PROGRAMMATIC DATA QUALITY OBJECTIVE
LEVIATHAN MINE
ALPINE COUNTY, CALIFORNIA

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ABBREVIATIONS AND ACRONYMS

ACSA	Aspen Creek Study Area
Amec	Amec Geomatrix, Inc.
AMSL	Above Mean Sea Level
ARAR	Applicable or Relevant and Appropriate Requirement
CCR	California Code of Regulations
CEC	Cation Exchange
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COPC	Chemical of Potential Concern
CSM	Conceptual Site Model
CUD	Channel Underdrain
CWA	Clean Water Act
DQA	Data Quality Assessment
DQO	Data Quality Objectives
DSA	Downstream Study Area
EFCR	East Fork Carson River
EPA	U.S. Environmental Protection Agency
ERA	Early Response Action
FRI	Focused Remedial Investigation
gpm	gallons per minute
LCSA	Leviathan Creek Study Area
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MW	Monitoring Well
PSA	Pit Study Area
ppm	parts per million
PUD	Pit Underdrain
PWP	Program Work Plan
RI/FS	Remedial Investigation and Feasibility Study
SC	Specific Conductance
S.U.	Standard Unit
UCL	Upper Confidence Limit
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey

Introduction

The following data quality objectives (DQO) were prepared by the U. S. Environmental Protection Agency (EPA) and are intended to be incorporated into the Remedial Investigation/Feasibility Study (RI/FS) Program Work Plan (PWP) for Leviathan Mine prepared by AMEC (2009). These program DQOs provide a framework for planning of the Leviathan RI/FS. This framework will be expanded in the work plans for focused remedial investigations (FRI), including the investigation of the area at and around the mine ("On Property"), downstream from Leviathan Mine, the reference areas and for the risk assessments. These program DQOs summarize much of the information available in the Leviathan Mine Database, identify the types of decisions to be evaluated using information gathered in the remedial investigation, and provide recommended limits on the acceptable errors for decisions at Leviathan Mine.

The DQOs for each FRI component are expected to include more complete evaluation of existing data relevant to that particular aspect of the Leviathan RI/FS. The FRI work plans will also identify more detailed study questions and decision statements specific to the media and areas of interest. In addition, each FRI work plan will provide a systematic and integrated sequence of investigations to efficiently and effectively provide the inputs to address decisions within acceptable error limits.

The sections that follow are organized in accordance with the seven steps of the systematic planning using the DQO process identified in EPA QA/G-4 (EPA 2006):

Step 1: State the Problem

Step 2: Identify the Goal of the Study

Step 3: Identify Information Inputs

Step 4: Define the Boundaries of the Study

Step 5: Develop the Analytical Approach

Step 6: Specify Performance or Acceptance Criteria

Step 7: Develop the Plan for Obtaining Data

Step 1 provides a conceptual framework for the RI/FS at Leviathan Mine that is intended to be flexible and is subject to revision based on incorporation of new information. Step 2 identifies questions to be answered by the RI/FS at Leviathan Mine. Step 3 provides a summary of existing information inputs and identifies the potential types of additional information needed to fill data gaps and possible ways to obtain such information. Step 4 describes spatial and temporal boundaries for the Leviathan Mine RI. Steps 5, 6, and 7 provide guidelines for development of detailed analytical programs, performance and acceptance criteria, and plans to obtain the data in support of the RI/FS.

Step 1: State the Problem

Give a concise description of the problem, Identify leader and members of the planning team, Develop a conceptual model of the environmental hazard to be investigated, Determine resources -budget, personnel, and schedule.

This section of the document includes discussion of a conceptual site model (CSM), describes the characteristics of reference areas, and concludes with a problem statement. The FRI Data Quality Objectives (DQO) and work plans will identify the leader and members of the planning team, and determine the necessary resources.

Conceptual Site Model

This CSM for Leviathan Mine addresses the potential migration pathways for chemicals of potential concern (COPC) from sources at Leviathan Mine to human and ecological receptors to provide a framework for development of more detailed conceptual site models necessary to support risk assessment and plan each FRI consistent with the risk assessment CSMs presented in the PWP. The CSM addresses mine waste and in situ material as primary COPC sources. Acid drainage, groundwater, surface water, soil, sediment, air, and biota are presented as secondary sources and pathways. An overview of the site is provided prior to addressing these sources and release mechanisms. Mine waste includes overburden and waste rock disturbed by mining activity. Biota includes terrestrial and aquatic plants and animals.

Leviathan Mine is located near the middle of the eastern portion of the Leviathan Canyon watershed, and receives runoff from the upper Leviathan and Aspen Creek watersheds (see Figures 1and 2). The western portion of the Leviathan Creek watershed and areas of Leviathan Creek above Leviathan Mine are not known to have been affected by activity or materials from Leviathan Mine and are not considered part of the site at this time.

Leviathan Mine operated intermittently from 1863 to 1962. Leviathan Mine was developed to produce copper salts, and later sulfur from an ore body deposited by hydrothermal solutions reacting with alluvial sediments and interbedded volcanic rocks. The hydrothermal system is no longer active at Leviathan Mine. Past site activity created underground workings and an open pit, overburden, and waste rock distributed on the ground at the site. Mining and subsequent reclamation work has altered the topography of the site and may be contributing to landslide activity (Figure 3).

In the early 1980s, work was performed by the State of California to control the migration of acid and metals from the site. The work included installation of five lined ponds (Ponds 1, 2N, 2S, 3 and 4), installation of a pit underdrain (PUD), installation of a diversion drainage from the adit and PUD into the collection ponds, construction of a concrete channel for Leviathan Creek through the mine waste including a channel underdrain (CUD), excavation and regrading of overburden piles, relocation of some mine waste and partial filling and regrading of the pit, construction of storm water collection systems and revegetation of disturbed areas.

The mine wastes contain sulfur and sulfide minerals that create acid when exposed to oxygen and water. Mining has resulted in significant increased exposure of minerals in the mine waste and in situ rock disturbed by mine workings to oxygen and water. Mining also increased the surface area of mineralized rock available for acid generating reactions. This increased reactive surface area is believed to have increased the amount of acid generated and metals mobilized to the environment from the site as compared to pre-mining conditions. Acid and metals mobilized by the acid are available for transport to groundwater and surface water, and create chemical precipitates (yellow boy) in the surface environment. Metals in mine waste are present at the ground surface and are available for transport as mechanically derived sediment in surface water and air. Humans, plants, and animals may be directly exposed through contact with the contaminated waters, sediment, soil, and mine waste. Humans and biota may also be indirectly exposed through inhalation of air, and/or ingestion of water, plants, and/or animals affected by chemicals from Leviathan Mine.

The remainder of this CSM describes each of the primary sources (mine waste and in situ rock) and transport pathways (leaching, groundwater transport, surface water runoff, erosion, deposition of sediment, biotic uptake) that lead to secondary sources (acid drainage, groundwater, surface water, soil, sediment, air and biota); and reference area attributes.

Primary Sources

Mine Waste. Mine waste is primarily distributed in the three study areas: the Aspen Creek Study Area (ACSA), the Pit Study Area (PSA), and the Leviathan Creek Study Area (LCSA) (see Figure 3). Mine waste is also present along the channel of Leviathan Creek in the LCSA and may be present in downstream sediment as a result of erosion and deposition from the other areas. Mine waste may also have been used as road base both on and off property. Other occurrences of mine waste may also be recognized during the remedial investigation (RI).

Mine wastes contain varying amounts of metals, sulfur, and sulfide minerals and may pose a risk to biota. Stressed vegetation and areas of little or no vegetation are associated with mine waste that contributes physical and chemical stressors impeding plant growth. In addition, the mine waste is capable of creating acid drainage when exposed to water and oxygen. The geotechnical stability of mine wastes is uncertain.

In Situ Rock. In situ rock consists of mineralized (sulfur and/or sulfide containing) rock remaining in place in the vicinity of the On-Property area at Leviathan Mine which has been affected by mining. These sulfur and sulfide occurrences remaining in the ground can be exposed to water and oxygen circulating through fractures and mine openings. Lowering of the water table from drainage through mine openings, and increased porosity due to mining disturbances, has resulted in exposing a much greater volume of mineralized and non-mineralized rock to circulating groundwater and oxygen, than under pre-mining conditions. Oxidation of the sulfur and sulfide minerals can create acid drainage which is capable of transporting COPCs to surface water and through the subsurface away from the site. In addition, the stability of in situ rock forming the pit highwalls is uncertain.

Pathways and Secondary Sources

Acid Drainage. COPCs may be transported from sources to groundwater and surface water in acid drainage. Acid drainage formed through oxidation of sulfur and/or sulfide minerals in mine waste and/or in situ mineralized rock may contain elevated concentrations of metals such as aluminum, arsenic, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, selenium, thallium, vanadium, and zinc. Ferric and ferrous sulfate, total sulfate, and sulfuric acid are also COPCs. Acid drainage pH ranges from about 2 to 5 standard units (s.u.) at Leviathan Mine. Metals are mobilized by acid-drainage interactions with in situ rock, mine waste, and/or soil, and remain in solution due to the low pH. COPCs in acid drainage are transported to soil, groundwater, and surface water at Leviathan Mine by infiltrating water. Acid drainage can create an orange metalliferous iron-oxy-hydroxy-sulfate chemical precipitate ('yellow boy') that coats rocks and covers sediment where it discharges to the surface. Acid drainage can also flow overland, and leave efflorescent minerals as it evaporates.

Surface Water. Leviathan Creek, in the upper Bryant Creek watershed, flows through the LCSA (see Figure 3). Aspen Creek in the ACSA is a tributary to Leviathan Creek and joins Leviathan Creek about 3/4 mile downstream. Water quality in Aspen Creek has been affected by discharge from Leviathan Mine. Bryant Creek begins at the confluence of Mountaineer and Leviathan Creeks in the Downstream Study Area (DSA), about 2.3 miles downstream from Leviathan Mine. Bryant Creek flows into the East Fork Carson River (EFCR) about 9 miles downstream from the mine. Discharges from Leviathan Mine are known to have historically impacted water quality in the EFCR. Historical accounts from the 1950s and 1960s include descriptions of fish kills in the EFCR attributed to discharges at Leviathan Mine.

Historically, the River Ranch, located in the DSA upstream from the confluence of Bryant Creek and EFCR, diverted water from Bryant Creek to irrigate pastures used to support cattle and horses. COPCs from Leviathan Mine may have impacted River Ranch soils.

Under current conditions, discharge of metals from acid drainage, detrital sediment, and chemical precipitates from Leviathan Mine degrades surface water in Leviathan Creek from the site to the confluence with Mountaineer Creek. These current conditions include year round containment and campaign treatment of acid drainage from the Adit and PUD, seasonal interception and treatment of acid drainage discharged from the CUD and Delta Seep during late spring summer and early fall, and year round treatment of the Aspen Seep. Dilution from mixing with Mountaineer Creek may mitigate some effects of modern Leviathan Mine discharges under current discharge conditions. Conditions in Bryant Creek downstream from Mountaineer Creek to the EFCR currently appear to have greatly improved based on invertebrate biomonitoring conducted since 1998. Impacts of the discharge from Leviathan Mine on the Bryant Creek watershed during stormwater runoff remain uncertain.

Sediment. Sediment in Leviathan Creek downstream from Leviathan Mine contains mine waste eroded from the site, and chemical precipitates resulting from mixing of acid drainage with surface water. Mine waste occurs in longitudinal bars upstream from the Leviathan Creek landslide. Yellow boy has been observed in Leviathan Creek as a coating on rocks, covering bottoms of pools, and as orange colored strata within overbank deposits. Aspen Creek also

contains mine waste eroded from the site, and chemical precipitates may also be present in Aspen Creek.

Visually, Bryant Creek currently does not show overt effects of mine waste deposition or chemical sediments from Leviathan Mine. However, yellow boy was historically transported through the Bryant Creek watershed to the EFCR. Some residual COPCs from yellow boy and mine waste may remain in sediment within Bryant Creek and EFCR. Further, some of the irrigated areas at River Ranch may contain accumulations of COPCs from Leviathan Mine. Erosive runoff events could mobilize these sediments, potentially degrading water quality and making COPCs available for uptake by receptors.

Ruhenstroth Dam (Douglas Power Dam) was constructed in 1912 on the EFCR about 16.5 miles downstream from Leviathan Mine and 7.4 miles downstream from Bryant Creek (Rigby and Others 1998). The dam provided power for a local mill and to Gardnerville, Nevada. In 1937 the east end of the dam, including the powerhouse, was washed away. In 1997, the dam was further damaged by flooding and the remainder of the dam was removed in October 1997. After the impoundment was drained, deposits of sediment were visible upstream from the dam site. These sediments may have accumulated before, during, and after the period of open pit mining at Leviathan Mine. These sediment deposits also include orange colored layers that may contain yellow boy. The sediment accumulated at Ruhenstroth Dam may offer an opportunity to examine a record of mining impacts to EFCR.

Plants containing elevated metals from exposure to COPCs from Leviathan Mine in sediment and soil could represent an exposure to foraging biota or humans. Future erosive flow events could suspend mine waste and/or chemical precipitates in the water column making COPCs more available to degrade water quality or affect the food chain.

Soil. Soil at Leviathan Mine may be affected by COPCs through mixing with eroded mine waste, settling of contaminated dust from the air, and/or deposition of COPCs from acid drainage. Any soil affected this way could then become a secondary source for COPCs to the environment.

Groundwater. Thirteen useful groundwater monitoring wells (MW) remain at Leviathan Mine (see Figure 3). These wells are completed in mine waste and various geologic units at varying elevations across the site. From these wells, groundwater is known to be present within mine waste and the underlying geologic units at the site. Groundwater elevations measured in these wells show that groundwater flow generally mimics the topography of the site, and that groundwater flow may be affected by mining-related features (ponds, tunnels and drains) at the site. A well survey is being conducted as part of an FRI initiated in 2009.

Springs are abundant in the region around Leviathan Mine, indicating that groundwater flows through the volcanic rock of the area. Thus, groundwater flowing through fractures and permeable horizons within the volcanic rock and mine waste may transport COPCs across the site, and off the site.

Six locations have been identified where acid drainage or acidified groundwater surfaces on-property (see Figure 3): Delta Seep, Aspen Seep, Adit, PUD, CUD and potentially Acid Marsh. Delta Seep and Aspen Seep are springs located near the bottoms of mine waste piles. The Adit

drains in situ rock disturbed by mining. The PUD drains the pit area and was constructed to dewater the pit sufficiently to allow grading and partial backfilling of the Pit during pond construction in the 1980s. The CUD was constructed to drain and allow sufficient compaction of the bedding material beneath and around the concrete pipeline and channel of Leviathan Creek. In the absence of capture by gravity-flow or mechanical pumping, acid drainage or acidified groundwater from each of these discharges reach Leviathan Creek or Aspen Creek. The Acid Marsh is located on the upstream side of the Leviathan Creek Landslide, and discharge to Leviathan Creek is uncertain. It is also possible that groundwater transports acid drainage and metals off site in the subsurface through fractures and permeable horizons in the volcanic rock

Air. Wind and mechanical disturbances may entrain COPC-containing particles from mine waste or dried yellow boy and deposit these particles on plant surfaces, soil, and in surface water. Respirable particles could be inhaled by humans or animals leading to exposure.

Summary. The CSM identifies two primary sources of COPCs and associated release mechanisms.

1. Mine Waste - COPCs might be released in airborne dust, storm water, and through water-rock interactions. The geotechnical stability of mine wastes is uncertain.
2. In situ Rock - COPCs might be released through water-rock interactions. The stability of in situ rock forming the pit highwalls is uncertain.

The CSM identifies six secondary sources for COPCs at Leviathan Mine:

1. Acid Drainage - COPCs might be released through water-rock interactions, discharge to surface water and groundwater, and off site transport.
2. Surface Water - COPCs might be transported throughout the Leviathan-Bryant-EFCR watersheds downstream from the site, suspended or dissolved in the water column. Erosive storm events may increase the mass of COPCs in surface water.
3. Sediment - COPCs might be accumulated as particulates, precipitated from solution, suspended in the water column and redeposited, or dissolved from accumulations.
4. Soil - COPCs might accumulate in soil and be released to sediment, suspended in air, and/or through water-soil interactions.
5. Groundwater - COPCs might be transported in groundwater, released through water-rock interactions and/or discharged to surface water.
6. Air - COPCs might be adsorbed on respirable particulates.

Figures 43 and 44 of the PWP provide CSMs to support human health and ecological risk assessment. The CSM herein identified six pathways for exposure to COPCs from Leviathan Mine:

1. Surface Water - Exposure routes for humans, terrestrial biota, and aquatic biota might include ingestion and direct contact.

2. Mine Waste - Exposure routes for humans, terrestrial biota, and aquatic biota might include ingestion, inhalation, and direct contact.
3. Sediment - Exposure routes for humans, terrestrial biota, and aquatic biota might include ingestion and direct contact.
4. Soil - Exposure routes for humans and terrestrial biota might include ingestion, inhalation, and direct contact.
5. Groundwater - Exposure routes for humans, terrestrial biota, and aquatic biota might include ingestion and direct (dermal) contact.
6. Air - Exposure routes for humans and terrestrial biota might include inhalation, and accumulation on plant tissues with subsequent uptake via ingestion by foraging humans and biota.

Reference Area

Reference areas are those areas that have characteristics similar to Leviathan Mine, but have not been disturbed or affected by mining activities. COPC concentrations in soil, rock, sediment, surface water, groundwater, and biota would be compared between a reference area and the Leviathan Mine affected area. This comparison would support evaluation of whether risks to human and ecological receptors are quantifiably increased through the effects of historical mining at Leviathan Mine. Reference areas are described for evaluating Leviathan Mine, and for comparison with media (surface water, sediment, groundwater, and biota) affected by Leviathan Mine.

Mine Reference Area. A suitable reference area for comparison with Leviathan Mine would require locating a similar ore deposit, in a similar geologic setting that has not been mined. COPC concentrations in surface water, sediment, and groundwater at such a reference ore deposit would be of great use to the Leviathan Mine RI. These COPC concentrations could be used to represent the possible range of pre-mining COPC concentrations for comparison with current concentrations at areas affected by Leviathan Mine to evaluate the impacts of mining activity. Given the exploration and mining history of the region around Leviathan Mine, it is very unlikely that such an ore deposit exists and it is uncertain that the time and resources needed to locate a similar and undisturbed ore deposit would be worthwhile to the RI at Leviathan Mine.

Investigations of such a reference ore deposit would yield COPC concentrations from rock, soil, sediment, surface water, groundwater and biota. However, the utility of the COPC concentrations in rock and soil may be limited with respect to RI goals because of the greater reactive surface area present in these materials at Leviathan Mine as compared to the same materials at a reference location. This difference in surface area (and grain size) may result in the COPCs at Leviathan Mine posing a greater threat via exposure pathways than the same chemicals at the same concentrations at the undisturbed reference area. However, a suitable, undisturbed ore deposit is not known at present. Thus, other means to evaluate the possible impacts of Leviathan Mine on the environment are necessary.

Reference Streams. In the absence of an undisturbed reference ore deposit it may be beneficial to identify reference streams to provide COPC concentrations in surface water, sediment, riparian soil, and biota not affected by Leviathan Mine to support identification of impacts from Leviathan Mine. Criteria for stream reference area identification should be developed more fully in the Reference FRI Work Plan. The geothermal nature of the copper and sulfur deposits at Leviathan Mine may have impacted local surface water quality prior to the onset of mining. Potential methods to evaluate such pre-mining impacts may include coring, analysis of COPC concentrations, and isotopic dating of sediments. Determining if a similar mineralized area in a different geographic area would serve as a suitable reference area could also be considered in the Reference FRI Work Plan.

Comparison of COPC concentrations in media from streams affected by Leviathan Mine to COPC concentrations in media from reference streams may allow assessment of Leviathan Mine impacts. Suitable reference streams would have a similar aspect, be located at similar elevations, occur in watersheds with similar geology, and contain similar vegetation to those of the reaches of Leviathan and Bryant Creeks downstream from Leviathan Mine. A few reference streams may be available near the site. An initial habitat survey was conducted for the PWP and a verification survey will be conducted as part of the FRIs to confirm habitats in the Leviathan Mine area.

Leviathan Creek in the LCSA and downstream from Leviathan Mine ranges in elevation from about 6,850 feet above mean seal level (amsl) at Delta Seep to about 6,300 feet amsl at the confluence with Mountaineer Creek, and has a northeast aspect. Leviathan Creek is located in a watershed underlain by volcanic rock composed mostly of andesite flows and andesite lahars that are fractured and faulted. The volcanic rock in the Leviathan Creek watershed ranges from almost unaltered to mineralized (mostly at and near Leviathan Mine). The vegetation community along this reach of Leviathan Creek consists of a montane riparian community (Holland and Keil 1995).

Bryant Creek consists of two differing reaches based on elevation and vegetation. Upper Bryant Creek extends from the confluence of Leviathan and Mountaineer Creeks (elevation about 6,300 feet amsl) downstream to the confluence with Barney Riley Creek (elevation about 5,800 feet amsl). Upper Bryant Creek is confined to a narrow steep-walled canyon and has a northeast to northwest aspect. Lower Bryant Creek extends from the confluence with Barney Riley Creek to the EFCR (elevation about 5,125 feet amsl). The vegetation community along upper of Bryant Creek is transitional from a montane riparian community to a desert riparian community (Holland and Keil 1995).

Lower Bryant Creek has a northern to western aspect and flows through a broader valley with a well-developed floodplain. Geology of the Bryant Creek watershed is similar to that of the Leviathan Creek watershed, with fractured and faulted andesitic volcanic rock and minor interbedded alluvial sediments with varying degrees of hydrothermal alteration. The vegetation community along Lower Bryant Creek consists of a desert riparian community (Holland and Keil 1995).

Based on these observations, desirable reference stream characteristics are summarized in the Table 1 below.

Table 1. Reference Stream Characteristics

Stream	Elevation (feet amsl)	Aspect	Vegetation Community	Geology
Leviathan Creek	6,300 to 6,850	Northeast	Montane Riparian	Andesite with variable hydrothermal alteration
Upper Bryant Creek	5,800 to 6,300	Northeast to Northwest	Montane-Desert Riparian Transition	Andesite with variable hydrothermal alteration
Lower Bryant Creek	5,100 to 5,800	North to Northwest	Desert Riparian	Andesite with variable hydrothermal alteration

Reference Soil Samples. To the extent possible soil reference data should be collected from areas that have the same physical, chemical, geological and biological characteristics as the mine, but that have not been disturbed by mining activities. The geographic area where these characteristics exist is limited to the on-property area or adjacent areas, unless a separate analog site with similar characteristics further away is identified. In order to select potential upland soil sample locations, the regional geology and mineralization and surface geology of the area surrounding the mine should be reviewed.

Reference Groundwater. To the extent possible, groundwater reference data should be collected from areas that have the same physical, chemical and geological characteristics as the mine, but that have not been disturbed by mining activities. The geographic area where these characteristics exist is limited to the on-property area or adjacent areas, unless a separate analog site with similar characteristics further away is identified.

Problem Statement

COPCs in mine waste and in situ rock at Leviathan Mine are transported through acid drainage to surface water and groundwater; COPCs also may be eroded and transported to sediment, soil and air. COPCs are potentially available for uptake by humans and ecological receptors. Impacts from release of COPCs are evident in the Leviathan Creek watershed, but are uncertain at this time in Bryant Creek and the EFCR. Concentrations of COPCs in surface water, sediment, soil, groundwater and biota from appropriate reference areas should be determined to assess possible impacts to these media within Bryant Creek and EFCR and quantify impacts to Leviathan Creek.

Step 2: Identify the Goal of the Study

Identify principal study question, consider alternative outcomes, develop decision statements, and organize multiple decisions.

The broad goals of the Leviathan Mine Remedial Investigation and Feasibility Study (RI/FS) are to determine if unacceptable risks to humans and the environment are posed by COPCs released at the site, and to identify remedies that would reduce such risks to acceptable levels. General RI/FS goals are provided for the COPC sources and media at Leviathan Mine in the form of study questions and decision statements. These general questions and decision statements are based on the programmatic CSM developed in Step 1, and are provided to guide the development of more detailed study questions and decision statements to support specific investigations at Leviathan Mine. The initial study questions developed in FRI work plans for the primary sources, secondary sources and pathways will address the following questions:

1. Is sufficient information available to characterize the COPC sources and distributions, in relevant media, evaluate risks and hazards, and satisfy regulatory requirements?
2. Do COPC concentrations exceed reference and/or risk thresholds, pose an unacceptable hazard, or trigger an applicable or relevant and appropriate regulatory requirement?
3. Is risk management necessary, feasible, and practicable?

Answering study questions developed to address the three factors above is expected to provide the information needed to assess risks and support feasibility studies needed to respond to those primary sources, secondary sources and pathways for which action may be necessary at Leviathan Mine.

Step 3: Identify Information Inputs

Identify types and sources of information needed to answer study questions, identify the basis of information, and select appropriate sampling and analysis methods for generating the information.

Existing Information

Information to answer the study questions will come from existing data and data to be collected during the RI. Existing data are maintained in the Leviathan Mine Database by AMEC. The most recent available version of the database contained analytical data through September 2009. Data summarized below were extracted directly from the Leviathan Mine database and were not subject to data validation procedures. The Leviathan Mine database contains data usability qualifiers based on the documentation available for each data set. The usability qualifiers in the database are not based on Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) data quality requirements and are defined in the database as indicated in Table 2 below.

Table 2. Leviathan Mine Database Usability Qualifiers

Usability Qualifier	Meaning	Description
1	High Documentation	High documentation data also includes documented source, sampling methods, lab analytical methods, and coordinates in addition to the low documentation information.
2	Low Documentation	Low documentation data includes information about the matrix, analyte, location, date, result, and units.
3	Rejected	Data records are missing one or more of the information parameters listed for low documentation level.

Quality of the existing information in the database has been assessed as part of the PWP with respect to its usefulness for supporting human and ecological risk assessment, identifying the types and quantities of COPCs present, and supporting engineering design. The data sources were evaluated to identify those data sets that may have sufficient information to support Data Quality Assessment (DQA) in accordance with DQA: A Reviewers Guide EPA QA/G9-R, February 2006. The results of this evaluation were summarized in Table 1 of the draft human health risk assessment work plan (AMEC 2010). Where sufficient documentation is not provided or available for existing information in the database to complete data validation, the data may remain useful for some RI/FS purposes. Utility of such information should be considered in light of available documentation, and comparability with similar information collected under the RI planning documents.

Findings based on the data summarized below are preliminary in nature. While these preliminary findings serve as the basis for initial data gathering in the RI, results of initial data

gathering activities should be carefully reviewed to determine if they are consistent with the data contained in the database, and preliminary findings herein. If found to be inconsistent with these findings, subsequent RI steps should be modified as necessary to reflect the new information, and further investigations adjusted accordingly. This description of inputs is intended to be a living document, and is not meant to be a definitive statement of conclusions and findings or a comprehensive summary of existing information that may be pertinent to the RI/FS. This description of inputs is intended to support more detailed development of DQOs to support development of the FRI work plans.

According to EPA QA/G4 (EPA 2006) step three identifies the types or sources of information needed to resolve decisions or produce estimates, identifies the basis of information that will guide or support choices to be made in later steps of the DQO process, and selects appropriate sampling and analysis methods for generating the information. These factors are described for each source/pathway in the following text beginning with a brief description of the basis of information, a cursory review of existing information from the Leviathan Mine database, identification of additional information needed, and description of potential sampling methods. A more detailed description of sampling and analytical methods will be provided in each of the FRI DQOs and associated work plans.

Is sufficient information available to:

1. Is sufficient information available to characterize the COPC sources and distributions, in relevant media, evaluate risks and hazards, and satisfy regulatory requirements?
2. Do COPC concentrations exceed reference and/or risk thresholds, pose an unacceptable hazard, or trigger an applicable or relevant and appropriate regulatory requirement?
3. Is risk management necessary, feasible, and practicable?

The initial study questions developed in FRI work plans for the primary sources, secondary sources and pathways will be based on available information, and information to be gathered during the RI. Information from the database is summarized below for each of the primary sources, secondary sources, and pathways. Potential new inputs are also described below.

Mine Waste

Estimates and measurements of the location, extent, physical characteristics, and chemical characteristics of mine wastes are necessary to support decision making in the RI/FS at Leviathan Mine. Decisions regarding mine waste are determined in part by Applicable or Relevant and Appropriate Requirements (ARAR), and in part through risk assessment. Potential ARARs such as portions of California Code of Regulations (CCR) Title 27 include prescriptive requirements for mine waste management. such as capping to minimize infiltration of water, and isolation from waterways. Classification of mine wastes in accordance with Title 27 depends on threats to water quality, acid-generating potential, whether the waste is readily containable and other factors. Risk assessment accounts for site-specific exposure and toxicity considerations.

These estimates and measurements will be supported in part by information from the Leviathan Mine database, and in part by collection of additional information. Sources of mine waste analytical data in the database include:

1. A 1977 University of Nevada at Reno Masters Thesis by Richard Butterfield: The Revegetation Potential of the Leviathan Mine Spoils. These data consist of agronomic soil analyses including pH of mine waste from Leviathan Mine.
2. Analytical results from field sampling performed in 1995 and 1996 by Vic Claassen and Michael Hogan of the University of California at Davis as part of revegetation efforts at the Leviathan Mine. These data consist of agronomic soil analyses of mine waste from Leviathan Mine. Measurements and analytes included pH, cation exchange capacity, organic matter, arsenic, boron, iron, manganese, and molybdenum.
3. A 1998 survey of field paste pH by SRK in mine waste at Leviathan Mine.

Information from these sources, and mineralogy and physical data for mine waste at Leviathan Mine reported by Hammermeister and Walmsley (1985) that are not included in the database are summarized below. These summaries are based on contents of the database and cursory review of Hammermeister and Walmsley (1985), and do not include review of the source documentation.

Butterfield (1977) reported information from the analysis of 13 surface samples of material described as 'spoil material' from Leviathan Mine. The locations of the spoil material samples were not included in the database, and the information is qualified as low documentation. In addition, this information was collected prior to the grading of mine wastes, construction of the ponds, and recontouring of the pit. The analytical methods used to determine metals contents are agronomic soil extraction methods, thus the resulting analytical values are not directly comparable to data generated using EPA methods and should not be used for supporting risk evaluations; however, the data may be relevant for use in evaluating the need for soil amendments for purposes of revegetation. The paste pH results (range from 2.9 s.u. to 7 s.u., mean 4.67 s.u.) are useful for evaluating the likelihood for the sampled material to create acid drainage when exposed to water.

Claasen and Hogan (1997) reported information resulting from the analysis of 30 mine waste samples collected from various areas at Leviathan Mine to evaluate soil chemistry for revegetation. The sample locations provided in the database are descriptive as to general area (for example 'surface soil from pit area'), but coordinates are not provided, and the information is qualified as rejected in the database due to lack of adequate location information. Analytical methods are not described in the database, thus comparability of these data to results from EPA analytical methods is questionable; however, the data may be useful in evaluating the need for soil amendments for purposes of revegetation. In addition, the data include cation exchange capacity and paste pH measurements. The paste pH results (range from 2.9 s.u. to 7.5 s.u., mean 4.48 s.u.) are useful for evaluating the likelihood for the sampled material to create acid drainage when exposed to water. The cation exchange capacity (CEC) results may be useful to evaluate potential ion exchange reactions as fluids migrate through the mine waste. The reported arsenic concentrations (12 samples, 40 milligrams/kilogram [mg/kg] to 720 mg/kg, mean of 262.5 mg/kg) show that mine waste at Leviathan Mine contains elevated total arsenic concentrations with respect to commonly used screening benchmarks.

SRK (1999) reported field paste pH and specific conductance (SC) measurements made at Leviathan Mine during July 1998. California State Plane Coordinate System locations of the samples are provided to the nearest 0.01 feet. The pH data are qualified as low documentation

and the field conductance data are qualified as rejected in the database. The field paste pH measurements ranged from 1.85 s.u. to 8.65 s.u. with a mean of 4.59. The SRK paste pH measurements are consistent with the earlier paste pH measurements of Butterfield (1977), and UC Davis (1997) and show that exposure of some mine waste at Leviathan Mine to water results in the generation of acid drainage. The field SC measurements range from 10 to 5,600 with a mean of 272. The units for the field SC measurements are not documented by SRK (1999). Figure 4 shows SRK's reported locations and paste pH values at the site. Some material in each area containing mine waste, including the Overburden Area, is capable of generating acid drainage when exposed to water.

Hammermeister and Walmsley (1985) collected samples of mine waste from soil borings in the Overburden Area and used X-Ray diffraction to identify the minerals present. The summary table provided by Hammermeister and Walmsley did not differentiate mine waste from in situ rock. However the shallowest samples at boring locations within mine waste contained quartz, opal, tridymite, and smectite in major quantities; pyroxene, kaolinite, chlorite, alunite, and goethite in moderate quantities; and minor anatase, chlorite, natrojarosite, sanidine and pyrite. Quantitative analysis of clay minerals in mine waste showed that smectite is much more abundant than kaolinite or illite.

Existing information supports the conclusion that some mine waste may be a source for acid drainage when exposed to oxygen and water. Existing information also documents that some mine waste contains elevated total arsenic concentrations with respect to screening benchmarks. Available topographic information may also support evaluation of the extent and physical characteristics of mine waste in each area.

Additional information regarding the mine waste is needed to evaluate ARARs, assess threats to water quality, support risk assessments, identify remedial action objectives, and support the FS. Information about mine waste used in road construction is also important. This information includes:

1. Extent of mine waste in each area.
2. Metal contents (concentration, mass, mobility, and availability) of the mine waste in each area.
3. Chemical properties of the mine waste that affect acid generation (potential sources) and COPC transport in each area.
4. Physical properties of the mine waste in each area, including properties affecting slope stability, and stability of response actions.

Suitable sampling and analysis methods for gathering this information may include, but are not limited to, high resolution geophysical surveys of the disturbed areas and surrounding areas at Leviathan Mine, mine waste sampling and field analyses (for example paste pH, field XRF), mine waste sampling and laboratory analysis for chemical and physical properties, and visual observations. Mine waste sampling technologies such as hand tools, drilling equipment, and excavation equipment may be desirable. Analytical methods will be determined by the specific goals of a given investigation activity, and should provide defensible documented analytical data

to support human health and ecological risk assessments, engineering decisions, and water quality assessment.

In situ Rock

Characterizing the quantity of acid drainage from in situ rock is necessary to evaluate the generation of acid drainage and exposure pathways and requires knowledge of the source(s) of water interacting with the rock, nature of water-rock interactions, physical characteristics (including fracture orientation and density, porosity, and permeability) of the in situ rock, extent to which in situ rock has been exposed to air and water through mining activity, and rock mineralogy. Therefore, estimates and measurements of the physical and chemical characteristics of mining impacted in situ rock and associated groundwater are necessary to support decision making in the RI/FS at Leviathan Mine.

Analytical data for in situ rock are not identified in the database. Some groundwater monitoring wells are completed within in situ rock; therefore, groundwater monitoring data exist. Historical mining records may also provide information about in situ rock characteristics.

Herbst and Sciacca (1982) mapped the geology of Leviathan Mine before grading was completed to construct the ponds and the concrete lining of Leviathan Creek. Their observations provide for the identification of geologic units and structures at Leviathan Mine.

Hammermeister and Walmsley (1985) collected samples of in situ rock from borings in the Overburden Area, landslide, and along Leviathan Creek; and used X-Ray diffraction to identify the minerals present. The summary table provided by Hammermeister and Walmsley did not differentiate mine waste from in situ rock. However the deeper samples at these boring locations contained plagioclase, smectite, orthoclase, cristobalite, and calcite in major quantities; quartz, pyroxene, and smectite in moderate quantities; and minor pyroxene, muscovite, kaolinite, pyrite, pentlandite, rhodochrosite, corellite, and quartz. Quantitative analysis of clay minerals present in in situ rock showed that smectite is much more abundant than kolinite or illite.

Existing information documents that at least one tunnel remains open within in situ rock. Most of the other underground mine workings may have been eliminated during development of the open pit. The open pit appears to have unstable high walls. Acid drainage emanating from the Adit indicates that in situ rock exposed to oxygen and water by mining activity creates acid drainage.

Additional information regarding the in situ rock is needed to identify remedial action objectives, and support the FS. This information may includes:

1. Location and extent of remaining underground mine workings.
2. Source of water contributing to acid generation from in situ rock.
3. Metal contents (concentration and mass) and mineralogy of the in situ rock disturbed by mining as necessary to assess acid generation and exposure pathways.
4. Chemical properties of selected in situ rock that affect acid generation and COPC transport.

5. Physical properties of the selected in situ rock disturbed by mining, including physical properties that support evaluation of slope stability in vicinity of the pit high wall and remaining underground mine workings.

Suitable sampling and analysis methods for gathering this information may include high resolution geophysical surveys of the in situ rock disturbed by mining and surrounding areas at Leviathan Mine, sampling and field analyses (for example water quality parameter measurement and field XRF), sampling the in situ rock and laboratory analyses for chemical and physical properties, installing monitoring wells, and sampling groundwater, hydraulic testing, and visual observations. In situ rock sampling technologies such as hand tools, drilling equipment, and excavation equipment may be desirable. Various drilling technologies and well materials are available for consideration. Analytical methods will be determined by the specific goals of a given investigation activity, and should provide defensible documented analytical data to support human health and ecological risk assessments, engineering decisions, and water quality assessment.

Acid Drainage

Estimates and measurements of the physical and chemical characteristics of acid source material, and associated water are necessary to support decision making in the RI/FS at Leviathan Mine. Capture and treatment of acid drainage requires significant effort and is not currently achievable year-round. Reducing the quantity of acid drainage discharged from Leviathan Mine would result in reducing the effort needed for capture, storage and treatment, and might make year round capture storage and treatment feasible. Reducing the quantity of acid drainage requires knowledge of the acid source(s), source(s) of water interacting with each acid source, nature of water-rock interactions, and physical characteristics (including porosity, permeability, location, and volume) of the acid source material, and source material mineralogy. Acid drainage contains COPCs at concentrations exceeding potential ARARs such as Basin Plan water quality objectives. These ARARs are based in part on risks to human and ecological receptors, and in part on degradation of beneficial uses.

The database contains abundant analytical data for acid drainage provided by the California Regional Water Quality Control Board—Lahontan Region (Regional Board), Atlantic Richfield Company, SRK (1999), and smaller amounts of information from University of Nevada at Reno, Brown and Caldwell, and EPA. The database contains significant amounts of analytical data from the Adit, Aspen Seep (Overburden Seep), CUD, Delta Seep, PUD, and lesser amounts of information from other sources of acid drainage at the site.

Regional Board data are collected as part of periodic surface water quality monitoring and as part of early response actions (ERA) at Leviathan Mine. Surface water quality monitoring is described in the Regional Board's sampling and analysis plan (Regional Board 2004). Regional Board sampling during ERAs is described in the Regional Board's annual work plan for Leviathan Mine.

Atlantic Richfield data are collected as part of source sampling during ERAs at Leviathan Mine. Atlantic Richfield sampling during ERAs is described in Atlantic Richfield's annual work plan for ERA's at Leviathan Mine.

In addition to the analytical data, flow data obtained from the United States Geological Survey (USGS) are described.

This summary focuses on the flow rate, and aluminum, arsenic, copper, iron, and sulfate contents of the Adit, Aspen Seep, CUD, and Delta Seep because these acid drainage sources represent the greatest volume of acid drainage recognized at Leviathan Mine. Most of the information used to support this discussion is from the database and was provided by the Regional Board and Atlantic Richfield.

Adit. Acid drainage from the Adit flows by gravity into Pond 1, Pond 2N, and Pond 2S. The Regional Board treats the water during each summer to prevent pond overflow and discharge to Leviathan Creek.

Acid drainage flow discharging from the Adit has been measured daily since 2001. Measured flows range from 15 gallons per minute (gpm) to 43 gpm. Adit discharge reaches a maximum each spring and a minimum each winter. Maximum flows were recorded during the spring of 2005 (about 35 gpm) and 2006 (about 43 gpm). A hydrograph for the Adit is provided in Figure 5.

The database contains analytical data from 1981 (one sample), 1982 (two samples), and monthly data from spring 1995 through spring 2008. A graph of aluminum, arsenic, iron, copper and sulfate in adit discharge over time is provided in Figure 6.

The database contains aluminum concentrations for adit drainage ranging from 28 milligrams per liter (mg/L) to 1,690 mg/L, although these two concentrations appear to be outliers. Aluminum concentrations may be decreasing from 1981 to the present; however, the lack of data from 1983 to 1995 make this observation difficult to support. Aluminum concentrations typically range from 200 mg/L to 400 mg/L. The dissolved and total aluminum concentrations are similar in most samples. Aluminum concentrations in Adit drainage increased to 300 mg/L and to 510 mg/L during 2005 and 2006, and decreased thereafter to more typical concentrations during 2007 and 2008.

The database contains arsenic concentrations for adit drainage ranging from 4.3 mg/L to 54.9 mg/L; the maximum value may be an outlier. Arsenic concentrations appear to have decreased from 27 mg/L to 35 mg/L during 1981/1982 to near 10 mg/L since 2000. Dissolved and total arsenic concentrations are generally similar, though some samples during 1998, 1999, 2002, and 2005 reported concentrations of dissolved arsenic exceeding total concentrations of arsenic. During 2005 and 2006 the arsenic concentration ranged from 12 mg/L to 21 mg/L, and decreased thereafter during 2007 and 2008.

The database contains copper concentrations for adit drainage ranging from 0.5 mg/L to 5.6 mg/L, although these maximum and minimum values may be outliers. A long-term trend in copper concentrations is not apparent in the data. Total and dissolved concentrations are generally similar, although in some samples from 1997, 1999, and 2005 dissolved concentrations exceeded total concentrations. Copper typically shows a seasonal change from about 2 mg/L during spring, to about 0.8 mg/L during summer and fall. During 1997, 1999, 2005, and 2006 the copper concentration increased above 3 mg/L, and decreased thereafter.

The database contains iron concentrations for adit drainage ranging from 65 mg/L to 2,400 mg/L. Iron concentrations appear to have decreased from above 1,000 mg/L during 1995, to more typical concentrations of 500 mg/L to 860 mg/L since the fall of 1996. Dissolved and total iron concentrations are generally similar, though in some samples from 2000 and 2003, the dissolved concentration was reported to exceed the total concentration. During 2005 and 2006 the iron concentrations increased, ranging from 1,140 mg/L and 990 mg/L respectively in the spring, to 770 mg/L and 610 mg/L respectively in the fall. During 2007 and 2008 iron concentrations remained at typical concentrations.

Sulfate data in the database are from 1968, 1981/1982, and 1995 through 2008. The database contains sulfate concentrations for adit drainage ranging from 1,600 mg/L to 12,000 mg/L. A long-term trend in sulfate data may be present, with a lower concentration in 1968 (only one data point) to higher concentrations during 1981/1982 during pond construction, and gradual decrease to 2000. However, the lack of data from the intervening years and variation in the existing data make this conclusion difficult to support. Seasonal decreases in sulfate concentration of adit discharge appear to occur from spring to fall during 1997, 1998, 1999, 2004, and 2006. Seasonal trends in sulfate concentration are not obvious during other years.

Adit drainage chemistry, as indicated by aluminum, arsenic, copper, iron, and sulfate, is consistent from 2001 to 2008, and appears to show seasonal trends for copper and sulfate during some years. Each of these analytes also increased in concentration during high flows observed in 2005 and/or 2006 compared to earlier and later years. The data suggest that long-term decreases of metal concentrations since the early 1980s may have occurred.

Aspen Seep. Acid drainage from the Aspen Seep discharges from an area to the southwest of Aspen Creek and flows through an inlet pipe and weir box to the Aspen Seep bioreactor. The bioreactor reduces sulfate to sulfide and precipitates metal sulfides while increasing the pH of the acid drainage prior to year round discharge to Aspen Creek.

Acid drainage flow discharging from the Aspen Seep has been measured since 1998. Measured flows range from less than 1 gpm to about 70 gpm. Aspen Seep discharge fluctuates seasonally from maximums each spring to minimums each fall. Maximum flows were recorded during the spring of 1999 (about 72 gpm) and 2002 (about 40 gpm). Aspen Seep flow exceeded 20 gpm during the spring in both 2005, and 2006. A hydrograph for the Aspen Seep is provided in Figure 7.

The database contains monthly analytical data from August 1995 to August 1996, every other month through fall 1997, and monthly data from fall 1997 through fall 2008. The sampling point at Aspen Seep has changed over time as the area around the seep was modified during ERAs. Figure 8 is a graph of aluminum, arsenic, iron, copper and sulfate in Aspen Seep discharge over time.

The database contains aluminum concentrations for Aspen Seep drainage ranging from 0.073 mg/L to 230 mg/L, although these maximum and minimum concentrations may be outliers. Aluminum concentrations appear to show a variable trend from 50 mg/L to 60 mg/L during the late 1990s, to 15 mg/L to 40 mg/L from 2000 to 2004 and above 50 mg/L during 2005/2006 and below 50 mg/L during 2007 and 2008. Total and dissolved aluminum concentrations are generally similar.

The database contains arsenic concentrations for Aspen Seep drainage ranging from below detection limits (0.001 mg/L) to 0.1 mg/L, arsenic concentrations appear to be randomly distributed within this range. For most of the data, dissolved and total arsenic concentrations are similar. In the April 25, 2007 sample, the dissolved concentration was reported to exceed the total concentration. No consistent pattern is observed in the Aspen Seep arsenic concentration data.

The database contains copper concentrations for Aspen Seep drainage ranging from 0.005 mg/L to 6.13 mg/L, although these maximum and minimum concentrations may be outliers. Copper concentrations show a variable long-term trend from 1 mg/L to 2 mg/L from 1997 to 2001, to about 0.7 mg/L from 2002 to 2004, and 1 mg/L to 3 mg/L from 2005 to 2007, and declining to below 1 mg/L in 2008. Superimposed on this long-term trend is a seasonal trend from higher concentrations in spring to lower concentrations in fall during 2002, 2003, 2004, and 2006. Total and dissolved copper concentrations are similar.

The database contains iron concentrations for Aspen Seep drainage ranging from 0.11 mg/L to 580 mg/L. The minimum and maximum concentrations may be outliers. Iron concentrations are typically around 100 mg/L. Dissolved and total iron concentrations are generally similar, and seasonal trends are not obvious. During 2005 and 2006, the iron concentrations increased, compared to 2004. Iron concentrations in 2007 and 2008 were lower than those in 2006.

The database contains sulfate concentrations for Aspen Seep ranging from 1,312 mg/L to 4,300 mg/L. The sulfate concentration in Aspen Seep is variable with no obvious long term or seasonal patterns. During 2003 to early 2005, the range of sulfate concentrations was narrower than during earlier and later years. Sulfate concentrations were also lower during this period (around 1,500 mg/L) than during the rest of the period for which data are available.

Aspen Seep drainage chemistry, as indicated by aluminum, arsenic, copper, iron, and sulfate, is consistent from 2001 to 2008, and appears to show seasonal trends for copper during most years. Each of these analytes also increased in concentration during high flows observed in 2005 and/or 2006 compared to earlier and later years.

Channel Underdrain. Acid drainage from the CUD discharges from a pipe beneath the downstream end of the concrete channel of Leviathan Creek and flows through a weir box. During the treatment season (June 1 to October 1) CUD discharge is captured for treatment prior to discharge to Leviathan Creek. When not captured for treatment, acid drainage from the CUD discharges from the weir box to Leviathan Creek.

Acid drainage flow discharging from the CUD has been measured daily since November 1999. Measured flows ranged from 8 gpm to 64 gpm. CUD discharge reaches a maximum each spring and a minimum each winter. Maximum flows were recorded during the spring of 2005 (about 40 gpm) and 2006 (about 64 gpm). A hydrograph for the CUD is provided in Figure 9.

The database contains analytical data from the years 1994 (4 samples), 1995 (8 samples), 1996 (10 samples), 1997 (5 samples), and monthly samples from 2001 through October 2009. Figure 10 is a graph of aluminum, arsenic, iron, copper and sulfate in CUD discharge over time.

The database contains aluminum concentrations for CUD drainage ranging from 0.04 mg/L to 120 mg/L, although these maximum and minimum concentrations may be outliers. Aluminum

concentrations appear to show a variable trend from about 40 mg/L to above 60 mg/L during the middle to late 1990s, to about 20 mg/L to 50 mg/L from 2000 to 2004, above 40 mg/L during 2005/2006, and below 40 mg/L during 2007 and 2008. Superimposed on this long-term trend are seasonal changes from higher aluminum concentrations in the spring to lower concentrations in the fall. Total and dissolved aluminum concentrations are generally similar.

The database contains arsenic concentrations for CUD drainage ranging from below detection limits (0.001 mg/L) to 2.09 mg/L, although these maximum and minimum concentrations may be outliers. Arsenic concentrations appear to show a seasonal fluctuation from higher concentrations in the spring to lower concentrations in the fall. Dissolved and total arsenic concentrations are similar.

The database contains copper concentrations for CUD drainage ranging from 0.005 mg/L (the detection limit) to 0.5 mg/L, although these minimum and maximum concentrations may be outliers. Copper concentrations show seasonal fluctuations from higher concentrations in spring to lower concentrations in fall during most years. Total and dissolved copper concentrations are similar, though in April 1995 the dissolved concentration exceeded the total concentration.

The database contains iron concentrations for CUD drainage ranging from 0.015 mg/L to 677 mg/L, although the minimum concentrations may be outliers. Iron concentrations in CUD discharge are typically around 300 mg/L to 400 mg/L. Iron concentrations show seasonal fluctuations from higher concentrations in the spring to lower concentrations in the fall during most years. In addition, the range of concentrations was smaller during the four years from late 1999 to late 2003. During 2005 and 2006, the iron concentrations increased, compared to 2004. Iron concentrations in 2007 and 2008 were lower than those in 2006. Dissolved and total iron concentrations were generally similar.

The database contains dissolved and total sulfate concentrations. This summary is based on dissolved sulfate concentrations for CUD ranging from 1,400 mg/L to 5,200 mg/L. The sulfate concentration in CUD is variable with no obvious seasonal patterns. During late 2002 to late 2004 the range of sulfate concentrations was narrower and lower than during earlier and later years.

CUD drainage chemistry, as indicated by aluminum, arsenic, copper, iron, and sulfate is consistent from 2001 to 2008, and appears to show seasonal trends for aluminum, arsenic, copper, and iron, with higher concentrations in the spring during most years. Each of these analytes also increased in concentration during high flows observed in 2005 and/or 2006 compared to earlier and later years.

Delta Seep. Some of the acid drainage from the Delta Seep is captured in a tank at the bottom of the Delta Slope adjacent to the channel of Leviathan Creek. During the treatment season (June 1 to October 1) a portion of the Delta Seep discharge is captured for treatment prior to discharge to Leviathan Creek. When not captured for treatment, acid drainage from the Delta Seep discharges from the tank to Leviathan Creek.

Accurate flow measurements are not available for the Delta Seep. The portion of flow intercepted during the treatment season is documented by Atlantic Richfield. However, a portion of the Delta Seep flow continues to discharge to Leviathan Creek throughout the treatment season.

The database contains analytical data from the years 1998 and 1999 (2 samples each year), and data collected during the Atlantic Richfield treatment season for the years 2000, 2001, and 2003 through 2009. Figure 11 shows metal concentrations over time for Delta Seep. The sample location at Delta Seep has not been stationary over time due to the diffuse area of discharge prior to installation of the interception system.

The database contains aluminum concentrations for Delta Seep drainage ranging from 0.04 mg/L to 29 mg/L, although these extreme concentrations may be outliers. Aluminum concentrations appear to show an increasing trend beginning in 2005. Aluminum concentrations varied from about 1 mg/L to 5 mg/L from 1998 through 2004. From 2005 through 2009 aluminum concentrations varied up to 29 mg/L. Seasonal changes from higher aluminum concentrations in the spring to lower concentrations in the fall appear to be superimposed on this long-term trend. Total and dissolved aluminum concentrations are generally similar.

The database contains arsenic concentrations for Delta Seep drainage ranging from below detection limits (0.001 mg/L) to 0.299 mg/L. Although, the extreme concentrations (high and low) may be outliers. From 1998 through 2003, arsenic concentrations were not higher than about 0.1 mg/L. During 2004 and 2005 total arsenic concentrations exceeded 0.1 mg/L. Since 2008, arsenic concentrations below 0.05 mg/L are more common. Seasonal fluctuations in arsenic concentrations at the Delta Seep are not obvious in the available data. Dissolved and total arsenic concentrations are not similar at the Delta Seep.

The database contains copper concentrations for Delta Seep drainage ranging from 0.005 mg/L (the detection limit) to 0.235 mg/L, although these extreme concentrations may be outliers. Copper concentrations appear to show seasonal fluctuations from higher concentrations in the spring to lower concentrations in the fall during 2003, 2004, 2005, 2008, and 2009. Maximum copper concentrations at Delta Seep appear to increase from 2005 through 2008, and decline in 2009. Total and dissolved copper concentrations are similar, although in April 2000 the dissolved concentration was reported as exceeding the total concentration.

The database contains iron concentrations for Delta Seep drainage ranging from 0.015 mg/L to 210 mg/L, although the extreme concentrations may be outliers. Iron concentrations in Delta Seep discharge are typically less than 50 mg/L. Seasonal fluctuation of iron concentrations is not obvious in the available data; this may be a function of the few months each year during which samples were collected. The maximum iron concentrations increased in 2005 and have remained higher than pre-2005 maxima through 2009. Dissolved and total iron concentrations are generally similar.

The database contains sulfate concentrations for Delta Seep drainage ranging from 520 mg/L to 3,100 mg/L. The sulfate concentration in Delta Seep drainage is variable between about 1,000 mg/L and 1,500 mg/L (with the exception of 2 maxima) with no obvious seasonal patterns. The lack of seasonal patterns may be due to the few months each year that samples were collected.

Delta Seep drainage chemistry as indicated by aluminum, arsenic, copper, iron and sulfate is consistent from 2001 to 2008, and appears to show an increase for aluminum, arsenic, copper, and iron in 2004 and/or 2005. Seasonal patterns for aluminum and copper may be present, and are not obvious in the other data for Delta Seep, likely because of the limited number of samples each year.

Acid Drainage Summary. Acid drainage may transport COPCs from in situ rock and mine waste to surface water and groundwater. Existing information can be used to evaluate the quantity of acid drainage and the mass of COPCs discharged from known sources annually. Additional information regarding acid drainage is necessary to support risk assessments, identify remedial action objectives, and support the FS. This information may include:

1. The locations of the source of acidity.
2. The location and extent of material that is a source of acidity.
3. The source(s) of water that contributes to creation of acid drainage.
4. The quantity of water that creates acid drainage.
5. The extent of acid drainage in the subsurface.
6. The quantity of acid drainage present.
7. The quantity of acid drainage created annually.
8. The relationships between the known/discrete discharges and other acid drainage occurrences (for example the acid marsh, and the acid springs in the overburden pile and below the ponds).
9. Water balance.
10. Effect of storm water on acid drainage chemistry and volume.

Suitable sampling and analysis methods for gathering this information may include high resolution geophysical surveys of Leviathan Mine and surrounding areas, sampling and field analyses (for example water quality parameter measurement), sampling the acid source material and laboratory analyses for chemical and physical properties, installing monitoring wells and sampling groundwater, hydraulic testing, and visual observations. Acid source material sampling technologies such as hand tools, drilling equipment and excavation equipment may be desirable. Various drilling technologies and well materials are available for consideration. Analytical methods will be determined by the specific goals of a given investigation activity, and should provide defensible documented analytical data to support human health and ecological risk assessments, engineering decisions, and water quality assessment.

Surface Water

Measurements and estimates of surface water flow rates, COPC concentration in surface water, effects of storm water runoff on COPCs in surface water, and extent of COPCs in surface water are important to determine if concentrations or loads are above levels of concern. This information and chemical characteristics of the surface water are needed to evaluate potential remedies in the FS. Levels of concern for surface water are identified in potential ARARs such as the Clean Water Act (CWA) and California Water Code. Numerical and narrative water quality objectives for surface water are stated in the Basin Plan prepared by the Regional Board. Risk assessment during the RI will also identify surface water levels of concern including reference levels.

Surface water information in the database includes analytical data, flow measurements and meteorological data. Only a limited set of On Property meteorological data are included in the database. A more complete set of weather data for Monitor Pass (about 3 miles east of Leviathan Mine) is accessible at the Snotel website at:

http://www.wcc.nrcs.usda.gov/snotel/California/california.html.

Due to the small amount of site-specific meteorological information, this discussion is focused on the flow and COPC concentration data from the site. It is possible that the on-site meteorological data could be correlated to the Snotel information to support use of the Snotel information in addressing site-related questions.

Flow Data

The database contains flow measurement from numerous locations along Leviathan, Aspen, and Bryant Creeks and the EFCR from a variety of sources. This discussion will focus on flow measurements made by the USGS at Stations 15 (Leviathan Creek below the mine) and 25 (Bryant Creek below Mountaineer Creek) that are available at the following web address: http://waterdata.usgs.gov/ca/nwis/current?type=flow. Flow at these two stations has been measured nearly continuously since October 1998 (Station 15) and November 1998 (Station 25). The flow characteristics at Stations 15 and 25 are believed to be representative of flows at other stations near the site.

Figure 12 shows hydrographs for mean daily flow observed at Stations 15 and 25. Figure 13 is the annual hydrograph for Station 15. The hydrographs show the minimum, mean, and maximum daily flows at both stations based on 11 years of flow measurement. At any specific time, the flow at Station 25 on Bryant Creek is significantly higher than the flow at Station 15 on Leviathan Creek, reflecting the relative sizes of the watersheds and consistent with Leviathan Creek being a tributary to Bryant Creek. Both hydrographs show an annual seasonal pattern to the flow with maximum flow in late April to May, declining flows to minimums from June through September, and increasing flows from October to April.

Superimposed on this annual cycle are sharp maximums in winter and spring at both stations, and sharp maximums occurring mid June through October that are most pronounced at Station 15. The winter and spring maximums are associated with storm events manifested in the hydrographs at both stations. The summer to fall maximums are associated with periodic discharges from seasonal treatment systems at Leviathan Mine, and are pronounced at Station 15 and barely discernable at Station 25. Similarly, the measured summer to fall minimums at Station 15 are extremely low (zero) due to interception of acid drainage during the treatment season.

Analytical Data

Sporadic analytical data from a variety of sources are available for Leviathan, Aspen, and Bryant Creeks; and the EFCR from 1957 through the 1990s. Webster and others (1994) evaluated transport of metals in Leviathan and Bryant Creeks based on information collected in 1982. Their paper is summarized herein. The Regional Board has conducted regular surface water

monitoring since 1998. The remainder of this discussion focuses on data from Station 15 and Station 25 collected by the Regional Board.

Webster and Others. This paper reflects conditions before Leviathan Creek at Leviathan Mine was lined with a concrete channel to prevent contact with mine waste and before the storage ponds were constructed to contain adit and PUD flows. Nevertheless, the observations they made are relevant to the fate and transport of COPCs from Leviathan Mine. Webster and others (1994) noted that during periods of high rainfall, the mainstream of Bryant Creek became turbid and appeared to carry a load of suspended iron precipitate.

Webster and others also determined through evaluation of mass flows, that arsenic was attenuated to background levels by precipitation as iron oxhydroxysulfate by the time flows reached Station 25, during June. During the lower mass flows observed in October, attenuation of arsenic was not observed, and attenuation of iron occurred down to the confluence with Doud Creek. Copper and zinc were not attenuated in June and their mass flow rate declined slightly to the confluence with Doud Creek. Copper and zinc were attenuated by the time flow reached Doud Creek at the lower mass flow rate observed in October.

Regional Board. This summary focuses on aluminum, arsenic, copper, iron, and sulfate in surface water at Station 15 and Station 24. Station 15 data represent concentrations in upper Leviathan Creek near the mine site, and Station 24 represents concentrations in lower Leviathan Creek above Mountaineer Creek and downstream from Aspen Creek.

Station 15

Figure 14 shows dissolved aluminum, arsenic, copper, iron and sulfate concentrations for Station 15 from the database.

The database contains dissolved aluminum concentrations at Station 15 ranging from 0.013 mg/L to 270 mg/L. The range of aluminum concentrations appears to show a decreasing trend since 2001. Aluminum concentrations regularly exceeded 10 mg/L during low flow periods from 1994 through 2001. From 2002 through 2008, aluminum concentrations remained below 10 mg/L except for November 29, 2006, when the concentration was 14 mg/L. Seasonal changes from lower aluminum concentrations in the spring to higher concentrations in the summer and fall appear to be superimposed on this long-term trend. Total and dissolved aluminum concentrations are generally similar.

The database contains dissolved arsenic concentrations at Station 15 ranging from 0.0005 mg/L to 7.1 mg/L. The range of arsenic concentrations and maximum arsenic concentrations appear to have decreased since 1995 when periodic sampling began. Prior to 2000, arsenic concentrations regularly exceeded 0.1 mg/L, and ranged from less than 0.01 mg/L to above 1 mg/L. Since 2000, all reported arsenic concentrations are below 0.1 mg/L, and the minimum concentrations are consistently lower than pre-2000 minimum concentrations. Since 2000, a cycle of maximum concentrations in the winter to lower concentrations during spring runoff, with increase in the spring as runoff diminishes, decrease to a minimum during summer treatment seasons, and increase from fall to winter, is present in the data. Total and dissolved arsenic concentrations are generally similar in post 2000 data. Prior to 2000, the dissolved arsenic concentrations occasionally exceeded the total arsenic concentrations.

The database contains dissolved copper concentrations at Station 15 ranging from detection limits (varied from 0.000072 mg/L to 0.01 mg/L) to 2.3 mg/L. The maximum copper concentrations appear to have decreased since 1995 when periodic sampling began. Prior to 1999, copper concentrations above 0.15 mg/L appear to have been a regular seasonal occurrence in the spring. Since 2000, maximum copper concentrations have exceeded 0.1 mg/L only two times (January 2003 and March 2008). A seasonal change from higher to lower concentrations may occur from winter to summer of 1997, 1998, 1999, 2000, 2002, 2003, 2004, and 2005. Total concentrations are similar to or higher than dissolved concentrations except for pre-2000 data in which some dissolved copper concentrations exceed total copper concentrations.

The database contains iron concentrations at Station 15 ranging from detection limits (varies from 0.002 mg/L to 0.1 mg/L) to 490 mg/L. The maximum iron concentrations appear to have decreased since 1995 when periodic sampling began. Prior to 2000, iron concentrations above 50 mg/L appear to have been a periodic seasonal occurrence in the fall and winter. Since 2001, only one concentration exceeding 50 mg/L (96 mg/L in August 2006) has been reported. Prior to 2000, an annual cycle from higher winter concentrations of iron, to lower concentrations during spring runoff, followed by increasing concentrations through summer and fall appears to be present. Since 2000, a more complex cycle is present in the data with higher concentrations in the winter, decreasing concentrations during spring runoff, an increase in the spring as runoff diminishes, decrease to a minimum during summer treatment seasons, and increase in mid-autumn. Total iron concentrations are similar to or higher than dissolved concentrations except for pre-2000 data in which some dissolved iron concentrations exceed total iron concentrations.

The database contains sulfate concentrations at Station 15 ranging from 60 mg/L to 3,400 mg/L. A long-term trend in sulfate concentrations at Station 15 is not apparent in the data. Two seasonal patterns appear to be present in the data. The earlier pattern for data before 2000 consists of an annual maximum in winter (January or February) and annual minimum in spring (April or May) that appears to correspond with the seasonal runoff patterns. The later pattern is for data since 2000 and consists of an annual minimum in the spring (April or May during most years) and maximum in the summer (July, August, September) that appears to correspond with seasonal runoff patterns and seasonal treatment of acid drainage at the site. This pattern shows a distinct fall to winter ‘shoulder’ of intermediate sulfate concentrations, particularly during 2000, 2003, and 2004.

Aluminum, arsenic, copper, iron, and sulfate concentrations measured through time at Station 15 appear to record a long-term decrease in concentrations of aluminum, arsenic, copper and iron. This decrease may be related to seasonal treatment activity at the CUD, Delta Seep, and ponds. Similarly, annual sulfate concentration trends record a change from the timing of concentration maximum from winter to summer/fall, apparently coinciding with implementation of regular seasonal treatment activity.

Station 23.

Figure 15 shows the dissolved aluminum, arsenic, copper, iron, and sulfate concentrations at Station 23. The database contains dissolved aluminum concentrations at Station 23 ranging from detection limits (0.02 mg/L to 0.25 mg/L) to 100 mg/L. Aluminum concentrations may have declined from a mean concentration of about 3.8 mg/L to a mean concentration of about 0.1 mg/L from before 2002 to after 2002; seasonal changes from higher aluminum

concentrations in the late winter/early spring to lower concentrations in the early summer, followed by higher concentrations during late summer and fall, appear to be present for 1998 through 2000. Seasonal concentration changes from spring highs to summer lows followed by autumn increases and winter decrease occur from 2004 through 2008. Total aluminum concentrations are generally higher than dissolved aluminum concentrations.

The database contains dissolved arsenic concentrations at Station 23 ranging from detection limits (0.001 mg/L to 0.01 mg/L) to 2.5 mg/L. The range of arsenic concentrations and maximum arsenic concentrations appear to have decreased since September 2002. Prior to November 2002, arsenic concentrations periodically exceeded 0.01 mg/L. Since November 2002, all arsenic concentrations are below 0.01 mg/L. A large number of non-detects from 1999 to 2002 make seasonal arsenic concentration cycles difficult to identify at Station 23. Seasonal concentration changes are not clear from the data, though a tendency for winter highs with lower concentrations in spring followed by increases in late spring may be present in data since 2002. Dissolved arsenic concentrations are generally below total arsenic concentrations.

The database contains dissolved copper concentrations at Station 23 ranging from detection limits (varied from 0.00026 mg/L to 0.02 mg/L) to 0.08 mg/L. The copper concentrations appear to have decreased since early 2002. Prior to 2002, copper concentrations were frequently reported above 0.01 mg/L. Since 2002, maximum copper concentrations have exceeded 0.01 mg/L only one time in July 2005. Seasonal patterns in copper concentrations are not obvious at Station 23. Total copper concentrations are above dissolved copper concentrations with a few exceptions.

The database contains iron concentrations at Station 23 ranging from detection limits (varies from 0.003 mg/L to 0.5 mg/L) to 150 mg/L. The iron concentrations appear to have decreased since November 1999. Prior to November 1999, concentrations above 10 mg/L were reported periodically. Since November 1999, concentrations above 10 mg/L were reported only in June and July 2005. Since 2003, annual seasonal variations of iron appear to be present with maximum spring concentrations and lower early summer concentrations. Total iron concentrations are similar to or higher than dissolved concentrations.

The database contains sulfate concentrations at Station 23 ranging from 70 mg/L to 1,700 mg/L. Sulfate concentrations appear to have remained similar throughout the sampling period. A seasonal pattern appears to be present with an annual minimum in spring (March, April or May) and annual maximum through late summer (July, August, or September) followed by a decrease through winter, that may correspond with the seasonal runoff and treatment patterns.

Aluminum, arsenic, copper, iron, and sulfate concentrations measured through time at Station 23 appear to record a long-term decrease in concentrations of aluminum, arsenic, copper, and iron in surface water. This decrease, may be related to seasonal treatment activity at the Aspen Seep, CUD, Delta Seep, and ponds. Annual aluminum, iron and sulfate concentration trends appear to correspond to seasonal changes in runoff patterns and implementation of regular seasonal treatment activity.

Surface Water Summary. Existing flow data document seasonal flow patterns throughout the Leviathan Creek watershed. These flow data show that flows peak due to spring runoff, and due to intense storms during spring, summer, and fall. The flow data also suggest that flow within

Leviathan Creek downstream from the mine is dominated by seasonal treatment system effluent discharge during the treatment season.

Existing analytical information documents that COPCs are discharged from Leviathan Mine to Leviathan Creek above acceptable concentrations. This information also documents that seasonal treatment may limit site-related COPC concentrations above acceptable limits in surface water to Leviathan Creek. The data also appear to show that even with consistent seasonal treatment, COPC concentrations are detectable within Leviathan Creek to Station 23, suggesting that COPCs continue to be transported downstream and away from Leviathan Mine via surface water.

Additional evaluation of the existing flow and analytical data should be completed (and additional information collected as needed) to support risk assessments, identify remedial action objectives, and support the FS. This information may include:

1. The extent of site-related COPCs from Leviathan Mine in surface water.
2. The nature of surface water-groundwater interactions.
3. The nature of surface water-sediment interactions.
4. The effect of high intensity rainfall/runoff events on site-related surface water COPC transport at Leviathan Mine.
5. The effect of mine waste in sediment on site-related COPC concentrations in surface water.
6. Surface water and site-related COPC chemistry and chemical reactions.
7. Water balance.
8. Expected flows for a 100 year storm during an average water year, and during a 100-year water year.

Abundant information is available to begin evaluating these factors. Additional information needs should be identified after evaluating the existing information related to the factors above. Sampling and analysis methods for gathering additional information may include flow measurement, precipitation (rainfall and snow) measurement, storm water sampling and analyses, surface water sampling and analyses, and field parameter measurement. This information should be collected, as needed, to supplement the existing information.

Biota

Determining if biota in Leviathan Creek, Bryant Creek, and/or EFCR are accumulating site-related COPCs from Leviathan Mine at levels that pose an unacceptable risk to receptors requires knowledge of the biota present, and the levels of COPCs expected in biota from similar reference areas not impacted by Leviathan Mine. Determining if biota are useful as an integrated measure of risks from Leviathan Mine requires knowledge of the biota present, their life stages and role in the food web, and COPC concentrations over differing time scales ranging from a few weeks to several years. In addition to these considerations, the significance of the biota to traditional human foragers should be considered when identifying the biota to be assessed.

Therefore, information needed to complete the RI/FS at Leviathan Mine includes observation and quantification of the relevant biota present in the Leviathan-Bryant and EFCR watersheds; identity of biota of special interest to the Washoe Tribe of Nevada and California; and presence of special status species, site-related COPC concentrations of the selected biota, and similar information for reference watersheds.

Information regarding biota contained in the database includes toxicity testing conducted in 1998, an electrofishing census completed in 1998, fish tissue analyses from 1998, streambed sediment and crayfish tissue analyses from 1998, benthic macroinvertebrate counts from 1968, 1982, and 1995 through 2003, and benthic macroinvertebrate tissue analyses from 1992, 1998, 1999, and 2001. This information provides detailed counts of benthic macroinvertebrates, a snapshot of macroinvertebrate tissue concentrations for a limited number of COPCs, snapshots of fish populations in the Leviathan-Bryant watershed, and fish tissue COPC concentrations in the EFCR at Bryant Creek and Ruhenstroth Dam. The database does not contain information supporting the quantification of vegetation types, or terrestrial vertebrate populations, or their COPC concentrations in the Leviathan-Bryant watershed.

In addition to information in the database, David Evans and JBR Environmental Consultants (2004) completed a report of investigation of concentrations of metals in vegetation, sediment, and floodplain soils from stream reaches downstream from Leviathan Mine, and stream reaches identified as reference areas. The information in this report should also be considered in future FRI planning efforts.

The summary of information from the database below describes benthic macroinvertebrate counts as reported by Herbst (2009) which includes benthic macroinvertebrate counts through 2006; and fish and benthic macroinvertebrate tissue analyses from Thompson and Welsh (1999).

Counts of Benthic Macroinvertebrates. Bioassessment monitoring of aquatic invertebrates such as insects has been conducted since 1995 in streams of the Leviathan Mine watershed to provide an ecological evaluation of acid drainage effects on aquatic life. Aquatic macroinvertebrate bioassessment was used to define the spatial extent of biological impacts in the Leviathan-Bryant Creek watershed in 1995, 1997, and 1998 through 2005, with most sampling also attempting to evaluate seasonal changes through sampling in June and September. These data help to establish the existing condition of the benthic invertebrate community in receiving waters and reference streams, and documented seasonal and year-to-year changes and natural variability.

Data were analyzed using descriptive statistics and graphical contrasts among sites and by season and time. The primary metrics used in interpreting community structure and biological integrity were based on measures of diversity, tolerance, density, and dominance. Mean taxa richness is a measure of overall taxonomic diversity for each site and should increase with heterogeneity of habitat, spatial, and food resources. Mean EPT richness index is a measure of the diversity of generally sensitive insects belonging to the mayfly (Ephemeroptera), stonefly (Plecoptera) and caddisfly (Trichoptera) orders and will increase in clean, cold, well-oxygenated waters exposed to minimal chemical pollution or habitat alteration (calculated as the sum number of taxa in these groups in each sample). The biotic index is a composite measure of overall community tolerance to pollution and will increase (over a scale of 0-10) as water and habitat quality are degraded (it is calculated as the product of relative abundance and tolerance value for each taxon, summed

overall taxa). Dominance is a measure of the relative abundance of the most common taxon and levels above 50% of the total community often indicate an imbalance or disturbance in food or habitat resources that permit one or a few species to dominate. Invertebrate density is often quite variable and unreliable as an indicator, but when pollution is severe, density of even tolerant taxa can be reduced as stream conditions become unsuitable for life.

Annual and seasonal trends for selected sites over the monitoring period 1997-2006 are presented in Figures 16 and 17 (from Herbst 2009). The taxa richness (Figure 16) shows that this measure of total diversity is typically in the range of 35 to 50 taxa at the Mountaineer reference site, and previously less than about 30 at the acid drainage-exposed sites. Improving trends were apparent up until 2003-2004 at all sites, including early signs at Leviathan Creek nearest the mine.

Bioassessment monitoring in the Leviathan Mine watershed has shown clear and consistent signals of progressive improvement in biological integrity on sites through 2004. Surveys performed in spring and fall of 2005 and 2006 showed that the populations at Leviathan Creek sites and Aspen Creek lost richness and density, and comprised more pollution-tolerant types of taxa. Sites on Bryant Creek (below Mountaineer Creek) were approaching the reference stream condition in several indicators including diversity and tolerance measures but have not yet reached this level consistently.

Dr. Herbst has also noted that factors not related to discharges from Leviathan Mine have also affected macroinvertebrates in the Bryant Creek watershed. The extent to which grazing, irrigation withdrawls, and extreme hydrologic conditions have affected benthic invertebrate community indices in Bryant Creek is unclear.

Fish Tissue Analyses. The fish tissue data are from a limited number of locations, and may be affected by return of diverted irrigation water from the River Ranch to EFCR upstream from the confluence with Bryant Creek. The fidelity of the fish to the sampling locations (the fish may move between sampling locations over time) may also affect the data. Thus, conclusions based on this information should be regarded as tentative.

The database includes analyses of whitefish liver and muscle tissue reported as mg/kg wet weight. The whitefish were collected in October 1998 from EFCR at a location just upstream from Bryant Creek, just downstream from Bryant Creek, and at Ruhenstroth Dam. The fish tissue samples were analyzed for silver, aluminum, arsenic, cadmium, cobalt, chromium, copper, iron, mercury, manganese, nickel, lead, selenium, vanadium, and zinc. Figure 18 presents graphs of metals in whitefish liver and muscle tissue. Liver tissue results are generally similar from the three locations, though the Ruhenstroth sample contains the highest reported cadmium and copper concentrations. Muscle tissue results are generally similar from the three locations, though the samples from EFCR downstream of Bryant Creek and Ruhenstroth contain higher nickel and cadmium than the sample from EFCR upstream of Bryant Creek. Muscle tissue from the Ruhenstroth location also contains the highest concentrations of cobalt and manganese. Mercury is highest in whitefish liver and muscle from EFCR upstream of Bryant Creek. Arsenic was not detected in any of the fish tissue samples.

Mayfly and Caddisfly Analyses. The database includes analyses of mayfly and caddisfly by Thompson and Welsh (1999) from locations along Leviathan, Aspen, Mountaineer, and Bryant Creeks and EFCR. Thompson and Welsh provided other information such as mountain whitefish

muscle and liver analyses from EFCR. This discussion focuses on the mayfly and caddis whole body analyses because they support comparisons in the vicinity of Leviathan Mine downstream to the vicinity of Dresslerville, Nevada.

The caddisfly and mayfly data are reported as parts per million (ppm) whole body dry weight and include analysis for total silver, aluminum, arsenic, cadmium, cobalt, chromium, iron, and mercury, manganese, nickel, lead, selenium, vanadium, and zinc.

Figure 19 is a graph of aluminum, arsenic, copper, iron and zinc concentrations in Caddisfly from above Leviathan Mine to the vicinity of Dresslerville. The first three points on the graph are samples from Leviathan and Aspen Creek above Leviathan Mine, and Mountaineer Creek. These three points are considered to represent upgradient conditions, not impacted by Leviathan Mine. The fourth point on the graph is from Station 25 in Bryant Creek downstream from the confluence of Leviathan and Mountaineer Creeks, and downstream from Leviathan Mine. Each of the metals shows a significant increase in caddisfly from the three upgradient locations to the downgradient location in Bryant Creek. Concentrations of iron and aluminum drop to near upgradient concentrations in caddisfly from Bryant Creek near Barney Riley Creek, and then increase to the confluence with EFCR. Iron and aluminum concentrations continue to increase within EFCR to the Riverview Bridge, the most downgradient sample location. Concentrations of arsenic and zinc in caddisfly remain nearly constant to the confluence with EFCR, and then decrease downstream to the Riverview Bridge. Arsenic remains elevated above upgradient sample concentrations, and zinc approaches upgradient sample concentrations. The concentration of copper gradually declines to the confluence with EFCR, approaching upgradient concentrations, and remains at this concentration to Riverview Bridge.

Figure 20 is a graph of aluminum, arsenic, copper, iron and zinc concentrations in mayfly from above Leviathan Mine to the vicinity of Dresslerville. The first three points on the graph are samples from Leviathan and Aspen Creek above Leviathan Mine and Mountaineer Creek. The fourth point on the graph is from Station 25 in Bryant Creek downstream from the confluence of Leviathan and Mountaineer Creeks. Mayfly concentrations are similar to caddisfly concentrations in that metals in mayfly increase significantly at Station 25 in comparison to upgradient mayfly concentrations. At and below the confluence with EFCR, mayfly concentrations of arsenic, copper, and zinc decrease to near upgradient concentrations and remain nearly constant downstream, with arsenic and copper showing slight increases between Ruenstroth Dam and Riverview Bridge. Iron and aluminum concentrations in mayfly decrease from the confluence with EFCR to Riverview Bridge.

For both caddisfly and mayfly , the iron and aluminum concentrations increase in EFCR upstream from the confluence with Bryant Creek, and are similar to the Bryant Creek concentrations in the EFCR downstream samples. The other metals decrease in the EFCR upstream samples and increase in the EFCR downstream samples.

Biota Summary. The macroinvertebrate count data provide a way to assess the health of the watershed downstream from Leviathan Mine, and appear to show that seasonal treatment activity has lead to an improvement in watershed health.

The fish tissue data appear to show that cadmium and copper concentrations in whitefish liver at Ruhenstroth; and nickel, cadmium, cobalt, and manganese concentrations in whitefish muscle from EFCR downstream from Bryant Creek, and at Ruhenstroth were higher than in whitefish

tissue samples from EFCR upstream from Bryant Creek. Other tissue metals concentrations were similar among the three sample locations.

The mayfly and caddisfly data suggest that metals were accumulated by mayfly and caddisfly throughout Bryant Creek in September 1998. The mayfly and caddisfly data also suggest that biota may be useful as indicators of exposure to COPCs, although some assessment of the bioavailability of macroinvertebrate body burdens to higher trophic level organisms may be needed.

Additional information necessary to support risk assessment and identify the need for remedial action may include:

1. The biota (terrestrial, aquatic, invertebrate, vertebrate, plants, animals) of interest for use in monitoring exposures to COPCs from Leviathan Mine.
2. The time scale for biota measurements.
3. Seasonal and temporal effects on biota measurements.
4. Effects of irrigation withdrawls, grazing and other habitat factors on biota measurements.
5. The spatial scale for biota measurements.
6. Acceptable levels and bioavailability of metals in biota .
7. Reference area levels of metals in biota.
8. Leviathan-Bryant-EFCR levels of metals in biota tissue.

Limited information is available to evaluate accumulation of COPCs in biota at Leviathan Mine. Additional information will need to be collected in the RI. Investigation methods for collecting the additional information may include literature review, consultation with agency personnel, vegetation surveys, stream surveys, aquatic and terrestrial biota collection and sampling, and laboratory analysis.

Sediment

Estimates and measurements of the location, physical characteristics, and chemical characteristics of site-impacted sediment and water in the Bryant Creek and EFCR watersheds may be necessary to support decision making in the RI/FS at Leviathan Mine. These estimates and measurements may be supported in part by information from the Leviathan Mine database, and in part by collection of additional information. Both chemical precipitates and mechanically derived (detrital) sediment from Leviathan Mine may have been discharged to Leviathan-Bryant-EFCR waterways. Information needed to evaluate the impact of detrital and chemical sediment from Leviathan Mine includes extent of sediment from Leviathan Mine, locations of accumulated sediment from Leviathan Mine, site-related COPC concentrations in sediment, and availability of site-related COPCs in sediment to biota, water, and humans.

Sediment will be evaluated with respect to water quality impacts and risk assessment. ARARs, toxicity testing, reference area data, and risk assessment will be used to evaluate sediment data. Sediment impacts on surface water quality will be evaluated with respect to narrative and

numerical water quality objectives summarized in the Basin Plan. Human health and ecological risk assessment will be used to determine if site-related COPCs in sediment pose an unacceptable risk. Part of the risk assessment will include consideration of COPC concentrations in reference area sediment.

The database contains sediment toxicity data from ENSR (1999) and metals analyses from Hammermeister and Walmsley (1985), Thompson and Welch (1999), ENSR (1999), and the Regional Board (samples collected in 2002 and 2003), and sediment textural data. In addition to these data, Webster and others (1994) described accumulations of iron-rich brown to orange precipitates on the stream bed of Bryant Creek below the confluence with Mountaineer Creek, and at the confluence with EFCR.

Information from these sources is summarized below, is based on contents of the database, and does not include review of the source documentation.

Sediment Toxicity Data. ENSR collected sediment for toxicity testing from several stations in Leviathan and Bryant Creeks. Sediment toxicity tests were performed on 'Coarse', 'Depositional', and 'Fine' sediment fractions. Results of the sediment toxicity tests were reported in terms of the percent surviving number of the organism Hyalella azteca. Toxicity tests showed lowest survivals in depositional sediment at Stations 15 (1 percent survival) and 25 (0 percent survival). Survival rates were above 85 percent at all other stations from which depositional sediment was tested.

Metals Analyses. Sediment sample metals analyses in the database were from sampling completed in 1982 (Hammermeister and Walmsley), 1998 (ENSR and Thompson and Welch), and 2002 and 2003 (Regional Board). Each of the sampling events included differing types of laboratory analyses; however the metals arsenic, copper and iron are common to each of the data sets. ENSR conducted analyses of differing size fractions of the sediment ('coarse' and 'depositional' fractions). Comparison of these analytical results to Regional Board total sediment analytical results showed that ENSR 'depositional' fractions most closely resembled the total sediment analytical values. Thus the analysis below is based on consideration of ENSR's 'depositional' analytical results.

Comparison of analytical results from Thompson and Welch (1999) and ENSR (1999) show that in general metal concentrations of the <63 micron fraction are greater than metal concentrations in the 'coarse' and 'depositional' fractions. The <63 micron fraction was analyzed by Thompson and Welch in triplicate for 42 metals and metalloids. ENSR analyzed the 'coarse' and 'depositional' fractions for 10 metals and metalloids.

Hammermeister and Walmsley analyzed sediment samples for 18 metals and metalloids, and the Regional Board analyzed sediment samples for 22 metals and metalloids.

Comparison of the ratios of arsenic, copper, and iron on ternary plots are the basis for the evaluation of the sediment data from the database. Iron as a proportion of these three metals ranges from about 0.15 to 6.8 and is not useful to distinguish trends with time and location. Copper and arsenic proportions have much wider ranges that appear to be related to sample location and time, and appear to be useful to evaluate trends with time and location.

Location. Figure 21 is a ternary plot comparing ratios of arsenic, copper, and iron concentrations reported for sediment by location for stations 1, 22, and 24 (upgradient); stations 15, 23, 25, 26, and 29 (downstream from Leviathan Mine). The ternary diagram shows ratios based on normalizing the concentration of each element to the sum of the three element concentrations for each sample. The proportion of arsenic to copper and iron in upgradient sediment is lower than the proportion of arsenic to copper and iron at Station 15. The proportion of arsenic to copper and iron in sediment samples from the other locations tend to plot between the Upgradient and Station 15 data sets.

Time. Stations 15 and 24 were each sampled in three different years; Stations 25 and 26 were each sampled in 4 different years. Figure 22 shows ternary plots of these samples from each station. Comparison of the changes in arsenic and copper proportions and concentrations at each station may support an evaluation of metals concentrations in sediment through time. The relation of these observed concentrations to changes over time are likely affected by sampling technique (limitations of the equipment used, how the specific location at each sample site was selected, the proportion of fine to coarse material collected, etc.), and laboratory analysis (comparability of analytical methods, accuracy, quality control, etc.). Antecedent conditions including peak or low flow events, type of water year, and interception and treatment of acid drainage sources also are expected to affect this analysis and were not fully considered. In addition, the following discussion assumes that the analytical data from each source are comparable.

At Station 15 (the sediment sample location closest to and downstream from Leviathan Mine) the proportion of arsenic in the sediment increased from 1998 to 2002, and decreased below the 1998 proportion by 2003. Copper showed inverse changes compared to arsenic. These changes were due to an increase in the arsenic concentration from 1998 to 2002 (231 mg/kg to 480 mg/kg) and a significant decrease to 2003 (arsenic to 110 mg/kg); and less dramatic changes in copper concentration decreasing from 37.5 mg/kg in 1998, to 21 mg/kg in 2002, and an increase to 75 mg/kg in 2003.

At Station 24 (located in Mountaineer Creek and not affected by Leviathan Mine) the proportion of arsenic increased from 1998 to 2002, and then decreased to 2003. The arsenic concentration remained constant (8.2 mg/kg to 8.6 mg/kg) during this time. Copper proportions at Station 24 decreased from 1998 to 2002, and increased to 2003. The copper concentrations were similar in 1998 (14.3 mg/kg) and 2002 (11 mg/kg), and increased in 2003 (180 mg/kg).

At Station 25 (in Bryant Creek downstream from the confluence of Leviathan and Mountaineer Creeks and from Leviathan Mine), the proportion of arsenic decreased from 1982 to 1998; and increased during 2002 and 2003. During this time the arsenic concentration decreased from 170 mg/kg in 1982 to 85 mg/kg in 1998; and increased to 100 mg/kg and 110 mg/kg in 2002 and 2003 respectively. Copper proportions increased from 1982 to 1998; and decreased to similar levels in 2002 and 2003 respectively. During this time copper concentrations increased from 18 mg/kg to 57 mg/kg from 1982 to 1998; decreased to 35 mg/kg in 2002, and increased to 42 mg/kg in 2003.

At Station 26 (in Bryant Creek above the confluence with Doud Creek), the proportion of arsenic decreased from 1982 to 1998, decreased further to 2002, and increased in 2003. During this time the arsenic concentration decreased from 250 mg/kg in 1982 to 69 mg/kg in 1998; increased to

94 mg/kg in 2002, and decreased to 80 mg/kg in 2003. The proportion of copper increased from 1982 to 1998, increased to 2002, and decreased in 2003. During this time the copper concentration increased from 17 mg/kg to 61 mg/kg (1982 to 1998), increased to 490 mg/kg in 2002, and decreased to 45 mg/kg in 2003.

The changes in proportions of copper to arsenic through time are nearly identical at Station 15 and 24, with the main difference being a higher proportion of arsenic in sediment at Station 15. A similar trend is present at Station 25, with a less pronounced change in the proportion of arsenic from 2002 to 2003. Stations 25 and 26 are similar in that the 1982 samples contained among the highest proportion of arsenic of any of the sediment samples. Later trends between Stations 25 and 26 are not similar other than a reduction in the proportion of arsenic over time as compared to the 1982 sample.

Sediment Summary. The available sediment toxicity test data document that sediment in Leviathan Creek at Station 15, and in Bryant Creek at Station 25 downstream from Leviathan Mine were toxic to Hyalella azteca during September 1998.

The analytical data shows concentration trends over time, although additional evaluation is necessary. Because the concentrations of metals appear to change over time, sediment data should be considered to provide a 'snapshot' of concentration at the time and location of the sample. Additional information is needed to assess the extent and concentration of COPCs from Leviathan Mine in sediment downstream from the site. This information may include:

1. Location of depositional areas within the Leviathan-Bryant EFCR watershed.
2. Determination of COPC concentrations, bioavailability of site-related COPCs, and sediment toxicity in accumulated and active sediment, and overbank areas.
3. Contribution of COPCs from sub-watersheds not affected by Leviathan Mine (for example copper from Mountaineer Creek).
4. Impact of Leviathan Mine and mine-related infrastructure on sedimentation in Leviathan Creek.
5. Impact of peak flow events on sediment and COPC transport within the Leviathan-Bryant-EFCR watershed.
6. Impact of capture and treatment of acid drainage on COPCs in sediment.
7. Effect of surface water-sediment and groundwater-sediment interactions on COPC concentrations in sediment.
8. Impact of sediment COPCs from Leviathan Mine on water quality, and biota and human receptors.

Some information is available to evaluate accumulation of COPCs in sediment downstream from Leviathan Mine, and additional information will need to be collected in the RI. Investigation methods for collecting the additional information may include literature review, mapping of sediment deposits, hand sampling of detrital and chemical sediment, physical property determination, and laboratory analysis.

Soil

Soil affected by COPCs from Leviathan Mine could be present at and near the mine site, in overbank areas along streams below the mine site (riparian soil), and in areas where water diverted from Bryant Creek was used to irrigate. Riparian soil in overbank areas along streams will be evaluated as part of the sediment investigations described above. Investigation of soil at and near the mine site and in irrigated areas will be described in this section.

Information needed to evaluate the impact of COPCs from Leviathan Mine in soil may include location and extent of COPC-affected soil, risk-based and water quality-based benchmarks, and availability of site-related COPCs in soil to biota, water, and humans. Therefore, estimates and measurements of the location, physical characteristics, and chemical characteristics of soil are important to support decision making in the RI/FS at Leviathan Mine. ARARs, reference area data, and risk assessment will be used to evaluate soil data. Soil impacts on surface water and groundwater quality will be evaluated with respect to narrative and numerical water quality objectives summarized in the Basin Plan. Human health and ecological risk assessments will be used to determine if site-related COPCs in soil pose an unacceptable risk. Part of the risk assessment will include consideration of COPC concentrations in reference area soil.

These estimates and measurements will be supported in part by information from the Leviathan Mine database, and in part by collection of additional information.

The database contains analytical data from Nelson Laboratories from an investigation of soil and irrigation water conditions on the Brooks Park - River Ranch in 1969 on behalf of the Regional Board (Nelson Laboratories 1969). Other information in the database identified as soil data appear to be for mine waste and were previously discussed.

Nelson Laboratories reported analytical results from six locations (18 samples) at depths of 0 to 3 inches, 3 to 6 inches, and 6 to 12 inches. Two locations (6 samples) were not irrigated (unirrigated) and four locations (12 samples) were from irrigated soils at the Brooks Park-River Ranch. Analyses were performed for specific conductance, pH, ammonia, nitrate, chloride, available calcium, potassium, magnesium, and phosphorous; and extractable boron, copper, iron, manganese, and zinc using a variety of agronomic soil analytical methods. The data are summarized with respect to the metal (copper, iron, manganese, and zinc) concentrations detected in a saturated soil extract.

The irrigated soils yielded leachate containing from 0.01 mg/L to 3.63 mg/L (mean 0.96 mg/L) copper, 0.08 mg/L to 128.2 mg/L (mean 68.6 mg/L) iron, 0.04 mg/L to 28.6 mg/L (mean 12.8 mg/L) manganese, and 0.07 mg/L to 1.69 mg/L (0.4 mg/L) zinc. Mean concentrations of the metals were highest in surface soil samples (0 to 3 inches) from irrigated soils.

The unirrigated soils yielded leachate containing from 0.25 mg/L to 1.39 mg/L (mean 0.65 mg/L) copper, 0.06 mg/L to 49 mg/L (mean 19.5 mg/L) iron, 0.02 mg/L to 29.6 mg/L (mean 10 mg/L) manganese, and 0.06 mg/L to 0.23 mg/L (0.12 mg/L) zinc. Mean concentrations of the metals were not always the highest in surface soil samples (0 to 3 inches) from unirrigated soils.

The pH of irrigated soils ranged from 4.9 s.u. to 6.45 s.u. (mean 5.9 s.u.), and the pH of unirrigated soils ranged from 6 s.u. to 6.4 s.u. (mean 6.3 s.u.).

Although not yet included in the database, additional soil chemistry data were reported for the River Ranch in 2008 by Robison Engineering Company (Robison 2008). Robison collected 32 soil samples from irrigated parcels at 0-6 and 6-12 inches and compared metals concentrations to EPA Region 9 Preliminary Remediation Goals (PRGs) for industrial and residential soils. Several soil samples contained concentrations of arsenic, cadmium, cobalt, and nickel that exceeded baseline concentrations established for Leviathan floodplain soils. Metals concentrations generally decreased with depth and were higher in surface soils receiving more irrigation water. Only arsenic was shown to exceed both residential and industrial PRGs. Soil samples were also subjected to meteoric water mobility and arsenic speciation testing. Results of these analyses revealed that under current site conditions, the arsenic is not mobile when leached using meteoric water. Further, the arsenic is present in the form of arsenic (V) rather than the more toxic arsenic (III). Several soil samples exceeded the residential soil PRG for iron, but baseline soil samples also exceeded this PRG. Soil pH values were not reported.

The Nelson Laboratories information shows that irrigated soils in 1969 had a lower pH, and yielded higher metals concentrations in leachate than unirrigated soils. Limited data are available to evaluate COPCs in soil at the Brooks Park - River Ranch, and no data are available to evaluate COPCs in soil at Leviathan Mine. Additional information about the location, physical characteristics, and chemical characteristics of soil affected by COPCs from Leviathan mine is needed. This information may include:

1. Concentrations of site-related COPCs in soil.
2. Mobility of site-related COPCs in soil.
3. Location and extent of affected soil.
4. Chemical and physical soil properties affecting site-related COPCs in soil.
5. Risk-based COPC concentrations for soil that are protective of biota and human receptors.

Limited information is available to evaluate these facets of soil at Leviathan Mine. Additional information will need to be collected in the RI. Sampling and analysis methods for collecting the additional information may include high resolution geophysics; drilling and soil sampling; field based and laboratory analysis; and visual observation.

Groundwater

Measurements and estimates of the site-related COPC concentration of groundwater, and extent of site-related COPCs in groundwater are important to determine if concentrations or loads are above levels of concern. This information and chemical characteristics of the groundwater, and analysis of complete exposure pathways are needed to evaluate potential remedies in the FS. Levels of concern for groundwater are identified in ARARs such as the CWA, and California Water Code. Potential groundwater ARARs are summarized as numerical and narrative water quality objectives in the Basin Plan prepared by the Regional Board. Risk assessment during the RI will also identify groundwater levels of concern and reference values for groundwater will be evaluated.

Groundwater information in the database includes analytical data, hydraulic conductivity measurements, and groundwater elevation measurements.

Groundwater Elevation. Groundwater elevation and depth measurements were reported by Hammermeister and Walmsley (1985), SRK (1998), Tetra Tech (2007), U.S. Army Corps of Engineers (USACE) (2008), and Burleson (2009). The database considers these groundwater elevation data to be of high documentation. Groundwater elevation data from Hammermeister and Walmsley were collected during the fall of 1982 and spring of 1983. SRK groundwater elevations were collected during the summer and fall in 1998 and 1999. Tetra Tech (2007) collected depth to groundwater measurements during the May to October 2006 work season, USACE collected depth to groundwater measurements during the 2007 work season, and Burleson collected depth to groundwater measurements during the 2008 and 2009 work seasons. AMEC collected well location and integrity data in 2009.

Figure 23 shows hydrographs of MW 1, MW 2D, MW 2S, and MW 7. Groundwater elevations in each well show a decrease from spring to fall measurements. This is consistent with the timing of groundwater recharge from melting of snow and rain in the spring, and losses to evapotranspiration and discharge through the summer and fall each year. The hydrographs also show a decrease in groundwater elevation after 2006 that coincides with the onset of three years of below average precipitation following above average precipitation during 2005 and 2006.

Figure 3 shows a map of the site with groundwater elevation contours interpreted from groundwater elevation measurements made on August 28, 2008. The groundwater elevation contours show that groundwater flow generally mimics surface topography. Deflections in the groundwater contour lines near the Pit, Adit, Leviathan Creek, and CUD collection area suggest that these features influence groundwater flow. The groundwater elevation contours were interpreted based on the assumption that all of the wells monitor an interconnected groundwater system.

Hydraulic Conductivity. Hammermeister and Walmsley (1985) performed single well conductivity tests at 67 piezometers. The resulting hydraulic conductivities ranged from 0.01 feet per day to 26 feet per day (mean value 2.73 ft/day). This range of hydraulic conductivities is characteristic of silt (low value) to silty or clean sand (high value). The mean value is characteristic of silty sand. Unfortunately, the material being tested was not identified as to whether it was in situ material or mine waste.

Analytical Data. Analytical data for groundwater at Leviathan Mine were collected by Hammermeister and Walmsley (1985) and SRK (1999). The database considers these data to be of high documentation.

Hammermeister and Walmsley (1985) collected samples from 71 piezometers in 1982. Samples were collected after bailing up to 5 gallons of water from each piezometer. The pH, specific conductance, and temperature of each sample were measured in the field. Water from 36 of the piezometers was collected for laboratory analysis. Laboratory analyses included acidity, pH, specific conductance, aluminum, arsenic, barium, beryllium, cadmium, calcium, chloride, chromium, cobalt, copper, iron, lead, lithium, magnesium manganese, mercury, molybdenum nickel, silica, sodium, strontium, sulfate, thallium, vanadium, and zinc. Data from Hammermeister and Walmsley (1985) do not include alkalinity or carbonate species.

SRK (1999) collected samples from 13 MWs installed during 1998, and two of the piezometers installed by Hammermeister and Walmsley (1985) (USGS-33 and USGS-25). The pH, specific conductance, and temperature were measured in the field. Laboratory analyses included pH, alkalinity as $CaCO_3$, bromide, chloride, fluoride, NO_3 as N, NO_2 as N, Ortho phosphate as phosphorous, total phosphorous, total suspended solids, total dissolved solids, sulfate, aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium manganese, mercury, molybdenum, nickel, potassium, selenium, silver, sodium, thallium, vanadium, and zinc.

Data from Hammermeister and Walmsley (1985) and SRK (1999) are compared with respect to calcium, total iron, and aluminum concentrations. Aluminum concentrations reported by Hammermeister and Walmsley ranged from 0.1 mg/L to 1,100 mg/L (arithmetic mean 128 mg/L). SRK aluminum concentrations ranged from 0.0135 mg/L to 319 mg/L (arithmetic mean 92 mg/L). Total iron concentrations reported by Hammermeister and Walmsley ranged from 0.004 mg/L to 2,600 mg/L (arithmetic mean 362 mg/L). Dissolved (< 0.45 micron) iron reported by SRK ranged from 0.025 mg/L to 936 mg/L (arithmetic mean 306 mg/L). Dissolved calcium reported by Hammermeister and Walmsley ranged from 11 mg/L to 700 mg/L (arithmetic mean 251 mg/L). Dissolved calcium reported by SRK ranged from 5.3 mg/L to 487 mg/L (arithmetic mean 248 mg/L).

This information is discussed in greater detail by area below. The data are described in accordance with the following areas: upgradient, LCSA, PSA, and ACSA (Figure 3). The areas are based on the reported locations of the wells or piezometers from which samples were collected with respect to site features. For example, wells located in mine waste and upgradient from Aspen Seep are considered to be within the ACSA. A more detailed review of information may support a revised organization of the information.

Upgradient Area: The Upgradient Area is located to the southeast of the disturbed surface area at Leviathan Mine. This area was named by Hammermeister and Walmsley (1985), and appears to have been used for piezometers located topographically above the surface area disturbed by mining. Based on groundwater elevations, these locations also appear to be upgradient of the area disturbed by mining. Piezometers 23A, 24, 32, 31, and 33; and MWs 1 and 7 were considered to be Upgradient. Use of this term herein does not necessarily mean that the groundwater is considered to be unaffected by COPCs.

Leviathan Creek Study Areas (LCSA): The LCSA consists of the ponds constructed to contain acid drainage and the surrounding areas of the mine site adjoining Leviathan Creek. Piezometers 1A, 1B, 1C, 9A, 9B, 9C, 10A, 10B, 10C, 14, 15, and 16; and MWs 2S, 2D, 6, 8 10S, 10D, 11 and 12 are considered to be within the LCSA.

Pit Study Area (PSA): The PSA consists of the open pit. Piezometers 2A1, 2A2, 2C1, 17A, 17B, 17C, and 26; and MWs 3, 4, 5S, and 5D are considered to be within the PSA.

Aspen Creek Study Area (ACSA): The ACSA consists of the Overburden Area, the landslide area and the area disturbed by mining upgradient (uphill) from the Aspen Seep. Peizometers 3B1, 3C, and 25 are within the Overburden Area. The Landslide Area of the ACSA extends from the vicinity of the Aspen Seep to Leviathan Creek to the southwest of Aspen Creek, and includes piezometers 4, 5A, 6, 7, 8, 8A, 20 and 21.

Box plots of calcium, iron, and aluminum concentrations were constructed for each area to allow comparison of any concentration differences. The box plots are shown in Figure 24. Upgradient groundwater contained the lowest range of calcium concentrations, and the LCSA and PSA groundwaters contained the highest and similar concentrations of calcium. The Landslide Area of the ACSA groundwater contained a wide range of calcium concentrations that overlapped the Upgradient, ACSA, and lower part of the LCSA/PSA ranges. Calcium concentrations reported by Hammermeister and Walmsley (1985) and SRK (1999) were similar, though the SRK calcium concentrations in the Upgradient Area had a higher range than those of Hammermeister and Walmsley (1985).

Box plots for iron are plotted on a log axis because of the range of reported iron concentrations. Groundwater from the Landslide Area of the ACSA had the lowest iron concentrations, and PSA and LCSA groundwater contained the highest iron concentrations. Upgradient groundwater contained about 10 times the concentration of iron reported in the Landslide Area/ACSA groundwater. ACSA groundwater contained a wide range of iron concentrations with a median concentration above that in Upgradient Area groundwater, and much lower than concentrations reported for PSA and LCSA groundwaters. PSA groundwater contained higher concentrations of iron than LCSA groundwater. Iron concentrations reported by Hammermeister and Walmsley (1985) and SRK (1999) were similar, though the SRK iron concentrations in the Upgradient, LCSA, and PSA had a wider range than those of Hammermeister and Walmsley (1985).

Box plots for aluminum are plotted on a log axis because of the range of reported aluminum concentrations. Groundwater from the Upgradient Area had the lowest reported aluminum concentrations, and LCSA groundwater contained the highest aluminum concentrations. ACSA and LCSA groundwaters contained similar concentrations of aluminum. Aluminum concentrations reported by Hammermeister and Walmsley (1985) for the Landslide/ACSA and Upgradient Areas were mostly below the detection limit (0.1 mg/L). SRK's detection limit was much lower for aluminum.

A ternary plot of calcium, iron, and aluminum concentrations in groundwater and acid drainage (Figure 25) shows that groundwater and acid drainage from the differing areas have differing chemical characteristics. For example, PSA and LCSA groundwater tend to contain much more iron than ACSA, Upgradient, and Landslide/ACSA groundwaters. Acid drainage appears to be aligned in discrete groups along a trend away from the calcium vertex. Further evaluation of the information would likely result in greater ability to differentiate these waters.

Based on comparison of the calcium, iron, and aluminum concentrations, it is likely that more detailed analysis of existing groundwater analytical data may support meaningful differentiation of groundwater from various areas at Leviathan Mine. Such an analysis may support identification of acid sources, site-related COPC migration pathways, and geochemical processes affecting site-related COPC transport. The comparisons of calcium, iron, and aluminum also suggest that area is not the only factor affecting metal chemical concentrations. The wide range of concentrations shown in some of the data (for example iron in PSA wells, or calcium in the Landslide Area/ACSA wells) are likely caused by comparison of water from differing water bearing zones.

Vertical COPC Extent. Calcium, iron, and aluminum concentrations in well pairs MW-2S and MW-2D, and MW-10S and MW-10D were compared. Concentrations of calcium are higher in

groundwater from MW-2D which has a top of screen that is 22 feet below the screened interval of MW-2S, concentrations of aluminum are higher in MW-2S than in MW-2D, and concentrations of iron are similar in the two wells. Concentrations of each analyte are higher in MW-10S than in MW-10D, with significantly lower iron and aluminum in MW-10D. However, the aluminum concentration from MW-10D is significantly higher than the highest aluminum concentrations from the Upgradient or Landslide Areas, and is at the high end of the range of aluminum reported for ACSA groundwater. This evaluation suggests that some COPCs in groundwater may extend beyond the shallowest water bearing zones at Leviathan Mine.

Horizontal Extent. Available information does not constrain the horizontal extent of site-related COPCs in groundwater. Comparison of the calcium, iron, and aluminum concentrations from each area show that the Landslide Area/ACSA contains the widest range of calcium concentrations outside of the LCSA and PSA. This raises the question as to whether groundwater is transporting site-related COPCs through the landslide, or whether mine waste or natural materials within the slide mass are contributing site-related COPCs to the groundwater (Greg, calcium is not a COPC at this point.).

Groundwater Summary. Existing information supports the idea that groundwater chemical characteristics may be used to differentiate water from different areas and that differing groundwater chemical characteristics can be used as indicators of site-related COPCs and their sources.

Additional groundwater information is important to support risk assessments, identify remedial action objectives, and support the FS. This information may include:

1. The source(s) for site-related COPCs in groundwater.
2. The source(s) for groundwater recharge.
3. The vertical extent of site-related COPCs in groundwater.
4. The horizontal extent of site-related COPCs in groundwater.
5. The hydraulic properties of water bearing zones.
6. The directions and quantity of groundwater flow throughout the site
7. The potential for groundwater exposure to humans and biota.
8. The influence of mine workings and other man-made features on groundwater flow.
9. The extent and quantity of site-related COPCs transported by groundwater.
10. The effect of fractures on groundwater flow.
11. The effects of seasonal groundwater elevation fluctuations on site-related COPC concentrations in groundwater.
12. The chemistry of site-related COPCs in groundwater.
13. The chemistry of the groundwater.
14. The relationship between groundwater and acid drainage.

15. The relationship between groundwater and surface water.
16. Water balance.
17. The nature of water-rock (and water-mine waste) interactions that mobilize site-related COPCs.

Limited information is available to evaluate these facets of groundwater at Leviathan Mine. Additional information will need to be collected in the RI. Sampling and analysis methods for collecting the additional information may include high resolution geophysics; monitoring well construction and groundwater sampling; grab groundwater sampling; laboratory analysis, field parameter measurement, and visual observation.

Air

Levels of concern for air will be identified through risk assessment and consideration of ARARs. Therefore, measurements to allow evaluation of site-related COPCs in air may be useful to support risk assessment, and evaluate potential remedies in the FS.

Data for air are limited to a small quantity of meteorological observations, with no analytical data.

Existing information documents that site-related COPCs are present at the surface in mine waste above levels of concern, suggesting that site-related COPCs are available for transport to air. Existing information supports the idea that site-related COPCs adhering to small particles could become airborne on respirable particles. Respirable particles containing site-related COPCs could then be inhaled by humans or animals, or accumulate on plant surfaces or otherwise uncontaminated surfaces.

Additional information on the air pathway is important to support risk assessments at Leviathan Mine. This information may include:

1. The quantity of dust generated from mine waste.
2. Site-related COPC concentrations in dust generated from mine waste.
3. Locations of roads with a surface of mine waste.
4. Site-related COPC concentrations in mine waste that provides a source for dust.
5. Site-related COPC concentrations in plant surface rinsate, and surface area rinsed.

Limited information is available to evaluate the air pathway at Leviathan Mine. Additional information might need to be collected in the RI. Sampling and analysis methods for collecting the additional information may include air sampling, plant rinse sampling, laboratory analysis, field parameter measurement (particulate mass in air), and visual observation.

Reference Area

Reference area concentrations assist in attributing COPC concentrations to the site as compared to ambient concentrations in surface water, biota, sediment, groundwater, and soil. This is

necessary to appropriately limit response activities to addressing site-related risks and hazards . Information needed to identify reference areas includes detailed habitat surveys, geologic surveys, stream morphology and hydrology. This information is not contained in the database. Therefore, additional information is needed to support identification of reference areas and evaluation of reference area COPC concentrations in surface water, biota, sediment, groundwater, and soil. This information may include:

1. Ecological community present along Leviathan Creek, Bryant Creek and EFCR.
2. Ecological communities present along potential reference streams.
3. Geology of Leviathan Creek, Bryant Creek and EFCR.
4. Geology of potential reference streams.
5. Morphology and hydrology of Leviathan Creek, Bryant Creek and EFCR.
6. Morphology and hydrology of potential reference streams.
7. COPC concentrations in upland soil, groundwater, surface water, biota, sediment, and soil of reference streams (if identified).

This information will need to be collected during the RI. Collecting this information will require consultation with agency personnel, literature search and review, vegetation surveys, geologic mapping; surface water, sediment, soil, groundwater, biota sampling and laboratory analyses; and visual observation.

Step 4: Define the Boundaries of the Study

Specify the target population, determine spatial and temporal limits, identify practical constraints, and define the scale of inference.

The RI/FS at Leviathan Mine will consider COPCs in the primary sources; mine waste and in situ rock; and in pathways and secondary sources - acid drainage, surface water, biota, sediment, soil, groundwater, and air; and reference area COPC concentrations in surface water, groundwater, sediment, soil, and biota. Spatial and temporal boundaries for each of these populations are described below.

Temporal limits applicable to all the investigation activities consist of practical limitations and administrative limitations. Practical limitations consist of limitations on site access due to the location of Leviathan Mine at an elevation of about 7,000 feet amsl in the Sierra Nevada Mountains, and severe winter weather conditions. Weather and safe access by personnel restrict ground based data collection activity to a field season that typically extends from May through October each year. Some additional field data can be collected during the winter season, if necessary, by remote instrumentation or occasional trips during accessible periods.

Administrative limitations consist of the desired time frame for decisions to be made. Currently, decisions about the RI/FS for Leviathan Mine are anticipated by 2015. Therefore, ground based data gathering should occur during the period from completion of planning through November 2013.

The boundaries for Primary Sources are discussed below.

Mine Waste

Mine waste contains COPCs that may be released to the environment, and includes waste material from mining activities present at the site, and material that may have been used historically to build roads to the site. Mine waste may be present beyond the current site property boundaries. If so, mine waste outside of property boundaries is also included in the target population. Sampling units for mine waste will vary with the specific type of investigation. For example, a geophysical survey could consider all mine waste, or a discrete area or volume of mine waste. As another example, drilling and sampling could include discrete sample intervals, or continuous cores as sampling units. The sampling unit will be identified in the FRI for each type of investigation determined to be necessary to address RI/FS decision statements.

The appropriate scale for decision making with respect to mine waste will be determined in part by ARARs and in part by risk assessment. Potential ARARs such as CCR Title 27 that prescribe management of certain classifications of mine waste, consider the extent of mine waste that could pose an unacceptable risk and/or degrade water quality. Risk assessments typically identify exposure areas dependant in part on the assessment endpoint and exposure assumptions and receptor populations. Thus the scale for decision making (decision units) will vary from an entire region of the site (for example the PSA) to exposure areas identified for a specific receptor

(for example 2 acres within the ACSA). These decision units will be identified in the FRI work plans.

In Situ Rock

In situ rock is a primary source for potential discharges of acid drainage at Leviathan Mine. This includes rock in the immediate vicinity of mine workings such as the pit and the adit. In situ rock also includes the extent of rock dewatered by mining and exposed to increased contact with oxygen where this rock has the potential to produce acid discharge. The extent of in situ rock disturbed by mining is currently not well known, and will require estimation based on mining records and professional judgment using available information and the results of investigation activities, as necessary, to estimate the potential for discharge. Sampling units for in situ rock will vary with the specific type of investigation. For example, a geophysical survey could assess in situ rock to a specified depth within a specified distance from mine workings; drilling and sampling could include discrete sample intervals, or continuous cores as sampling units. The sampling unit will be identified in the FRI for each type of investigation determined to be necessary to address RI/FS decision statements. It is likely that the On Property FRI source characterization activities will address in situ rock.

The appropriate scale for decision making will include the extent of in situ rock determined to be affected by mining, and the nature of the affected material. For example, decisions related to high wall stability will include the high wall and adjacent rock as it affects remedial decision making. Decisions related to minimizing the generation of acid drainage may be concerned with collection and treatment of adit flows, sealing a set of fractures, installing an adit plug, or passivating a volume of rock. Each of these decisions would require consideration of a differing area and/or volume of in situ rock. FRI work plans will consider these differing scales for decision making.

The boundaries for the pathways and secondary sources are discussed below.

Acid Drainage

Acid drainage is formed by the contact of sulfide minerals, oxygen and water and can be contributed from mine waste and in situ rock. The flow rate and concentration of COPCs vary with the quantity of water and oxygen that contact the acid sources. The flow rate and COPC concentration of acid drainage discharged at Leviathan Mine each year are not completely known and will require estimation based on results of the RI. The difference between acid drainage and groundwater affected by acid drainage is currently not defined. This differentiation may support identification of acid drainage source areas. Sampling units for acid drainage will vary in the RI from large areas and volumes evaluated through geophysics, to sub-liter quantities collected for laboratory analyses. Appropriate sampling units will be described in the FRI work plans.

Decisions for acid drainage will be guided in part by ARARs concerning water quality, and in part by risk assessment. The scale of decisions will include the locations where acid drainage is generated and discharged; the extent of surface water impacted by acid drainage; and may also include the pathway from acid source to the affected water body. Thus the scale of decision

making will include point locations, surface water flows, and extent of subsurface materials. FRI work plans will further consider these differing scales for decision making.

Temporal limits specific to acid drainage include what appear to be historical and seasonal changes in COPC concentrations, historical and seasonal flow variations, and changes in COPC concentration and acid drainage flow rates in response to varying amounts of seasonal precipitation. Additional investigations of acid drainage should be planned to further evaluate seasonal and precipitation-related variations in acid drainage.

Surface Water

Surface water includes the reaches of Leviathan, Aspen and Bryant Creeks, and EFCR affected by discharges from Leviathan Mine. Sampling units for surface water will vary with the specific type of investigation. For example, flow measurements range seasonally from nearly zero flow to several tens of cubic feet per second, and sampling for laboratory analysis can include from sub-liter grab samples to multi-liter composite samples. The sampling unit will be identified in the FRI for each type of investigation determined to be necessary to address RI/FS decision statements.

The appropriate scale for decision making with respect to surface water will be determined in part by ARARs, in part by reference area comparisons, and in part by risk assessment. Potential ARARs such as the CWA that include chemical specific numerical objectives to protect beneficial use rely on point measurement of concentrations, and other numerical standards such as total maximum daily loads that rely on loading estimates. Risk assessments typically identify exposure areas dependant in part on the assessment endpoint and exposure assumptions and receptor populations. Thus the scale for decision making will vary from a reach of a stream to exposure areas identified for a specific receptor. These decision units will be identified in the FRI work plans.

Temporal limits specific to surface water include historical and seasonal variations in flow and COPC concentrations. One temporal effect in particular that is not well characterized by existing information is the effect of short-term runoff associated with storm events on surface water quality. Additional investigations of COPCs in surface water may be needed to further evaluate seasonal and precipitation-related variations in surface water quality.

Biota

Biota includes terrestrial and aquatic plants and animals potentially affected by releases from Leviathan Mine. Biota of concern in Section 3.4 of the PWP are identified through review of federal and state lists of special status species, consideration of human use patterns including biota used by the Washoe Tribe of Nevada and California consideration of the food web, and consultation with agency personnel. Biota of concern may be modified during FRI development. The population of biota will consist of those organisms selected for further analysis and present in the area affected by releases from Leviathan Mine. Sampling units will consist of individuals and/or composite samples, and/or tissue samples as appropriate and identified in the FRI work plans.

The appropriate spatial scale for decision making with respect to biota will vary with the biota being considered based on foraging ranges and life stages for animals, to specific locations and life stages for plants and benthic macroinvertebrates. Thus, decision making will require sampling at differing spatial scales as identified in the FRI work plans.

Temporal considerations for biota include seasonality due to the weather extremes experienced in the region affected by Leviathan Mine, timing of life stages of biota selected for assessment, and timing and duration of exposures related to mining activity at Leviathan Mine. Temporal considerations also include consideration of the differing uses of the investigation-derived data ranging from estimating life time exposure for human health risk assessment, to evaluating effects levels for ecological risk assessment. These temporal scales will be considered in the FRI planning documents.

Sediment

Sediment includes impacted bed material and riparian deposits downstream of Leviathan Mine within the Leviathan and Bryant Creek and EFCR watershed deposited since the start of active mining at Leviathan Mine. The sediment of interest includes sediment containing COPCs from Leviathan Mine either as detrital particles or chemical precipitates. Sampling units for sediment will vary with the specific goals of the investigation. For example, a stream survey could consider all sediment within a specified reach, a specific type of sedimentary deposit (such as point bars) within a watershed, or a discrete area or volume of sediment. As another example, drilling and sampling could include discrete sample intervals, or composite samples to represent sampling units. The sampling unit will be identified in the FRI for each type of investigation determined to be necessary to address RI/FS decision statements.

The appropriate scale for decision making with respect to sediment will be determined in part by ARARs, in part by reference stream comparisons, and in part by risk assessment. Potential ARARs such as the CWA that include numerical and narrative water quality criteria could require addressing the presence of COPCs from Leviathan Mine in specific sediment deposits, or along a reach of an affected stream. Risk assessments typically identify exposure areas dependant in part on the assessment endpoint and exposure assumptions. Thus the scale for decision making will vary from an affected reach of a stream (for example Leviathan Creek from Delta Seep to Station 15) to a specific sediment deposit (for example sediment accumulated behind Ruhenstroth Dam). Appropriate decision units will be identified in the FRI work plans.

Temporal considerations specific to sediment include age of sediment deposits and historical trends in COPC concentrations. For example, the COPC content of sediments older than about 147 years would not be attributed to mining disturbances at Leviathan Mine, while any sediment deposited during the last 147 years could contain COPCs from Leviathan Mine. Sediment deposited since 1952 and prior to 1985 may be expected to contain higher COPC concentrations from Leviathan Mine because this was the period of large scale mining (1952 to 1962), and prior to implementing controls that reduced the offsite migration of COPCs (1983 to 1985). COPC concentrations in surface sediments are likely affected by recent improvements in water quality discharges leaving the site, erosion control efforts implemented in the last two decades and storm-related scouring of stream bottoms. These temporal scales will be considered in the FRI work plans.

Soil

Soil containing site-related COPCs released from Leviathan Mine may be present within and beyond the current site property boundaries. Impacted soil outside of property boundaries is also included in the target population. Sampling units for soil will vary with the specific type of investigation. For example, drilling and sampling could include discrete sample intervals, or continuous cores as sampling units. The sampling unit will be identified in the FRI for each type of investigation determined to be necessary to address RI/FS decision statements.

The appropriate scale for decision making with respect to soil will be determined in part by ARARs, in part by reference area comparisons, and in part by risk assessment. Potential ARARs such as regulations summarized in the Basin Plan that protect water quality, and require isolating contaminated soil from surface water, consider the areas where soil could pose an unacceptable risk and/or degrade water quality. Risk assessments typically identify exposure areas dependant in part on the assessment endpoint and exposure assumptions. Thus the scale for decision making will vary from an entire region of the site (for example impacted soils within and adjacent to the ACSA) to exposure areas identified for a specific receptor (for example half-acre parcels at River Ranch). These decision units will be identified in the FRI work plans.

Groundwater

Groundwater includes groundwater affected by mining activity. The horizontal and vertical extent of contaminated groundwater and range of COPC concentrations at Leviathan Mine have not been fully characterized. Some degree of estimation based on professional judgment using available information and the results of the investigation activities will be required. Differentiating acid drainage and groundwater affected by acid drainage may assist in identifying and controlling both types of impacts. Sampling units for groundwater will vary in the RI from large areas and volumes evaluated through geophysics, to sub-liter quantities collected for laboratory analyses. Appropriate sampling units will be described in the FRI work plans.

Decisions for groundwater will be guided in part by ARARs concerning water quality, in part by reference area comparisons and in part by risk assessment. The scale of decisions will include the extent of groundwater impacted by Leviathan Mine, and will be guided by the pathway from acid source to the affected receptor. Thus the scale of decision making will include point locations, and areas and volumes of groundwater, and subsurface materials. FRI work plans will further consider these differing scales for decision making.

Temporal limits specific to groundwater include potential historical and seasonal changes in COPC concentrations, seasonal flow variations, and the changes of COPC concentration with flow rates. Additional investigations of groundwater should be planned to further evaluate annual, seasonal and precipitation related variations in groundwater flow and COPC concentrations.

Air

COPCs may be entrained in air by suspension of respirable particles and dust during windy conditions. Volatilization is not believed to be significant at Leviathan Mine. The extent to which COPCs may become suspended varies with the wind speed and inversely with the grain size of the source material. Air-related impacts at Leviathan Mine are not well understood and may require estimation based on results of the RI. Sampling units for air, if necessary, will vary in the RI from large areas and volumes affecting nearby areas, to near surface breathing zone samples collected for laboratory analyses. Appropriate sampling units will be described in the FRI work plans.

Decisions for air will be guided in part by ARARs concerning air quality, and in part by risk assessment. The scale of decisions will include the locations where receptors may be exposed to COPCs in air, and the extent of air impacted by COPCs. For example, the suspension of COPCs in air along road segments that may have been surfaced with mine waste could affect site workers and recreational users differently. Thus, the scale of decision making will include point locations, areas of exposed mine waste, and affected air. FRI work plans will further consider these differing scales for decision making.

Temporal limits specific to air likely include seasonal changes in COPC concentrations, and possible increase of COPC concentrations in air during dry years. Investigations of COPCs in air should be planned to determine if this pathway is complete, and if so, its significance. One approach may be to first perform modeling to assess whether there is significant potential for concentrations of COPCs in air to exceed risk-based threshold concentrations and durations.

Reference Area

Reference area surface water, groundwater, sediment, soil, and biota populations are expected to be similar to those described above for the Leviathan Mine affected media with the exception that reference populations are not affected by releases from Leviathan Mine. Selection of reference areas will be in accordance with criteria provided in the FRI work plan and consultation with appropriate agency technical personnel. Reasonable efforts should be made to ensure that reference populations are sampled at similar times and using the same sampling techniques as used for sampling Leviathan Mine-affected populations.

Step 5. Develop the Analytic Approach

Define the parameter of interest, specify the type of inference, and develop the logic for drawing conclusions from findings

Parameters of interest include COPCs defined in the RI statement of work prepared by EPA, and other hazardous substances determined to be released due to mining activities within the spatial boundaries and media defined in Step 4. Data collected will be of sufficient quality and quantity to make inferences and conclusions as outlined below. Two inferences, and resulting conclusions, will be made using the results of data collected.

First, collected data will be compared to appropriate values to show that the nature and extent of contamination have been adequately characterized. Appropriate values could include, but are not limited to, reference concentrations, risk-based screening values, or remedial action objectives. If the site has been adequately characterized based on comparison to appropriate values, then no further sampling or characterization is required; otherwise subject to practicable limitations further characterization may be necessary as an iterative process. Professional judgment and consultation with EPA as the lead agency will be used to determine if the nature and extent of contamination have been adequately defined.

Second, collected data will be used to evaluate the risks and hazards posed to human and ecological receptors via potentially complete exposure pathways. For each medium and exposure pathway, data of sufficient quality and quantity will be collected to estimate the upper confidence limit (UCL) of the mean. The appropriate UCLs will be calculated following EPA guidance (EPA 2002) and statistical software such as EPA's ProUCL (Version # 4.00.04) (http://www.epa.gov/esd/tsc/software.htm). Exposure units and comparison criteria will be clearly defined in each FRI work plan. If reference data are available, site-related COPC concentrations will be statistically compared to reference data. Site-related COPC concentrations will also be compared to other appropriate benchmarks. If site-related concentrations are statistically greater than reference or benchmark concentrations, then further evaluation may be necessary to determine incremental risks and hazards above reference risks or other appropriate benchmarks and hazards associated with site-related constituents. Further evaluations include, but are not limited to, risk-screening evaluations, quantitative risk assessments, or remedial actions. If reference data are not available, then site data will be evaluated against other appropriate benchmarks agreed upon by EPA.

For both characterization and risk assessment evaluations for each of the spatial boundaries described in Step 4, appropriate comparison criteria will be clearly defined in the corresponding FRI work plan.

Step 6: Specify Performance or Acceptance Criteria

For Decision problems, specify the decision rule as a statistical hypothesis test, examine consequences of making incorrect decisions from the test, and place acceptable limits on the likelihood of making decision errors. For estimation problems specify acceptable limits on estimation uncertainty.

This section of the programmatic DQO describes guidelines for specifying the decision rules as statistical hypothesis tests, examining consequences of making incorrect decisions from the test, and placing acceptable limits on the likelihood of making decision errors for decision problems; and specifying acceptable limits on estimation uncertainty for estimation problems. Decision rules and limits on estimation uncertainty in the FRIs will be developed in accordance with EPA QA/G-4 (2006).

Decision Rules. Decision rules will be formulated in accordance with guidelines in EPA QA/G-4 (2006) for situations in which the consequences of making a decision error are considered to be severe. Specifically, the true case for the outcome with the most severe consequence will serve as the baseline or null hypothesis. The default or initial error limits for false acceptance and false rejection of the baseline condition or null hypothesis are typically 0.05 and 0.20 respectively, with the actual values determined through consultation with EPA as lead agency and balancing the consequences of making these decision errors with the resources required to achieve the decision error limits that they would set.

Parameter Estimates. Parameter estimates (for example means, or exposure point concentrations) will be established using confidence intervals, and tolerance limits as appropriate. A 95 percent confidence interval is typically a general default value, with actual values determined on a case by case basis in consultation with EPA and in consideration of the benefits gained by modifying this confidence interval compared to the resources needed or saved to increase or by decreasing the confidence respectively. Tolerance intervals are typically defined initially using 95 percent confidence and 95 percent of the population. Modifications may be made to the tolerance interval specifications through consultation with EPA and in consideration of benefits and resource requirements.

Step 7: Develop the Plan for Obtaining Data

Develop the detailed plan for obtaining data.

- *Compile all information and outputs generated in Steps 1 through 6.*
- *Use this information to identify alternative sampling and analysis designs that are appropriate for the intended use*
- *Select and document a design that will yield data that will best achieve performance or acceptance criteria.*

Detailed plans for obtaining data should be provided so that sampling efforts are integrated to provide an appropriate quantity of information at the specified level of quality needed to address the study questions. The plan for obtaining data should be integrated so that information is collected in a logical manner, and so that preliminary results can be used to re-evaluate assumptions and adjust future sampling activities, as needed, to update the CSM and achieve project goals. As an example, it may benefit later investigations if geophysical surveys are completed prior to other activities such as drilling and monitoring well installation. This is because the geophysical surveys are likely to provide information supporting professional judgment as to where additional MWs and exploratory borings for mine waste and in situ rock sampling should be located. Geophysical surveys could also support identifying boundaries of mine waste for defining decision units, allow estimation of the thickness of mine waste, and detect the presence of geologic boundaries and structures such as faults.

Each FRI sampling and analysis plan should be based on collecting sufficient samples to achieve the confidence and power determined for each decision rule in Step 6. Various methods for determining the appropriate number of samples are available including calculations based on statistical distributions. Potential tools available to support these calculations include Visual Sample Plan (Pacific Northwest National Lab 2007), Guidance on Choosing a Sampling Design for Environmental Data Collection (EPA 2002), and various commercial software packages.

For those decisions involving professional judgment, consultation with EPA (working with local and regional sources of technical expertise) should be conducted to ensure that professional judgments are clearly communicated.

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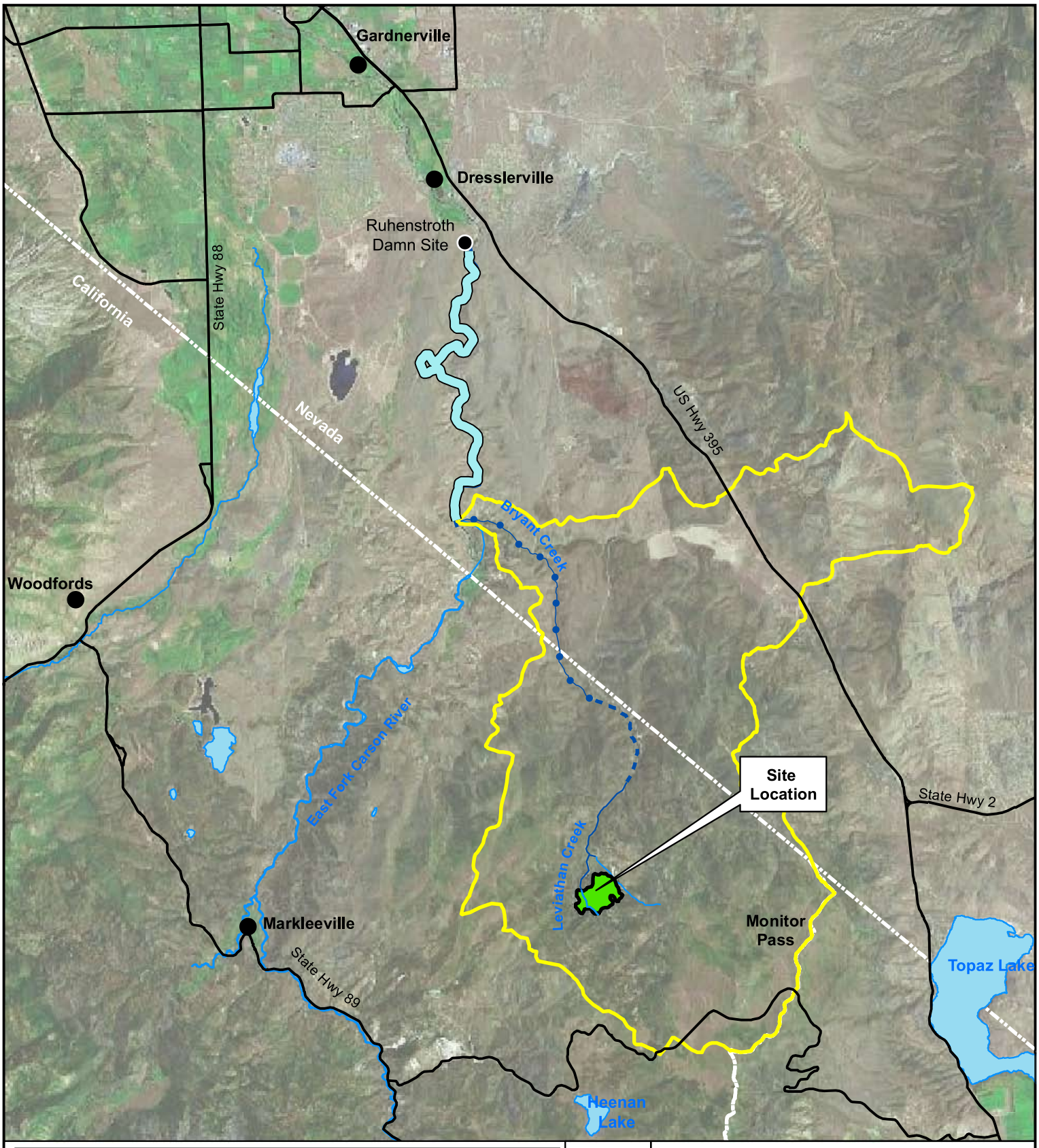
FIGURES



Legend

- Cities
- Roads
- Site Location
- Lakes and Ponds
- Rivers and Creeks
- Leviathan Canyon Watershed Boundary

Downstream Study Areas

- Leviathan Creek
- Lower Bryant Creek
- Upper Bryant Creek
- EFCR

Data Source: Aerial image provided by Digital Globe
Watershed data provided by the NRCS website

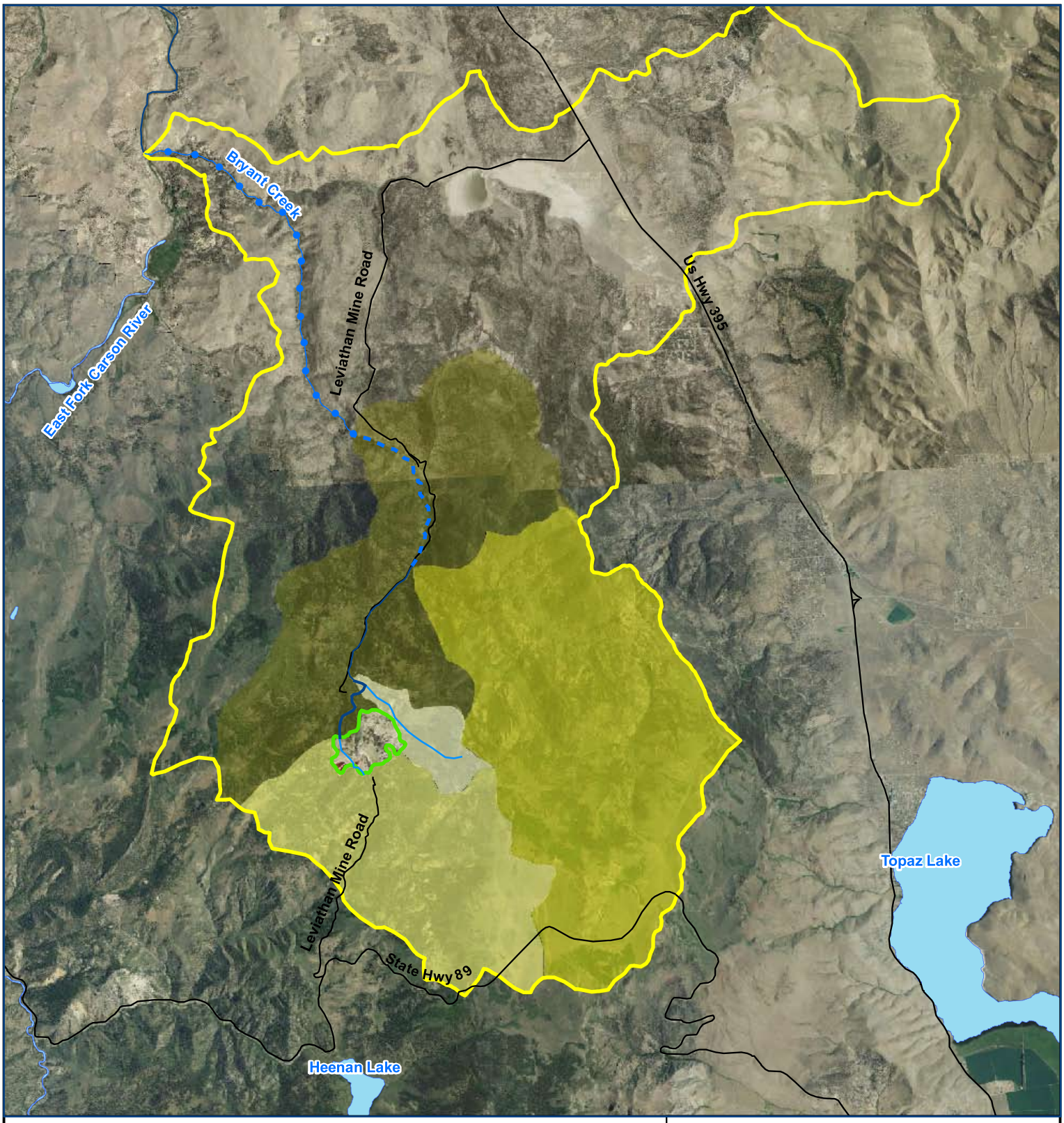
N

Figure 1

Site Location Map
Leviathan Mine Superfund Site
Alpine County, California

0 2 4 6
Miles

Burleson Consulting, Inc.



Legend

- Leviathan Mine
- Roads
- Rivers and Creeks
- Lakes

Downstream Study Areas

- Leviathan Creek
- Lower Bryant Creek
- Upper Bryant Creek

- Leviathan Canyon Watershed Boundary (32,653 Acres)
- Upper Bryant Watershed (16,067 Acres)
- Mountaineer Creek Watershed (6,852 Acres)
- Leviathan Creek Watershed (6,156 Acres)
- Aspen Creek Watershed (498 Acres)

N

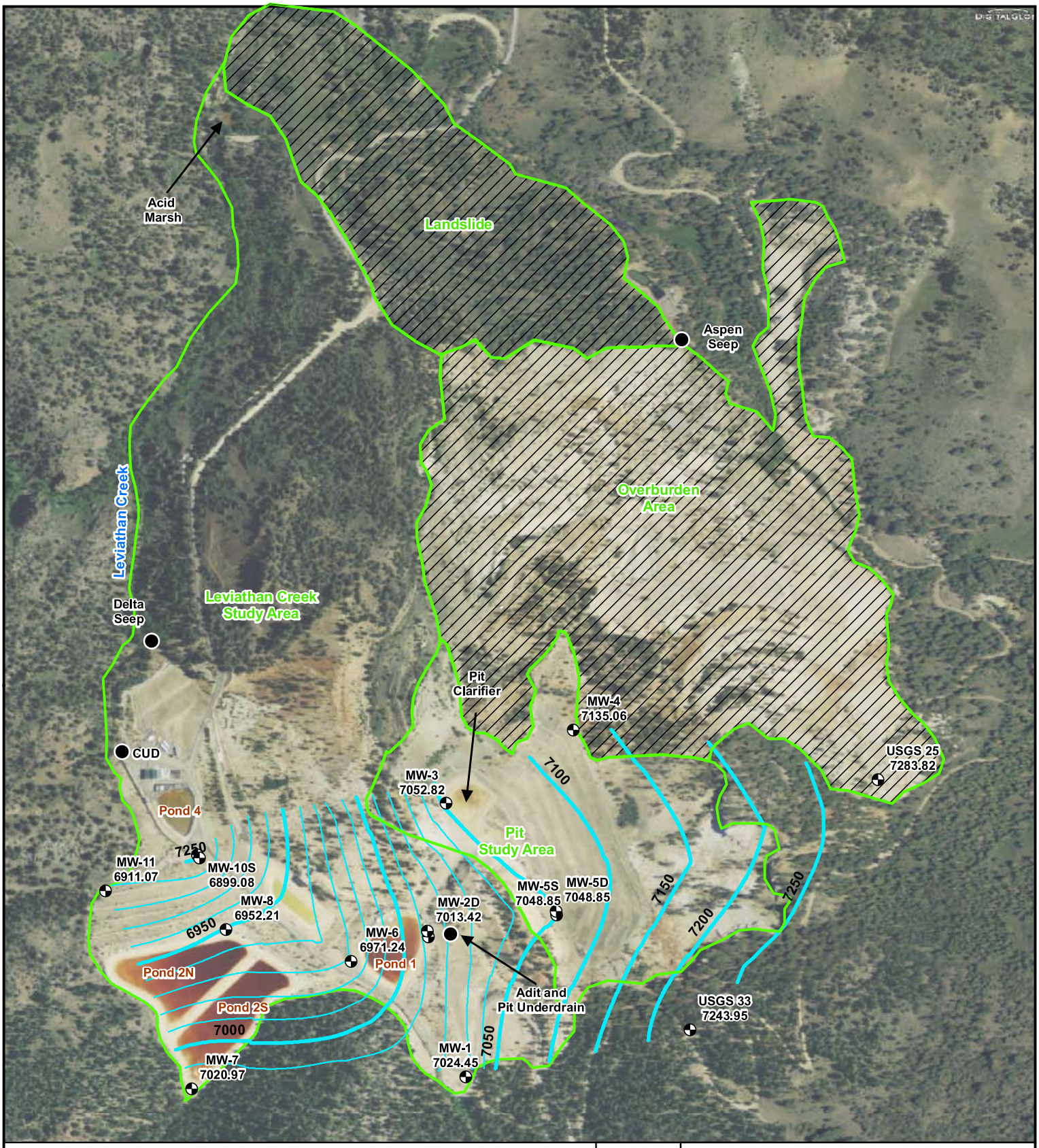
Data Source: Watershed Data derived from the NRCS website

Figure 2

Leviathan Canyon Watershed Map
Leviathan Mine Superfund Site
Alpine County, California

0 1 2 3
Miles

Burleson Consulting, Inc.



Legend

- Monitoring Wells
- 50ft Groundwater Contour Intervals
- 10ft Groundwater Contour Intervals
- Aspen Creek Study Area

Data Source: Aerial image provided by Digital Globe 6-22-2009

N

Figure 3

Areas and Monitoring Well Locations
Leviathan Mine Superfund Site
Alpine County, California

0 500 1,000 1,500
Feet

Burleson Consulting, Inc.

Legend

- Soil Sample Locations
- Soil ph Contours (0.5 intervals)

Data Source: SRK, 1999

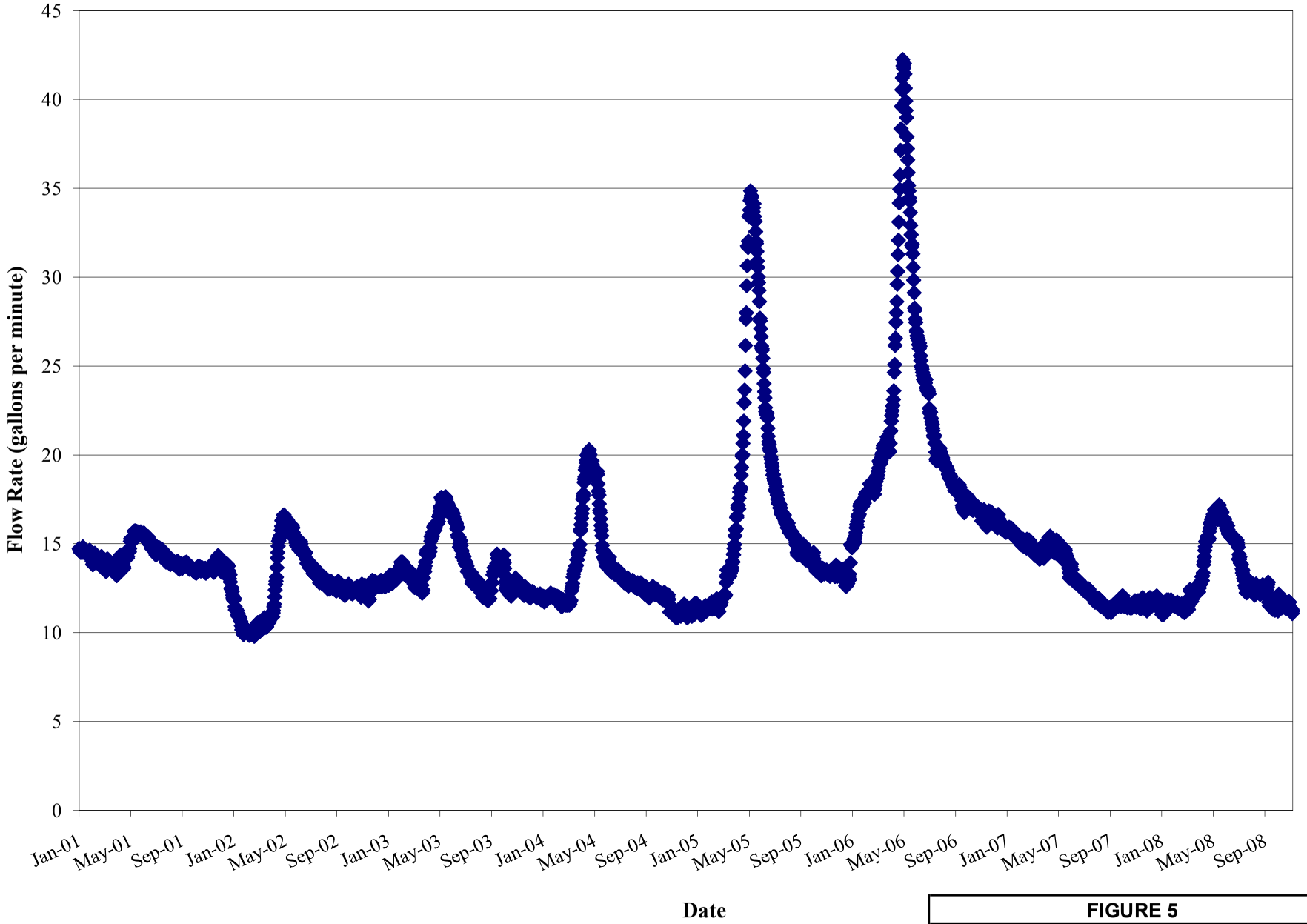
N

Figure 4

Leviathan Soil Paste pH
Leviathan Mine Superfund Site
Alpine County, California

0 400 800 1,200
Feet

Burleson Consulting, Inc.



Data Sources:

U.S. Geological Survey. 2009. Recent Daily Water Data for California, Monitoring Station 10308784. Accessed online at: http://waterdata.usgs.gov/ca/nwis/uv/?site_no=10308784&amp.

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FIGURE 5

ADIT DISCHARGE RATES
LEVIATHAN MINE SUPERFUND SITE
ALPINE COUNTY, CALIFORNIA

Burleson Consulting, Inc.

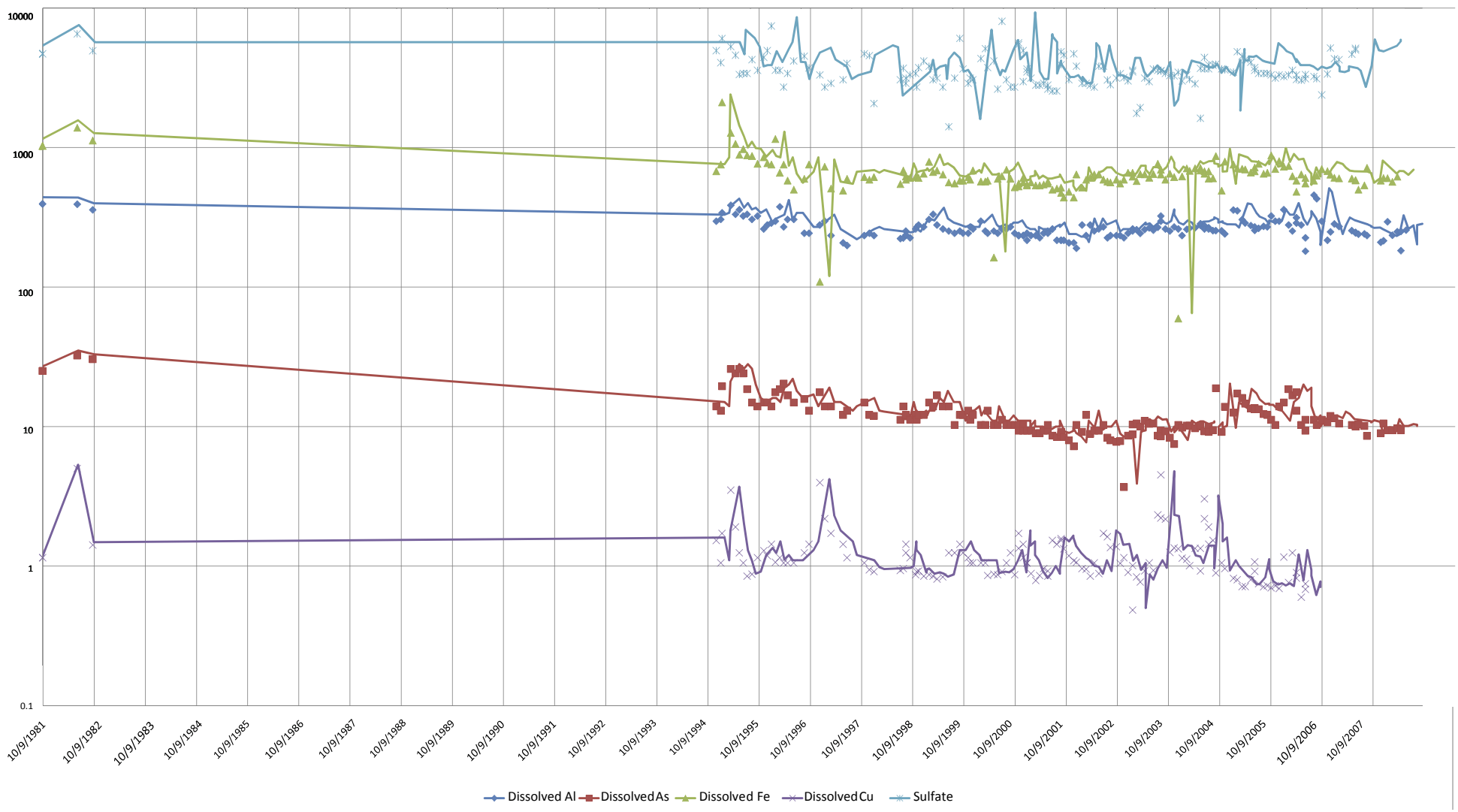


FIGURE 6

ALUMINUM, ARSENIC, IRON, COPPER, AND SULFATE IN ADIT DISCHARGE LEVIATHAN MINE SUPERFUND SITE ALPINE COUNTY, CALIFORNIA

Burleson Consulting, Inc.

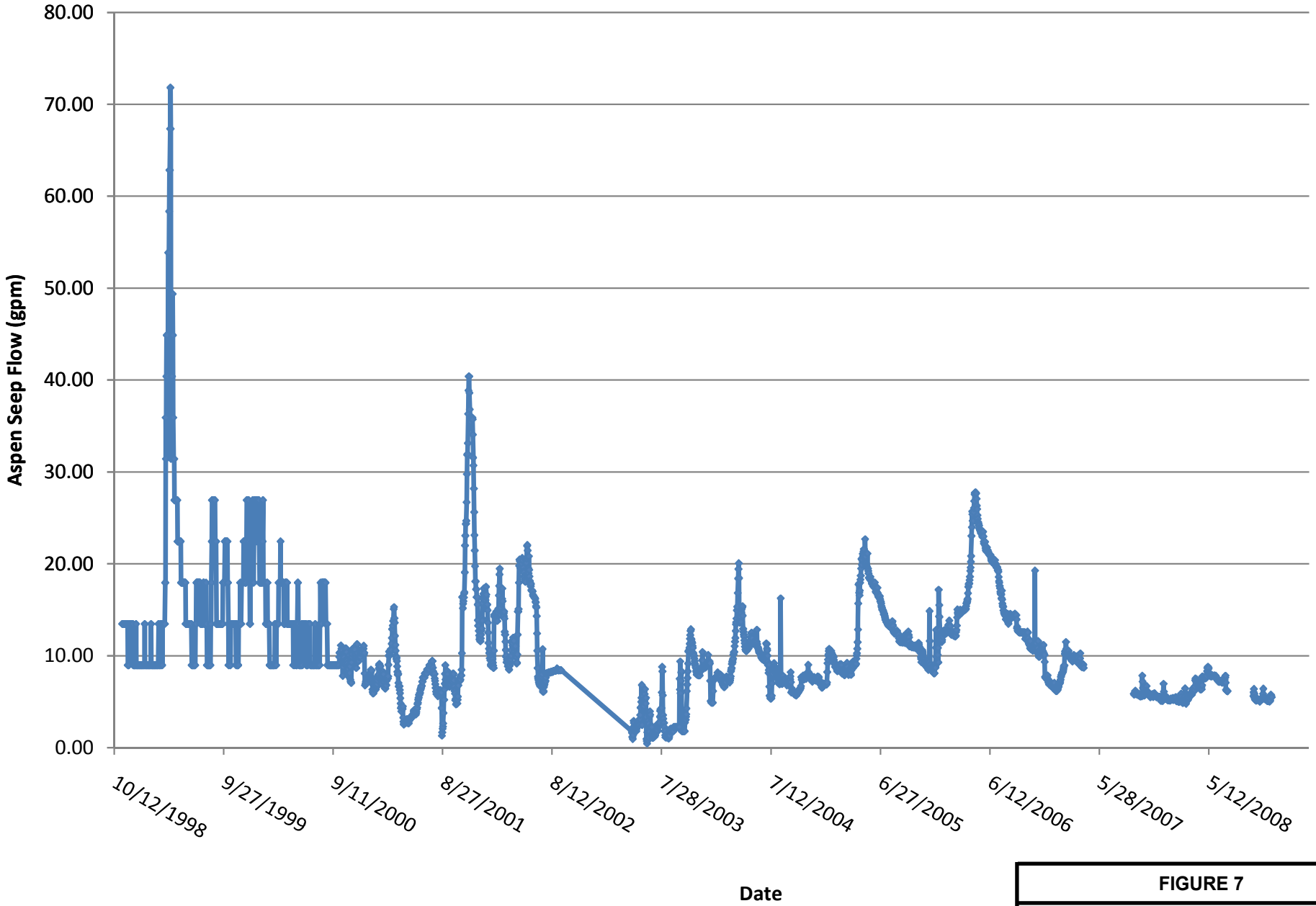


FIGURE 7

ASPEN SEEP FLOW 1998 TO 2008
LEVIATHAN MINE SUPERFUND SITE
ALPINE COUNTY, CALIFORNIA

Burleson Consulting, Inc.

Source: Leviathan Mine Database and Quarterly Monitoring Reports from USGS to Regional Board.

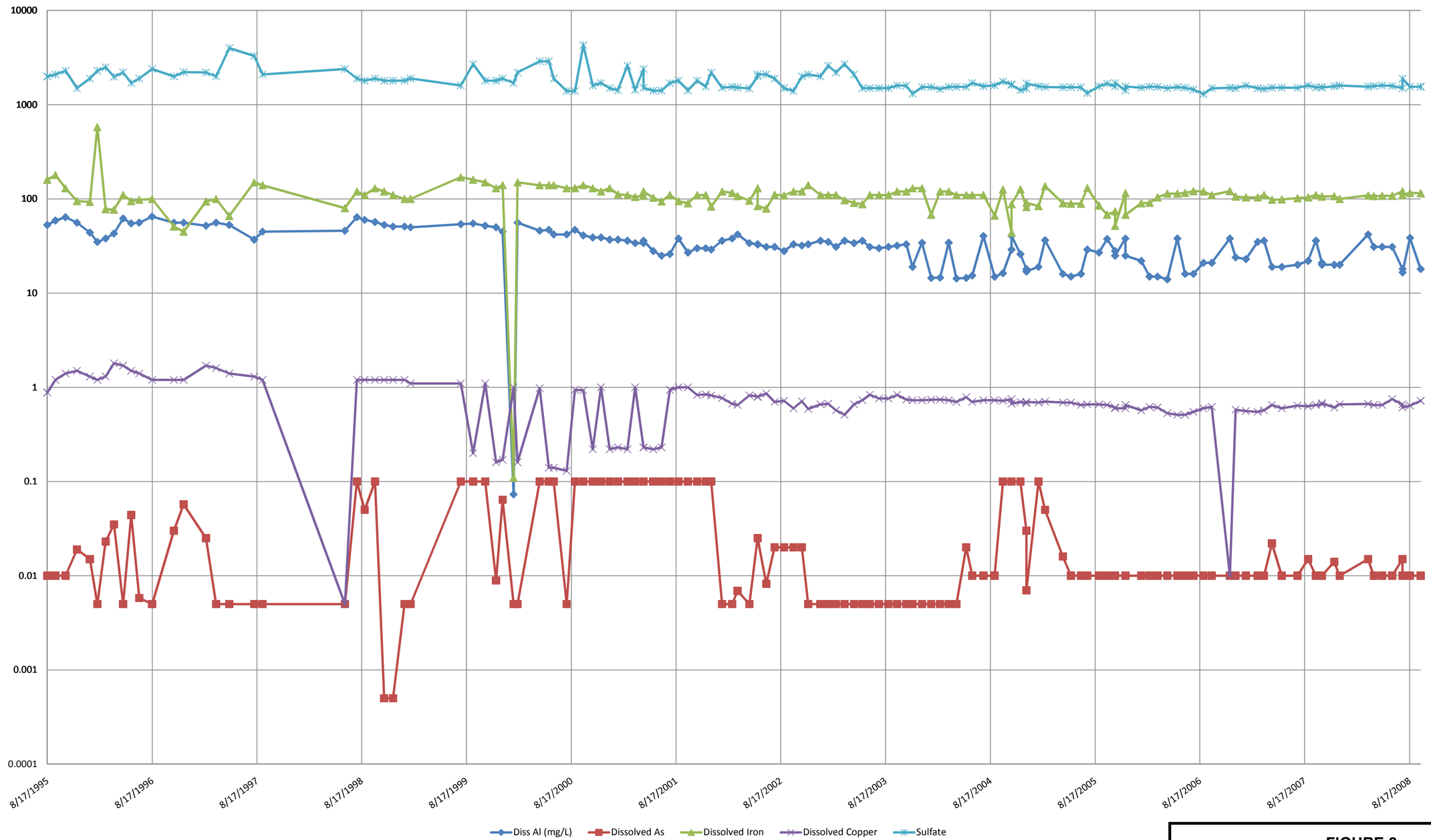


FIGURE 8

ALUMINUM, ARSENIC, IRON, COPPER, AND SULFATE IN ASPEN SEEP DISCHARGE LEVIATHAN MINE SUPERFUND SITE ALPINE COUNTY, CALIFORNIA

Burleson Consulting, Inc.

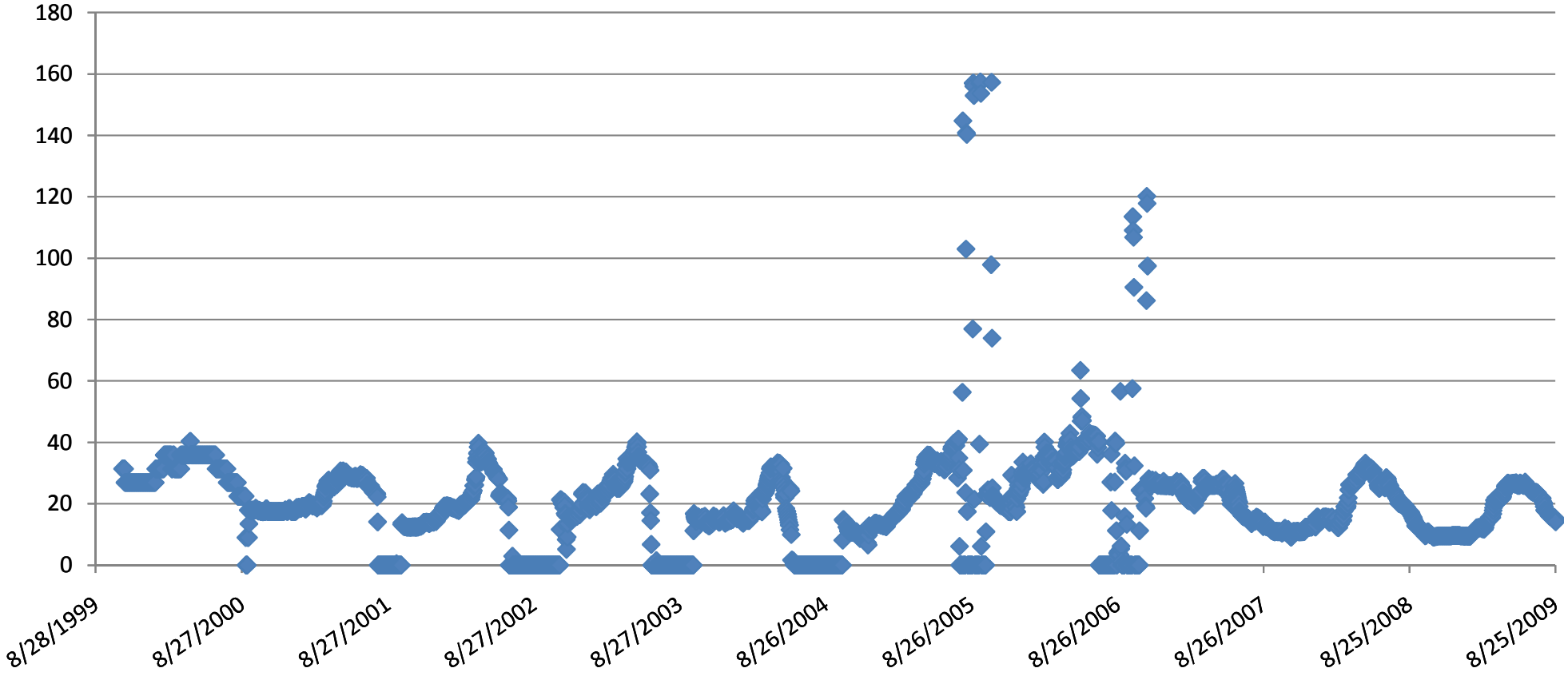


FIGURE 9

CHANNEL UNDERDRAIN DISCHARGE
LEVIATHAN MINE SUPERFUND SITE
ALPINE COUNTY, CALIFORNIA

Burleson Consulting, Inc.

Note: High flows during 2005 and 2006 are believed to have been caused by water treatment related interferences

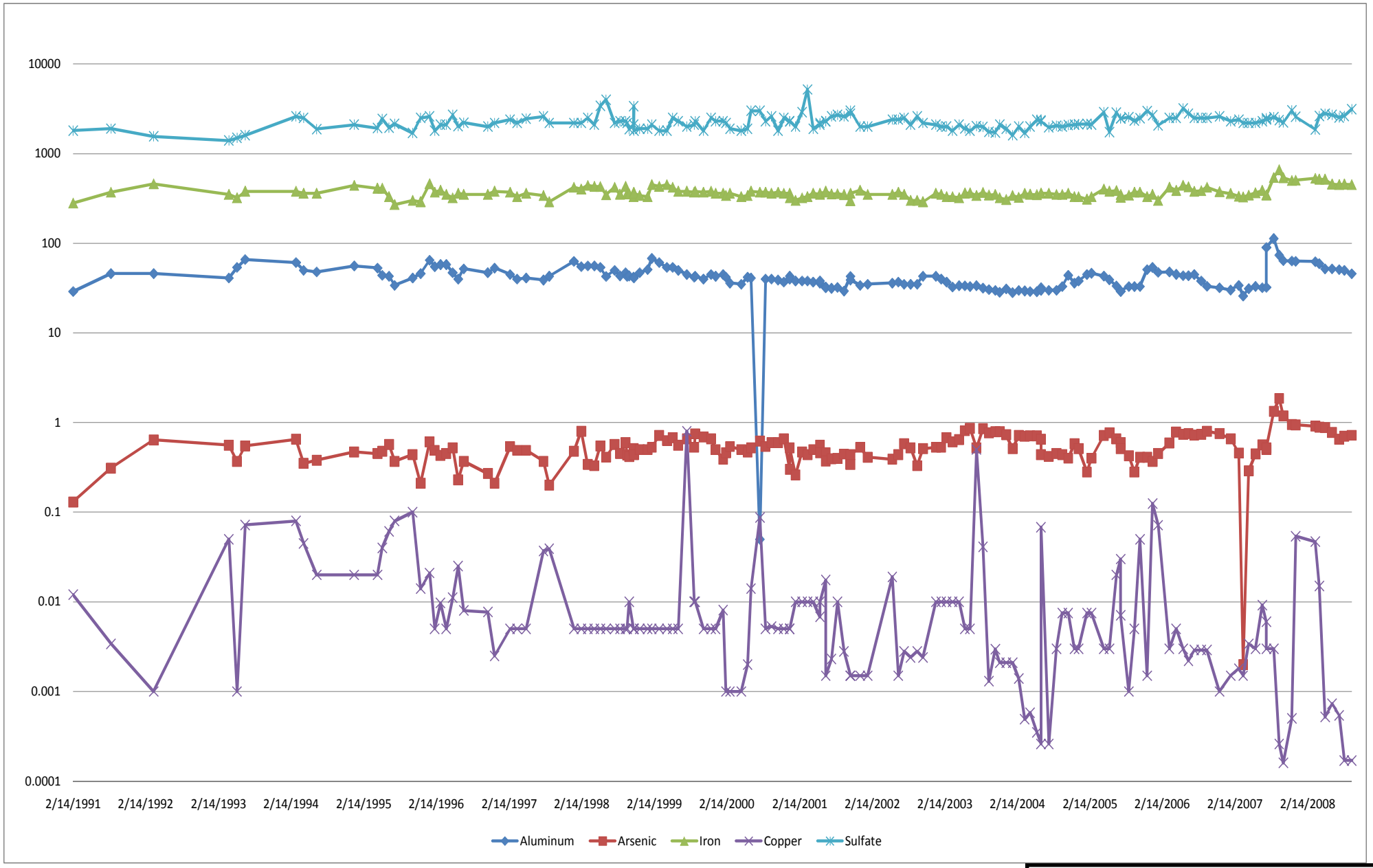


Figure 10

Aluminum, Arsenic, Iron, Copper and Sulfate in CUD Discharge

Burleson Consulting, Inc.

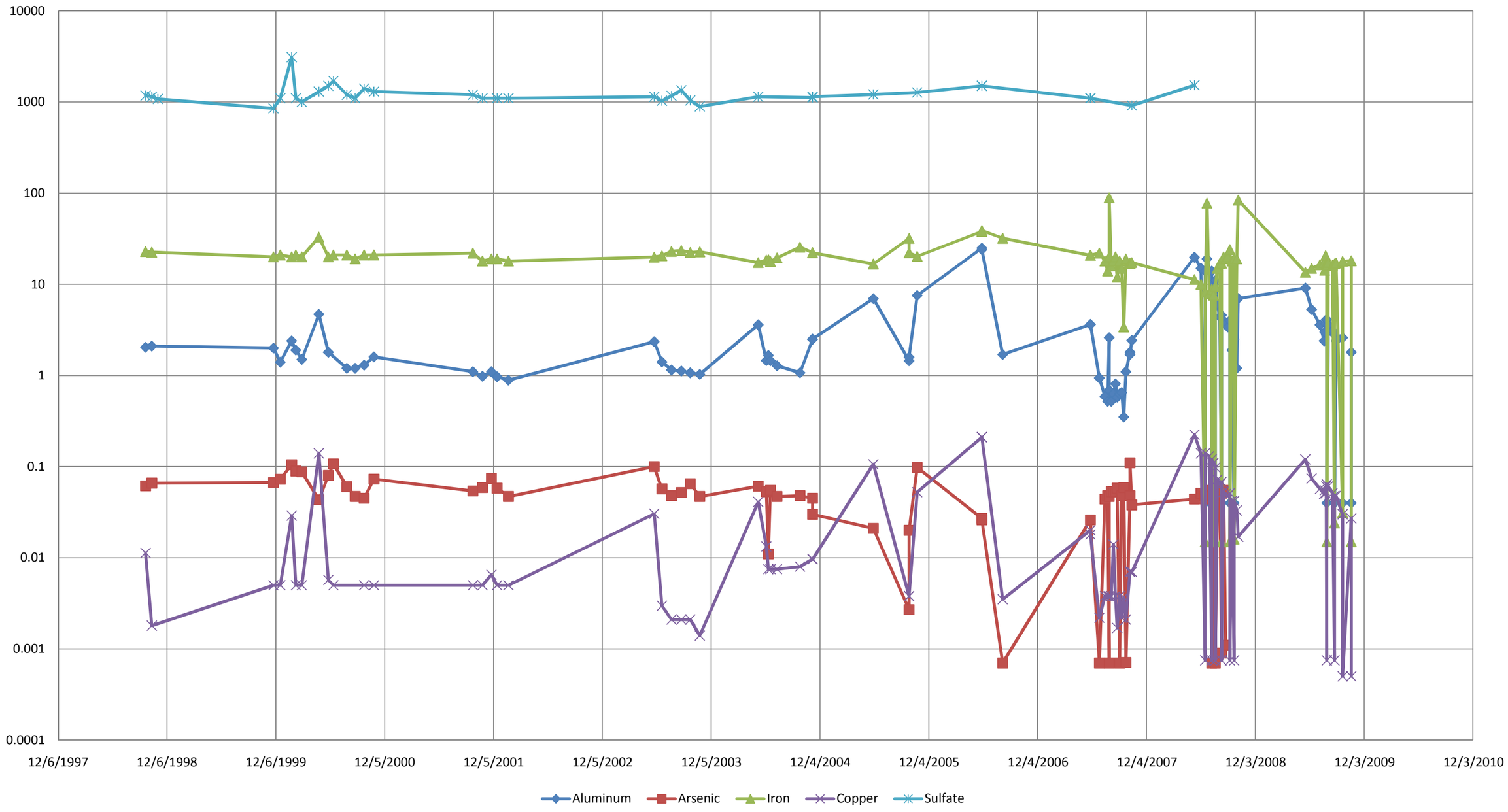
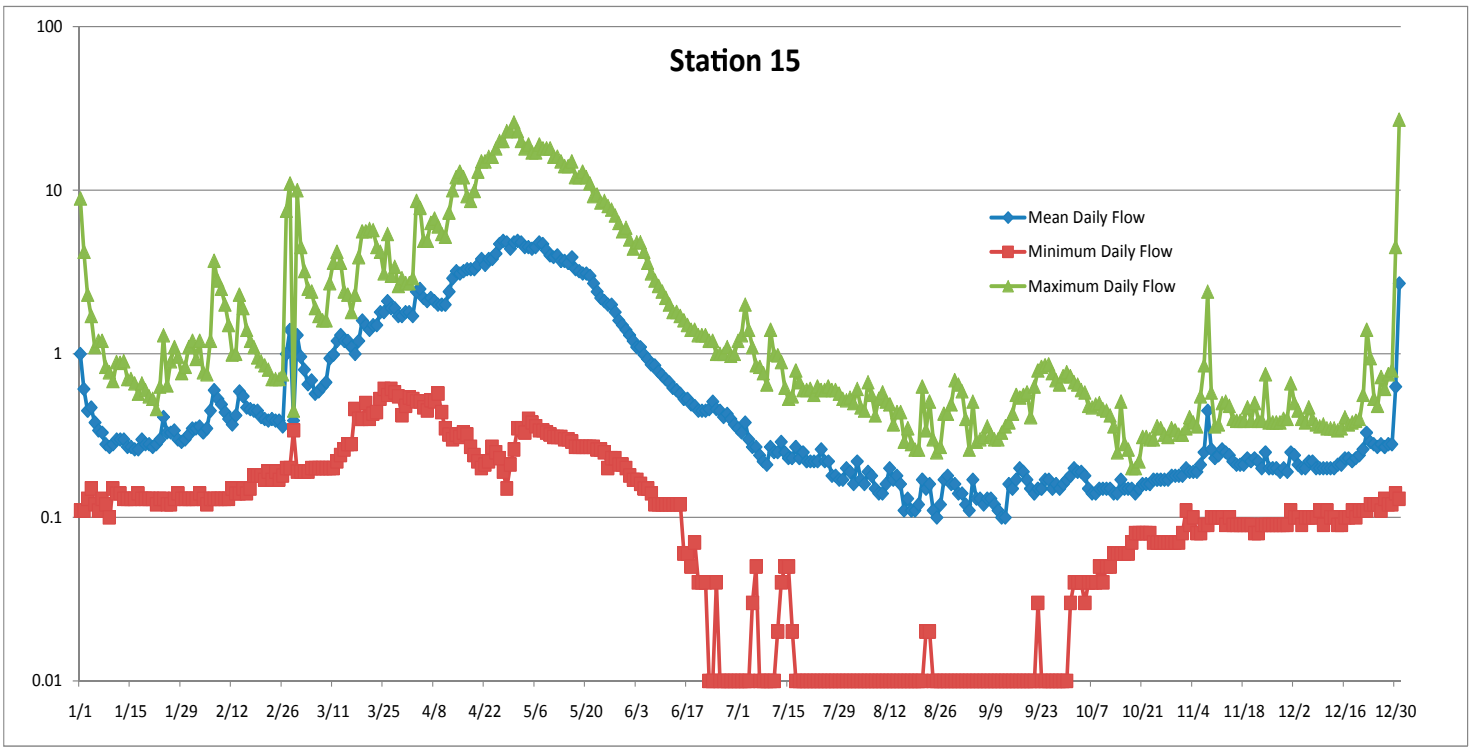


FIGURE 11

ALUMINUM, ARSENIC, IRON, COPPER, AND SULFATE IN DELTA SEEP DISCHARGE LEVIATHAN MINE SUPERFUND SITE ALPINE COUNTY, CALIFORNIA

Burleson Consulting, Inc.



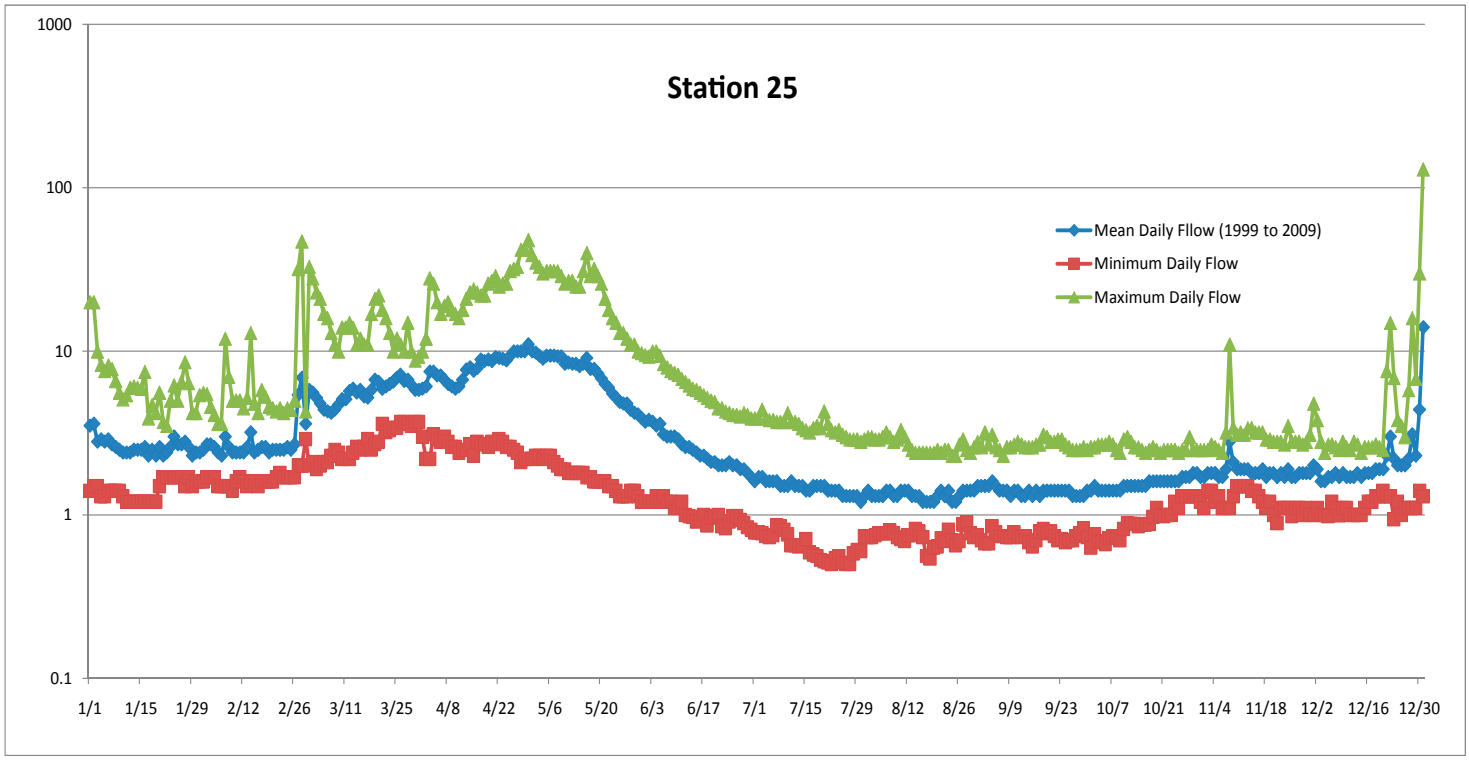


FIGURE 12

MEAN DAILY FLOW AT STATION 15 AND 25 LEVIATHAN MINE SUPERFUND SITE ALPINE COUNTY, CALIFORNIA

Burleson Consulting, Inc.

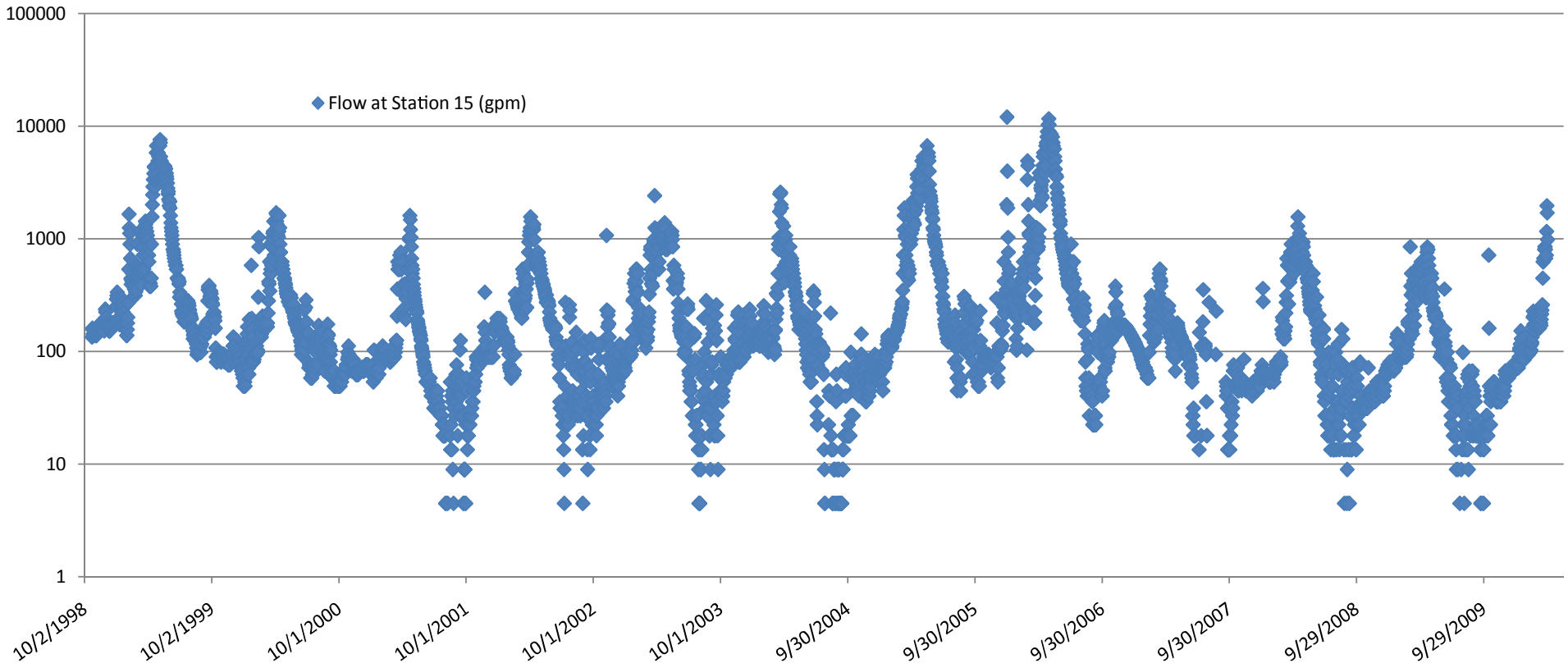


FIGURE 13

FLOW AT STATION 15
LEVIATHAN MINE SUPERFUND SITE
ALPINE COUNTY, CALIFORNIA

Burleson Consulting, Inc.

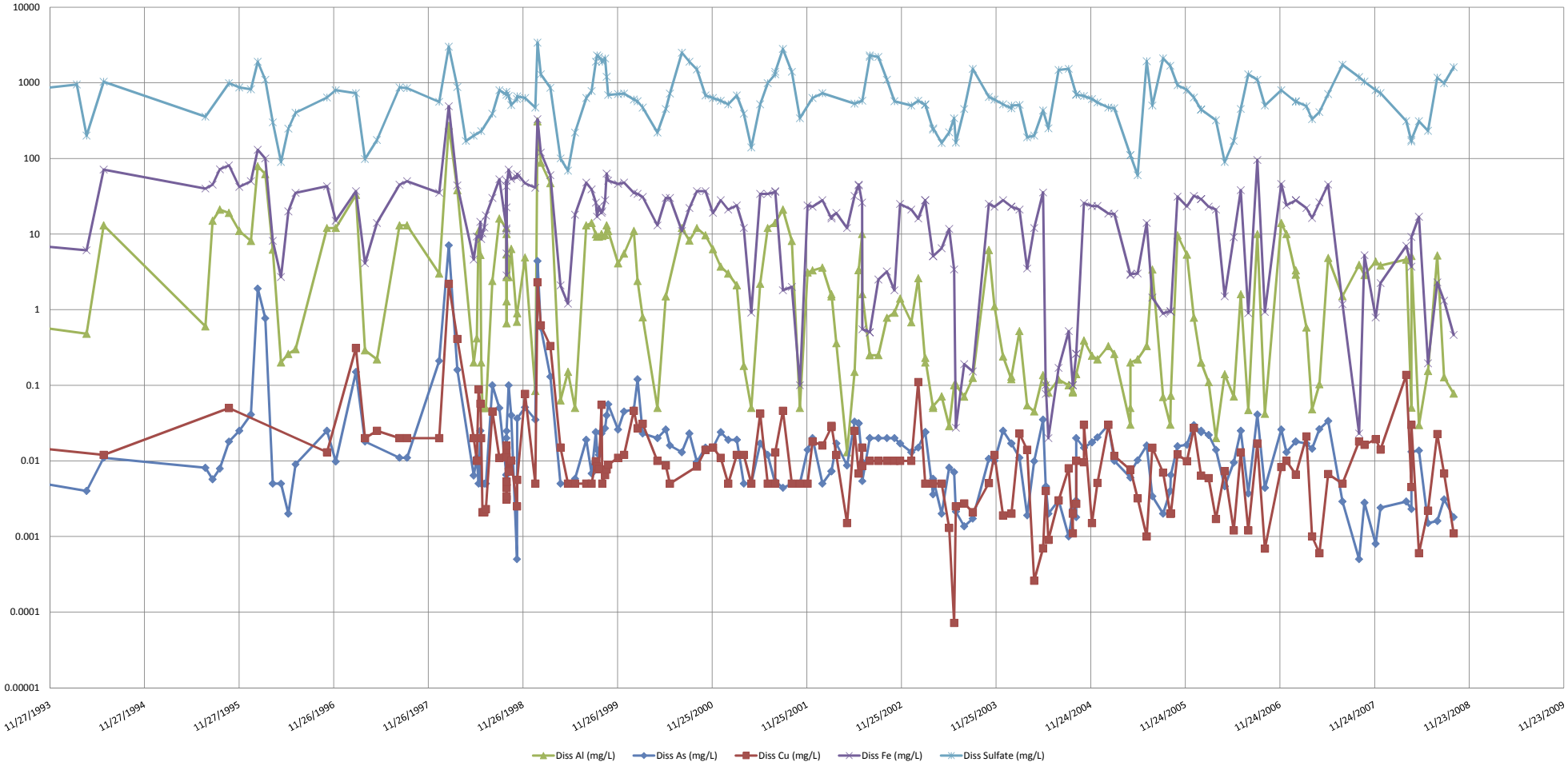


FIGURE 14

ALUMINUM, ARSENIC, COPPER, IRON AND SULFATE AT STATION 15
LEVIATHAN MINE SUPERFUND SITE
ALPINE COUNTY, CALIFORNIA

Burleson Consulting, Inc.

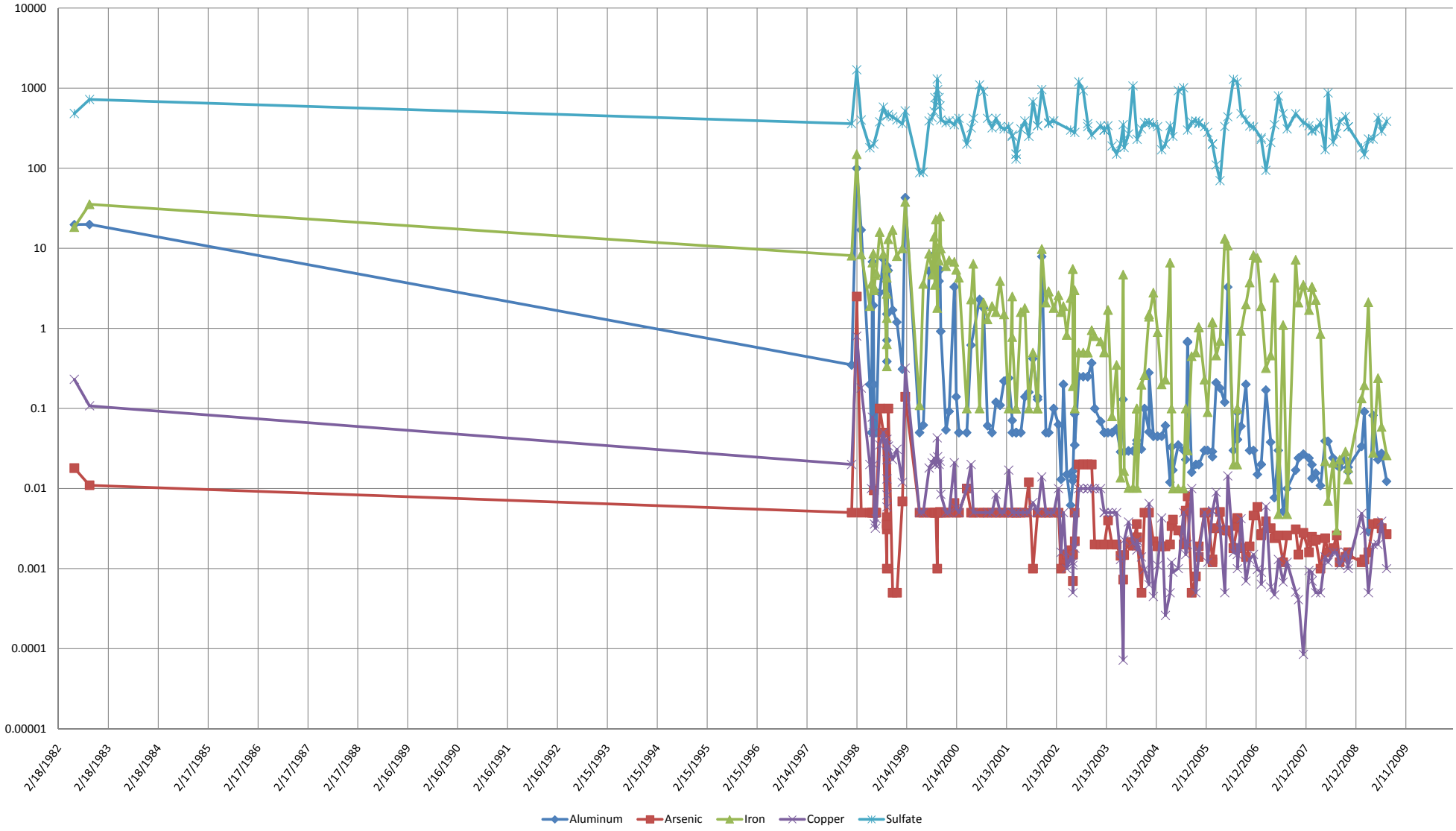


FIGURE 15

ALUMINUM, ARSENIC, COPPER, IRON AND SULFATE AT STATION 23 LEVIATHAN MINE SUPERFUND SITE ALPINE COUNTY, CALIFORNIA

Burleson Consulting, Inc.

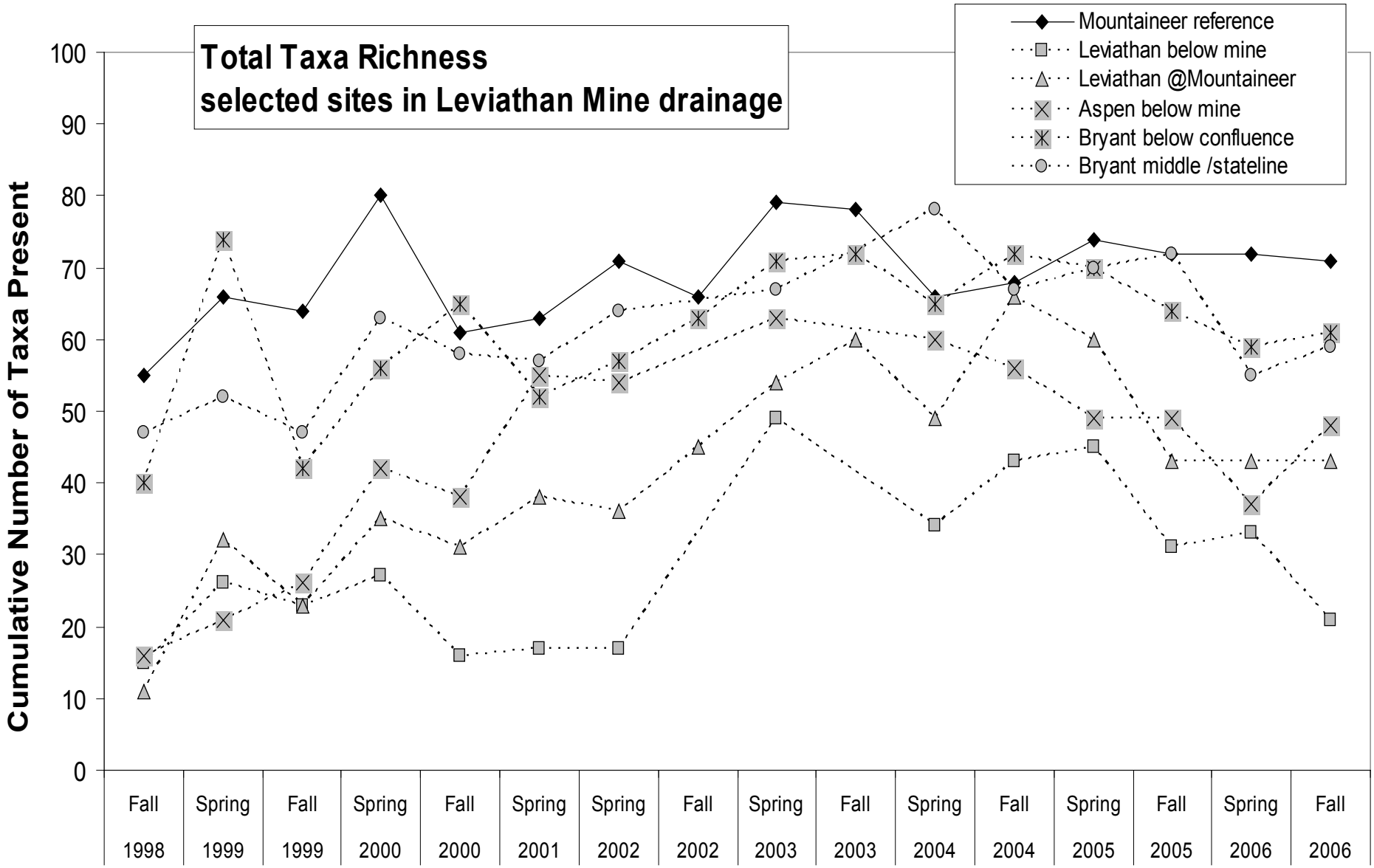


FIGURE 16

TOTAL TAXA RICHNESS AT SELECTED SITES IN LEVIATHAN MINE DRAINAGE LEVIATHAN MINE SUPERFUND SITE ALPINE COUNTY, CALIFORNIA

Burleson Consulting, Inc.

DATA SOURCE: HERBST 2010 IN PRESS
RICHNESS EXPRESSED AS THE COMBINED NUMBER OF TOTAL TAXA PRESENT FROM 5 SAMPLES AT EACH SITE OVER TIME (SEASON AND YEAR) FOR SELECTED SITES IN THE LEVIATHAN MINE WATERSHED
SOLID LINE FOR REFERENCE SITE, DASHED LINES FOR AMD-EXPOSED SITES

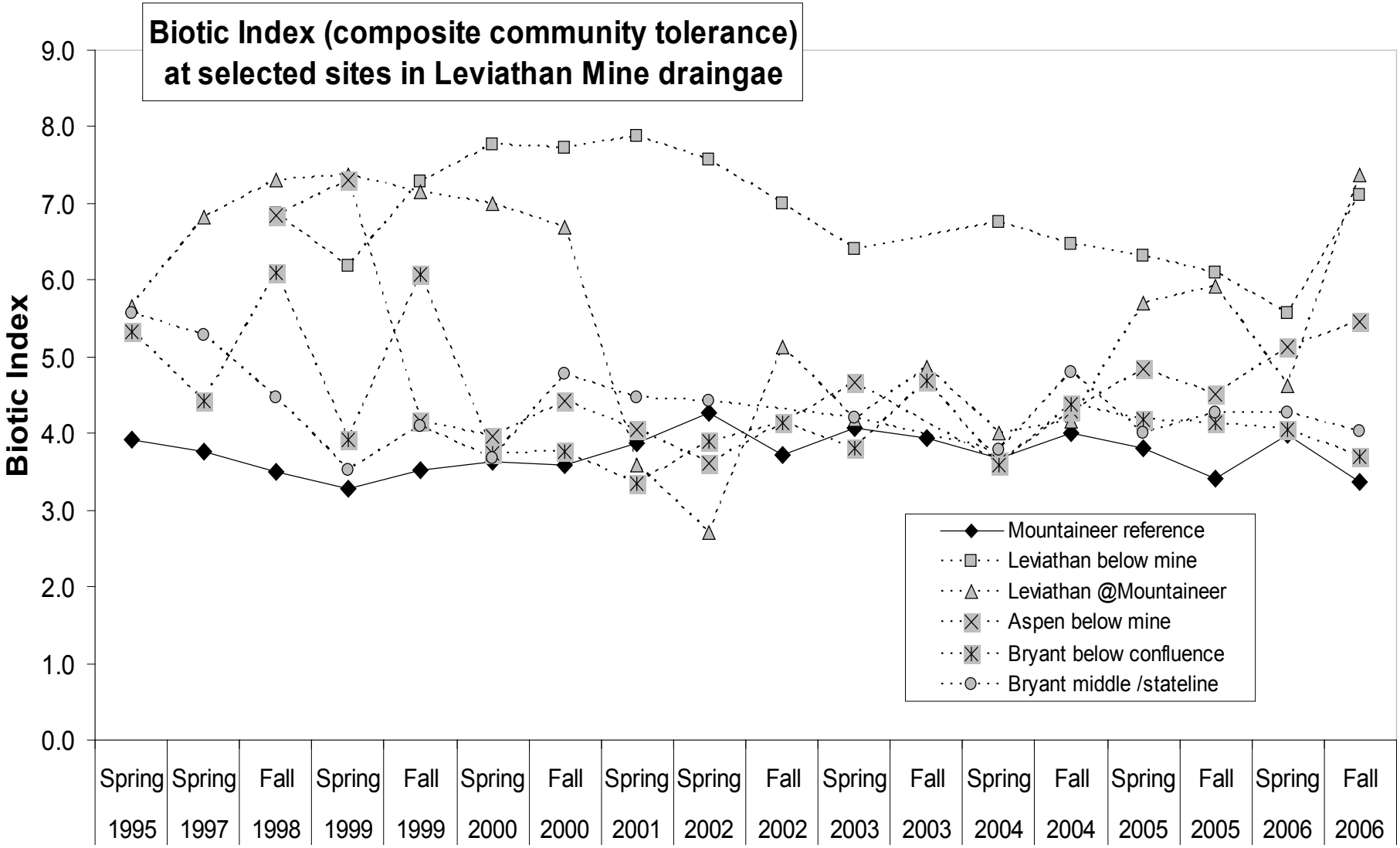
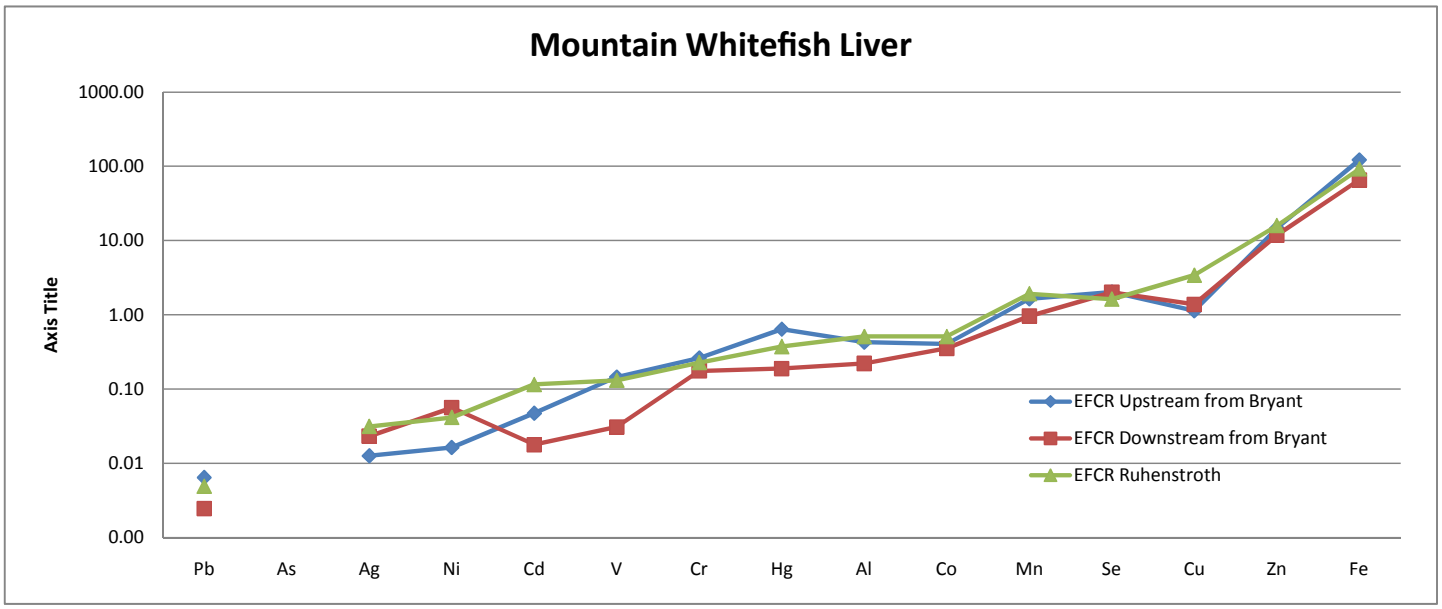


FIGURE 17

BIOTIC INDEX AT SELECTED SITES IN LEVIATHAN MINE DRAINAGE LEVIATHAN MINE SUPERFUND SITE ALPINE COUNTY, CALIFORNIA

Burleson Consulting, Inc.

DATA SOURCE: HERBST 2010 IN PRESS
BIOTIC INDEX AS THE MEAN OF 5 REPLICATE SAMPLES AT EACH SITE OVER TIME (SEASON AND YEAR) FOR SELECTED SITES IN THE LEVIATHAN MINE WATERSHED
SOLID LINE FOR REFERENCE SITE, DASHED LINES FOR AMD-EXPOSED SITES



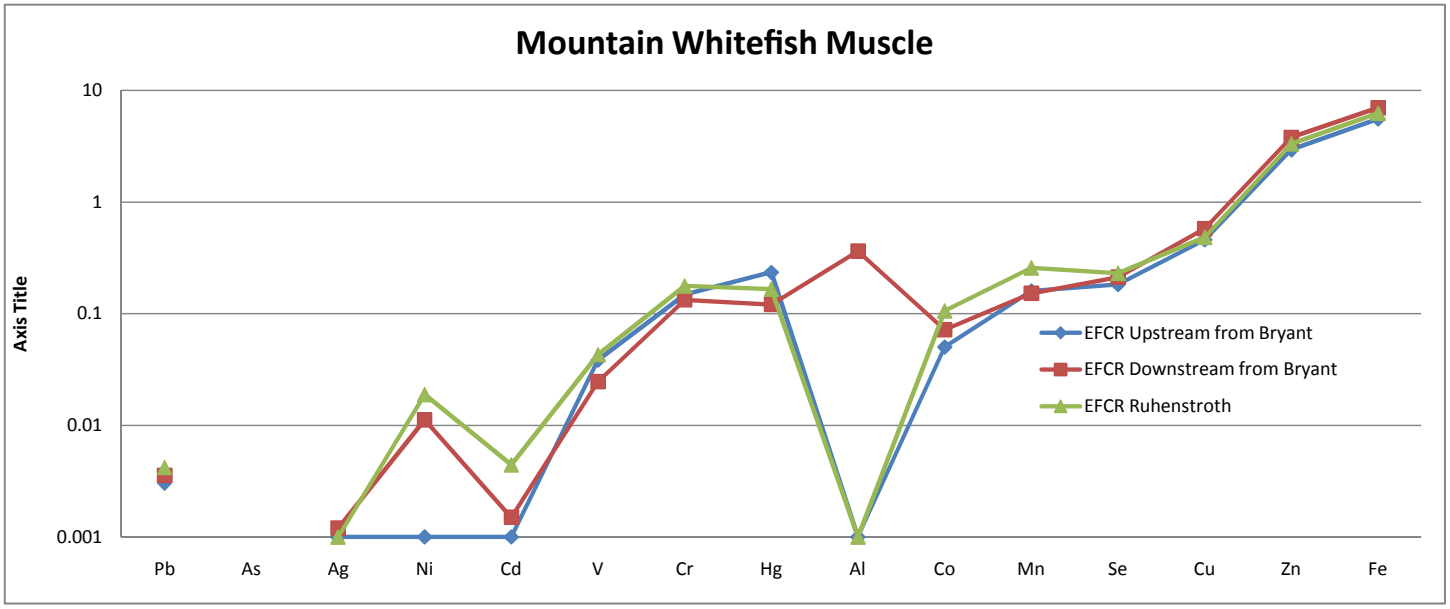


FIGURE 18

METALS IN WHITEFISH LIVER AND MUSCLE TISSUE
LEVIATHAN MINE SUPERFUND SITE
ALPINE COUNTY, CALIFORNIA

Burleson Consulting, Inc.

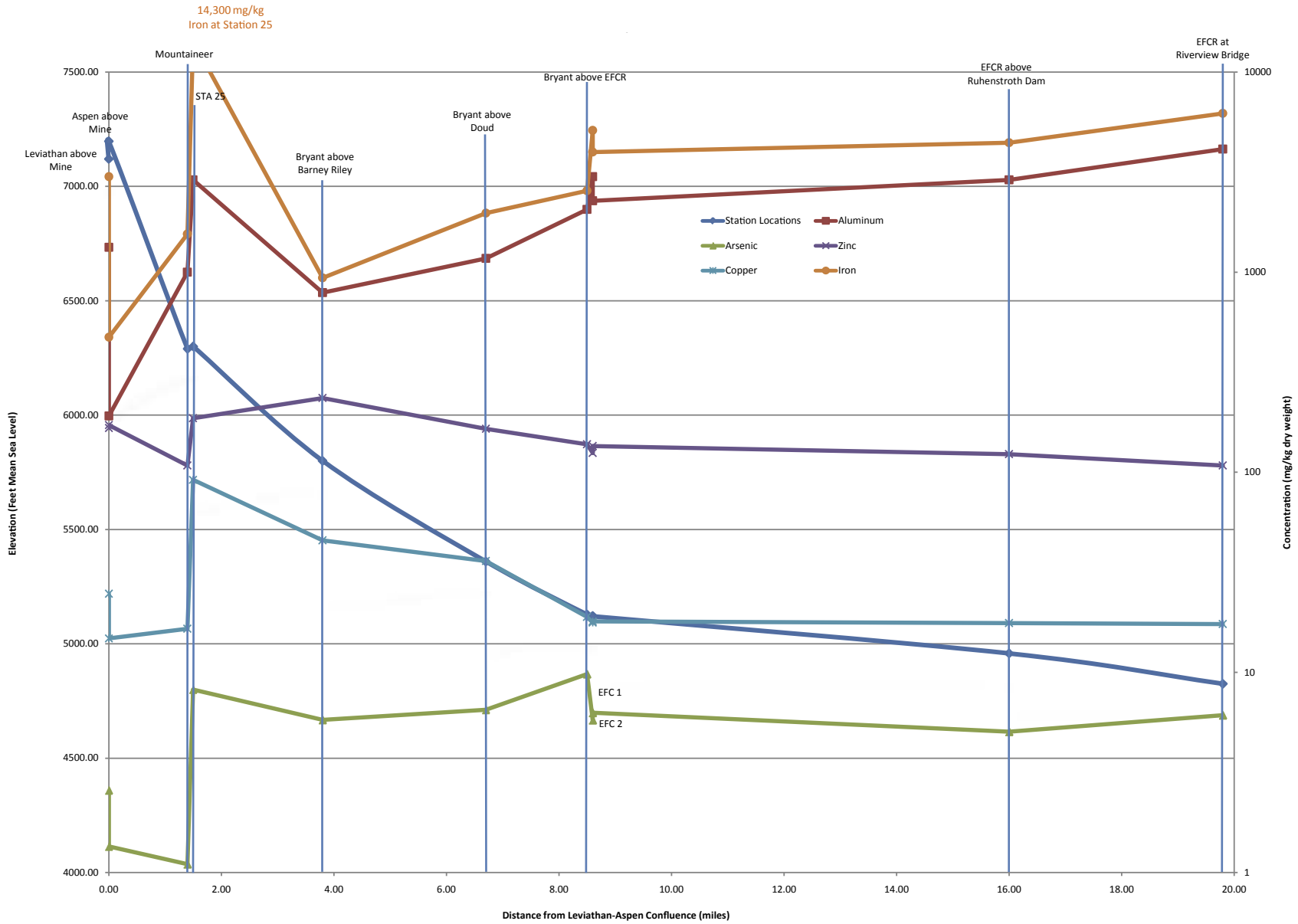


FIGURE 19

METALS IN CADDISFLY SEPT 1998
LEVIATHAN-BRYANT-EFCR
LEVIATHAN MINE SUPERFUND SITE
ALPINE COUNTY, CALIFORNIA

Burleson Consulting, Inc.

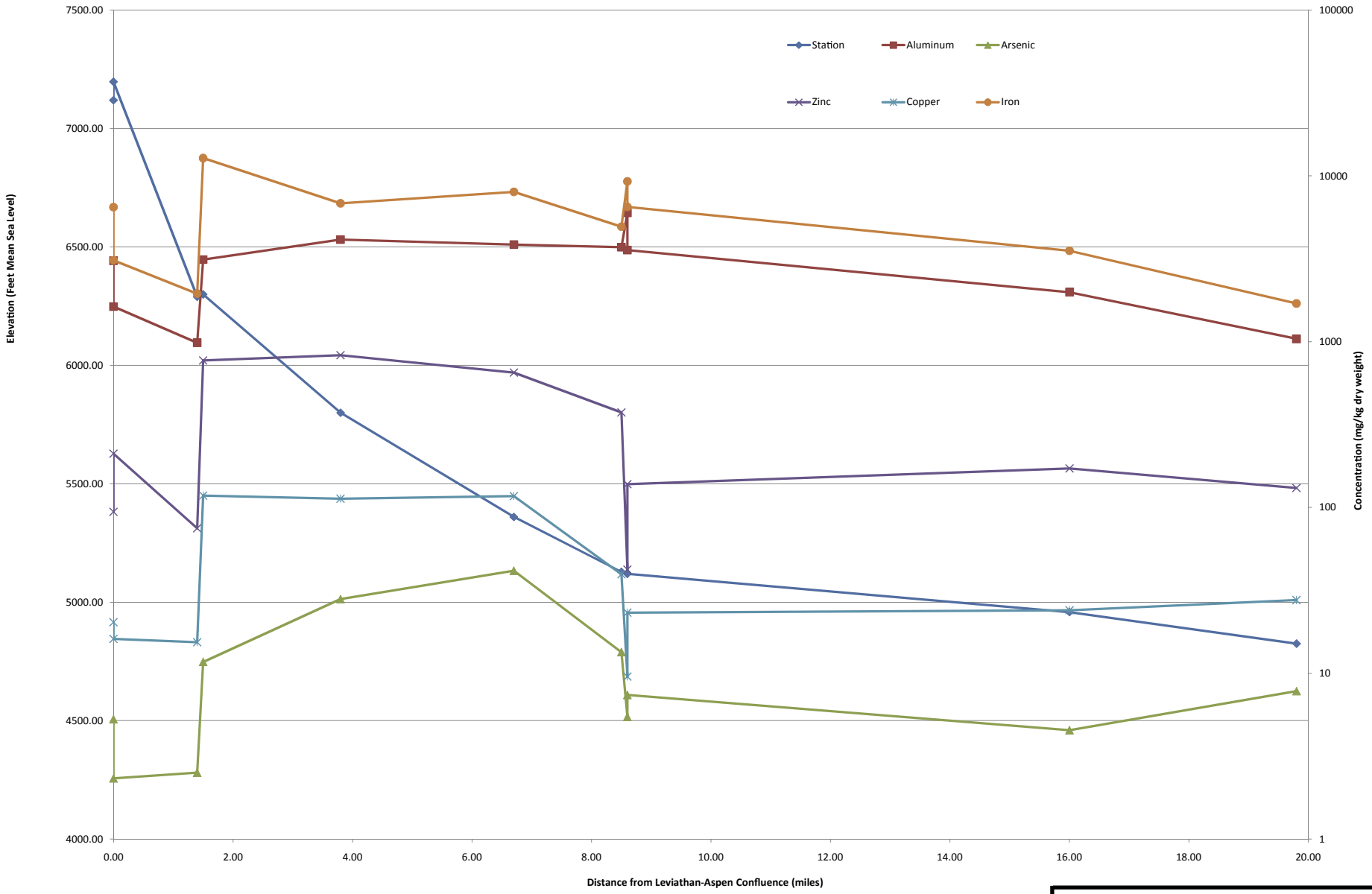


FIGURE 20

METALS IN MAYFLY 1998
LEVIATHAN-BRYANT-EFCR
LEVIATHAN MINE SUPERFUND SITE
ALPINE COUNTY, CALIFORNIA

Burleson Consulting, Inc.

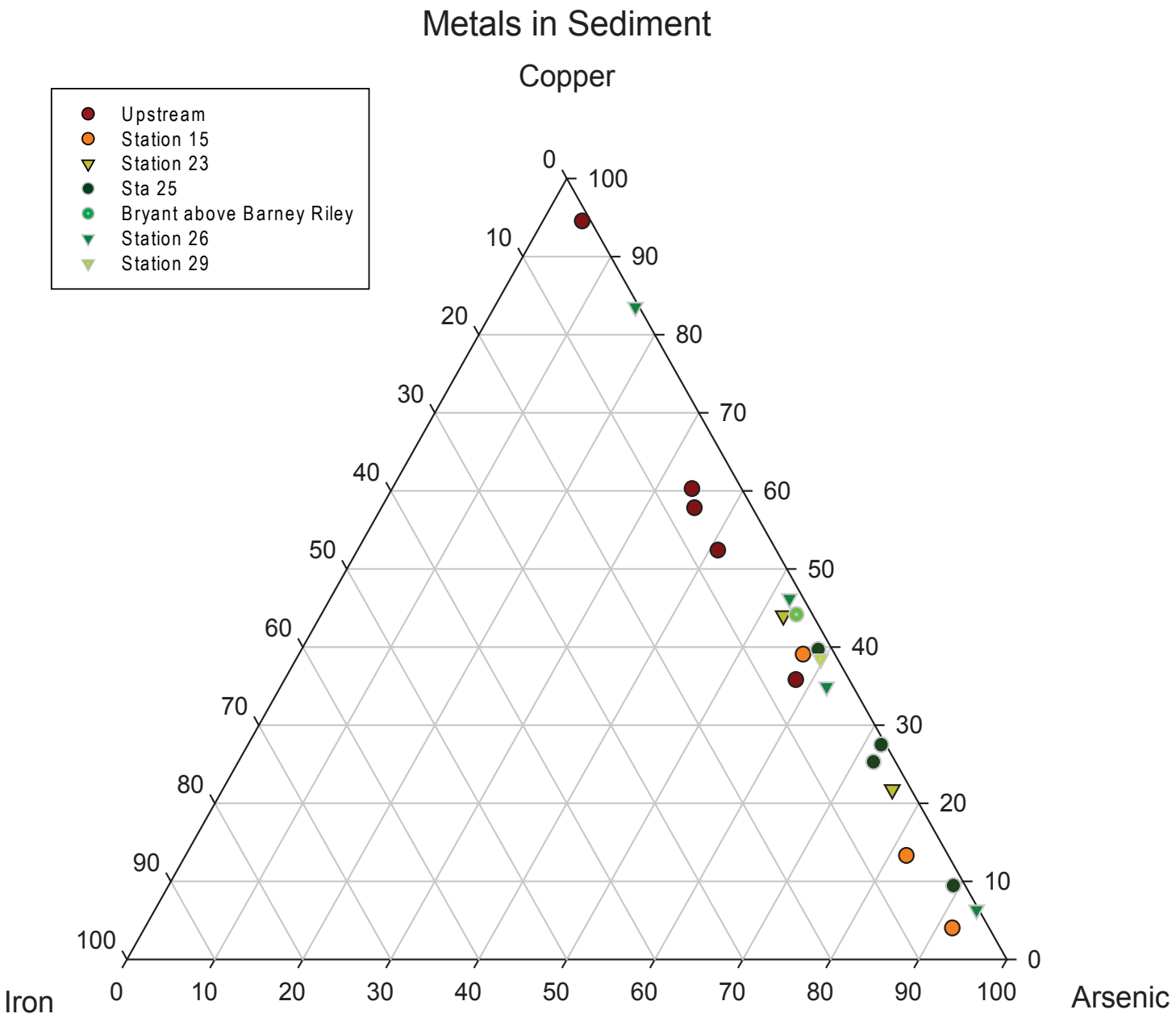
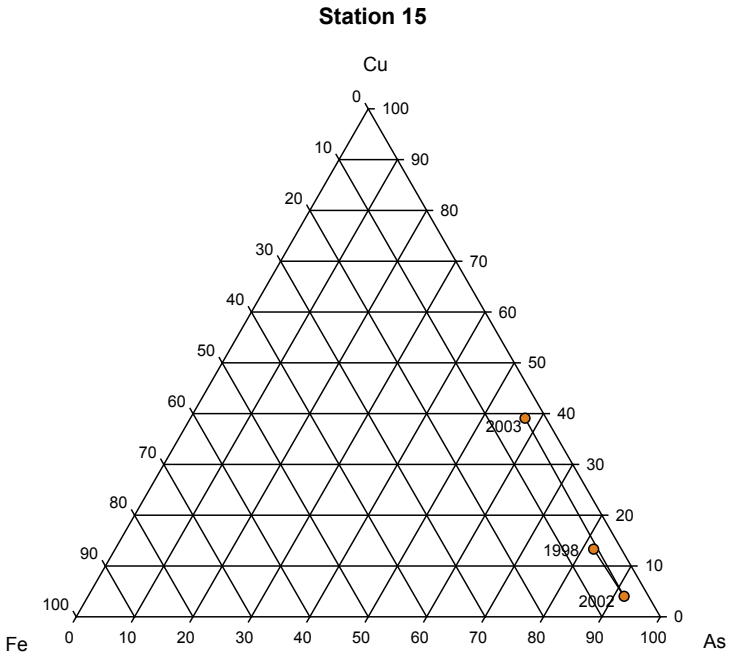
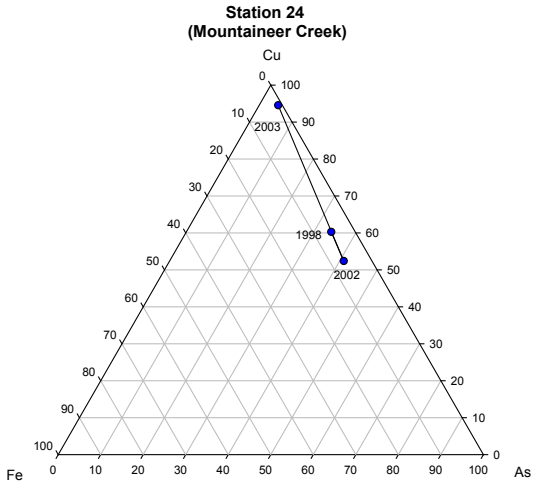


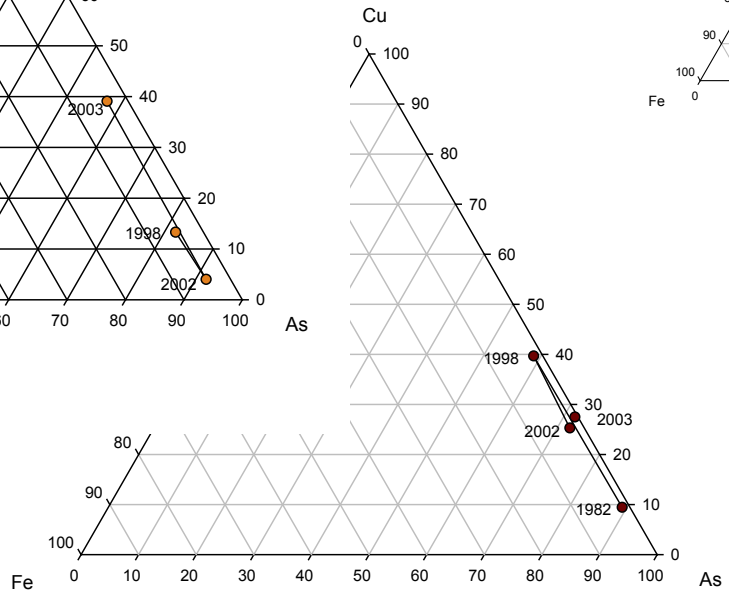
FIGURE 21

METAL IN SEDIMENTS
LEVIATHAN MINE SUPERFUND SITE
ALPINE COUNTY, CALIFORNIA

Burleson Consulting, Inc.

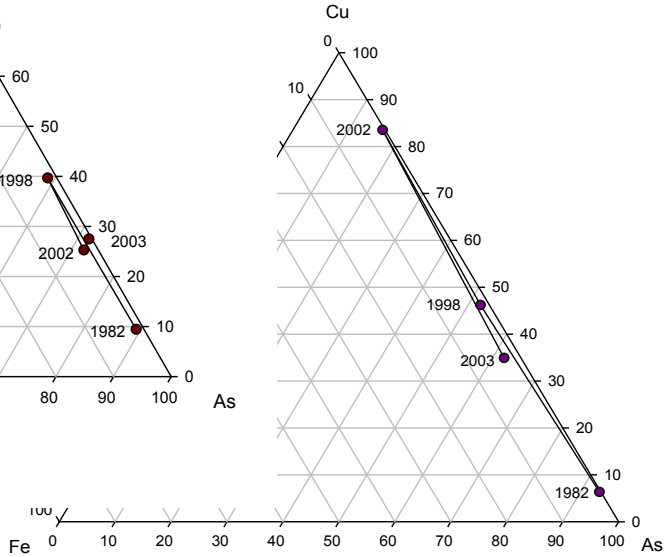






Station 25

Bryant Creek



Station 26

Bryant Creek above Doud Creek

FIGURE 22

TIME TERNARY SEDIMENT
LEVIATHAN MINE SUPERFUND SITE
ALPINE COUNTY, CALIFORNIA

Burleson Consulting, Inc.

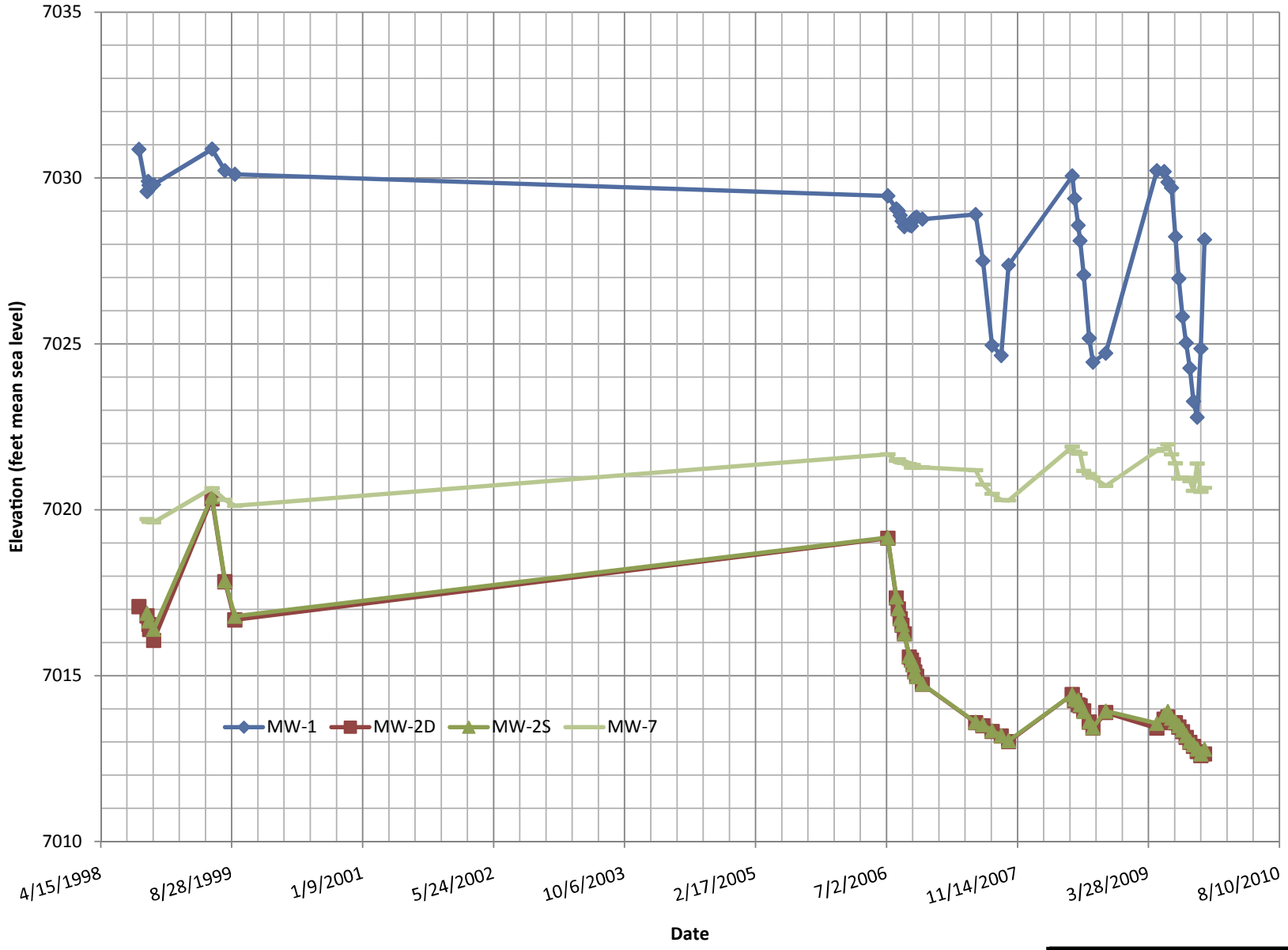


FIGURE 23

GROUNDWATER ELEVATIONS AT MW 1, MW 2D, MW 2S, AND MW 7 LEVIATHAN MINE SUPERFUND SITE ALPINE COUNTY, CALIFORNIA

Burleson Consulting, Inc.

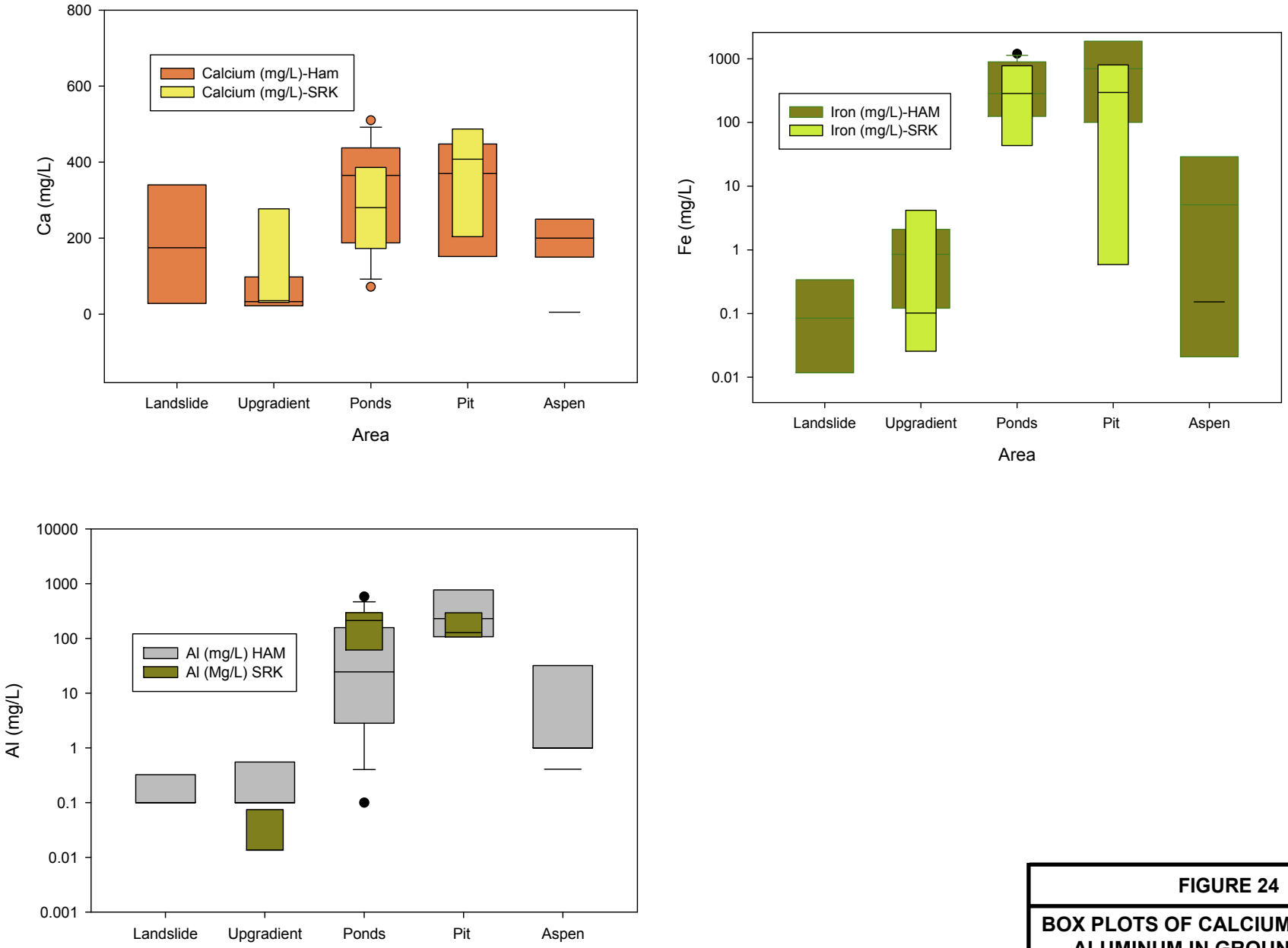


FIGURE 24

BOX PLOTS OF CALCIUM, IRON, AND ALUMINUM IN GROUNDWATER LEVIATHAN MINE SUPERFUND SITE ALPINE COUNTY, CALIFORNIA

Burleson Consulting, Inc.

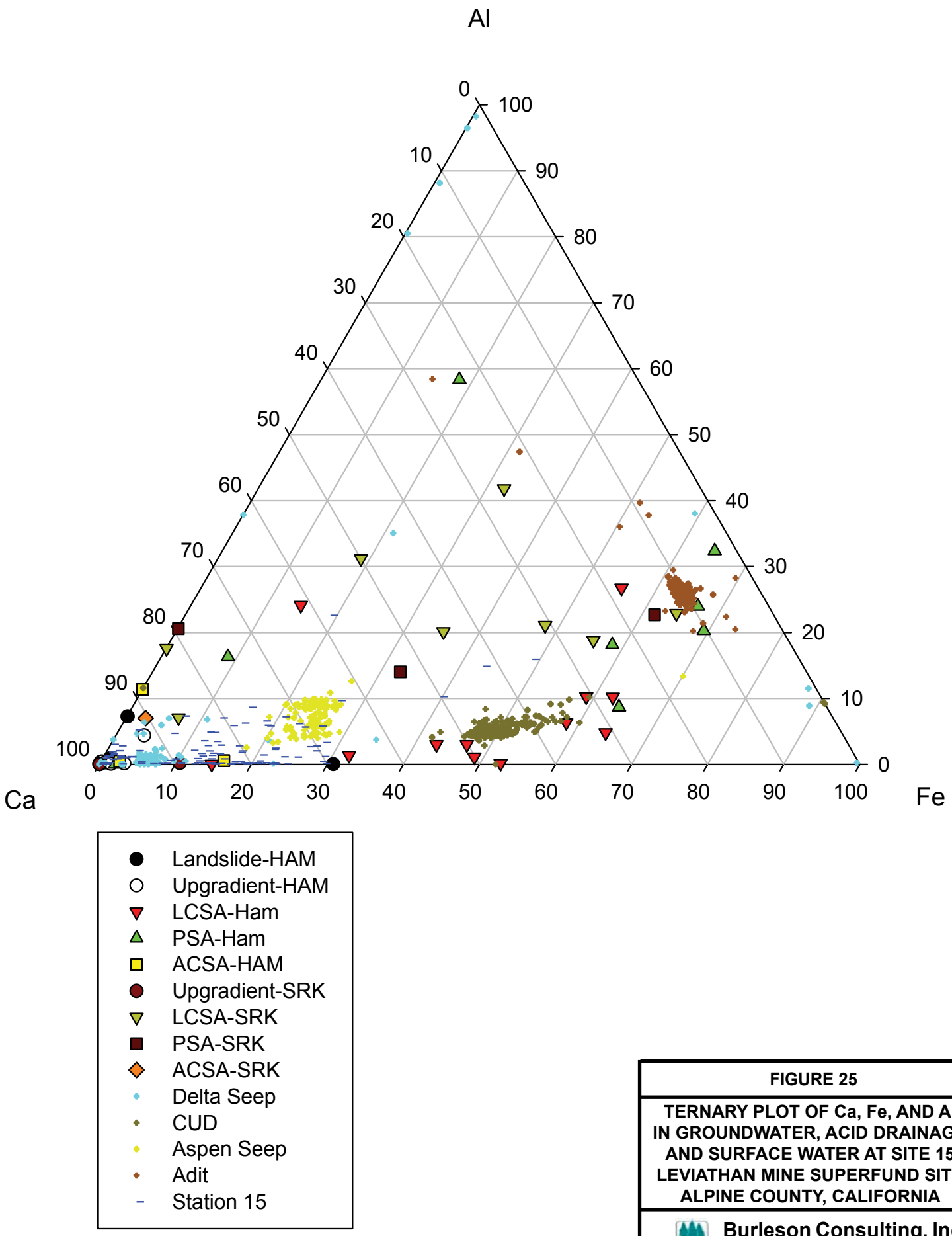


FIGURE 25

TERNARY PLOT OF Ca, Fe, AND Al IN GROUNDWATER, ACID DRAINAGE AND SURFACE WATER AT SITE 15 LEVIATHAN MINE SUPERFUND SITE ALPINE COUNTY, CALIFORNIA

Burleson Consulting, Inc.