestrial wildlife.

- Potential exposure routes associated with COPCs in soil are ingestion, dermal contact, and inhalation of resuspended particulates. Additional exposure routes include ecological receptors that consume plants or wildlife that accumulate COPCs from soil. Additional data are required to characterize soil COPC concentrations in on-site and surrounding area habitats utilized by ecological receptors.

- Potential exposure routes associated with COPCs in surface water are ingestion and dermal contact. The risk assessment will evaluate surface water exposure point concentrations of different streams and stream segments within the Site and surrounding areas.

- Potential exposure routes associated with COPCs in sediment are ingestion, dermal contact. Additional exposure routes include ecological receptors that consume plants or aquatic wildlife that accumulate COPCs from sediment. The risk assessment will evaluate sediment exposure point concentrations of different streams and stream segments within the Site and surrounding areas.

- Potential exposure routes associated with COPCs in air are inhalation of resuspended soil or dust generated from road traffic. Additional data are required to characterize the area potential impacted by road-generated dust and the types of habitat that occur within this area.

- Potential exposure routes associated with aquatic and terrestrial plants are the uptake of COPCs from water, sediment or soil and potential impacts to plants and organisms consuming plants.

- Potential exposure routes associated with aquatic and terrestrial wildlife are the uptake of COPCs from water, sediment or soil and potential impacts to organisms consuming aquatic and terrestrial wildlife.

3.5.3 Exposure Pathways

Figure 27 shows the exposure pathways identified for the ecological risk conceptual model. Exposure pathways for ecological receptors include ingestion, dermal contact, and inhalation. Complete exposure pathways for ecological receptors are denoted by a filled circle. At this time, the ecological risk of inhalation of dust generated from road traffic or inhalation of soil particles resuspended by wind or human activities is considered insignificant; however, this issue will be further evaluated in the RI/FS and once the areas receiving road dust have been determined along with the habitat and ecological receptors likely to utilize those habitats, this assumption will be reevaluated.

4.0 SITE MANAGEMENT STRATEGY

This section describes the initial SMS for the RI/FS to be conducted for the Site. The purpose of developing a SMS is to tailor the RI and FS to Site physical characteristics and impacts. Tailoring the RI/FS to the level of Site complexity does not change the information requirements but does involve identifying specific techniques that may be used to streamline the process to save time and costs while ensuring that information is sufficient in quantity and quality to select an appropriate remedy (OSWER, 1988).

The SMS being proposed for Leviathan has already been defined to some extent by the implementation of the interim remedial measures (IRMs) in the Aspen, pit, CUD, and Delta Seep areas. Unchecked, the discharges from these areas represent the greatest exposure to human health and the environment, and therefore justify the need for interim measures. Similarly, the majority of the data collection to date has been stream flow and surface water quality data to assess the impacts from these discharges on the creeks. Ongoing operation of these IRMs and collection of this data will be part of the SMS for the upcoming RI/FS as defined below.

4.1 IDENTIFICATION OF STUDY AREAS

The SMS includes the definition of study areas that are used to develop the DQOs and to facilitate the implementation of further investigation. These study areas are shown on Figure 28 and include:

1. Study Area 1, The Aspen Creek Study Area (ACSA) – This area includes the overburden piles, the reach of Aspen Creek that passes by the eastern side of the Site and the historic landslide area.

2. Study Area 2, The Pit Study Area (PSA) – This area includes the entire pit area (reclaimed and not reclaimed portions), the adit, the PUD and the clarifier areas.

3. Study Area 3, Leviathan Creek Study Area (LCSA) – This area includes the area west and north of the pit, the storage ponds, the diversion channel and CUD, other surface water diversion structures, the Delta Seep and the length of Leviathan Creek from above the Site to the confluence of Leviathan and Aspen creeks.

4. Off-Site Study Area (OSA) – The off-site study area starts at the confluence of Leviathan and Aspen creeks and continues into the upper portion of Bryant Creek to the extent impacts from the Site above background have been recorded in previous data collection exercises.

5. Background Study Area (BSA) – The background study area(s) will include areas with similar characteristics to the Site where analog sites can be established to conduct background studies.

4.2 CONTINUED USE OF INTERIM REMEDIAL ACTIONS

As noted above, the current SMS includes the use of IRMs to capture and treat discharges from several areas. These IRMs currently include:

1. the Aspen Seep Bioreactor (ASB) is used to treat flows from the Overburden seep in the ACSA;
2. lime treatment is used to treat flows captured and held in Site ponds over the winter from the adit in the PSA and the PUD; and
3. lime treatment is currently used and High-Density Sludge Treatment (HDS) will begin in 2009 to treat flows from the CUD and the Delta Seep.

Also, as described in other sections of this Report, a channel conveys Leviathan Creek, past the waste piles along the western border of the Site. As part of the SMS for the RI/FS, these and other IRMs will be evaluated through treatability or pilot studies and additional measures may be tested/implemented as part of the program in the next few years.

4.3 PRIORITIZATION OF DATA COLLECTION AND CLEANUP

Exposure pathways and the degree of risk to human health and the environment are significant criteria that can be used to prioritize the work to be conducted under the RI/FS. Based on the CSMs, the greatest current and future risk remaining to human health and the environment is from on-site source and discharge areas (Aspen, pit, CUD, Delta Seep and ponds). Cleanup needs to occur in these areas prior to being able to evaluate and address cleanup in the off-site area. In addition, background data needs to be collected as a high priority because this data are necessary to assess exposure and to evaluate cleanup standards from both on and off-site study areas. A general prioritization criterion for data collection and cleanup during the RI/FS is presented below.

High Priority

- high potential current or future exposure to human health or the environment;
- data necessary to study or address other areas; and
- cleanup necessary to address other areas.

Moderate Priority

- moderate current or future potential exposure to human health or the environment;
- potential that cleanup efforts could recontaminate areas located downstream, downwind or downgradient; and

- unusual complexity of problems that could require lengthy evaluation.

Low Priority

- low current or future potential for exposure to human health or the environment; and
- low risk recontamination of other areas.

Therefore, the strategy for the highest priority for the RI/FS will be data collection and cleanup in the on-site study areas 1 through 3 and from the BSA Area 5.

4.4 BACKGROUND DATA COLLECTION

As noted above, background and/or pre-mining data collection are necessary as a high priority in the RI/FS. Investigation of the natural background condition can be used to establish or evaluate the feasibility of achieving cleanup goals. For the RI/FS it is anticipated that to collect background data for groundwater, surface water, sediment and soil, and develop biological reference data for the risk assessment, more than one background area or analog Site will need to be selected.

Reference areas will be selected where sample collection and analysis will be used to collect data to differentiate between naturally occurring releases from altered releases. The reference areas may be located in a nearby creek such as Mountaineer or Monitor Creek, near the Site, or they may be located in a nearby watershed with similar characteristics. In selecting a reference area, anthropogenic contributors other than mining will be considered. Locations that reflect obvious contributions of human activity may be judged inappropriate for background data collection.

In selecting background areas for sample collection, it will be important to understand early in the process the ways in which the data will be used. For example, to ensure that spatially relevant and statistically significant results can be obtained, background sample collection plans will need to include an adequate number of samples over an appropriate area and in a relevant pattern. The DQO for Area 5 will address these issues (Section 8).

4.5 STREAMLINING TECHNIQUES

Where possible, streamlining techniques will be used to expedite the RI/FS data collection and decision making process. There are a number of methods that can be used. All of the approaches involve conducting a review of existing information on the Site and stressing the importance of developing a comprehensive understanding of the probable Site conditions, so that accurate predictions regarding contaminant source area, contamination distribution and the presence of preferential migration and exposure pathways can be made.

The Expedited Site Characterization (ESC) approach described in American Society for Testing Materials (ASTM) for Expedited Site Characterization of Vadose Zone and Groundwater Contamination of Hazardous Waste Sites, ASTM D-6235 and several U.S. Department of Energy (DOE) documents (Burton 1993; Burtin et al., 1995; U.S. DOE 1998, 2001); the Triad approach described in Technical and Regulatory Guidance for the Triad approach, New Paradigm for Environmental Project Management (ITRC, 2003), and in several U.S. EPA documents (Crumbling, 2001; Crumbling et al., 2003; U.S. EPA, 2004); and the Dynamic Field Activities (DFA) approach described in several U.S. EPA Superfund documents (U.S. EPA, 2001, 2003) are all good examples of approaches that may be used to streamline the RI/FS process at the Site.

5.0 STUDY AREA DESCRIPTIONS

As defined in Chapter 4, as part of the SMS (Section 4), the Site has been divided into study areas. The location and boundaries, physical description, results of previous studies and conceptual model for each study area are presented below. Figure 28 shows the approximate boundaries for the study areas. The area boundaries are approximate and are not intended to limit the RI/FS investigation if work outside of the study area is necessary. For example, the habitat for some of the ecological receptors to be evaluated in the RI/FS extends outside of the study area boundaries.

As described in Section 4, the study areas are the ACSA, PSA, LCSA, OSA, and BSA. Each of these areas is described in more detail below.

5.1 ASPEN CREEK STUDY AREA (ACSA)

The ACSA is described in this section. The ACSA is shown on Figure 29.

5.1.1 Location and Physical Characteristics

The ACSA is located along the eastern boundary of the disturbed portion of the Site. The area is bound on the east by Aspen Creek, on the south by the limit of the overburden piles, on the west by the pit and the western edge of the landslide and the area extends north to the confluence of Aspen and Leviathan creeks. Figure 29 presents the ACSA.

The southern portion of the ACSA is dominated by the overburden piles of varying relief. The piles were placed on the ground surface of the original topography and rise several hundred feet above Aspen Creek. Some of the southern piles are benched and the topography of the area grades and therefore drains from west to east, which mimics the original topography. The material in the piles is largely off-white in color due to leaching and clay replacement of the original materials from hydrothermal fluids. The surface of the piles appears fine grained but reportedly there is larger material present in the subsurface. The overburden piles have little to no vegetation. A few aspen trees are growing in the small catch basin below the Upper Overburden Seep (Figure 29). An Upper Tailings scarp/slump defined by Sciacca is visible above the piles to the west and north. Movement within the piles has been reported due to movement in the greater landslide and the steep angle of the overburden piles. The top of the lower transitional slide begins somewhere under the lower middle portion of the overburden piles.

The northern portion of the ACSA consists of the northern portion of the landslide and continues north to where the slide ends at the confluence of Aspen and Leviathan creeks. This area has not been disturbed by mining, but the landslide movement has resulted in

slumps and sags, cracks, and a number of the large pine trees leaning in the downhill direction. Landslide movement is evident in the road cuts that cross the landslide in several locations.

Aspen Creek runs along the entire eastern boundary of the study area. There is a small amount of overburden piles on the eastern part of the creek in the central ACSA. The creek has small meanders and is rapidly down-cutting its channel. The creek has some wider erosional areas in the central study area and then becomes narrower to the north until it widens and mixes with Leviathan Creek at the confluence.

5.1.2 Previous Data Collection Activities in the ACSA

Previous data collection activities in the ACSA include the following:

1. USGS performed soil borings, soil sampling, and piezometers in 1983;
2. Sciacca studied the landslide area and prepared his master's thesis in 1983;
3. From 1981 through 2008, RWQCB has collected surface water samples in Aspen Creek and from the Upper Overburden Seep;
4. Sciacca and Matthews evaluated the distribution of pyrite at the Site in 1988;
5. USGS collected limited sediment samples in Aspen Creek;
6. SRK collected shallow soil samples in the area in 1998; and
7. Atlantic Richfield currently monitors the Lower Overburden Seep and operates the ASB and monitors discharge to Aspen Creek.

Results of surface soil sampling in the area showed relatively low concentrations of metals across the overburden piles compared to other areas of the Site. Sciacca's work in the overburden, however, shows local areas with higher concentrations of pyrite (Sciacca and Matthews, 1985). Similarly, data collected from the USGS piezometers showed low concentrations of metals in groundwater compared to other areas of the Site.

None of the surface water samples collected in Aspen Creek and analyzed for arsenic or turbidity are elevated compared to regulatory standards. TDS is elevated in the creek and average concentrations of copper, lead, selenium, and alkalinity are high compared to Station 22 upstream. Maximum concentrations of cadmium, nickel, and zinc were elevated in only a small amount of samples collected.

The overburden seep consistently has a pH in the 4 range. Metals are elevated in the influent to the ASB. The ASB significantly reduces metals loading to Aspen Creek.

No metals were elevated in whole sediment samples collected from Aspen Creek. Selected metals were elevated above background in the fine fraction samples.

5.1.3 ACSA Conceptual Model

There are two known discharges that occur in the ACSA; the Upper Overburden Seep and the Overburden Seep (also know as the Aspen Seep). The Overburden Seep is treated with the ASB. The upper discharge has the same flow rate, pH and temperature as the lower seep and it is likely that the source water for the seeps is the same or related.

Above the Upper Overburden Seep in the ACSA there is a flat geographic area with higher sides that acts as a collection basin that may be the source of the water to both seeps (Figure 29). There is a notch in the edge of the basin just above the upper seep that may contribute to the migration pathway. It is unknown where the water becomes acidic or where the migration pathway of the water through the overburden piles is located though it is likely that the migration pathway is along the contact between the piles and the original ground surface. Below the Upper Overburden Seep there is a small aspen grove fed by the seep water. The water goes underground after the grove area though this water would be expected to migrate in an easterly direction prior to discharging most likely as the flow that is currently captured and treated with the ASB.

The overburden piles are known to contain some areas with an increased percentage of pyrite where if water comes in contact with these areas it would likely become impacted. Where these areas exist at the ground surface they will need to be evaluated for human and ecological health exposure. Otherwise investigation of the overburden piles is not considered necessary. It is unclear what impact the re-grading of the overburden piles in the early 1980s had on the discharges in the ACSA.

The geology below the ACSA consists of sedimentary rocks that are reported to contain calcareous material. Infiltration or injection of water into these materials may provide buffering of the acidic flows.

Since the ASB has been operating, the quality of surface water in the creek has improved greatly. The current CSMs identify the current on-site trespasser and future recreational user as the primary human receptor and potentially avian and aquatic receptors. These receptors will be further evaluated in the risk assessment.

The landslide and the overburden slump were considered to be reactivated by placement of overburden on the upper portion of the slide. The slide is not considered an issue in the assessment of current or future exposure or in the need to develop remedial alternatives in the RI/FS except as it affects subsurface migration of impacted water and the stability of facilities that may be constructed in the ACSA.

5.2 PIT STUDY AREA (PSA)

The PSA is the most prominent feature on the Site and it includes the PUD, the adit, and the pit clarifier. These features are shown on Figure 30 and discussed below.

5.2.1 Location and Physical Description

The PSA is located in the south and southeastern portion of the Site. The pit is approximately 50 acres in size and has very steep walls in excess of 200 ft. high. There are numerous slope failures around the perimeter of the pit. There are exposures in the pit wall of the ore body and the ore zone containing crystalline sulfur can be seen on the west, north, and south sides of the pit.

Approximately 23 acres of the pit were regraded in the early 1980s to control storm water runoff and the remaining acreage was left unchanged from when mining ceased in 1962. The regraded area is benched and has surface water channels to drain precipitation. Reportedly, the material used for the regraded area came from waste rock formerly stored in the area of what is now Pond 2. Revegetation efforts have been attempted on the regraded area with limited success.

The PUD is a collection feature installed as part of the mitigation measures constructed by the state in the 1980s. This collection system consists of approximately 1,500 linear ft. of 12-inch-diameter perforated pipe set in bed rock beneath the pit bottom. The perforated pipe connects to a nonperforated 18-inch-diameter pipe that conveys PUD discharge to the flow control structure. The approximate location of the PUD piping is presented on Figure 30.

The adit is the only known remaining component of the underground workings present at the Site. The portal (elevation ± 7,050 ft.) is located just south of the pit opening and near the PUD collection point. The RWQCB installed a drain in the adit in 1985. The drain consists of a 12-inch-diameter perforated pipe in a bed of drain rock buried in native material. The perforated pipe is then connected with a nonperforated pipe to a concrete flow control structure.

The pit clarifier is a ±1-acre shallow pond used as a final process step for water treatment prior to discharge to Leviathan Creek located just inside the western opening to the pit. It was constructed during the mid-1980s, when the other earthwork was completed.

5.2.2 Previous Data Collection Activities in the PSA

Previous data collection activities in the PSA area include:

1. 1981 to 1983, USGS collected soil samples, installed groundwater monitoring wells/piezometers, collected groundwater samples, performed downhole geophysics, collected core from nine borings in the mineralized zones, produced a groundwater elevation map;

2. 1998 to 1999, SRK installed groundwater monitoring wells and collected surface water samples; and

3. the RWQCB monitors the adit and PUD flows and collects water level elevation data from monitoring wells in the pit.

Results of surface soil sampling in the PSA show the highest concentrations of metals compared to any other area of the Site. Similarly, data collected from the USGS piezometers and the SRK monitoring wells show the highest concentrations of metals and lowest pH in groundwater wells installed in the PSA.

The water flowing from the adit has a pH of less than 3 and typically has a discharge rate between 9 and 15 gpm. AMD from the PUD also has a pH of less than 3 and typically has a flow rate between 1 and 4 gpm, with rates as high as 38 gpm seasonally.

5.2.3 PSA Conceptual Model

The pit is a large groundwater sink, and groundwater flow, precipitation, and runoff into the pit come in contact with in-place materials and re-graded rock with sulfide mineralization. The PUD and adit are both beneath the pit floor. It is unclear how much of the adit flow comes through the surrounding materials compared to groundwater in the adit. It is also unclear how much of the pit flows are not captured by the PUD and have the potential to migrate outside of the pit.

A certain amount of the water not captured would infiltrate into unconsolidated material at the base of the pit and have the potential to migrate in groundwater. Some shallow groundwater likely migrates beyond the pit boundary towards Leviathan Creek. With a downward vertical component to groundwater flow, a certain amount of the infiltration may go deeper.

The 980-foot long generally east west trending adit tunnel was reported to be mostly dry in late-1982 when only the easterly most 60 ft. had encountered groundwater. Site maps used

during the time of the underground workings assumed relative elevations and a unique coordinate system making them hard to rely upon (Brown and Caldwell, 1983). At a later date, a year round seep/spring developed close to the adit portal resulting in a point discharge.

The key receptors in the PSA are the current on-site trespasser and future recreational user, and avian and terrestrial organisms coming in contact with the Site waste or ARD/AMD. The water captured from the adit and the PUD in the PSA is treated prior to discharge except on the rare occasion when the treatment system has a mechanical failure.

The pit slopes are unstable and the area outside of the reclaimed slopes has a large recharge potential. An unknown amount of explosives were reported to have been left in a shaft that collapsed shortly after the Site closed and has never been found. The open pit mining operation reportedly destroyed all the remnants of the underground operation (e.g., stopes, adits, raise and shafts) with the exception of adit #5 though this needs to be confirmed as part of the RI/FS.

5.3 LEVIATHAN CREEK STUDY AREA (LCSA)

The LCSA includes Leviathan Creek, the diversion channel, Delta Seep, CUD, other concrete structures and the four storage ponds (study area 3, Figure 31).

5.3.1 Location and Physical Description

This study area is bounded on the west by Leviathan Creek, on the east by the PSA and then the western edge of the landslide, on the south by the southern boundary of the disturbed Site area and on the north by the confluence of Leviathan and Aspen creeks. A physical description of the study area is provided below and is presented on Figure 31.

Upper Leviathan Creek from above the Site to the confluence of Aspen Creek is included in this study area. The creek is channeled for approximately 3,600 ft. from near where it enters the Site to the area by the Delta Seep. The channel consists of a 72-inch concrete pipe in the southern portion of the LCSA which spills to an open concrete channel in the northern study area. The concrete channel consists of a box structure with weep holes in the sides to allow seepage of water into the channel. From the CUD and the Delta slope discharge northward the creek remains in its original channel to the confluence.

The CUD is a 12-inch polyvinyl chloride (PVC) perforated drainage pipe that was installed to remove water during construction of the Leviathan Creek channel. The drainage pipe is reported to be installed in a gravel bed approximately 2 ft. below the channel. There is a collection tank near the CUD discharge where the water is captured seasonally for treatment at Pond 4. During the winter, or off-treatment season the CUD discharges to Leviathan Creek.

A Delta slope repair project was implemented by the RWQCB in 2005 where the slope was benched, surface drainage was constructed to route storm water flows around the slope and finger drains were installed in the slope to drain subsurface flow. On-site rock was used as rip-rap to form a buttress at the base of the slope. The seep at the bottom of the slope is located in the paleo-channel of Leviathan Creek. There is a capture tank for the collection and treatment of the Delta Seep flows seasonally by the Pond 4 treatment system. The finger drains also are captured by the tank.

Four retention ponds are designed to contain acidic water collected from the Site and to promote evaporation. Historically during periods of high flows the evaporation ponds have periodically reached maximum capacity and overflowed. The ponds consist of:

- Pond 1 is located just outside the pit opening and is used to collect water from the adit and the PUD. Pond 1 is constructed with waste rock and is located within the area of mineralization.
- Ponds 2n and 2s are located at the southwestern portion of the Site constructed geographically higher than other areas. The high slope where these ponds are built is made of waste rock. Historically, both of these ponds were seasonally overtopped during periods of heavy runoff.
- Pond 3 is located at the northeast base of the waste rock piles where ponds 2n and 2s are constructed and just northwest of Pond 1. Pond 3 is designed to accept overflow from Ponds 2n and 2s. It is also constructed with waste rock. This overflow can be routed to either pond or Leviathan Creek.
- Pond 4 is located on the northern portion of the waste rock piles. It is constructed at the lowest elevation of all ponds and it is located adjacent to the channelized portion of Leviathan Creek. Pond 4 receives overflow and seepage from Pond 3. Pond 4 is currently being used by Atlantic Richfield to receive rotating cylinder treatment system (RCTS) treated water from the CUD and Delta Seep.

Leviathan Creek from the CUD and Delta discharge to the confluence of Aspen Creek is impaired due to past and seasonal discharges of AMD/ARD. During the summer months when the CUD and Delta Seep are captured the channel flow and treated effluent discharge benefits the creek in this reach. The stream enters the Site at approximately 7075-foot elevation and exits at 6,850 ft. in elevation above sea level at the confluence with Aspen Creek.

5.3.2 Previous Data Collection Activities in the LCSA

Previous data collection activities in the LCSA are similar to other areas of the Site and include:

- water quality sampling of the creek started in the early 1980s and continues today by the RWQCB (Brown and Caldwell,1983);
- 1981 to 1983 - USGS collected soil samples, installed groundwater monitoring wells/piezometers, collected groundwater samples, performed downhole geophysics, collected core from nine borings in the mineralized zones, produced a groundwater elevation map;
- 1998 to 1999 - SRK installed groundwater monitoring wells and collected surface water samples;
- 2001 - Kleinfelder installed nine boreholes (B-1 through B-9) in the vicinity of the Delta slope adjacent to Leviathan Creek. Six of the boreholes were completed as monitoring wells and slope inclinometers were installed in the other three. The boreholes terminated at or near the contact of fill and bedrock therefore useful groundwater data from these wells is very limited;
- additional data was collected by the RWQCB during the Delta slope repair work in 2005;
- 1981 to 2008 - RWQCB has collected surface water samples in Leviathan Creek; and
- Atlantic Richfield continues monitoring flow and quality of the CUD and the Delta discharge and the quality and flow of treated effluent as it discharges back to Leviathan Creek.

Results of surface soil sampling in the LCSA show generally higher concentrations of metals compared to the overburden areas of the Site. Similarly, data collected from the USGS piezometers and the SRK monitoring wells show higher metals concentrations in the wells in the LCSA than near the overburden.

Dissolved concentrations of metals in surface water in Leviathan Creek above the Site are low to non-detect. When the CUD and the Delta Seep are discharging without treatment, the metals and sulfate concentrations in the creek increase and pH decreases. Average concentrations of cadmium, copper, iron, nickel, lead, zinc, arsenic, and selenium are elevated compared to background downgradient of the Site in Leviathan Creek.

5.3.3 LCSA Conceptual Model

The LCSA has a relatively large water collection area that would drain mostly to the west and north towards Leviathan Creek. Water sources include precipitation, pond and channel leakage or water discharging through the pit. Water migrating through the waste piles has a good potential to contact waste rock containing sulfides and become ARD. The presence of shallow groundwater is confirmed seasonally as water is intercepted in the waste piles near Pond 4 at shallow depths even during the late summer months.

It is likely that preferential flow paths for subsurface flows would be along the interface of the waste piles with original topography, and along and around the pipe or channelized Leviathan Creek. Pond and channel leakage would contribute to these flows seasonally. It is unclear if, and if so, how much uncaptured subsurface flows from the pit could be contributing to the water found in the waste piles in the LCSA.

The water that passes through the primary LCSA would discharge either in the CUD, the Delta slope or infiltrate and discharge as surface water further downslope of the LCSA. A minimal amount of water may infiltrate as deeper groundwater though the expectation is that this groundwater would eventually discharge and mix with surface water further downstream.

The RWQCB has suggested that the discharge from the CUD may be caused by the relatively discreet sources along the upper reach Leviathan Creek near where the discharge from the pit comes into the channelized portion of Leviathan Creek.

The Delta discharge collection point is in the paleo channel of Leviathan Creek. It is unclear how efficiently the capture is in this area. It is also unclear how complete the interception of seepage and storm water is in the Delta slope drains. These drains were installed based on observation during the construction in 2005 and collection systems in the slope may not be removing all flows from the slope. Some of the storm water flows measured in 2007 had a low pH also suggesting that storm water collected by the surface drains installed on the slope can be impacted. It is suspected that a certain amount of the Delta discharge comes from water in the current channel of Leviathan Creek.

Limited or no testing of pond liner integrity has occurred since installation. In addition, the piping installed to connect the ponds may be providing a man-made secondary permeability in the back fill material used. Seepage has been noted to occur seasonally in the gravel used to back fill the piping trenches between Ponds 3 and 4.

Leviathan Creek from the CUD/Delta Seep to the confluence of Leviathan and Aspen creeks likely includes reaches that both lose and gain water. During the later summer months the

creek closest to the Site is dry, although further downstream there is flow. Closer to the confluence with Aspen Creek, there is a pond that contains water measured in late summer of 2008 with a pH of 4. The source of this water is unknown.

Current potential receptors in the LCSA include trespassers and recreational users and aquatic and terrestrial biota.

5.4 OFF-SITE STUDY AREA (OSA)

The OSA includes Leviathan Creek from the confluence of Aspen Creek, which becomes Bryant Creek past the confluence of Mountaineer Creek to where Barney Riley Creek enters Bryant Creek downstream. There are some potentially complete exposure pathways being considered in the CSM for impacts of the confluence of Barney Riley Creek and Bryant Creek (e.g., use of diversion water on the River Ranch property). If these exposure pathways are determined to be complete and the impacts are confirmed to be from the Site, the OSA may be extended. The OSA is shown on Figure 32.

5.4.1 Location and Physical Description

The OSA consists of lower Leviathan Creek past the confluence of Aspen and Leviathan Creek, and Bryant Creek from Mountaineer Creek to where Bryant Creek meets Barney Riley Creek. The elevation at the upstream point in this study area is approximately 6,600 ft. and the downstream elevation is approximately 5,690 ft. in elevation.

The upper portion of the OSA above Mountaineer Creek is characterized by shallow creek beds, soft side slopes and a number of abandoned channels due to intermittent high-energy discharge years. Certain areas of the upper creek are being eroded by cattle grazing. In the upper area, the creek is recovering quickly with residual iron staining remaining only in localized reaches. Below Mountaineer Creek, Bryant Creek flows at higher energy due to steepened topography (the creek is located in steep valleys bounded by volcanic cliffs until the creek floodplain broadens near Barney Riley Creek). All along Bryant Creek there is abundant aquatic life and obvious evidence of bears and other wildlife. A number of seeps enter Bryant Creek, especially as the creek approaches the area where Barney Riley Creek enters Bryant Creek.

Several unnamed creeks and streams drain the OSA. There is a wide variation in climatic conditions and, therefore, vegetation and uses of the creek in the OSA. The stream has low flows in the summer and fall, and high flows in the spring and during intense storms.

5.4.2 Previous Data Collection Activities in the OSA

Previous data collection activities in the study area included:

- USGS collects surface water and stream sediment samples in Leviathan Creek and surrounding creeks; and
- U.S. EPA collects surface water samples along Leviathan and Bryant creeks.

As discussed in Section 2, concentrations of metals in surface water continually decrease downstream from the Site. The pH measured in the Leviathan Creek OSA in late 2008 was neutral in all locations. The majority of dissolved iron previously measured in surface water is calculated to be removed before Station 25, which is at the confluence of Leviathan Creek and Mountaineer Creek. Arsenic is also removed in the same distance. Nickel and zinc have been shown to be removed more slowly. Several metals increase further downstream in the OSA, including aluminum, arsenic, copper, and zinc.

The primary current exposure pathways in the OSA are the recreational user, the Washoe Tribe, and aquatic receptors.

5.4.3 OSA Conceptual Model

The OSA consists of almost six miles of surface water with many tributaries and springs. As indicated above approximately 42 percent of the flow to Bryant Creek at its headwaters is from Leviathan Creek (MWH, 2002). There are both losing and gaining reaches of the stream in the OSA.

The OSA is surrounded by historic mining activities for gold, silver, copper, lead, zinc, tungsten, and antimony, as evidenced by multiple historic mines in and around the area. These deposits were the result of regional hydrothermal alteration of the existing rock formations and volcanic activity. Hot springs are present in the area, most notably along the banks of the East Fork of the Carson River. The Leviathan, Aspen, and Mountaineer creeks are tributaries to the East Fork of the Carson River.

Currently, with treatment of the sources at the Site at least seasonally, the environmental condition of the creeks in the OSA is quickly repairing. As noted above, pH in surface water downstream of where Aspen Creek enters Leviathan Creek is neutral. Biota monitored in the creek in this area is also recovering quickly.

Current receptors in the OSA include the recreational visitor, off-site resident and the Washoe Tribe members. Ecological receptors include avian, aquatic, terrestrial and mammals.

5.5 BACKGROUND STUDY AREA (BSA)

The BSA will include areas that will be used to collect background and/or pre-mining data for the RI/FS. These areas have not yet been selected, but as discussed in Section 4, identifying them will be a priority in the early phases of the RI/FS to allow adequate data collection time to account for seasonal variability in conditions affecting certain media.

5.5.1 Location and Physical Description

No locations have been selected for the RI/FS background studies.

5.5.2 Previous Background Data Collection

Limited background studies have been completed for the Site. Currently, surface water sampling stations upstream from the Site in Leviathan and Aspen creeks are used for comparison with downstream data. Groundwater monitoring wells 31 and 32 were used for background groundwater sample collection in the past, although these wells are not located or completed in similar geologic materials as the Site.

5.5.3 Background Area Conceptual Site Model

The goal will be to identify areas that have similar conditions to the Site but that have not been disturbed. This may be difficult as historical mining exploration methods were relatively thorough.

A review of natural background conditions will be used to assess cleanup goals, ARARs, and exposure, and may also support the analysis of technical impracticability. If necessary, spatially relevant and statistically significant results may need to be obtained.

The anticipated minimum background data needs include:

1. Analog creek site(s) for surface water, sediment, and biota – The site(s) that would best be located near the Site would represent similar rock types and alteration and preferably would not have been disturbed by mining. Areas along Mountaineer Creek and Monitor Creek have been reviewed as potential analog sites for surface water.

2. Background groundwater – Groundwater monitoring wells used for background data collection should be installed in areas that have similar geologic alteration patterns but have not been disturbed by mining. Considering that groundwater flow on-site is mostly in disturbed materials (overburden, waste piles, or colluvium), and most of the groundwater becomes surface water, background groundwater concentrations are of less concern than for surface water and sediment.

3. Background soil – Soil samples will be collected from areas that have similar mineralization but have not been disturbed by mining.

4. Background seeps – Samples will be collected from seeps present in background study areas to compare the chemistry to onsite seeps.

6.0 REMEDIAL ACTION OBJECTIVES AND INITIAL REMEDIAL ACTIONS

This section presents remedial action objectives (RAOs) and initial remedial actions for each area of the Site. Now that the data has been analyzed and the CSM has been developed, potential RAOs are identified and a preliminary range of remedial actions and associated technologies are identified. As indicated earlier in the Report, the purpose of identifying initial remedial actions now is not to conduct a detailed investigation of alternatives but instead to provide a more general classification of potential remedial actions based on the initially identified potential routes of exposure and associated receptors identified for the Site. The identification of the initial remedial actions at this stage will help ensure that data needed to conduct the technical evaluation can be collected as early as possible in the RI/FS process.

6.1 REMEDIAL ACTION OBJECTIVES (RAOS)

RAOs are proposed goals for protecting human health and the environment. RAOs provide the framework for developing and evaluating remedial action alternatives. RAOs will be developed using information gathered during the RI and the risk assessment. Most of the RAOs will be based on human health and environmental protection. For the purposes of the RI/FS scoping and this Report, the RAOs for developing the initial list of the response actions are to do the following:

- prevent, mitigate, or reduce potential human health and environmental exposure;
- support long-term restoration of surface water and groundwater; and
- minimize threats to the environment, especially sensitive habitats and critical habitats of species protected under the Endangered Species Act.

6.2 TECHNOLOGY DESCRIPTIONS

The general remedial action technologies currently under evaluation for the Site are grouped into six categories:

1. no action;
2. administrative controls;
3. engineering controls;
4. removal actions;
5. physical/chemical treatment; and
6. biologic treatment.

These alternatives are described by category in Table 15.

6.3 REMEDIAL TECHNOLOGY IDENTIFICATION AND DESCRIPTION BY STUDY AREA

A list of technologies being considered or in use at the Site is presented by study area and medium on Tables 16 through 19.

7.0 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

7.1 ARARS, TBCS AND WAIVERS

Presented below in Section 7.1.1 is a description of ARARs as defined in CERCLA, and a discussion of the difference between applicable and relevant, and appropriate ARAR categories. Section 7.1.2 describes to be considered criteria (TBC) and section 7.1.3 describes limited waivers to ARARs provided by CERCLA and the NCP. The ARARs will be used throughout the DQO seven-step process Specifically, ARARs are used to:

- refine the problem statement;
- clarify the decision statement;
- define the inputs necessary; and
- evaluate if numerical cleanup values for contaminates exist or if a risk-based method is necessary for Site specific conditions.

7.1.1 ARARs as Defined Under the National Contingency Plan

Section 121(d) of CERCLA provides that any and all remedial actions selected shall, at a minimum, attain a degree of cleanup which "assures protection of human health and the environment." 42 U.S.C. §9621(d)(1). CERCLA further provides that such remedial actions "shall be relevant and appropriate under the circumstances presented by the release or threatened release of such substance, pollutant or contaminant." *Id.*

A requirement may be either "applicable" or "relevant and appropriate," but not both. Identification of ARARs must be completed on a site-specific basis and involves a two-part analysis:

- a determination whether a given requirement is applicable; and
- if it is not applicable, a determination of whether it is nevertheless both relevant <u>and</u> appropriate.

Applicable requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations properly promulgated under Federal or State law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site.

Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations properly promulgated under Federal or State law that, while not "applicable" to a hazardous substance,

pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site (*CERCLA Compliance with Other Laws Manual*, August 8, 1988).

In some circumstances, a requirement may be "relevant" but not appropriate for the site-specific situation. Such a requirement would not be an ARAR for the Site. Further, if only part of a requirement is "relevant and appropriate," the portion that is not considered "relevant and appropriate" need not be addressed. Finally, if a determination is made that a requirement is both "relevant and appropriate," such a requirement should be given the same consideration as an "applicable" requirement.

The criteria for determining relevance and appropriateness are listed at 40 CFR 300.400.(g)(2) of the NCP, as follows:

1. the purpose of the requirement and the purpose of the CERCLA action;
2. the medium regulated or affected by the requirement and the medium contaminated or affected at the CERCLA site;
3. the substances regulated by the requirement and the substances found at the CERCLA site;
4. the actions or activities regulated by the requirement and the remedial action contemplated at the CERCLA site;
5. any variances, waivers, or exemptions of the requirement and their availability for the circumstances at the CERCLA site;
6. the type of place regulated and the type of place affected by the release or CERCLA action;
7. the type and size of structure or facility regulated and the type and size of structure or facility affected by the release or contemplated by the CERCLA action; and
8. any consideration of use or potential use of affected resources in the requirement and the use or potential use of the affected resource at the CERCLA site.

It is important to note that Federal and State standards, policies, advisories, guidance documents, and local requirements that have not undergone formal promulgation (usually through "notice and comment" rulemaking) are *not* ARARs.[1] However, as set forth below, they

[1] The NCP defines promulgated as standards that are of general applicability and are legally enforceable. 40 CFR Part 300.400(g)(4). Further, state standards which are not as stringent as federal standards are not to be considered ARARs. *Id.*

may constitute criteria “to be considered” when remediating to protect human health and the environment, and may be binding with respect to site activities.

Federal and State ARARs can be divided into the following three categories:

- **Chemical-specific ARARs**: Chemical-specific or ambient requirements include those laws and regulations that regulate the release to the environment of materials possessing certain chemical or physical characteristics, or containing specified chemical compounds. These requirements generally set health- or risk-based concentrations limits or discharge limitations for specific hazardous substances that may be found in, or discharged to the ambient environment. If, in a specific situation, a chemical is subject to more than one discharge or exposure limit, the more stringent of the requirements should generally be applied

- **Action-specific ARARs**: Action-specific ARARs consist of requirements that define acceptable handling, treatment, and disposal procedures for hazardous substances. These ARARS generally set performance, design, or other similar action-specific controls or restrictions on particular kinds of activities related to management of hazardous substances or pollutants. These requirements are triggered by the particular remedial activities that are selected to accomplish the cleanup remedy.

- **Location-specific ARARs**: Location-specific ARARs are those requirements that relate to the geographical or physical position of the Site, rather than the nature of the contaminants or the proposed Site remedial actions. These requirements may limit the type of remedial action that can be implemented, and may impose additional constraints on the cleanup action. *(CERCLA Compliance With Other Laws Manual, August 8, 1998).*

ARARs are concerned only with substantive, not administrative, requirements of a statute or regulation. The substantive portions of the regulation are those requirements that directly pertain to actions or conditions in the environment.

Examples of substantive requirements include quantitative health- or risk-based restrictions upon exposure to types of contaminants [e.g., maximum contaminant levels (MCLs)]. Administrative requirements are the mechanisms that facilitate implementation of the substantive requirements. Administrative requirements include issuance of permits, documentation, reporting, recordkeeping, and enforcement. Thus, in determining the extent to which on-site response actions must comply with environmental standards, a distinction should be made between substantive requirements, which may be ARARs, and administrative requirements, which are not. “On-site” is defined as the areal extent of contamination and includes affected groundwater plumes to be remediated.

The potential ARARs and TBCs identified for this Site are those that could impact the selection of remedial action alternatives and the ultimate clean up standards. The purpose of this

section is to present the universe of ARARs and TBCs that may apply to the remedial alternatives under consideration at the Site and to identify how the ARARs influence the feasibility of those alternatives at this point in the RI/FS scoping process. ARARs may also identify specific numerical cleanup objectives for the Site or may require application of a certain approach to cleanup level development.

7.1.2 Definition of TBCs

A requirement may not meet the definition of an ARAR as defined above, but may still be useful in determining whether to take action at a site or to what degree action is necessary. This can be particularly true when there are no ARARs for a site, action, or contaminant (e.g., contaminants for which MCLs have not been established). Such requirements are called TBC criteria. The TBC requirements are non-promulgated advisories or guidance issued by Federal or State government that are not legally binding but may provide useful information or recommended procedures for remedial action. Although TBCs do not have the status of ARARs, they are considered along with ARARs as part of the Site risk assessment in establishing the required level of cleanup for protection of health or the environment.

7.1.3 Waivers

Section 121 in CERCLA and the NCP at 40 CFR Par 300.430(F)(ii)(C) provide that, under certain circumstances, an otherwise ARAR may be waived. These waivers apply only to the attainment of the ARAR; other statutory requirements, involving remedies that are protective of human health and the environment, cannot be waived. The types of waivers provided by CERCLA Section 121(d)(4) are listed below:

1. **Interim Remedy** – The remedial action selected is only part of a total remedial action that will attain such a level or standard of control when completed.

2. **Greater Risk to Human Health or the Environment** – Compliance with the requirement at the Site will result in greater risk to human health and the environment than alternative options.

3. **Technical Impracticability** – Compliance with the requirement is technically impracticable from an engineering perspective.

4. **Equivalent Standard of Performance** – The remedial action selected will attain a standard of performance that is equivalent to that required under the otherwise applicable standard, requirement, criterion, or limitation through use of another method or approach.

5. **Inconsistent Application of State Requirements** – With respect to a state standard, requirement, criterion, or limitation, the state has not consistently applied (or demonstrated the intention to apply consistently) the standard, requirement, criterion, or limitation in similar circumstances at other remedial actions.

6. **Fund Balancing** – In the case of a remedial action to be undertaken solely under Section 104 of CERCLA using the fund, selection of a remedial action that attains the level or standard of control in the requirement will not provide a balance between the need for protection of public health and welfare and the environment at the Site under consideration, and the availability of amounts from the fund to respond to other sites that present or may present a threat to public health or welfare or the environment, taking into consideration the relative immediacy of such threats. The fund-balancing waiver is not applicable to the Site because proposed remedial actions at the Site are not fund actions.

7.2 POTENTIAL CHEMICAL-SPECIFIC ARARS AND TBCS

Chemical-specific ARARs and TBCs are typically health-based or risk-based numerical values or methodologies that, when applied to site-specific conditions, result in the establishment of numerical values. These values, in turn, establish the acceptable amount or concentration of a chemical that may be found in, or discharged to, the environment (soil, groundwater, surface water, or air) as a result of the final remedial action(s) selected. Table 20 presents the potential action-specific ARARs and TBCs for the Site.

7.3 POTENTIAL ACTION-SPECIFIC ARARS

Action-specific ARARs generally set performance, design, or other similar action-specific controls or restrictions on certain activities related to management of contaminants or pollutants. Table 21 presents the potential action-specific ARARs and TBCs for the Site.

7.4 POTENTIAL LOCATION-SPECIFIC ARARS

Location-specific ARARs are requirements that affect the management of hazardous constituents due to the location of the Site. Location-specific ARARs differ from chemical-specific or action-specific ARARs in that they are not closely related to the Site's waste characteristics or to the specific remedial alternative under consideration. Location-specific ARARs are concerned with the area in which the Site is located. They might be triggered, for example, if groundwater remediation were selected as the remedy that required the construction of new surface wastewater treatment units. Examples of sensitive locations for such units include wetlands, floodplains, historic areas, and wildlife refuges. To the extent that the remedial action will affect historical resources, streams, flood plains, or wetlands, U.S. EPA requires that the potential remedial alternatives comply with the location-specific requirements.

8.0 DATA QUALITY OBJECTIVES

As described in Section 1, the DQO process is a 7-step systematic planning process recommended by the U.S. EPA when environmental data are used to select between potential alternatives or estimate the extent of contamination. On some complicated sites, the DQO process will be used to both estimate the extent of contamination and as a decision tool for selection of appropriate alternatives.

The seven steps of the DQO process were described in Section 1.4 and will not be reiterated here. The purpose of this section is to develop each of these steps in the appropriate detail for each of the study areas described in Section 4 and 5 as an interim step towards preparing the RI/FS Work Plan for the Site.

8.1 STUDY AREA 1 – ASPEN CREEK STUDY AREA (ACSA)

8.1.1 Step 1 – State the Problem

The primary objective of Step 1 of the DQO process is to define the problem that needs to be resolved. The following problem statement was developed for the ACSA.

Conceptual Model Statement: There are two known discharges that occur in the ACSA; the Upper Overburden Seep and the Overburden Seep (also know as the Aspen Seep). The upper discharge has the same flow rate, pH and temperature as the lower seep and it is likely that the source water for the seeps are the same or related. Up hill from the upper seep there is a flat geographic area with higher sides that acts as a collection basin and may be the source of the water to both seeps. It is unknown where the water becomes acidic or where the migration pathway is for the water through the overburden piles though it is likely that the migration pathway is along the contact between the piles and the original ground surface.

The overburden piles are known to contain some areas with an increased percentage of pyrite where if water comes in contact with these areas it would likely become impacted. Where these areas exist at the ground surface they will need to be assessed from a human and ecological health exposure standpoint. Otherwise data collected from the overburden piles and Aspen Creek sampling suggest that the piles as a whole do not represent a current or future exposure concern.

Since the ASB has been operating the quality of surface water in the creek has improved greatly. The current CSM identifies the on-site trespasser as the primary human receptor and potentially aquatic organisms as ecological receptors if the treatment system fails.

Problem Statement: In the past, ARD from the ACSA discharged to Aspen Creek. The discharge is currently captured by the ASB. Since capture began, water quality in the creek has improved. However, to more completely evaluate the extent of impact the overburden has had on the surrounding environmental media (air, soil, sediment, surface water, and groundwater) and human/ecological populations to the point of requiring some form of remedial action, data regarding contaminant distributions, contaminant concentration ranges, aquifer characteristics, receptor uptake, and/or various modeling parameters are needed to support the preparation of a RI report, baseline risk assessment, screening of remedial alternatives, and remedial designs. In addition, data necessary to evaluate the long-term effectiveness of the ASB compared to other remedial and mitigation alternatives should be collected.

Planning Team and Available Resources:

U.S. EPA
RWQCB
Atlantic Richfield

The necessary resources are available to collect the data needed. Access to the Site is limited due to weather conditions and the majority of the data collection generally needs to occur between June 1 and September 30 of each year. Source and contaminant pathway characterization data are planned to be collected in the ACSA during the first two years of the RI/FS.

8.1.2 Step 2 – Identify the Goal(s) of the Study

The purpose of DQO Step 2 is to define the principal study questions (PSQs) that need to be answered to address the problem statement and the alternative actions (AAs) that would result from the resolution of these questions. Each PSQ and the associated AAs are then combined into decision statements (DSs) that express a choice among AAs. Table 8-1 presents the task-specific PSQs, AAs, and resulting DSs that apply to the ACSA. This table also provides a qualitative assessment of the consequences of taking an AA if it is incorrect.

Table 8-1
Summary of Data Quality Objective Step 2 Information for the ACSA

PSQ-AA#	Alternative Action	Description of Consequences of Implementing the Wrong Alternative Action
PSQ #1 – Are sufficient data available to construct a water balance for the study area and estimate the primary migration/transport pathways for precipitation falling on the overburden and discharging at Aspen Seep?		
AA 1-1	No; obtain additional data.	Unnecessary cost in obtaining redundant data.

Table 8-1 (Continued)

PSQ-AA#	Alternative Action	Description of Consequences of Implementing the Wrong Alternative Action
AA 1-2	Yes; no additional data needed.	If the water balance is not adequately defined there is a potential to underestimate/over estimate balance components.
DS #1 – Evaluate whether sufficient data are available to construct a water balance, or if additional data are needed.		
PSQ #2 – Does impacted soil, sediment, surface water, or groundwater in the ACSA represent an unacceptable current or future risk to human health or biota and need to be evaluated through further study?		
AA 2-1	Compare current data set to applicable benchmarks to qualitatively evaluate potential risk to humans and biota in study area.	Potential current and future risks to humans and biota could be under/over estimated due to a limited data set.
AA 2-2	Collect additional data and conduct baseline risk assessment to quantitatively evaluate potential risk to humans and biota in study area.	Quantitative baseline risk assessments may underestimate or overestimate potential risk to humans and biota because of uncertainty inherent in risk assessment methods.
DS #2 – Evaluate appropriate human health and ecological benchmarks and use both qualitative and quantitative risk assessment methods.		
PSQ #3 – Are sufficient data available to estimate COPC distribution in the shallow groundwater and estimate COPC fate and transport (e.g., groundwater elevations, gradients, hydraulic properties)?		
AA 3-1	No; obtain additional data.	Unnecessary cost in obtaining redundant data.
AA 3-2	Yes; no additional data needed.	If inadequate data are used to estimate the fate and transport of COPCs in the shallow unconfined aquifer, then monitoring or remediation of COPCs may either waste money or fail to provide protection to human and biological receptors.
DS #3 – Evaluate whether current data set is sufficient to allow estimation of the COPC plume in shallow groundwater and predict future fate and transport of COPCs in the unconfined aquifer, or if additional data are needed.		

Table 8-1 (Continued)

PSQ-AA#	Alternative Action	Description of Consequences of Implementing the Wrong Alternative Action
PSQ #4 – Are sufficient data available to evaluate if remedial actions are necessary and support a feasibility study of relevant remedial action alternatives (e.g., range of COPC concentrations, depth and distribution of contaminants, chemical form, aquifer properties)?		
AA 4-1	No; obtain additional data to support FS.	Unnecessary cost in obtaining redundant data.
AA 4-2	Yes; no additional data needed.	If inadequate data are used, unnecessary and/or ineffective remedial actions may be implemented.
DS #4 – Evaluate if current data set is adequate to evaluate remedial action need and assess the feasibility of implementation at the ACSA.		
PSQ #5 – If a long-term remedy is necessary is the facility area stable and has the facility been constructed to address seismic concerns?		
AA 5-1	No; perform measurements to evaluate what steps need to be taken to ensure facility stability.	If unnecessary measurements are performed, money and time will be wasted.
AA 5-2	Yes; no additional action required.	If necessary measurements are not performed, and the stability is overestimated, remediation in the ACSA could be disrupted and ARD released to the creek.
DS #5 – Review current data and As-Built diagrams for the ASB and available geotechnical data to evaluate if this information is sufficient to evaluate the stability or if additional measurements and data are needed.		

AA = alternative action
COPC = chemical of potential concern
DS = decision statement
PSQ = principal study question

8.1.3 Step 3 – Identify Information Inputs (Data Needs)

The objective of Step 3 of the DQO process is to identify the types of data required to resolve each of the decision statements identified in DQO Step 2 and to evaluate if existing data are of adequate quality and quantity for use in resolving these decisions.

Table 8-2 provides a summary of the types of data that will be required to resolve the decision statements from Step 2 and an evaluation as to the sufficiency of the existing data set.

8.1.3.1 Action Levels

Appropriate site-specific action levels will be evaluated during completion of the RI/FS.

8.1.3.2 Analytical Performance Requirements

Analytical performance requirements will be established as appropriate to support decisions regarding site-specific action levels.

8.1.3.3 Sampling and Analysis Methods

All analytical procedures will adhere to current U.S. EPA and/or American Society for Testing Materials (ASTM) published analytical protocols and all analyses will be conducted by certified personnel at accredited laboratories. Sampling will be conducted in accordance with the *"Leviathan Mine Site: Site-Wide Sampling and Analysis Plan"* (MWH, 2002) as updated as necessary for the RI/FS Work Plan.

Table 8-2
Required Information and Reference Sources

Variable	Required Data	Do Data Exist? (Y/N)	Sufficient Quality? (Y/N)	Additional Information Required? (Y/N)
DS #1 – Evaluate whether sufficient data are available to construct a water balance, or if additional data are needed.				
Inflow/Outflow data	Precipitation, evaporation, stream flow, groundwater, temperature, wind speed, evapotranspiration.	Y	N	Y
DS #2 – Evaluate appropriate human health and ecological benchmarks and use both qualitative and quantitative risk assessment methods.				
Risk levels for COPCs at appropriate times and spatial boundaries under agreed upon end-use scenarios	Concentrations and distribution of COPCs in surface soils and sediments. Spatial extent for any COPCs that reach the groundwater. End-use scenarios.	Y	N	Y
DS #3 – Evaluate whether current data set is sufficient to allow estimation of the COPC plume in shallow groundwater and predict future fate and transport of COPCs in the shallow aquifer, or if additional data are needed.				
Data required to evaluate COPC groundwater distribution and predict fate and transport	COPC concentrations in shallow groundwater. Properties of unconfined aquifer (e.g., hydraulic conductivity, porosity, and transmissivity), and groundwater gradient.	Y	N	Y

Table 8-2 (Continued)

DS #4 – Evaluate if current data set is adequate to evaluate remedial action need and assess the feasibility of implementation at the ACSA.				
Data needed to evaluate potential remedial alternatives	Levels of current groundwater contamination. Surface water quality data. Concentrations of COPCs in soils and sediments. Spatial extent of any COPCs that reach or may reach the groundwater.	Y	N	Y
DS #5 – Review current data and As-Built diagrams for the ASB to evaluate if this information is sufficient to evaluate stability or if additional measurements and data are needed.				
Geotechnical stability of facility area.	Engineering specifications of facilities. Soil properties.	N	N	Y

[1]COPCs include pH, aluminum, arsenic, cadmium, chromium, copper, iron, lead, nickel, selenium, and zinc. (AHV – beryllium, cobalt, manganese, mercury, thallium; TSS, TDS, sulfate)

8.1.4 Step 4 – Define the Boundaries of the Study Area

The primary objective of DQO Step 4 is to identify the population of interest, define the spatial and temporal boundaries that apply to each DS, define the scale of decision making, and identify any practical constraints (e.g., hindrances or obstacles) that must be taken into consideration.

8.1.4.1 Target Populations of Interest

Prior to defining the spatial and temporal boundaries of the Site under investigation, it is first necessary to clearly define the populations of interest that apply for each DS (Table 8-3). The intent of Table 8-3 is to clearly define the attributes that make up each population of interest by stating them in a way that makes the focus of the study unambiguous.

Table 8-3
Characteristics that Define the Population of Interest for the ACSA

DS#	Population(s) of Interest
1	Data to construct water balance (precipitation, evaporation, stream flow, temperature, wind speed, evaporation, evapotranspiration).
2	Concentrations of COPCs in vadose zone soils, surface waters and sediments of Aspen Creek, and shallow groundwater. Habitats of plants and wildlife species that occur in the study area.
3	Data required to evaluate the distribution of COPCs in the shallow alluvial aquifer. Hydrological properties of the aquifer required to support plume delineation and fate & transport evaluation.
4	Data required to evaluate potential remedial action alternatives.
5	Geotechnical parameters sufficient to support assessment of facility stability. Engineering specifications of treatment facilities.

COPC = chemical of potential concern

8.1.4.2 Geographic Boundaries

The spatial boundaries for the ACSA over which these populations will be evaluated is a three dimensional area that is defined in the X – Y plane as a wedge shaped study area, bounded on the northeast and east by Aspen Creek, on the south by the pit wall and the west and northwest along the landslide scarp (Figure 29). The Z direction is defined by the depth of the population being studied (e.g., for soils – the depth of the overburden, for surface water the depth of the Creek/seep).

8.1.4.3 Temporal Boundaries

Source and contaminant pathway characterization data are planned to be collected in the ACSA during the first two years of the RI/FS. Where possible data collected will provide information on seasonal variability. However, access to the Site is limited due to weather conditions and the majority of the data collection needs to occur between June 1 and September 30 of the year.

8.1.4.4 Practical Constraints on Data Collection

Weather conditions may impose limitations on the ability to collect data at the Site especially in the winter and spring when access to the Site and specific media (populations) is restricted.

8.1.4.5 Scale of Decision Making

In Table 8-4, the scale of decision making has been defined for each DS. The scale of decision making is defined by merging the population of interest and the geographic and temporal boundaries of the area under investigation (Byrnes, 2008). The "*scale of decision making*" refers to the smallest unit of area or volume over which data will be collected, analyzed, and interpreted to make a decision (Byrnes, 2008). For this DQO Report, the scale of decision making has been maintained in general terms. As discussed in recent U.S. EPA's DQO guidance (U.S. EPA, 2000), the scale of decision making may be based on widely different project needs. It is expected that as the cleanup of the Site progresses, more specific and different decision-making scales will be developed.

Table 8-4
Scale of Decision Making for the ACSA

DS#	Population of Interest	Scale of Decision
1	Data to construct water balance (precipitation, evaporation, stream flow, groundwater, temperature, wind speed, evaporation, and evapotranspiration).	Regional and site-specific data collected over a period of time to allow for water balance estimation.
2	Concentrations of COPCs in vadose zone soils, sediments of Aspen Creek, and shallow groundwater. Habitats of plants and wildlife species that occur in the study area.	Vadose zone soils, sediments, and shallow groundwater samples collected within the geographical boundaries (see Figure 29) over two years (samples to be collected between June 1 and September 30). Plant and wildlife habitats identified over the next two years.

Table 8-4 (Continued)

DS#	Population of Interest	Scale of Decision
3	Data required to evaluate the distribution of COPCs in the shallow alluvial aquifer. Hydrological properties of aquifer required to support plume delineation and fate & transport evaluation.	Upper confined aquifer within the geographic boundaries over the next two years.
4	Data required to evaluate potential remedial action alternatives.	Groundwater, vadose zone, sediments, and surface water within the geographic boundaries over the next two years.
5	Geotechnical parameters sufficient to support assessment of facility stability. Engineering specifications of treatment facilities.	Soils and facility construction materials within the geographic boundaries over the next 3 years.

8.1.5 Step 5 – Develop the Analytical Approach

The objective of DQO Step 5 is to define the statistical parameter of interest (e.g., mean, median, percentile, maximum) to be used to resolve the decision statements identified in DQO Step 2. The statistical parameter of interest is then combined with outputs from the previous DQO steps to produce decision rules that provide a basis for choosing between alternative actions (Byrnes, 2008).

The statistical parameter often selected to characterize a site is the “mean” because it is frequently used to model random exposure to environmental contamination (Byrnes, 2008). However, the maximum concentration can be the appropriate statistical parameter if the intent is to estimate the worst-case situation at the Site, such as to evaluate potential risk to human and/or potential ecological receptors (Byrnes, 2008).

For the ACSA, historical data and any new data collected will primarily support the evaluation of the potential risks to human and ecological receptors (see Sections 3.0), evaluate long-term treatment options for surface water discharges, and evaluate potential geotechnical stability issues that could affect implementation of long-term remedies. In the evaluation of these parameters, maximum concentrations and upper confidence intervals will provide the greatest degree of conservatism and are expected to be used for analysis of ACSA data.

8.1.5.1 Decision Rules

The final output of DQO Step 5 is a set of decision rules that are the result of combining the parameter of interest with the scale of decision making, the action level, and the alternative actions. Decision rules (DRs) for each of the DSs from Step 2 are shown in Table 8-5.

Table 8-5
Decision Rules for Each Decision Statement for the ACSA

DS# / DR#	Decision Statement or Decision Rule
DS #1	Evaluate whether sufficient data are available to construct a water balance, or if additional data are needed.
DR #1	IF sufficient data are available as estimated by representative values of data reported in appropriate units and adjusted to the local topography as defined by the geological boundaries are sufficient based on professional judgment of Atlantic Richfield, regulatory and contractor staff to evaluate a water balance for the ACSA THEN collect no more data and proceed with construction of the water balance; OTHERWISE collect additional data to support water balance construction.
DS #2	Evaluate appropriate human health and ecological benchmarks and use both qualitative and quantitative risk assessment methods.
DR #2	IF screening level human health and ecological risk as estimated by measurement or modeling and approved risk assessment procedure of the COPC within the geographic boundaries is appropriately protective, THEN complete screening level assessment; OTHERWISE conduct more quantitative risk assessments.
DS #3	Evaluate whether current data set is sufficient to allow estimation of the COPC plume in shallow groundwater and predict future fate and transport of COPCs in the shallow aquifer, or if additional data are needed.
DR #3	IF the concentration of COPCs and hydrological characteristics of the shallow aquifer as defined by representative analytical or test data measured in appropriate units over the next two years within the geographic boundary are adequately known based on professional judgment of Atlantic Richfield, regulatory, and contractor staff THEN gather no more data; OTHERWISE gather additional data.
DS #4	Evaluate if current data set is adequate to evaluate remedial action need and assess the feasibility of implementation at the ACSA.
DR # 4	IF the data required to evaluate potential remedial action alternatives as defined by representative values of the COPC concentrations in the appropriate units for a specific medium under consideration and within the geographic boundaries over the next two years are available for comparison to the operational requirements of potential remedial actions THEN evaluate potential remedial action alternatives; OTHERWISE obtain data necessary to allow evaluation of remediation alternatives.

Table 8-5 (Continued)

DS# / DR#	Decision Statement or Decision Rule
DS #5	Review current data and As-Built diagrams for the ASB and available geotechnical data for this and other alternatives to evaluate if this information is sufficient to evaluate stability or if additional measurements and data are needed.
DR # 5	IF the data required to evaluate the potential long-term stability of the ASB and other alternatives in the ACSA are available based on professional judgment of Atlantic Richfield, regulatory, and contractor staff THEN gather no more data; OTHERWISE gather additional data.

8.1.6 Step 6 – Specify Performance or Acceptance Criteria

Analytical data can only estimate the true condition of the Site under investigation, and therefore decisions that are made based on measurement data could potentially be in error (e.g., decision error). The objective of Step 6 in the DQO process is to differentiate between those decision rules that require a statistical sampling design versus those that can be addressed using a nonstatistical (e.g., judgmental) design that utilizes field screening and/or surveying (U.S. EPA, 2006; Byrnes, 2008). The DRs identified in Step 5 require professional judgment (nonstatistical approach) to assess the available data for adequacy and to evaluate what data are missing or whether available data should be augmented.

For those decision rules that will be addressed using a judgmental design, it is appropriate to omit DQO Step 6 and proceed to DQO Step 7.

8.1.7 Step 7 – Develop the Detailed Plan for Obtaining Data

The objective of DQO Step 7 is to define the sampling and analysis design to obtain the data needs identified in the previous steps.

As discussed in Section 8.2.6 it is expected that the DRs for the ACSA require a judgmental sampling design, which is appropriate to provide data that represents the worst-case scenario, used to support Site characterization where the objective is to define the nature and extent of chemical contamination, and to support risk assessments (Byrnes, 2008).

DQO Step 7 may contain as a final output from the process an analysis of all potential surveying technologies or judgmental samplings methods that could potentially be employed to provide the required data for each type of media, and a selection of the optimal implementation design. As discussed in Section 4.5 we anticipate using a DFA approach and/or other streamlining techniques during the RI/FS investigation. The implementation of the various streamlining techniques requires flexibility in sampling design and methodology. Hence, a more comprehensive description of the data collection program will be provided in

the RI/FS Work Plan. Dependant on further review of existing data the scope of sampling at the ACSA may include:

- better characterization of mine features;
- topographical mapping of the area;
- site-specific meteorological and other inflow/outflow data to support the water balance;
- sampling and measurement of COPC concentrations to support risk assessment/remedial evaluation;
  - soil to assess distribution, source and potential ingestion and dermal contact exposures;
  - groundwater to assess source, contaminant migration and potential use;
  - sediments to assess potential ingestion and dermal contact exposures; and
  - surface water to assess potential dermal contact exposures.
- if necessary to support uptake models plants to assess potential ingestion exposure;
- if necessary to support uptake models fish to assess potential ingestion exposure;
- stability; and
  - soil physical properties to assess stability.
- hydrologic
  - grain size and soil properties;
  - water levels;
  - surface water flows;
  - aquifer hydraulic conductivity (pump tests/slug testing);
  - aquifer porosity/effective porosity;
  - assessment of surface water groundwater interactions; and
  - identifications of ponds and springs.

8.2 STUDY AREA 2 – THE PIT STUDY AREA (PSA)

8.2.1 Step 1 – State the Problem

Conceptual Model Statement: The pit is a groundwater sink with inflow from storm water surface water and groundwater. Water entering the pit comes in contact with mineralized geologic materials in and adjacent to the open pit and the imported waste rock material used to recontour the pit and create ARD at the PSA. Historical discharge of ARD from the PSA impacted Leviathan Creek. Currently, at least a portion of the ARD discharging from the pit and PUD is collected and treated prior to discharge to the creek. The key potential receptors in this study area are the on-site trespasser and terrestrial organisms coming in contact with the Site waste or ARD.

Problem Statement: To evaluate the extent to which the pit, PUD, adit, and Site waste materials contained therein have impacted the surrounding environmental media (air, soil, sediment, surface water, and groundwater) and potential human and ecological receptors to the point of requiring some form of remedial action, data regarding contaminant distributions, contaminant concentration ranges, aquifer characteristics, receptor uptake, and/or various modeling parameters are needed to support the preparation of a remedial investigation report, baseline risk assessment, screening of remedial alternatives, and remedial designs.

Planning Team and Available Resources:

U.S. EPA
RWQCB
Atlantic Richfield

The necessary resources are available to collect the data needed. Access to the Site is limited due to weather conditions and the majority of the data collection generally needs to occur between June 1 and September 30 of each year. Source and contaminant pathway characterization data are planned to be collected in the PSA during the first two years of the RI/FS.

8.2.2 Step 2 – Identify the Goal(s) of the PSA

Table 8.6 presents the task-specific PSQs, AAs, and resulting DSs that apply to the PSA. This table also provides a qualitative assessment of the consequences of taking an AA if it is incorrect.

Table 8-6

Summary of Data Quality Objective Step 2 Information for the PSA

PSQ-AA-DS#	Alternative Action	Description of Consequences of Implementing the Wrong Alternative Action
PSQ #1 - Is sufficient data available to construct a water balance for the study area and estimate the primary migration/transport pathways for precipitation falling on the PSA?		
AA 1-1	No; obtain additional data.	Unnecessary cost in obtaining redundant data.
AA 1-2	Yes; no additional data needed.	If the water balance is not adequately defined there is a potential to underestimate/overestimate balance components.
DS #1 – Evaluate whether sufficient data are available to construct a water balance, or if additional data are needed.		
PSQ #2 – Does exposure to COPC impacted soil, surface water (e.g.,* clarifier pond) *or groundwater in the PSA pose an unacceptable current or future risk to human health or ecological receptors and need to be evaluated through further study?		
AA 2-1	Compare current data set to applicable benchmarks to qualitatively evaluate potential risk to humans and biota in study area.	Potential current and future risks to humans and biota could be improperly estimated due to a limited data set.
AA 2-2	Collect additional data and conduct baseline risk assessment to quantitatively evaluate potential risk to humans and biota in study area.	Quantitative baseline risk assessments may underestimate or overestimate potential risk to humans and biota because of uncertainty inherent in risk assessment methods.
DS #2 – Evaluate appropriate human health and ecological benchmarks and use both qualitative and quantitative risk assessment methods.		
PSQ #3 – Are sufficient data available to estimate COPC distribution in the shallow alluvial groundwater and estimate COPC fate and transport (e.g., groundwater elevations, gradients, hydraulic properties)?		
AA 3-1	No; obtain additional data.	Unnecessary cost in obtaining redundant data.
AA 3-2	Yes; no additional data needed.	If inadequate data are used to model future movement of COPCs in the shallow unconfined aquifer, then monitoring or remediation of COPCs may either waste money or fail to provide protection to human and biota.

Table 8-6 (Continued)

PSQ-AA-DS#	Alternative Action	Description of Consequences of Implementing the Wrong Alternative Action
DS #3 – Evaluate whether current data set is sufficient to allow estimation of the COPC plume in shallow groundwater and predict future fate and transport of COPCs in the unconfined aquifer, or if additional data are needed.		
PSQ #4 – Are sufficient data available to evaluate the location of all relevant Site features (e.g., adits, lifts, raises) and manmade structures (e.g., PUD) and evaluate the inter-connectedness of pit features and pit features with external features (e.g., CUD and DS)?		
AA 4-1	No; Obtain data to locate features and evaluate potential connectedness.	Unnecessary cost in obtaining redundant data.
AA 4-2	Yes; no additional data needed.	If inadequate data are used, the potential current and/or future impacts of groundwater migrating from the PSA could be over or under estimated.
DS #4 – Evaluate whether sufficient data are available to evaluate the location of subsurface structural features in the PSA and potential contribution to contaminant transport, or if additional data are needed.		
PSQ #5 – Are sufficient geotechnical data available to evaluate the stability of pit features (e.g., clarifier berms and pit high walls) and assess potential long-term safety concerns?		
AA 5-1	No; perform measurements to evaluate what steps need to be taken to ensure facility stability.	If unnecessary measurements are performed, money and time will be wasted.
AA 5-2	Yes; no additional action required.	If necessary measurements are not performed, and the stability is assumed, contaminant releases could occur and risks to human safety could be under estimated.
DS #5 – Review current geotechnical data and as-built diagrams for the clarifier to evaluate if this information is sufficient to evaluate stability or if additional measurements and data are needed.		
PSQ #6 – Are sufficient data available to evaluate if remedial actions are necessary and support a feasibility study of possible remedial action alternatives (e.g., range of COPC concentrations, depth and distribution of contaminants, chemical form, aquifer properties)?		
AA 6-1	No; obtain additional data to support FS.	Unnecessary cost in obtaining redundant data.
AA 6-2	Yes; no additional data needed.	If inadequate data are used, unnecessary and/or ineffective remedial actions may be implemented.

Table 8-6 (Continued)

PSQ-AA-DS#	Alternative Action	Description of Consequences of Implementing the Wrong Alternative Action
DS #6 – Evaluate if current data set is adequate to evaluate remedial action need and assess the feasibility of implementation at the PSA.		
PSQ #7 – Are sufficient data available to assess the geotechnical stability and liner integrity of clarifier?		
AA 7-1	No; perform measurements to evaluate pond stability, liner integrity.	If unnecessary measurements are performed, money and time will be wasted.
AA 7-2	Yes; no additional action required.	If necessary measurements are not performed, and the stability is assumed or the liner integrity is misjudged, unexpected releases of ARD and unaccounted contaminant contribution to groundwater could occur.
DS #7 – Review current data to evaluate if this information is sufficient to evaluate the integrity of the clarifier liner or if additional data are needed.		

AA = alternative action
COPC = chemical of potential concern
DS = decision statement
PSQ = principal study question

8.2.3 Step 3 – Identify Information Inputs

Table 8-7 provides a summary of the types of data that will be required to resolve the decision statements from Step 2 and an evaluation as to the sufficiency of the existing data set.

8.2.3.1 Action Levels

Appropriate Site-specific action levels will be evaluated during completion of the RI/FS.

8.2.3.2 Analytical Performance Requirements

Analytical performance requirements will be established as appropriate to support decisions regarding Site-specific action levels.

8.2.3.3 Sampling and Analysis Methods

All analytical procedures will adhere to current U.S. EPA and/or ASTM published analytical protocols and all analyses will be conducted by certified personnel at accredited laboratories. Sampling will be conducted in accordance with the *"Leviathan Mine Site: Site-Wide Sampling and Analysis Plan"* (MWH, 2002) updated as necessary for the RI/FS.

Table 8-7

Required Information and Reference Sources for the PSA

Variable	Required Data	Do Data Exist? (Y/N)	Sufficient Quality? (Y/N)	Additional Information Required? (Y/N)
DS #1 – Evaluate whether sufficient data are available to construct a water balance, or if additional data are needed.				
Meteorological data	Precipitation, evaporation, stream flow, temperature, wind speed, evapotranspiration.	Y	N	Y
DS #2 – Evaluate appropriate human health and ecological benchmarks and use both qualitative and quantitative risk assessment methods.				
Risk levels for COPCs at appropriate times and spatial boundaries under agreed upon end-use scenarios	Concentrations and distribution of COPCs in surface soils. Spatial extent for any COPCs that reach the groundwater. End-use scenarios.	Y	N	Y
DS #3 – Evaluate whether current data set is sufficient to allow estimation of the COPC plume in shallow groundwater and predict future fate and transport of COPCs in the shallow aquifer, or if additional data are needed.				
Data required to evaluate COPC groundwater distribution and predict fate and transport	COPC concentrations in shallow groundwater. Geotechnical properties of unconfined aquifer (e.g., hydraulic conductivity, porosity, and transmissivity), and groundwater gradient.	Y	N	Y

Table 8-7 (Continued)

Variable	Required Data	Do Data Exist? (Y/N)	Sufficient Quality? (Y/N)	Additional Information Required? (Y/N)
DS #4 – Evaluate whether sufficient data are available to evaluate the location of subsurface structural features in the PSA and potential contribution to contaminant transport, or if additional data are needed.				
Location and interconnectedness of sub-pit features	Geophysical data COPC and major ion concentrations in shallow groundwater	N	N	Y
DS #5 – Review current geotechnical data and as-built diagrams for the clarifier to evaluate if this information is sufficient to evaluate stability or if additional measurements and data are needed.				
Geotechnical stability of pit high walls and clarifier berms.	Engineering specifications of facilities. Soil properties	Y	N	Y
DS #6 – Evaluate if current data set is adequate to evaluate remedial action need and assess the feasibility of implementation at the PSA.				
Data needed to evaluate potential remedial alternatives	Levels of current groundwater contamination and Spatial extent of any COPCs that reach or may reach the groundwater Concentrations of COPCs in soils and surface water	N	N	Y
DS #7 – Review current data to evaluate if this information is sufficient to evaluate the integrity of the clarifier liner or if additional data are needed.				
Data to assess liner integrity	As-built drawings/specifications Soil moisture measurements beneath/adjacent to clarifier.	N	N	Y

[1]COPCs include pH, aluminum, arsenic, cadmium, chromium, copper, iron, lead, nickel, selenium, and zinc. (AHV – beryllium, cobalt, manganese, mercury, thallium; TSS, TDS, sulfate).

8.2.4 Step 4 – Define the Boundaries of the PSA

The primary objective of DQO Step 4 is to identify the population of interest, define the spatial and temporal boundaries that apply to each DS, define the scale of decision making, and identify any practical constraints (e.g., hindrances or obstacles) that must be taken into consideration.

8.2.4.1 Target Populations of Interest

Prior to defining the spatial and temporal boundaries of the Site under investigation, it is first necessary to clearly define the populations of interest that apply for each DS (Table 8-8). The intent of Table 8-8 is to clearly define the attributes that make up each population of interest by stating them in a way that makes the focus of the study unambiguous.

Table 8-8
Characteristics that Define the Population of Interest for the PSA

DS#	Population(s) of Interest
1	Data to construct water balance (precipitation, evaporation, temperature, wind speed, evaporation, evapotranspiration).
2	Concentrations of COPCs in vadose zone soils and shallow groundwater below the PSA. Habitats of plants and wildlife species that occur in the study area.
3	Data required to evaluate the distribution of COPCs in the shallow alluvial aquifer. Hydrological properties of the aquifer required to support plume delineation and fate & transport evaluation.
4	Data required to locate subsurface structures within the PSA and evaluate the extent of groundwater communication between each.
5	Geotechnical parameters sufficient to support assessment of the clarifier stability.
6	Data required to evaluate potential remedial action alternatives.
7	Data required to assess the integrity of the clarifier liner.

COPC = chemical of potential concern

8.2.4.2 Geographic Boundaries

This study area is located in the southern and southeastern portions of the Site as shown on Figure 30. The geographic boundaries for the PSA over which these populations will be evaluated is a three dimensional area that is defined as a plane in the X and Y dimension by the area shown on Figure 30 and in the Z direction is defined by the depth of the population being studied (e.g., depth of shallow groundwater, waste rock, and surface water).

8.2.4.3 Temporal Boundaries

Source and contaminant pathway characterization data are planned to be collected in the PSA during the first two years of the RI/FS. Where possible data collected will provide information on seasonal variability. However, access to the Site is limited due to weather conditions and the majority of the data collection needs to occur between June 1 and September 30 of each year.

8.2.4.4 Practical Constraints on Data Collections

Weather conditions may impose limitations on the ability to collect data at the Site especially in the winter and spring when access to the Site and specific media (populations) is restricted.

8.2.4.5 Scale of Decision Making

In Table 8-9 the scale of decision making has been defined for each DS identified for the PSA in Step 2. See Section 8.1.4.5 for a description of the development of this variable.

Table 8-9
Scale of Decision Making for the PSA

DS#	Population of Interest	Scale of Decision
1	Data to construct water balance (precipitation, groundwater, evaporation, temperature, wind speed, evaporation, and evapotranspiration).	Regional and site-specific meteorological data collected over a period of time to allow for water balance estimation.
2	Concentrations of COPCs in vadose zone soils, and shallow groundwater. Habitats of plants and wildlife species that occur in the study area.	Vadose zone soils, sediments, and shallow groundwater samples collected within the geographical boundaries (see Figure 30) over two years (samples to be collected between June 1 and September 30). Plant and wildlife habitats identified over the next two years.
3	Data required to evaluate the distribution of COPCs in the shallow alluvial aquifer. Hydrological properties of aquifer required to support plume delineation and fate & transport evaluation.	Samples collected from the shallow upper aquifer within the geographic boundaries over the next two years.

Table 8-9 (Continued)

DS#	Population of Interest	Scale of Decision
4	Data required to locate subsurface structures within the PSA and evaluate the extent of groundwater communication between each.	Geophysical data and groundwater samples collected from within geographic boundary over the next two years.
5	Geotechnical parameters sufficient to support assessment of the clarifier stability.	Soils and facility construction materials within the geographic boundaries over the next year.
6	Data required to evaluate potential remedial action alternatives.	Groundwater, vadose zone, sediments, and surface water within the geographic boundaries over the next two years.
7	Data required to assess the integrity of the clarifier liner.	Soil moisture and groundwater samples collected from area beneath or adjacent to clarifier pond over the next two years.

8.2.5 Step 5 – Develop Analytical Approach

The objective of DQO Step 5 is to define the statistical parameter of interest (e.g., mean, median, percentile, maximum) to be used to resolve the decision statements identified in DQO Step 2. The discussion of the analytical approach developed for the ACSA as provided in Section 8.2.5 is applicable to the PSA and will not be repeated here.

8.2.5.1 Decision Rules

The final output of DQO Step 5 is a set of decision rules that are the result of combining the parameter of interest with the scale of decision making, the action level, and the alternative actions. DRs for each of the DSs from Step 2 are shown in Table 8-10.

Table 8-10

Decision Rules for Each Decision Statement for the PSA

DS# / DR#	Decision Statement or Decision Rule
DS #1	Evaluate whether sufficient data are available to construct a water balance, or if additional data are needed.
DR #1	IF sufficient data are available as estimated by representative values of data reported in appropriate units and adjusted to the local topography as defined by the geological boundaries are sufficient based on professional judgment of Atlantic Richfield, regulatory and contractor staff to evaluate a water balance for the PSA. THEN collect no more data and proceed with construction of the water balance; OTHERWISE collect additional data to support water balance construction.
DS #2	Evaluate appropriate human health and ecological benchmarks and use both qualitative and quantitative risk assessment methods.
DR #2	IF screening level human health and ecological risk as estimated by measurement or modeling and approved risk assessment procedure of the COPC within the geographic boundaries is appropriately protective, THEN complete screening level assessment; OTHERWISE conduct baseline risk assessments.
DS #3	Evaluate whether current data set is sufficient to allow estimation of the COPC plume in shallow groundwater and predict future fate and transport of COPCs in the shallow aquifer, or if additional data are needed.
DR #3	IF the concentration of COPCs in the shallow aquifer and hydrological characteristics of the shallow aquifer as defined by representative analytical or test data measured in appropriate units over the next two years within the geographic boundary are adequately known based on professional judgment of Atlantic Richfield, regulatory, and contractor staff THEN gather no more data; OTHERWISE gather additional data.
DS #4	Evaluate whether sufficient data are available to evaluate the location of subsurface structural features in the PSA and potential contribution to contaminant transport, or if additional data are needed.
DR # 4	IF sufficient historical data are available to located subsurface structures in the PSA and assess the interconnectedness of these structures as related to groundwater flow, THEN collect no more data; OTHERWISE gather additional data.
DS #5	Review current geotechnical data and as-built diagrams for the clarifier to evaluate if this information is sufficient to evaluate stability or if additional measurements and data are needed.
DR # 5	IF the data required to evaluate the potential long-term stability of the clarifier are available based on professional judgment of Atlantic Richfield, regulatory, and contractor staff THEN gather no more data; OTHERWISE gather additional data.

Table 8-10 (Continued)

DS# / DR#	Decision Statement or Decision Rule
DS #6	Evaluate if current data set is adequate to evaluate remedial action need and assess the feasibility of implementation at the PSA.
DR #6	IF the data required to evaluate potential remedial action alternatives as defined by representative values of the COPC concentrations in the appropriate units for a specific medium under consideration and within the geographic boundaries over the next two years are available for comparison to the operational requirements of potential remedial actions THEN evaluate potential remedial action alternatives; OTHERWISE obtain data necessary to allow evaluation of remediation alternatives.
DS #7	Review current data to evaluate if this information is sufficient to evaluate the integrity of the clarifier liner or if additional data are needed.
DR #7	IF the currently available data are sufficient to assess the integrity of the clarifier THEN collect no additional data; OTHERWISE collect additional data.

8.2.6 Step 6 – Specify Performance and Acceptance Criteria

The discussion of performance and acceptance criteria for the ACSA and presented in Section 8.2.6 is also applicable to the PSA.

8.2.7 Step 7 – Develop a Detailed Plan for Obtaining Data

The discussion on the development of a detailed plan for collection of data that was presented in Section 8.2.6 for the ACSA is also applicable to the PSA. Dependant on further review of existing data, the sampling and analysis program in the PSA is anticipated to include:

- better physical characterization and “as-built” data for mine features;
- topographical mapping of the area;
- collection of site-specific inflow/outflow data to support the water balance;
- sampling and measurement of COPC concentrations to support risk assessment/remedial evaluation;
- soil to assess distribution and potential ingestion and dermal contact exposures;
- groundwater to assess contaminant migration and use;
- hydrologic; and
  - grain size and soil properties;

- water levels;
- surface water flows;
- aquifer hydraulic conductivity (pump tests/slug testing);
- aquifer porosity/effective porosity;
- assessment of surface water/groundwater interaction; and
- identification of springs.

- geophysical surveys to identify subsurface structures that may include Electromagnetic Induction and/or Electrical Resistivity.

8.3 STUDY AREA 3 – THE LEVIATHAN CREEK (LCSA)

8.3.1 Step 1 – State the Problem

Conceptual Model Statement: The LCSA includes four ponds (Ponds 1, 2n, 2s, 3, and 4), two known ARD discharge locations (CUD and Delta Seep) and the "on-site" area of Leviathan Creek. The discharges from the CUD and the Delta Seep represent point discharges of shallow groundwater and not actual sources. Potential sources for the shallow groundwater that forms these discharges are currently unknown but could be recharge from precipitation falling on the LCSA, shallow groundwater originating within the LCSA, leakage of water stored in the ponds, and/or leakage from subsurface distribution piping.

Problem Statement: To evaluate potential source terms for the discharges at the CUD and Delta Seep and to evaluate the extent to which the mine waste materials contained within the LCSA have impacted the surrounding environmental media (air, soil, sediment, surface water, and groundwater) and potential human and ecological receptors to the point of requiring some form of remedial action, data regarding contaminant distributions, contaminant concentration ranges, aquifer characteristics, receptor uptake, and/or various modeling parameters are needed to support the preparation of a RI report, baseline risk assessment, screening of remedial alternatives, and remedial designs.

Planning Team and Available Resources:

U.S. EPA
RWQCB
Atlantic Richfield

The necessary resources are available to collect the data needed. Access to the Site is limited due to weather conditions and the majority of the data collection generally needs to occur between June 1 and September 30 of each year. Source and contaminant pathway

characterization data are planned to be collected in the LCSA during the first two years of the RI/FS.

8.3.2 Step 2 – Identify the Goal(s) of Study

Table 8.11 presents the task-specific PSQs, AAs, and resulting DSs that apply to the LCSA. This table also provides a qualitative assessment of the consequences of taking an AA if it is incorrect.

Table 8-11
Summary of Data Quality Objective Step 2 Information for the LCSA

PSQ-AA-DS#	Alternative Action	Description of Consequences of Implementing the Wrong Alternative Action
PSQ #1 - Are sufficient data available to construct a water balance for the LCSA and estimate the primary migration/transport pathways for precipitation falling on the LCSA?		
AA 1-1	No; obtain additional data.	Unnecessary cost in obtaining redundant data.
AA 1-2	Yes; no additional data needed.	If the water balance is not adequately defined there is a potential to underestimate/overestimate balance components.
DS #1 – Evaluate whether sufficient data are available to construct a water balance, or if additional data are needed.		
PSQ #2 – Does exposure to COPC impacted soil, surface water or groundwater in the LCSA pose an unacceptable current or future risk to human health or ecological receptors and need to be evaluated through further study?		
AA 2-1	Compare current data set to applicable benchmarks to qualitatively evaluate potential risk to humans and biota in study area.	Potential current and future risks to humans and biota could be improperly estimated due to a limited data set.
AA 2-2	Collect additional data and conduct baseline risk assessment to quantitatively evaluate potential risk to humans and biota in study area.	Quantitative baseline risk assessments may underestimate or overestimate potential risk to humans and biota because of uncertainty inherent in risk assessment methods.
DS #2 – Evaluate appropriate human health and ecological benchmarks and use both qualitative and quantitative risk assessment methods.		

Table 8-11 (Continued)

PSQ-AA-DS#	Alternative Action	Description of Consequences of Implementing the Wrong Alternative Action
PSQ #3 – Are sufficient data available to estimate COPC distribution in the shallow alluvial groundwater and estimate COPC fate and transport (e.g., groundwater elevations, gradients, hydraulic properties)?		
AA 3-1	No; obtain additional data.	Unnecessary cost in obtaining redundant data.
AA 3-2	Yes; no additional data needed.	If inadequate data are used to model future movement of COPCs in the shallow unconfined aquifer, then monitoring or remediation of COPCs may either waste money or fail to provide protection to humans and biota.
DS #3 – Evaluate whether current data set is sufficient to allow estimation of the COPC plume in shallow groundwater and predict future fate and transport of COPCs in the unconfined aquifer, or if additional data are needed.		
PSQ #4 – Are sufficient data available evaluate potential shallow groundwater sources that discharge to the CUD and Delta Seep?		
AA 4-1	No; Collect additional data that might delineate shallow groundwater sources.	Unnecessary cost in obtaining redundant data.
AA 4-2	Yes; no additional data needed.	If current data set is inadequate then possible sources may be overlooked alternative remedial options missed.
DS #4 – Evaluate whether sufficient data are available to evaluate potential shallow groundwater sources discharging to the CUD and DS.		
PSQ #5 – Are sufficient geotechnical data available to evaluate the long-term stability of the ponds (Ponds 1, 2 north (2n), 2 south (2s), 3 and 4) and evaluate if the pond capacity could be expanded to accommodate additional water storage?		
AA 5-1	No; collect additional data and measurements to evaluate stability and expandability of impoundments.	If unnecessary measurements are performed, money and time will be wasted.
AA 5-2	Yes; no additional measurement and data collection required proceed with evaluation.	If necessary data collection and measurements are not performed, and the stability is overestimated, contaminant releases could occur and risks to human safety could be under estimated.
DS #5 – Review current geotechnical data and as-built diagrams for Ponds 1, 2n, 2s, 3 and 4 to evaluate if this information is sufficient to evaluate stability or if additional measurements and data are needed.		

Table 8-11 (Continued)

PSQ-AA-DS#	Alternative Action	Description of Consequences of Implementing the Wrong Alternative Action
PSQ #6 – Are sufficient data available to evaluate if remedial actions are necessary and support a feasibility study of possible remedial action alternatives (e.g., range of COPC concentrations, depth and distribution of contaminants, chemical form, aquifer properties)?		
AA 6-1	No; obtain additional data to support FS.	Unnecessary cost in obtaining redundant data.
AA 6-2	Yes; no additional data needed.	If inadequate data are used, unnecessary and/or ineffective remedial actions may be implemented.
DS #6 – Evaluate if current data set is adequate to evaluate remedial action needs and assess the feasibility of implementation for the LCSA.		
PSQ #7 – Are sufficient data available to assess the liner integrity of Ponds 1, 2n, 2s, 3, and 4, and the subsurface water distribution system?		
AA 7-1	No; perform measurements to evaluate pond stability, liner integrity.	If unnecessary measurements are performed, money and time will be wasted.
AA 7-2	Yes; no additional action required.	If necessary measurements are not performed, and the stability is overestimated or the liner integrity is misjudged, unexpected releases of ARD and unaccounted contaminant contribution to groundwater could occur.
DS #7 – Review current data to evaluate if this information is sufficient to evaluate the integrity liners of the five ponds located in the LCSA or if additional data are needed.		

AA = alternative action
COPC = chemical of potential concern
DS = decision statement
PSQ = principal study question

8.3.3 Step 3 – Identify Information Inputs (Data Needs)

Table 8-12 provides a summary of the types of data that will be required to resolve the decision statements from Step 2 and an evaluation as to the sufficiency of the existing data set.

Table 8-12
Required Information and Reference Sources for the LCSA

Variable	Required Data	Do Data Exist? (Y/N)	Sufficient Quality? (Y/N)	Additional Information Required? (Y/N)
DS #1 – Evaluate whether sufficient data are available to construct a water balance, or if additional data are needed.				
Inflow/Outflow data	Precipitation, evaporation, surface water, groundwater, temperature, wind speed, evapotranspiration.	Y	N	Y
DS #2 – Evaluate appropriate human health and ecological benchmarks and use both qualitative and quantitative risk assessment methods.				
Risk levels for COPCs at appropriate times and spatial boundaries under agreed upon end-use scenarios	Concentrations and distribution of COPCs in surface soils and sediments. Spatial extent for any COPCs that reach the groundwater. End-use scenarios.	Y	N	Y
DS #3 – Evaluate whether current data set is sufficient to allow estimation of the COPC plume in shallow groundwater and predict future fate and transport of COPCs in the unconfined aquifer, or if additional data are needed.				
Data required to evaluate COPC groundwater distribution and predict fate and transport	COPC concentrations in shallow groundwater. Geotechnical properties of unconfined aquifer (e.g., hydraulic conductivity, porosity, and transmissivity), and groundwater gradient.	Y	N	Y

Variable	Required Data	Do Data Exist? (Y/N)	Sufficient Quality? (Y/N)	Additional Information Required? (Y/N)
DS #4 – Evaluate whether sufficient data are available to evaluate potential shallow groundwater sources discharging to the CUD and Delta Seep.				
Groundwater data to support identification of source	COPC and major ion chemistry of groundwater. Surface water quality data. Tracer data.	Y	N	Y
DS #5 – Review current geotechnical data and as-built diagrams for Ponds 1, 2n, 2s, 3 and 4 to evaluate if this information is sufficient to evaluate stability or if additional measurements and data are needed.				
Geotechnical stability of facility area.	Engineering specifications of facilities. Soil properties.	Y	N	Y
DS #6 – Evaluate if current data set is adequate to evaluate remedial action needs and assess the feasibility of implementation for the LCSA.				
Data needed to evaluate potential remedial alternatives	Levels of current groundwater contamination. Surface water quality data. Concentrations of COPCs in soils and sediments. Spatial extent of any COPCs that reach or may reach the groundwater.	N	N	Y
DS #7 – Review current data to evaluate if this information is sufficient to evaluate the integrity liners of the 4 ponds located in the LCSA or if additional data are needed.				
Data required to evaluate liner integrity	As-built drawings/specifications Soil moisture measurements beneath/adjacent to the ponds	Y	N	Y

[1]COPCs include pH, aluminum, arsenic, cadmium, chromium, copper, iron, lead, nickel, selenium, and zinc. (AHV – beryllium, cobalt, manganese, mercury, thallium; TSS, TDS, sulfate.

8.3.3.1 Action Levels

Appropriate Site-specific action levels will be evaluated during completion of the RI/FS.

8.3.3.2 Analytical Performance Requirements

Analytical performance requirements will be established as appropriate to support decisions regarding site-specific action levels.

8.3.3.3 Sampling and Analysis Methods

All analytical procedures will adhere to current U.S. EPA and/or ASTM published analytical protocols and all analyses will be conducted by certified personnel at accredited laboratories. Sampling will be conducted in accordance with the *"Leviathan Mine Site: Site-Wide Sampling and Analysis Plan"* (MWH, 2002) updated as necessary for the RI/FS.

8.3.4 Step 4 – Define the Boundaries of the Study Area

The primary objective of DQO Step 4 is to identify the population of interest, define the spatial and temporal boundaries that apply to each DS, define the scale of decision making, and identify any practical constraints (e.g., hindrances or obstacles) that must be taken into consideration.

8.3.4.1 Target Populations of Interest

Prior to defining the spatial and temporal boundaries of the Site under investigation, it is first necessary to clearly define the populations of interest that apply for each DS (Table 8-13). The intent of Table 8-13 is to clearly define the attributes that make up each population of interest by stating them in a way that makes the focus of the study unambiguous.

Table 8-13
Characteristics that Define the Population of Interest for the LCSA

DS#	Population(s) of Interest
1	Data to construct water balance (precipitation, evaporation, surface water, groundwater, temperature, wind speed, evaporation, evapotranspiration).
2	Concentrations of COPCs in vadose zone soils, shallow groundwater, and sediments within the LCSA. Habitats of plants and wildlife species that occur in the study area.
3	Data required to evaluate the distribution of COPCs in the shallow alluvial aquifer. Hydrological properties of the aquifer required to support plume delineation and fate & transport evaluation.
4	Data required to identify potential sources of groundwater discharging from the CUD and Delta Seep.

Table 8-13 (Continued)

DS#	Population(s) of Interest
5	Geotechnical parameters sufficient to support assessment of the stability of Ponds 1, 2n, 2s, 3, and 4 and expandability (additional storage).
6	Data required to evaluate potential remedial action alternatives.
7	Data required to assess the integrity of the liners of the 5 ponds in the study area.

COPC = chemical of potential concern

8.3.4.2 Geographic Boundaries

This study area is bounded on the southwest and west by the disturbed Site waste disposal area and proceeding northward the high water mark of Leviathan Creek, on the north and east by the western edge of the aspen landslide and the pit and the southern boundary is the edge of the disturbed area as shown on Figure 31. The geographic boundaries for the LCSA over which these populations will be evaluated is a three dimensional area that is defined as a plane in the X and Y dimension by the area shown on Figure 31 and in the Z direction is defined by the depth of the population being studied (e.g., depth of shallow groundwater, waste rock, and surface water).

8.3.4.3 Temporal Boundaries

Source and contaminant pathway characterization data are planned to be collected in the LCSA during the first two years of the RI/FS. Where possible data collected will provide information on seasonal variability. However, access to the Site is limited due to weather conditions and the majority of the data collection needs to occur between June 1 and September 30 of each year.

8.3.4.4 Practical Constraints on Data Collections

Weather conditions may impose limitations on the ability to collect data at the Site especially in the winter and spring when access to the Site and specific media (populations) are restricted.

8.3.4.5 Scale of Decision Making

In Table 8-14 the scale of decision making has been defined for each DS identified for the LCSA in Step 2. For this Report, the scale of decision making for the LCSA as in the other study areas has been maintained in fairly global terms. As discussed in recent U.S. EPA's DQO guidance (U.S. EPA, 2000), the scale of decision making may be based on widely different project needs. It is anticipated that as the RI/FS at the Site progresses, more specific and/or different decision-making scales may be developed.

Table 8-14
Scale of Decision Making for the LCSA

DS#	Population of Interest	Scale of Decision
1	Data to construct a water balance (precipitation, surface water, evaporation, surface water, groundwater, temperature, wind speed, evaporation, and evapotranspiration).	Regional and site-specific data collected over a period of time to allow for water balance estimation.
2	Concentrations of COPCs in vadose zone soils, sediments in Leviathan Creek, and shallow groundwater. Habitats of plants and wildlife species that occur in the study area.	Vadose zone soils, sediments, and shallow groundwater samples collected within the geographical boundaries (see Figure 31) over two years (samples to be collected between June 1 and September 30). Plant and wildlife habitats identified over the next two years.
3	Data required to evaluate the distribution of COPCs in the shallow alluvial aquifer. Hydrological properties of aquifer required to support plume delineation and fate & transport evaluation.	Samples collected from the shallow upper aquifer within the geographic boundaries over the next two years.
4	Data required to identify potential sources of groundwater discharging from the CUD and Delta Seep.	Groundwater samples collected in vicinity of the ponds, CUD and Delta Seep.
5	Geotechnical parameters sufficient to support assessment of the stability of Ponds 1, 2n, 2s, 3, and 4 and expandability.	Soils and facility construction materials within the geographic boundaries over the next two years.
6	Data required to evaluate potential remedial action alternatives.	Groundwater, vadose zone, sediments, and surface water within the geographic boundaries over the next two years.
7	Data required to assess the integrity of the liners of the five ponds in the study area.	Soil moisture and groundwater samples collected form area beneath or adjacent to the ponds pond over the next two years.

8.3.5 Step 5 – Develop the Analytical Approach

The objective of DQO Step 5 is to define the statistical parameter of interest (e.g., mean, median, percentile, maximum) to be used to resolve the decision statements identified in DQO Step 2. The discussion of analytical approach developed for the other areas, which is applicable to the LCSA is provided in Section 8.2.5.

8.3.5.1 Decision Rules

The final output of DQO Step 5 is a set of decision rules that are the result of combining the parameter of interest with the scale of decision making, the action level, and the alternative actions. DRs for each of the DSs from Step 2 are shown in Table 8-15

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Table 8-15
Decision Rules for Each Decision Statement for the LCSA

DS# / DR#	Decision Statement or Decision Rule
DS #1	Evaluate whether sufficient data are available to construct a water balance, or if additional data are needed.
DR #1	IF sufficient data are available as estimated by representative values of data reported in appropriate units and adjusted to the local topography as defined by the geological boundaries are sufficient based on professional judgment of Atlantic Richfield, regulatory and contractor staff to evaluate a water balance for the LCSA THEN collect no more data and proceed with construction of the water balance; OTHERWISE collect additional data to support water balance construction.
DS #2	Evaluate appropriate human health and ecological benchmarks and use both qualitative and quantitative risk assessment methods.
DR #2	IF screening level human health and ecological risk as estimated by measurement or modeling and approved risk assessment procedure of the COPC within the geographic boundaries is appropriately protective, THEN complete screening level assessment; OTHERWISE conduct baseline risk assessments.
DS #3	Evaluate whether current data set is sufficient to allow estimation of the COPC plume in shallow groundwater and predict future fate and transport of COPCs in the shallow aquifer, or if additional data are needed.
DR #3	IF the concentration of COPCs and hydrological characteristics of the shallow aquifer as defined by representative analytical or test data measured in appropriate units over the next two years within the geographic boundary are adequately known based on professional judgment of Atlantic Richfield, regulatory, and contractor staff THEN gather no more data; OTHERWISE gather additional data.

Table 8-15 (Continued)

DS# / DR#	Decision Statement or Decision Rule
DS #4	Evaluate whether sufficient data are available to evaluate potential shallow groundwater sources discharging to the CUD and Delta Seep.
DR # 4	IF sufficient groundwater and surface water data are available to identify potential sources that result in discharges at the CUD and Delta Seep THEN collect no more data; OTHERWISE gather additional data.
DS #5	Review current geotechnical data and as-built diagrams for Ponds 1, 2n, 2s, 3, 4 and the Delta Slope to evaluate if this information is sufficient to evaluate stability or if additional measurements and data are needed.
DR # 5	IF the data required to evaluate the potential long-term stability of the five ponds within the LCSA are available as based on professional judgment of Atlantic Richfield, regulatory, and contractor staff THEN gather no more data; OTHERWISE gather additional data.
DS #6	Evaluate if current data set is adequate to evaluate remedial action need and assess the feasibility of implementation at the LCSA.
DR #6	IF the data required to evaluate potential remedial action alternatives as defined by representative values of the COPC concentrations in the appropriate units for a specific medium under consideration and within the geographic boundaries over the next two years are available for comparison to the operational requirements of potential remedial actions THEN evaluate potential remedial action alternatives; OTHERWISE obtain data necessary to allow evaluation of remediation alternatives.
DS #7	Review current data to evaluate if this information is sufficient to evaluate the integrity liners of the five ponds located in the LCSA or if additional data are needed.
DR #7	IF the currently available data are sufficient to assess the integrity of the liners of the five ponds within the study area based on professional judgment of Atlantic Richfield, regulatory, and contractor staff THEN collect no additional data; OTHERWISE collect additional data.

8.3.6 Step 6 – Specify Performance or Acceptance Criteria

The discussion of performance and acceptance criteria for the ACSA and presented in Section 8.2.6 is also applicable to the LCSA.

8.3.7 Step 7 – Develop the Detailed Plan for Obtaining Data

The discussion on the development of a detailed plan for collection of data that was presented in Section 8.2.6 for the ACSA is also applicable to the LCSA. Dependant on further review of existing data the sampling and analysis program in the LCSA is anticipated to include:

- better physical characterization of mine features;
- topographical mapping of the area;

- collection of site-specific meteorological and other inflow/outflow data to support the water balance;
- sampling and measurement of COPC concentrations to support risk assessment/remedial evaluation;
  - soil to assess potential COPC distribution, source and ingestion and dermal contact exposures (including deposits along creek banks during flood conditions);
  - groundwater to assess potential COPC migration and use;
  - sediment to assess potential ingestion and dermal contact exposures; and
  - surface water to assess potential dermal contact exposures.
- if necessary to support uptake models plants to assess potential ingestion exposure;
- if necessary to support uptake models fish to assess potential ingestion exposure; and
- hydrologic/geochemical.
  - grain size and soil properties;
  - water levels;
  - surface water flows;
  - aquifer hydraulic conductivity (pump tests/slug testing);
  - aquifer porosity/effective porosity;
  - synoptic geochemical survey to assess mass loading;
  - assessment of surface water groundwater interactions; and
  - identification of springs.

8.4 STUDY AREA 4 – OFF-SITE STUDY AREA (OSA)

8.4.1 Step 1 – State the Problem

Conceptual Model Statement: Leviathan and Bryant creeks were historically impacted from AMD/ARD discharges and contaminant sediment loading. Early remedial measures implemented beginning in the 1980s and continuing to present have significantly mitigated the impacts to Leviathan Creek downstream from the Site and the Bryant Creek drainage.

Problem Statement: To evaluate the extent to which historic Site discharges have impacted Leviathan and Upper Bryant creeks and potential human and ecological receptors to the point of requiring some form of remedial action, data regarding contaminant distributions, contaminant concentration ranges, and receptor uptake are needed to support the preparation of a remedial investigation report, baseline risk assessment, screening of remedial alternatives, and remedial designs.

Planning Team and Available Resources:

U.S. EPA
RWQCB
Atlantic Richfield

The necessary resources are available to collect data needed. Access to the Site is limited due to weather conditions and the majority of the data collection generally needs to occur between June 1 and September 30 of each year. Source and contaminant pathway characterization data are planned to be collected in the OSA during the first two years of the RI/FS.

8.4.2 Step 2 – Identify the Goal(s) of Study

Table 8-16 presents the task-specific PSQs, AAs, and resulting DSs that apply to the OSA. This table also provides a qualitative assessment of the consequences of taking an AA if it is incorrect.

Table 8-16
Summary of Data Quality Objective Step 2 Information for the OSA

PSQ-AA-DS#	Alternative Action	Description of Consequences of Implementing the Wrong Alternative Action
PSQ #1 - Does exposure to COPC impacted surface water or sediments within the OSA pose an unacceptable current or future risk to human health or ecological receptors and need to be evaluated in further study?		
AA 1-1	Compare current data set to applicable benchmarks to qualitatively evaluate potential risk to humans and biota in study area.	Potential current and future risks to humans and biota could be under/over estimated due to limited data set.

PSQ-AA-DS#	Alternative Action	Description of Consequences of Implementing the Wrong Alternative Action
AA 1-2	Collect additional data and conduct baseline risk assessment to quantitatively evaluate potential risk to humans and biota in study area.	Quantitative baseline risk assessments may underestimate or overestimate potential risk to humans and biota because of uncertainty inherent in risk assessment methods.
DS #1 – Evaluate appropriate human health and ecological benchmarks and use both qualitative and quantitative risk assessment methods.		
PSQ #2 – Are data for stream flows and COPC concentrations know sufficiently well to evaluate potential mass loading of metals to off-site surface waters from on-site and off-site sources?		
AA 2-1	No; obtain additional data.	Unnecessary cost in obtaining redundant data.
AA 2-2	Yes; no additional data needed.	If inadequate data are used to assess mass loading of metals to off-site streams, the origin of the metals (on-site versus off-site) could be over or underestimated.
DS #2 – Evaluate whether current data are sufficient to assess current and future metal mass loading to the off-site reaches of Leviathan Creek and upper Bryant Creek.		

AA = alternative action
COPC = chemical of potential concern
DS = decision statement
PSQ = principal study question

8.4.3 Step 3 – Identify Information Inputs (Data Needs)

Table 8-17 provides a summary of the types of data that will be required to resolve the decision statements from Step 2 and an evaluation as to the sufficiency of the existing data set.

8.4.3.1 Action Levels

Analytical performance requirements will be established as appropriate to support decisions required regarding site-specific action levels.

8.4.3.2 Analytical Performance Requirements

Analytical performance requirements will be established as appropriate to support decisions regarding site-specific action levels.

8.4.3.3 Sampling and Analysis Methods

All analytical procedures will adhere to current U.S. EPA and/or ASTM published analytical protocols and all analyses will be conducted by certified personnel at accredited laboratories. Sampling will be conducted in accordance with the *"Leviathan Mine Site: Site-Wide Sampling and Analysis Plan"* (MWH, 2002) updated as necessary for the RI/FS.

Table 8-17

Required Information and Reference Sources for the OSA

Variable	Required Data	Do Data Exist? (Y/N)	Sufficient Quality? (Y/N)	Additional Information Required? (Y/N)
DS #1 – Evaluate appropriate human health and ecological benchmarks and use both qualitative and quantitative risk assessment methods.				
Risk levels for COPCs at appropriate times and spatial boundaries under agreed upon end-use scenarios	Concentrations and distribution of COPCs in surface soils and sediments. Spatial extent for any COPCs that reach the groundwater. End-use scenarios.	Y	N	Y
DS #2 – Evaluate whether current data are sufficient to assess current and future metal mass loading to the off-site reaches of Leviathan Creek and upper Bryant Creek.				
Data required to evaluate metals mass loading	Concentrations of metals in surface water and sediments. Stream flow data.	Y	N	Y

8.4.4 Step 4 – Define the Boundaries of the Study Area

The primary objective of DQO Step 4 is to identify the population of interest, define the spatial and temporal boundaries that apply to each DS, define the scale of decision making, and identify any practical constraints (e.g., hindrances or obstacles) that must be taken into consideration.

8.4.4.1 Target Populations of Interest

Prior to defining the spatial and temporal boundaries of the Site under investigation, it is first necessary to clearly define the populations of interest that apply for each DS (Table 8-18). The intent of Table 8-18 is to clearly define the attributes that make up each population of interest by stating them in a way that makes the focus of the study unambiguous.

Table 8-18
Characteristics that Define the Population of Interest for the OSA

DS#	Population(s) of Interest
1	Concentrations of COPCs in surface water and sediments in Leviathan Creek downstream of the confluence of Aspen Creek and the upper reaches of Bryant Creek. Habitats of plants and wildlife species that occur in the study area.
2	Data required to estimate metal mass loading.

COPC = chemical of potential concern

8.4.4.2 Geographic Boundaries

The OSA consists of lower Leviathan Creek past the confluence of Aspen and Leviathan Creek, and Bryant Creek from Mountaineer Creek to where Bryant Creek meets Barney Riley Creek as shown on Figure 32. The geographic boundaries for the OSA over which these populations will be evaluated is a three dimensional area that is defined in the X and Y dimension by the area shown on Figure 32 and in the Z direction is defined by the depth of the population being studied (e.g., depth surface water and shallow sediments).

8.4.4.3 Temporal Boundaries

Source and contaminant pathway characterization data are planned to be collected in the OSA during the later years of the RI/FS. Where possible data collected will provide information on seasonal variability. However, access to the Site is limited due to weather conditions and the majority of the data collection needs to occur between June 1 and September 30 of each year.

8.4.4.4 Practical Constraints on Data Collections

Weather conditions may impose limitations on the ability to collect data at the Site especially in the winter and spring when access to the Site and specific media (populations) are restricted.

8.4.4.5 Scale of Decision Making

In Table 8-19 the scale of decision making has been defined for each DS identified for the PSA in Step 2. For this Report, the scale of decision making has been maintained in fairly global terms. As discussed in recent U.S. EPA DQO guidance (U.S. EPA, 2000), the scale of decision making may be based on widely different project needs. It is anticipated that as the RI/FS at the Site progresses, more specific and/or different decision-making scales may be developed.

Table 8-19
Scale of Decision Making for the OSA

DS#	Population of Interest	Scale of Decision
1	Concentrations of COPCs in surface water and sediments Leviathan Creek downstream of the confluence of Aspen Creek and the upper reaches of Bryant Creek. Habitats of plants and wildlife species that occur in the study area.	Surface water and sediment samples collected within the geographical boundaries (see Figure 32) during the later years of the RI/FS (samples to be collected between June 1 and September 30). Plant and wildlife habitats identified over the next two years.
2	Data required to estimate metal mass loading.	Surface water samples and flow data collected within the geographic boundaries (Figure 32) during the RI (samples to be collected between June 1 and September 30).

8.4.5 Step 5 – Develop the Analytical Approach

The objective of DQO Step 5 is to define the statistical parameter of interest (e.g., mean, median, percentile, maximum) to be used to resolve the decision statements identified in DQO Step 2. The discussion of analytical approach developed for the ACSA, which is applicable to the OSA is provided in Section 8.2.5.

8.4.5.1 Decision Rules

The final output of DQO Step 5 is a set of decision rules that are the result of combining the parameter of interest with the scale of decision making, the action level, and the alternative actions. DRs for each of the DSs from Step 2 are shown in Table 8-20.

Table 8-20
Decision Rules for Each Decision Statement for the OSA

DS# / DR#	Decision Statement or Decision Rule
DS #1	Evaluate appropriate human health and ecological benchmarks and use both qualitative and quantitative risk assessment methods.
DR #1	IF screening level human health and ecological risk as estimated by measurement or modeling and approved risk assessment procedure within the geographic boundaries is appropriately protective, THEN complete screening level assessment; OTHERWISE conduct baseline risk assessments.
DS #2	Evaluate whether current data are sufficient to assess current and future metal mass loading to the off-site reaches of Leviathan Creek and upper Bryant Creek.
DR #2	IF stream flow data and the concentration of metals and other appropriate water quality parameters measured in Leviathan and the upper reach of Bryant Creek during the RI within the geographic boundary are adequately known to assess mass loading based on professional judgment of Atlantic Richfield, regulatory, and contractor staff THEN gather no more data; OTHERWISE gather additional data.

8.4.6 Step 6 – Specify Performance or Acceptance Criteria

The discussion of performance and acceptance criteria for the ACSA and presented in Section 8.2.6 is also applicable to the OSA.

8.4.7 Step 7 – Develop the Detailed Plan for Obtaining Data

The discussion on the development of a detailed plan for collection of data that was presented in Section 8.2.6 for the ACSA is also applicable to the OSA. Dependant on further review of existing data the sampling and analysis program in the OSA is anticipated to include:

- sampling and measurement of COPC concentrations to support risk assessment/remedial evaluation;
  - soil deposited along creek banks during flood conditions to assess potential ingestion and dermal contact exposure;

  - overburden used on mine roads to assess potential inhalation of suspended particulate matter;
  - groundwater to assess potential use as a drinking water source (to the extent that impacted groundwater is present in the OSA);
  - sediment to assess potential ingestion and dermal contact exposures; and
  - surface water to assess potential dermal contact exposures.
- plants to assess potential ingestion exposure;
- fish to assess potential ingestion exposure; and
- hydrologic/geochemical.
  - surface water flows;
  - synoptic geochemical survey to assess mass loading;
  - surface water/groundwater interaction; and
  - identification and characterization of springs/seeps.

8.5 STUDY AREA 5 – BACKGROUND STUDY AREA (BSA)

8.5.1 Step 1 – State the Problem

Problem Statement: To estimate the natural background concentrations of identified COPCs in surface soils, groundwater, and surface water geochemical data from other similar mineralized areas needs to be collected to support establishment of realistic and site-specific action levels.

Planning Team and Available Resources:

U.S. EPA
RWQCB
Atlantic Richfield

The necessary resources are available to collect the data needed. Access to the Site is limited due to weather conditions and the majority of the data collection generally needs to occur between June 1 and September 30 of each year. Source and contaminant pathway characterization data are planned to be collected in the BSA during the first two years of the RI/FS.

8.5.2 Step 2 – Identify the Goal(s) of Study

Table 8.21 presents the task-specific PSQs, AAs, and resulting DSs that apply to the BSA. This table also provides a qualitative assessment of the consequences of taking an AA if it is incorrect.

Table 8-21
Summary of Data Quality Objective Step 2 Information for the BSA

PSQ-AA-DS#	Alternative Action	Description of Consequences of Implementing the Wrong Alternative Action
PSQ #1 – Are sufficient premining data available from the Leviathan Mine Site and/or from other similar mineralized areas to adequately estimate natural background levels of COPCs in surface soils, groundwater, and surface water?		
AA 1-1	No; obtain additional data	Unnecessary cost in obtaining redundant data.
AA 1-2	Yes; no additional data needed.	If inadequate data are available and used to estimate natural background conditions, those estimates could significantly over or under estimate true background and associated Site-specific action levels.
DS #1 – Evaluate whether current data are sufficient to assess natural background levels of COPCs.		

AA = alternative action
COPC = chemical of potential concern
DS = decision statement
PSQ = principal study question

8.5.3 Step 3 – Identify Information Inputs (Data Needs)

The objective of Step 3 in the DQO process is to identify the types of data needed to resolve the decision statement(s) identified in Step 2, and evaluate if existing data are adequate for resolution.

The variables identified for the DS developed in Step 2 above data required to estimate background COPC concentrations in soils, groundwater, and surface water. The data required to resolve the DS are COPC concentrations measured in surface soil, groundwater, and surface water from an analogue, unmined mineralized area(s).

8.5.4 Step 4 – Define the Boundaries of the Study Area

The primary objective of DQO Step 4 is to identify the population of interest, define the spatial and temporal boundaries that apply to each DS, define the scale of decision making, and

identify any practical constraints (e.g., hindrances or obstacles) that must be taken into consideration.

8.5.4.1 Target Populations of Interest

The populations of interest with respect to estimation of background are soils, groundwater, and surface water within and/or adjacent to mineralized zones similar to those found at the Site.

8.5.4.2 Geographic Boundaries

Geographic boundaries have not yet been established and the determination of appropriate locations for assessing background will be one of the tasks defined in the RI Work Plan.

8.5.4.3 Temporal Boundaries

Because access to the Site is limited due to weather conditions, it is anticipated that the majority of the data, as with data to collected for other study areas, will need to be collected between June 1 and September 30 of each year of the study.

8.5.4.4 Practical Constraints on Data Collections

Weather conditions may impose limitations on the ability to collect data at the Site especially in the winter and spring when access to the Site and specific media (populations) is restricted. In addition, analogue sites for data collection have not yet been identified and therefore if such sites are located, there may be other practical constraints imposed on data collection that are not foreseen at present.

8.5.4.5 Scale of Decision Making

In Table 8-22 the scale of decision making has been defined for the DS identified for the BSA in Step 2.

Table 8-22
Scale of Decision Making for BSA

DS#	Population(s) of Interest	Scale of Decision
1	COPC concentrations measured in surface soil, groundwater, and surface water from an analogue, unmined mineralized area(s).	Soil, groundwater, and surface water samples collected from the identified background study area(s) over two years (samples to be collected between June 1 and September 30).

8.5.5 Step 5 – Develop the Analytical Approach

The objective of DQO Step 5 is to define the statistical parameter of interest (e.g., mean, median, percentile, maximum) to be used to resolve the decision statements identified in DQO Step 2. The discussion of analytical approach developed for the ACSA, which is applicable to the BSA is provided in Section 8.2.5.

8.5.5.1 Decision Rules

The final output of DQO Step 5 is a set of decision rules that are the result of combining the parameter of interest with the scale of decision making, the action level, and the alternative actions. DRs for each of the DSs from Step 2 are shown in Table 8-23.

Table 8-23
Decision Rules for Each Decision Statement for the BSA

DS# / DR#	Decision Statement or Decision Rule
DS #1	Evaluate whether current data are sufficient to assess natural background levels of COPCs.
DR #1	IF the concentration of COPCs in surface soils, shallow groundwater, and surface water from an analogue, undisturbed, mineralized study area as defined by representative analytical or test data measured in appropriate units over the next two years within the geographic boundary identified are adequately known based on professional judgment of Atlantic Richfield, regulatory, and contractor staff THEN gather no more data; OTHERWISE gather additional data to support background estimation.

8.5.6 Step 6 – Specify Performance or Acceptance Criteria

Performance and acceptance criteria will be developed when appropriate background site(s) have been located.

8.5.7 Step 7 – Develop the Detailed Plan for Obtaining Data

A detailed plan for data collection will be prepared when the appropriate background sites have been located. Because COPCs occur naturally in the environment, samples in the BSA should be collected in all media sampled in the four main study areas (e.g. soils, sediments, surface water and groundwater).

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