

**ABANDONED MINE
SITE INVESTIGATION
OF THE
IDORA MINE SITE
ALONG
BEAVER CREEK
IDAHO**

Prepared for:

U.S. Army Corps of Engineers, Sacramento District and
U.S. Army Corps of Engineers, Omaha District

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EXECUTIVE SUMMARY

In a collaborative effort by the United States Army Corps of Engineers - Restoration of Abandoned Mine Site program and the United States Forest Service, Bitterroot Restoration, Inc. completed a fall 2002 field characterization of the Idora Mine/Mill site north of Wallace, Idaho. The purpose of the site characterization is to determine the nature, extent and magnitude of environmental disturbance in the drainage and to assess potential impacts to human health and the environment. The findings of the characterization will guide future restoration efforts in the Beaver Creek stream drainage. The Idora Mine/Mill site assessment is the first Restoration of Abandoned Mine Site project undertaken in the State of Idaho.

Developed in the early twentieth century, the Idora Mine was active through the mid 1950s. The mine produced commercial quantities of silver and zinc, but the primary ore was lead. The mill site and tailings are located in and adjacent to Beaver Creek and are being actively eroded. Preliminary evidence indicates that the site is the source of a significant amount of heavy metal contamination to the downstream reaches, which contain residences, frequent recreation usage, and wildlife habitat.

The Idora mine and mill sites are located in the headwaters of Beaver Creek, a tributary of the North Fork of the Coeur d'Alene River, Idaho Panhandle National Forests, Shoshone County, Idaho. The Beaver Creek watershed has been identified by the United States Forest Service as a priority watershed for Abandoned Mine Land reclamation. In addition, the United States Bureau of Land Management and State of Idaho are also actively involved with abandoned mine reclamation at other sites in the Beaver Creek watershed.

This characterization occurred between July 2002 and March 2003, and the field investigation took place over six days, from October 1 to October 8, 2002. It involved creating a topographic site map, as well as collecting and analyzing surface water, sediment, soil, and mine waste samples from Beaver Creek, downstream from the Idora mine site. Additional information related to the vegetative and geomorphic characteristics within the drainage aided in our understanding of the site. Seven surface water samples, seven sediment samples, and 17 soil/mine waste samples were collected and analyzed. In addition, 135 soil and mine waste samples were analyzed for total metals concentrations via X-ray fluorescence.

It is estimated that the injured area on Beaver Creek contains approximately 2.3 million cubic feet of contaminated materials. The materials are spread fairly evenly across the site. The upper 1,100 feet of the site (accounting for 17 percent of the total injured area), however, contains 25 percent of the total volume of materials. A disproportionately high volume of materials is found in this area because it houses the Idora Mine and Mill.

The results from this site investigation indicate that the levels of contamination in and around the Idora Mine project site exceed established protective limits for recreational populations. Lead is the major Chemical of Potential Concern in the system. Over 75 percent of soil/mine waste samples and over 85 percent of the sediment samples contained total lead concentrations above Chemicals of Potential Concern limits for recreational visitors. In addition, all soil/mine waste samples were acidic in nature, with three-quarters of samples exhibiting continuing acid

generating properties. Other metals in the soil are elevated, although not above action thresholds. The surface water in the Idora Mine project site does not show levels of Chemicals of Potential Concern elevated above health limits.

The riparian health assessments also indicate that the ecological integrity of the system is compromised. Many parts of the flood-prone zone are devoid of vegetation, likely due to a combination of soil chemistry and physical disturbance. In addition, the Beaver Creek channel is deeply entrenched with high levels of mobile cobbles and pebbles, reflecting probable historic changes in the hydrology of the system caused by mining and milling activities.

Based upon the site investigation, the Idora Mine project site appears significantly impacted, with levels of Chemicals of Potential Concern in the floodplain materials and streambed sediments exceeding the limits for recreational exposure and human health. It is recommended that approximately 2.3 million cubic feet of contaminated tailings materials be removed, the impacted stream channel and floodplain areas reconstructed, and the impacted riparian zone restored.

1.0 PROJECT GOALS AND OBJECTIVES

In a collaborative effort by the United States Army Corps of Engineers (USACE) - Restoration of Abandoned Mine Site (RAMS) program and the United States Forest Service (USFS), and Bitterroot Restoration, Inc. (BRI), a field characterization of the Idora Mine/Mill site north of Wallace, Idaho was completed in the fall of 2002. The purpose of the site characterization was to determine the nature, extent and magnitude of environmental disturbance in the drainage and to assess potential impacts to human health and the environment. The findings of the characterization will guide future efforts to remove contaminated materials and restore the stream drainages. The Idora Mine/Mill site assessment is the first RAMS project undertaken in the State of Idaho.

The investigation involved collecting and analyzing surface water, sediment, soil, and mine waste samples from the Idora mine site. Additional information related to the vegetative and geomorphic characteristics within the drainage aided in our understanding of the site. For this project, seven surface water samples, 17 soil/mine waste samples, and seven sediment samples were collected and analyzed. The analytical results are being used to gain information about the extent of mine-related contamination.

This document has been prepared in fulfillment of the requirements of the USACE contract DACW05-01-D-0019 / Idora, Delivery Order 004.

2.0 PROJECT SETTING

The Idora mine and mill sites are located in the headwaters of Beaver Creek, a tributary of the North Fork of the Coeur d'Alene River, Idaho Panhandle National Forests, Shoshone County, Idaho (refer to Figure 1). The Beaver Creek watershed has been identified by the USFS as a priority watershed for Abandoned Mine Land reclamation. In addition, the United States Bureau of Land Management (BLM) and State of Idaho are actively involved with abandoned mine reclamation at other sites in the Beaver Creek watershed.



Photo of the Idora Mine looking down on Beaver Creek

The elevation of the Beaver Creek project site ranges from 3,501 feet at the Idora Mine to 3,068 feet at the confluence of Beaver and Carbon Creeks. The area experiences warm summers (the average high temperature in July is of 83.7 degrees F) and moderately cold, wet winters (the average low in January is 20.2 degrees F). The area's annual average rainfall is approximately 40 inches and average annual total snowfall is six feet. (Western Regional Climate Center, 2002).

The predominant vegetation around the site consists of Western Red Cedar (*Thuja plicata*)

in the overstory and numerous shrubs, ferns, and forbs in the understory. Ladyfern (*Athyrium filix-femina*) is the dominant understory plant.

3.0 PROJECT BACKGROUND



Idora Mine Site on Beaver Creek

Developed in the early twentieth century, the Idora Mine was active through the mid 1950s. The mine produced commercial quantities of silver and zinc, but the primary ore was lead. The mill site and tailings, located in and adjacent to Beaver Creek, are being actively eroded. Preliminary evidence indicates that the site is the source of a significant amount of heavy metal contamination to the downstream reaches, which contain residences, frequent recreation usage, and wildlife habitat.

Spot samples of tailings collected in 1999 by the United States Geographic Service (USGS) both at the mill site and along the stream, contained lead concentrations greater than 20,000-70,000 parts per million (ppm). Similar spot samples of tailings in the streambed sediments of Beaver Creek contained lead concentrations of 5,000-10,000 ppm (USGS, 2000).

4.0 SITE ASSESSMENT METHODS

Project Planning

The Standard Operating Procedures (SOPs), outlined in the *Restoration of Abandoned Mine Sites Final Workplan* (U.S. Army Corps of Engineers, Omaha District, 2002), were adhered to during the course of this field investigation: A1 (Surface Soil/Rock Sampling Equipment and Procedures); A3 (Subsurface Soil/Rock Sampling Equipment and Procedures); A4 (Soil/Rock Homogenization Equipment and Procedures); A7 (Investigative Derived Waste Procedures); A11 (Surface Water and Sediment Sampling Equipment and Procedures), A12 (Equipment Decontamination Procedures); A13 (Sample Handling, Documentation, and Tracking Procedures); and A14 (Field Documentation).

Figure 1. Idora Site Location Map

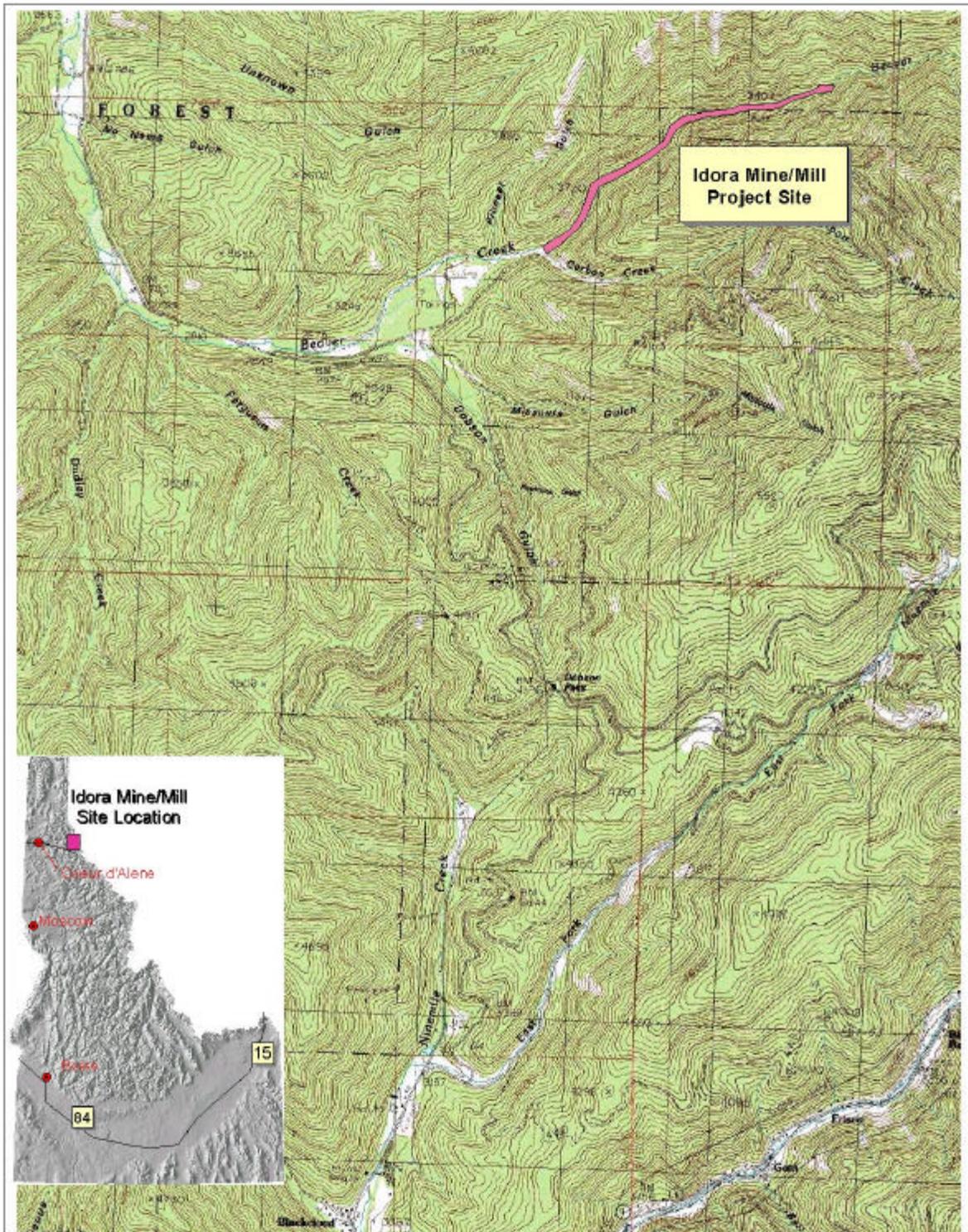


Figure 1. Idora Locational Map

4.1.1 Health and Safety Plans

Prior to conducting fieldwork, BRI developed a health and safety plan for the Idora project. Information on health and safety issues associated with this field effort may be found in the *Idora Site Safety and Health Plan (SSHP)*, Sept. 2002.

4.1.2 Sampling Methodology

Sampling plans were developed for the collection of surface water, sediment, soil, and mine waste material. Information on sampling methods followed is found in *The Standard Operating Procedures (SOPs), Surface Soil/Rock Sampling Equipment and Procedures* (U.S. Army Corps of Engineers, Omaha District, 2002).

4.1.3 Sample Identification Scheme

The sample identification (ID) scheme for soil and mine waste samples, described in *The Standard Operating Procedures (SOPs)* (U.S. Army Corps of Engineers, Omaha District, 2002), used the following designation.

A-BB-CC-DD where:

A = Designation of sampling area location – **I** (For Idora)

BB = A numerical digit that indicates if the sample is normal, a duplicate, or a confirmation. 01 = Normal; 02 = Duplicate; 04 = Confirmation

CC = A numerical digit that indicates the depth from which the sample is extracted. 01 = between 0 inches and 1 foot; 02 = greater than 1 foot to 2 feet; 03 = greater than 2 feet to 3 feet; 04 = greater than 3 feet to 4 feet;

DD = two or three digit sample identification number

For example, a confirmation soil sample collected from a depth of 1.5 feet at the Idora Mine site would be coded I-04-02-75. The last two digits (75) are the sample identification number.

The sample identification scheme for water and stream sediment samples used the designation below.

AA-CSB-CCC where:

AA= Designation of sampling area location – **ID** (for Idora in Idaho)

CSB = Three character identification code that identifies the sample with the subreach where it was collected. CS stands for “Cross-Section.”

CCC = Identifies if the sample is water (H₂O) or sediment (SED)

For example, a water sample collected from Subreach 3 at the Idora Mine site in Idaho would be coded ID-CS3-H₂O.

4.2 Field Investigation Activities

This investigation occurred between July 2002 and March 2003. The field investigation, described in the *Site Specific Addendum to RAMS General Work Plan and Safety and Health Plan for Idora Mine* (Bitterroot Restoration, Inc. [BRI], 2002), took place over seven days, from October 1 through October 8, 2002. The first project task involved developing sampling and safety plans. Fieldwork was conducted by BRI and EMC². A topographic/site features survey of the mine waste impacted area was completed by Territorial Engineering and Surveying, Inc., a licensed professional surveying company, from November 1 through November 6, 2002. Data analysis and reporting occurred between March 15 and March 31, 2003.

Upon arrival at the project site, the field team first delineated the boundary of the injured area. The field team then collected mine waste, soil, surface water, and sediment data; estimated the volume of contaminated material; and completed riparian health assessments. Finally, Territorial Engineering and Surveying, Inc. created a topographic site map on one-foot contours, delineated areas of interest, and surveyed all sampling locations (See Appendix B). Field notes from the field investigation are contained in Appendix A.

4.3 Boundary Delineation

Delineating the project boundary first involved a physical examination of the project site. Boundary limits were based upon visual clues regarding the extent of contamination including: the absence of ground cover; type, quantity, and diversity of plant species; the location of the floodplain; old stream channels; tailings/waste materials; and erosion features on either side of the stream. Boundaries were subsequently confirmed or relocated according to contamination levels recorded with an X-ray Fluorescence (XRF) unit. White flags were placed every 100 feet along the border of the project site. Boundaries were used to determine the extent of the professional survey, to delineate the riparian assessment survey subreaches, and to provide XRF sampling boundaries. Sampling location coordinates, obtained from a hand-held Garmin Etrex Global Positioning System (GPS) device with an accuracy of 15 meters, were recorded in the field logbook. The boundaries and sampling locations were also mapped by Territorial Engineering and Surveying, Inc. The survey met minimum conventional theodolite traverse control standards (third order geodetic control and 1:5000 accuracy).

In addition to boundary determinations, seven hydrologic subreaches (displayed in Figures 2-A and 2-B) were delineated across the injured area. Subreach boundaries were based upon hydrologic and geomorphic changes within the stream channel, as well as distinct changes in mine waste deposition. Subreaches are described below sequentially from the top (highest elevation) boundary on Beaver Creek to the lower boundary at the confluence of Beaver and Carbon Creeks.

Subreach 1 lies immediately upstream of the injured area on Beaver Creek. The intent was to use this site as a reference reach, but after further exploration upstream of Subreach 1, it was discovered that historic mining impacted the entire length of Beaver Creek. Hence, the full suite of vegetation, hydrologic, and chemical data was not collected on this subreach, nor was a suitable reference reach found for this investigation.

Subreach 2 includes the Idora Mine and Mill. The top of Subreach 2 is near the main Idora mill, which is the main source of tailings and waste rock found in the system. The stream channel in Subreach 2 is incised several feet down into the surrounding tailings.



Tailings piles on Subreach 2

The stream gradient (8 percent) is moderately steep. The tailings piles are virtually devoid of vegetation. However, the remaining 80 percent of the subreach floodplain is well vegetated, both in terms of plant coverage and plant diversity. One habitat type, defined by the dominance of Western Redcedar in the overstory and Lady Fern in the understory, is found in Subreach 2. This short segment is approximately 400 feet long and ranges from 3,501 feet to 3,469 feet in elevation.

Subreach 3 is characterized by numerous braids cut down into terraced tailings. The stream incline is moderately steep, eight percent. Similar to Subreach 2, the area surrounding the stream is a barren tailings and waste rock terrace. Most of the floodplain, however, is well vegetated by numerous plants that fall into a single habitat type: Western Redcedar/ Lady Fern. This approximately 800 feet long segment ranges in elevation from 3,469 feet to 3,406 feet.



Creek braid cut into a terraced tailings pile on Subreach 3



Forested hummocks pile and cedar forest on Subreach 4

Subreach 4 ranges from 3,406 to 3,375 feet in elevation. This 430 feet long subreach is confined on the right side by relatively high embankments and an old road. The left side is open, containing a wide cobbled floodplain. Forested hummocks (tailings piles) and cobble piles are interspersed throughout the floodplain as a result of aggradation. Subreach 4 is characterized as a boulder/log cascade sequence with a moderate (seven percent) incline. It is also classified as a Western Redcedar/ Lady Fern habitat type.

Approximately 20 percent of the floodplain contains unvegetated cobblebars.

Subreach 5, spanning over 2,400 feet in length, is the longest subreach in the injured area. The elevation is 3,375 feet at the top of Subreach 5 and 3,223 feet at the bottom. It is confined by a flat cobble, narrow floodplain on the left bank and a cedar grove on the right bank. An old road, located directly north of the stream, is present throughout Subreach 5. Although this subreach is classified as a Western Redcedar/ Lady Fern habitat type, vegetation coverage is moderate due to excessive aggradation by gravel and cobbles and a lack of fine soil material.

Subreach 6, located within a wide cobble floodplain, is approximately 1,500 feet long. The elevation is 3,223 feet at the top of Subreach 5 and 3,142 feet at the bottom. It is characterized as boulder/log cascade sequence. The old road is present on the upper length of Subreach 6, but disappears into the cobble floodplain on the lower half of the subreach. The stream gradient decreases to five percent on this subreach. Subreach 6 is also classified as a Western Redcedar/ Lady Fern habitat type, although vegetation coverage is modest. Cobble accumulations and a lack of fine soil material are evident on this subreach.

Subreach 7 is also located within a wide cobble floodplain. The top of Subreach 7 is 3,142 feet



Wide cobble floodplain on Subreach 7

in elevation. The bottom of the subreach, at 3,068 feet in elevation, is at the confluence of Beaver and Carbon Creeks. Its lower end is populated with tailings and cobble piles. This approximately 1,500 feet long reach has a moderate incline (five percent) with numerous high flow scour channels. The wide, rocky floodplain associated with this subreach is sparsely vegetated. There are, however, a few bermed areas with grasses, forbs, and conifers. An estimated 30 percent of Subreach 7 is dominated by the Western Redcedar/Lady Fern habitat type. An additional 70 percent is categorized as an unclassified habitat type that is dominated by cobbles. This subreach lacks fine soil material.

4.4 Mine Waste and Soil Sampling

Field analyses were completed on 135 samples using a Spectrace 9000 portable XRF, which allows for an on-site rapid assessment of the elemental spectrum. The XRF's detection limits, precision, and accuracy are provided in Appendix F. The samples were analyzed for total metals concentration following EPA Method 6200. In addition, a subset of 17 confirmation



In-field sample analysis using an XRF

Figure 2-A.

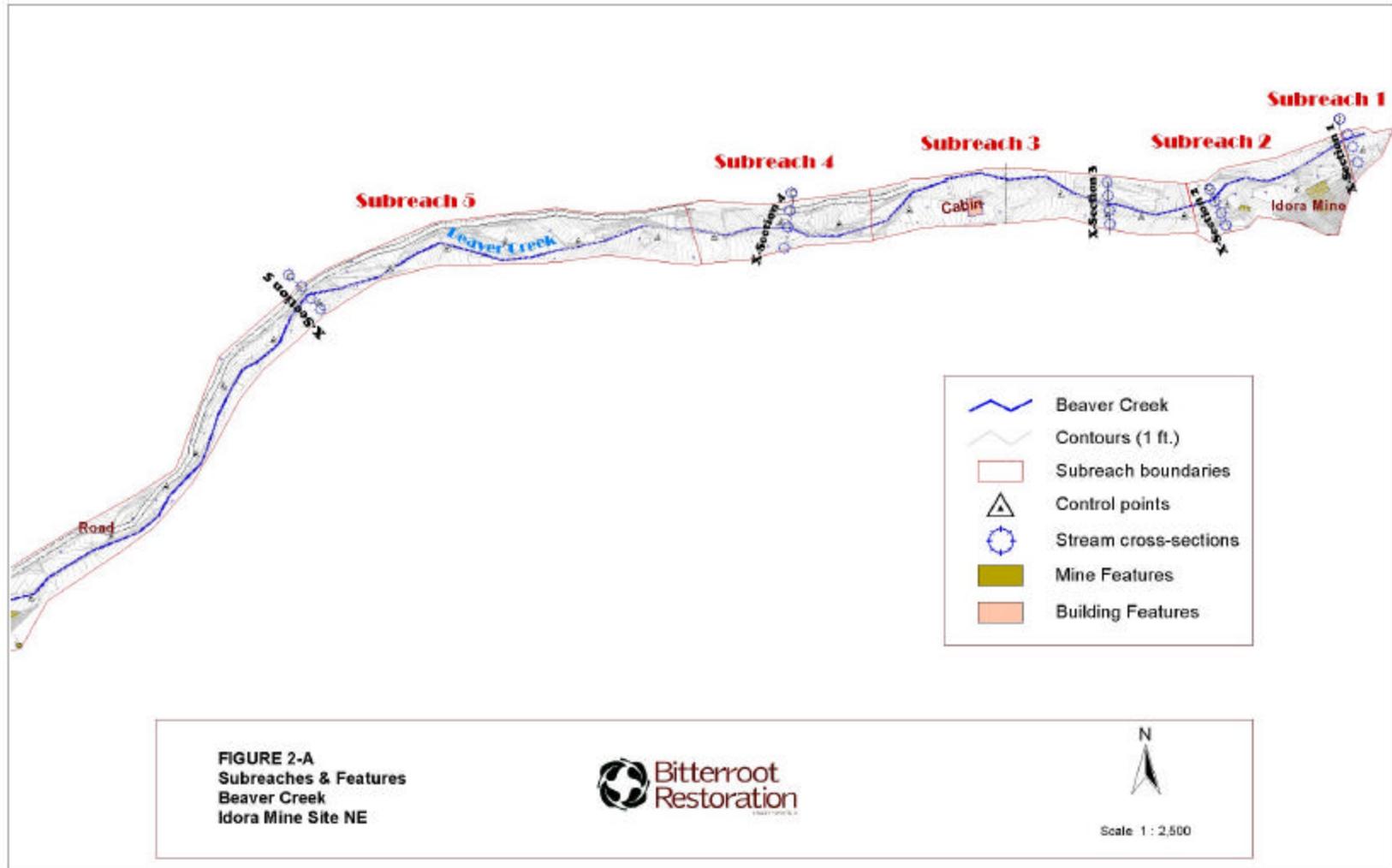
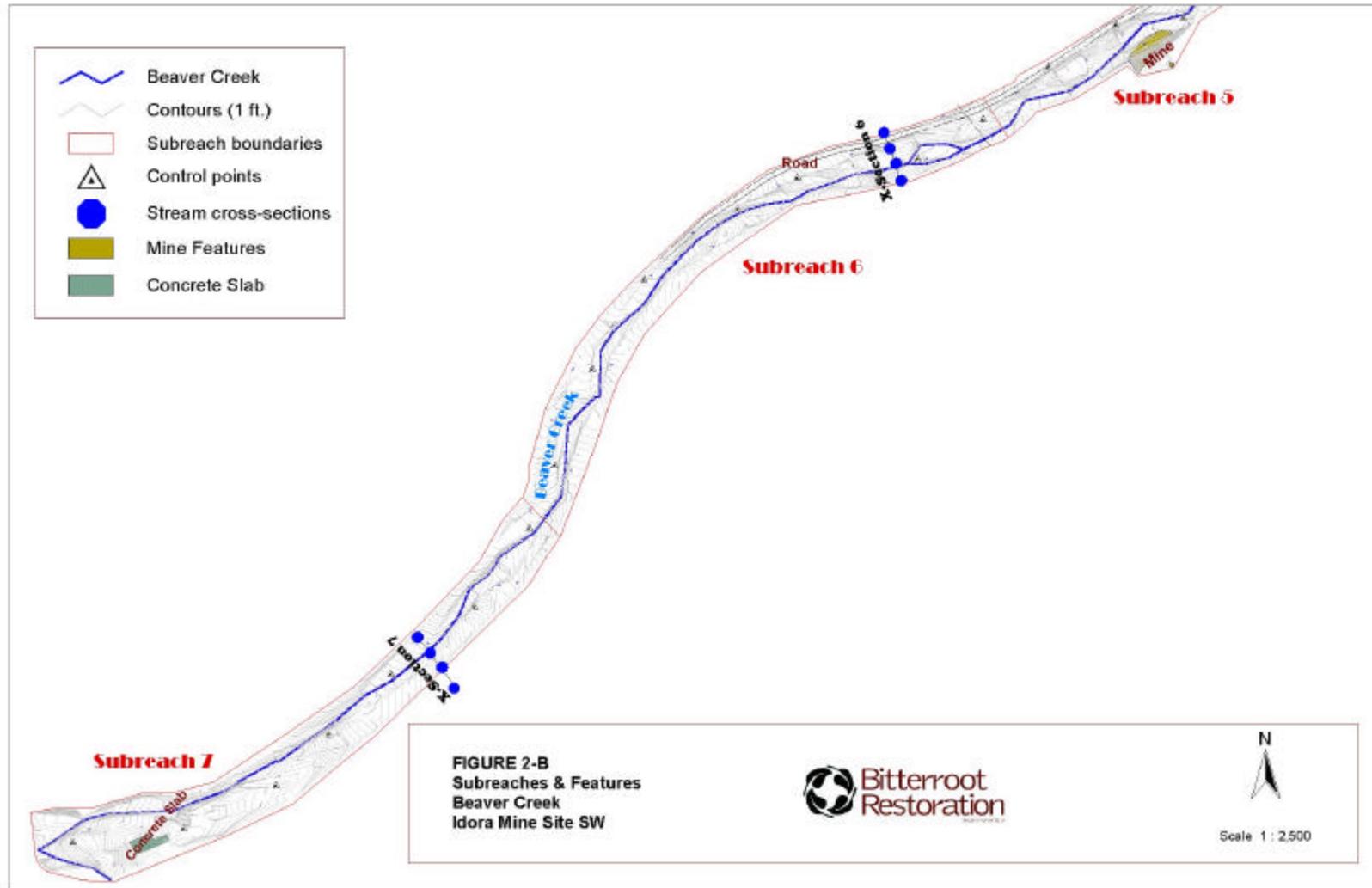


Figure 2-B.



samples, co-located with the XRF sampling sites, was analyzed for total metals, water extractable metals, pH, electrical conductivity and Acid-Base Accounting (ABA). Total metals concentration results from the 17 co-located sites were used for confirmatory analysis and to calibrate the XRF against the more accurate laboratory-analyzed samples. Laboratory analyses for Contaminants of Potential Concern (COPC) occurred at SVL Analytic using atomic emission spectrometry (EPA Methods 200.2 Series).

Due to the disturbance ecology of the Idora Site riparian system, field personnel found that it was impossible to distinguish between “soil” and “mine waste” materials. Cobbles, pebbles, sand, fines and organic-rich material were mixed together, and neither texture, color, nor position on the floodplain correlated with elemental concentrations as determined by field XFR readings. As a result, the soil/mine waste samples were composited into a single set of samples.

The sampling locations were situated on and around mine waste tailings piles, as well as in areas adjacent to mine waste materials, such as surface soils in places exposed to runoff/erosion from waste areas and/or soils beneath waste piles. The sampling sites, located at cross-sections along the contaminated stream, were designed to determine the types and amounts of contamination. For the most part, sampling locations were evenly distributed throughout the site. Samples were extracted to a maximum depth of one meter (39.4 inches). The samples were composited by mixing them in a clean container (a new heavy gauge plastic “trash compactor” bag for each sample, lining a five-gallon plastic bucket). Sample locations are displayed on maps in Figures 3-A and 3-B.

Following collection, laboratory samples, each weighing approximately one kilogram, were stored in individually sealed containers and shipped on ice to SVL Analytic in Kellogg, Idaho for analysis. Standard Chain of Custody (COC) procedures were followed to track and identify the individual samples. COC procedures are described in SOP A13 – Sample Handling, Documentation, and Tracking Procedures.

4.5 Surface Water Sampling

Surface water sampling was performed to monitor stream water volumes, flows, and analyte concentrations. Surface water quality analyses included total metals concentrations, hardness, temperature, and pH. Laboratory analyses for COPC concentrations occurred via atomic emission spectrometry (EPA Methods 200.7 series). Samples were collected at seven representative cross-sections, one within each subreach. Cross-section locations are displayed and numbered on the map in Figures 2-A and 2-B. At each cross-section, the stream channel was



Representative cross-section location

Figure 3-A.

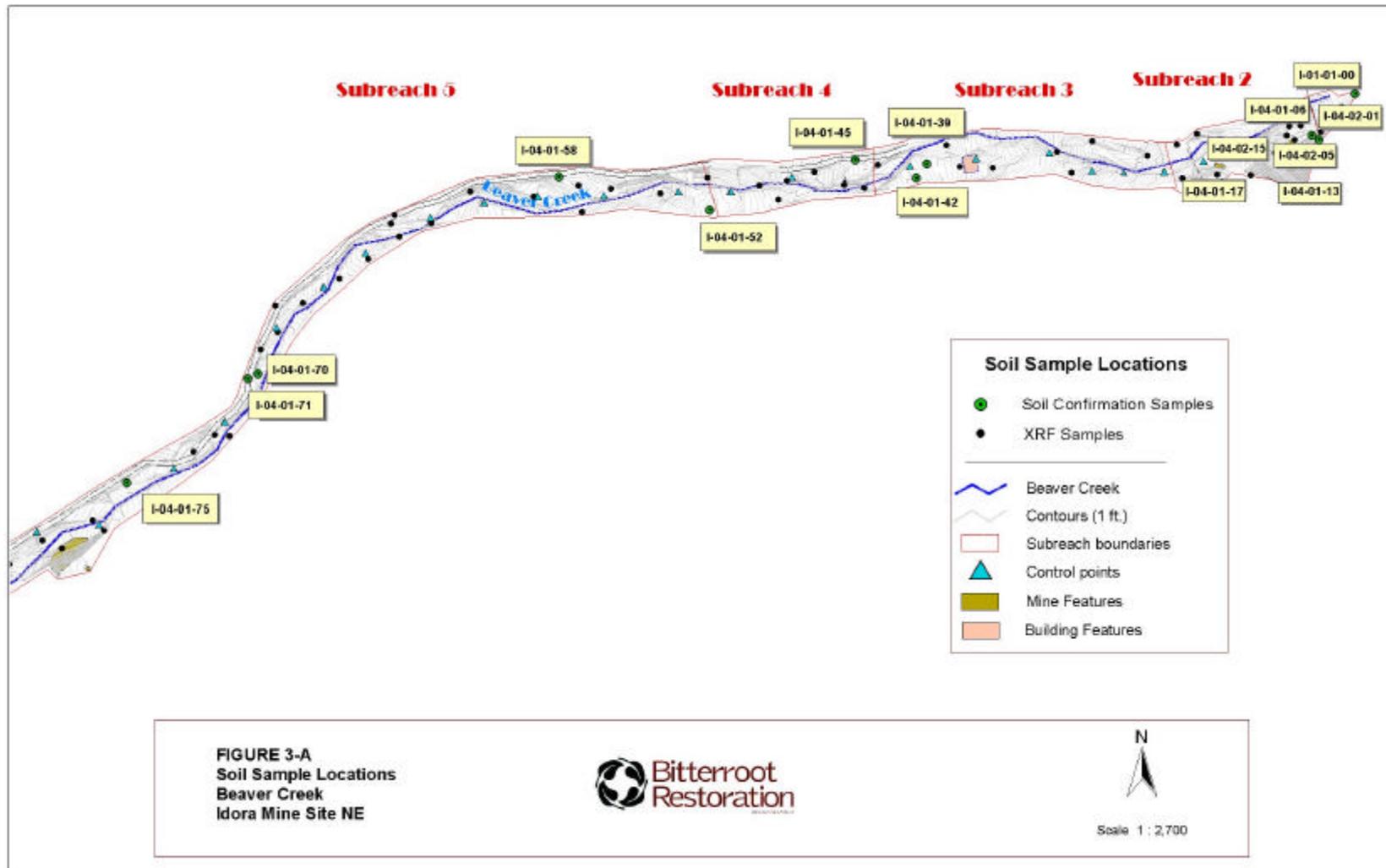
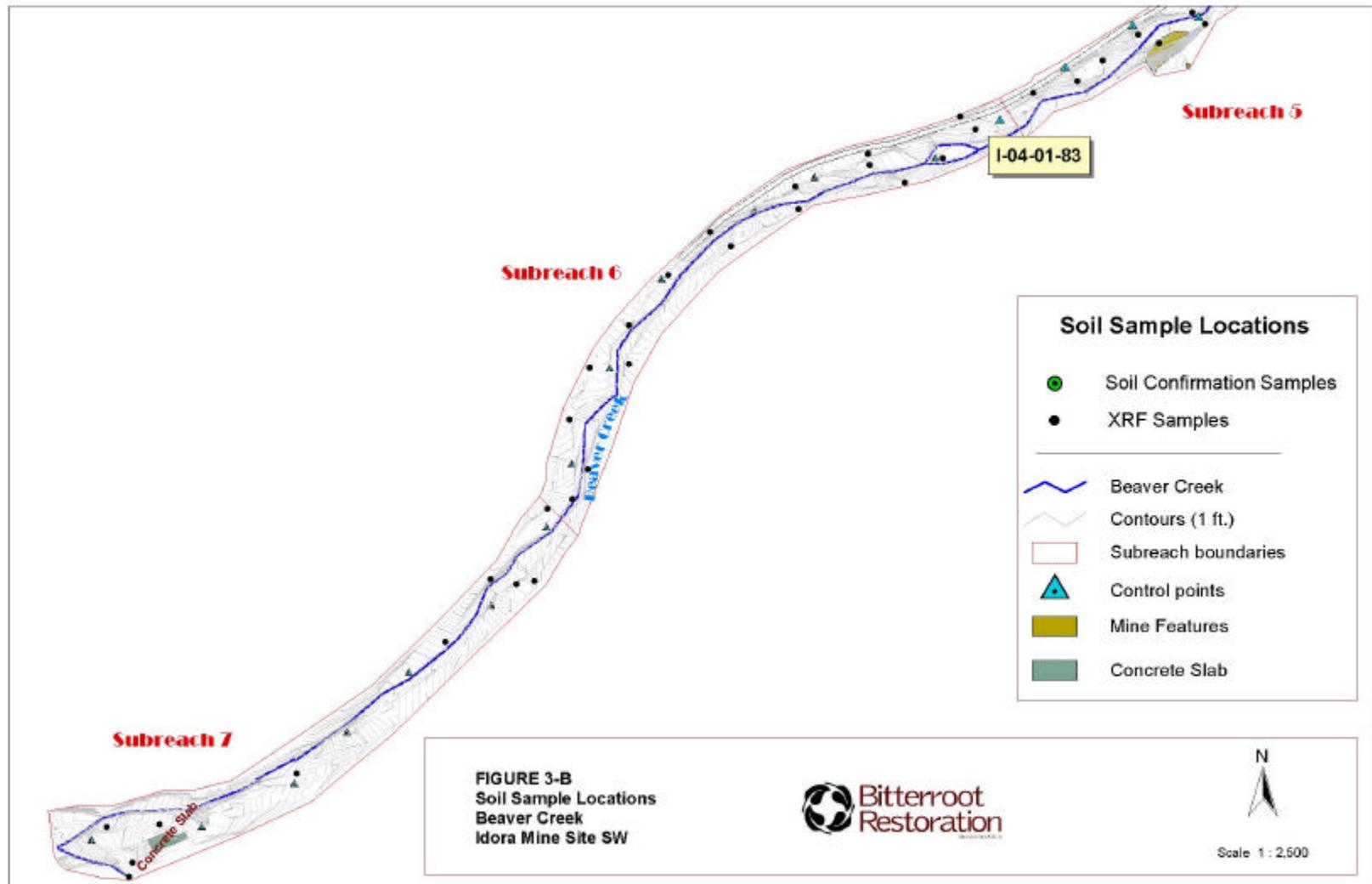


Figure 3-B.



subdivided into one to ten segments of equal length depending on the width of the channel. The depth of the stream was measured in the middle of each segment. Velocity measurements were obtained from each stream segment using an FP201 Global Flow Probe hand-held flow meter with a five- to 15-foot expandable handle. Velocity readings were measured in feet per second with accuracies of plus-or-minus 0.1 feet per second for instantaneous velocity and plus-or-minus 0.01 feet per second for average and maximum velocity.

Velocity readings were determined by extending the flow meter handle to the appropriate length and placing the probe in the center of the channel of each stream segment within the respective cross-sections. The flow probe was moved slowly back and forth from the top of the water surface to the bottom of the channel for a minimum of one-minute to obtain a vertical flow profile. The average flow velocity for the stream cross-section, along with the date and time, was recorded in the field logbook. The stream discharge was calculated by first determining the cross-sectional area of each stream channel segment, then multiplying the average velocity by the cross-sectional area, and finally averaging together the discharge of each segment to obtain a total stream discharge. If flows were below the instrument's Limit of Detection (LOD) of 0.3 feet per second, velocity was estimated as half the difference between zero and the LOD (i.e., 0.15 feet per second).

Stream temperature and pH measurements were collected using a waterproof Hanna instruments HI-9023 microcomputer pH and temperature meter. To use the instrument, the probe was placed in the stream at the cross-section. Keeping the probe submerged, it was moved slowly back and forth across the stream until the pH and temperature readings stabilized (approximately two minutes). The results were recorded into a permanent notebook. The instrument was calibrated before each set of samples was obtained. The pH meter is accuracy to 0.01 units and its collection capabilities range from 0.00 to 14.00 pH. The temperature meter can record temperatures ranging from 32 to 212 degrees Fahrenheit and is accurate to 0.7° F.

Surface water samples were collected at each of the seven cross-sections with a depth-integrated wading device and were stored in sample containers supplied by SVL. To operate the wading device, it was moved up and down through the water column at set locations across the stream for a predetermined timeframe that depended on the stream size. The device was calibrated to collect equal amounts of water through the water column and across the stream. All excess water was disposed of by pouring it gently onto the stream bank adjacent to the sampling location.

Once collected, the water samples were immediately preserved with nitric acid. The filled sample bottles and jars were labeled as specified in the *RAMS Final Work Plan, 2002*. The labeled bottles were placed in ice chests and cooled to approximately 4° C with the appropriate chain-of-custody paperwork. The cooler was delivered to SVL Analytic in Kellogg, Idaho.

4.6 Sediment Samples

Seven streambed sediment samples were collected from the streambed directly under the surface water sampling locations. Samples, gathered at depths ranging from one-half inch to four inches, were collected in the interstices of cobbles with a stainless steel spoon. The samples were labeled and stored in one-liter sample containers provided by SVL Analytic with the appropriate

COC paperwork as specified in the *RAMS Final Work Plan, 2002*. The labeled bottles were stored in ice chests and cooled to approximately 4^o C. They were delivered to SVL Analytic in Kellogg, Idaho. Laboratory analyses followed EPA Method 200.7.

4.7 Riparian Health Assessment

Riparian assessments were conducted with a focus on vegetative health. The rationale for looking at vegetation data is that the condition of plants in the riparian zone is a major component in determining the vigor of riparian ecosystems.

The injured area along Beaver Creek was divided into four Riparian Reaches. Each reach was representative of unique stream and vegetation characteristics found on Beaver Creek. Detailed vegetation data, physical site data, some wildlife data, trend commentary, and photographs were collected. Concerning vegetation, data were gathered on species identification and canopy cover estimations, as well as age class breakdowns for each tree and shrub species. Physical site data included channel morphology and condition, substrate composition, disturbance degree and kind, amount and cause of bare ground, and commentary. Wildlife data included details of beaver activity and observations of fishery, amphibian, and reptile data.

In general, the Riparian Reaches corresponded with the hydrologic subreaches described in *Section 4.3 Boundary Delineation* of this report. In cases where stream and vegetation characteristics were uniform over more than one hydrologic subreach, the subreaches were combined into a single Riparian Reach. The relationship between subreach and riparian reach boundaries follows.

- Riparian Reach A (referred to as *Record ID No. 2020380* or *Polygon 1* on the Wetland Inventory Forms) corresponds with the hydrologic Subreaches 2 and 3.
- Riparian Reach B (referred to as *Record ID No. 2020381* or *Polygon 2* on the Wetland Inventory Forms) corresponds with Subreach 4.
- Riparian Reach C (referred to as *Record ID No. 2020379* or *Polygon 3* on the Wetland Inventory Forms) corresponds with Subreaches 5 and 6.
- Riparian Reach D (referred to as *Record ID No. 2020382* or *Polygon 4* on the Wetland Inventory Forms) corresponds with Subreach 7.

A goal of this investigation was to perform a riparian health assessment on a reference reach above the Idora Mine site, but after exploring upstream of the mine, it was discovered that historic mining impacted the entire length of Beaver Creek. Hence, the full suite of vegetation, hydrologic, and chemical data was not collected on a reference reach for this project.

The riparian inventory data collected for this project was originally gathered on the entire riparian zone, which extends laterally out to the valley toe slope foot. This area includes both the near-channel zone of mine tailing deposits, and a wide outer band on both sides unimpacted by these tailings contaminants. Subsequently, the width dimension was adjusted to reflect only the narrower floodplain impacted by deposition of mine tailings. The species data was also adjusted by eliminating those species found only under the forest canopy at the outer edge of the riparian

zone. These steps were undertaken to reflect conditions within the narrower impacted zone, as opposed to the entire riparian habitat area.

The assessment was developed by Dr. Paul Hansen and his team at the Riparian and Wetland Research Program, University of Montana at Missoula. Refer to BRI's riparian and wetland website (<http://bitterrootrestoration.com/index.html>) for more information on the methodology used to conduct the riparian health assessments.

4.8 Rosgen Stream Classification—Level II

Reaches of stream channel may be classified according to morphological characteristics that reflect the stream's capacity to store/transport sediment. The relevant parameters, in order of importance, are channel slope, channel pattern, channel material size, the ratio of channel width to depth, the entrenchment ratio, and channel sinuosity (Rosgen, 1996).

The bankfull channel width, flood prone width, maximum and mean stream depths at bankfull stage, and the average channel material size were measured at a representative cross-section within each subreach. These measurements were used to determine the width-to-depth ratio (bankfull width divided by bankfull mean depth), the width of the flood prone area (defined as the area of floodplain inundated by a flood that reaches a depth twice the maximum bankfull stage depth), and the entrenchment ratio (entrenchment is the ratio of width of the channel at bankfull stage and that of the flood prone area). The channel material size was visually estimated within each subreach.

The channel slope and channel pattern data were derived in a GIS from the one-foot contour survey map. For each riparian reach classified, average channel slope was computed as the percent drop(rise/run). The change in elevation and the segment length were used for this calculation. Channel pattern refers to sinuosity and number of threads (split around islands or a single stream body). Sinuosity was calculated as the ratio of channel length to valley length for the reach. These parameters are described by Rosgen (1996) and the calculations are in Appendix C.

4.9 Volume of Contaminated Material

The volume of material within the Beaver Creek floodplain was estimated by calculating the area, the amounts and size classes of materials within distinctive features (e.g., roads, cobble floodplains, and tailing piles) on 21 reaches along the stream. The length of the reaches, ranging from 250 to 465 feet, varied according to changes in the stream geomorphology and mining features. The size classes of materials in each feature were divided into the following categories: fines, sand, gravel, cobbles, and boulders.

In the office, a representative cross-section within each reach was drawn on the one-foot contour survey map (See Appendix D). The area of 15 cross-sections was computed using an area calculation technique, described by Landphair and Motloch (1985). This technique assumes that the stream cross-section is an unequal trapezoid. The steps involved in the area calculation technique follow. First, the cross-section, which spans the width of the floodplain, is divided

into five to ten intervals of equal length. The area of each interval is determined by measuring the height on both ends of the interval section. Then the average height and the interval length are multiplied, resulting in the area of the interval. The areas of the intervals are added together, giving the total area of the cross-section. Next, the volume is derived by multiplying the total area by the length of the reach. Finally, the volume is calculated for each materials size class. The volume estimate used in this report includes materials in the gravel, sand, and fines size classes.

The following assumptions were used:

- All locations in the streambed equal zero. In other words, no materials would be excavated from the actual streambed.
- The height of materials used in the calculation assumes that the elevation of the streambed is the lowest point, and ground level is the highest point. The width extends from floodplain right to floodplain left.
- No material would be removed below groundwater level.
- The final volume excludes materials in the boulder and cobble size class categories.

4.10 Topographic/Site Features Survey

A Topographic/Site Features Survey of the mine-waste impacted area, displayed in Appendix B, was completed by Territorial Engineering and Surveying, Inc., a licensed professional surveying company. The site was mapped on a local coordinate system using traditional surveying methods. Key points were mapped in latitude/longitude using a survey grade (sub-centimeter accurate) Global Positioning System (GPS) unit. The survey met minimum conventional theodolite traverse control standards (third order geodetic control and 1:5000 accuracy). In addition to constructing a survey with one-foot contours of the injured area, the surveying team mapped features of interest (adits and buildings, for example), stream cross-sections, and mine waste and soil sampling locations.

4.11 Quality Assurance and Control

Quality Control (QC) procedures used for mine wastes, soil, and water testing were consistent with methods described by the EPA and the *RAMS Final Workplan* (U.S. Army Corps of Engineers, Omaha District, 2002). All samples collected in the field were prepared with appropriate COC documentation, including sample logs, sample identification (ID) numbers, and appropriate seals.

All samples were individually sealed in plastic bags prior to shipment. Mine waste and soil sample containers were wrapped in bubble wrap or other protective wrapping and stored in plastic boxes. Upon collection, nitric acid (reagent grade) was added to all water samples. The samples were immediately placed in ice chests and cooled to 4^o C or less. Boxes and ice chests were taped shut and sealed with custody seals. COC forms were signed as relinquished and sealed in bags and taped inside each box. COC forms were reviewed and signed by the laboratory upon receipt. The laboratory sent the final analytical results to BRI.

Field notes were kept in bound, waterproof notebooks. Notes were written in waterproof ink or pencil. Sample numbers were transferred to COC forms.

QC of the XRF analysis was ensured by following EPA Standard Operating Procedure No. 1713 (1995). The XRF calibration procedures included verification of potential multiple soil matrix types. Matrix differences, such as large variations in calcium or iron content, may affect XRF measurements.

5.0 LABORATORY ANALYSIS

5.1 Mine Waste and Soil Analysis

Seventeen confirmation samples, co-located with XRF sampling sites, were analyzed for total metals. Sample results from the 17 co-located sites were used to calibrate the XRF against the more accurate laboratory-analyzed samples. Total metal concentrations were analyzed in the laboratory analyses through atomic emission spectrometry (see Table 5.1 below). In addition, the confirmation samples were assessed for acid-generating potential.

TABLE 5.1 TOTAL METALS ANALYSIS

Target Constituent	Analytical Method
Arsenic	EPA M200.2 ICP- Total metals
Cadmium	EPA M200.2 ICP- Total metals
Copper	EPA M200.2 ICP- Total metals
Lead	EPA M200.2 ICP- Total metals
Zinc	EPA M200.2 ICP- Total metals

Six mine waste samples (surface rock/soil samples) were analyzed for water extractable metals (see Table 5.2).

TABLE 5.2 WATER EXTRACTABLE METALS ANALYSIS

Target Constituent	Analytical Method
Arsenic	EPA M200.7 ICP- water-extractable
Cadmium	EPA M200.7 ICP- water-extractable
Copper	EPA M200.7 ICP- water-extractable
Lead	EPA M200.2 ICP- water-extractable
Zinc	EPA M200.7 ICP- water-extractable

5.2 Surface Water and Sediment Analysis

Table 5.3 presents the analytical methods used to determine total metals and water quality variables for the seven surface water and streambed sediment samples.

TABLE 5.3 WATER AND STREAMBED SEDIMENT ANALYSES

Target Constituent	Analytical Method
Arsenic	EPA M200.2 ICP- Total metals
Cadmium	EPA M200.2 ICP- Total metals
Copper	EPA M200.2 ICP- Total metals
Lead	EPA M200.2 ICP- Total metals
Zinc	EPA M200.2 ICP- Total metals
PH	EPA M150.1
Conductivity	EPA M120.1
Hardness	EPA M120.1
Temperature	EPA M120.1

Sample analysis followed the quality control criteria set by the Environmental Chemistry Branch Laboratory and/or as per the *RAMS Final Work Plan* (June 2002). Laboratory QC data are included with the raw analytic results in Appendix E.

6.0 DATA SCREENING CRITERIA

6.1 Mine Waste and Soil Standards

This report concentrates on the following five COPCs: Arsenic, Cadmium, Copper, Lead, and Zinc. These COPCs are the standard suite of contaminants investigated on minelands in western Montana and northern Idaho. The remoteness of the site suggests that recreational users (e.g., rock hounds, gold panners, hunters, and hikers) will be the population most likely to visit. The EPA's exposure limits for recreational users, presented in Table 6.1, govern contact to the COPCs in soil material. The primary exposure pathways are soil contact, inhalation and water ingestion. The standards assume that potential carcinogenic and non-carcinogenic health risks vary between recreational populations. The cleanup guidelines used in this report are based on a Hazard Index of 0.5 or an increased cancer risk of 5×10^{-4} . The latter is the carcinogenic risk for the gold panner/rock hound recreational population (Tetra Tech, 1996).

TABLE 6.1 EPA CLEANUP GUIDELINES FOR FIVE CHEMICALS OF POTENTIAL CONCERN FOR RECREATIONAL VISITORS

COPC	Arsenic	Cadmium	Copper	Lead	Zinc
Soil Ingestion/ Inhalation Cleanup Guideline (mg/kg)*	700	19,500	27,100	1,100	220,000

* Concentrations for Arsenic and Cadmium are based on an increased cancer risk of 5×10^{-4} , while Copper, Lead, and Zinc are based on a Hazard Index of 0.5.

6.2 Surface and Groundwater Standards

Table 6.2 presents water quality guidelines for the COPCs of concern for this study. These standards govern exposure to COPCs by water ingestion.

TABLE 6.2 WATER QUALITY GUIDELINES

COPC	National Recommended Water Quality Criteria for Aquatic Life		Required Reporting Value	EPA National Primary Drinking Water Standards
	Acute	Chronic		
Arsenic	340	150	3	10 (as of 1/23/06)
Cadmium	2.0*	0.25*	0.1	5
Copper	13*	9.0*	1	1,300
Lead	65*	2.5*	3	15
Zinc	120*	120*	10	n/a

All values stated as micrograms/liter ($\mu\text{g/L}$)

* @ 100 mg/L hardness

7.0 RESULTS AND DISCUSSION

7.1 Mine Waste and Soil Results and Discussion

Field personnel could not distinguish between “soil” and “mine waste” materials. Cobbles, pebbles, sand, fines and organic-rich material were mixed together. Neither texture, nor color, nor position on the floodplain correlated with elemental concentrations as determined by field XRF reading. As a result, the 17 soil/mine waste samples were composited into a single set of samples, which were analyzed for total metals via ICP, water extractable metals, pH, conductivity and Acid-Base Accounting (ABA). In addition, 135 soil/mine waste samples were analyzed for total metals concentrations via XRF. Lab analyses data are in Appendix E, and XRF field analyses data are included in Appendix F.

7.1.1 Total Metals from Field XRF Results

Table 7.1 and Figures 4-A and 4-B present total metal concentrations statistics for the soil/mine waste samples collected from the Idora Mine project site, as analyzed by field XRF. The XRF trends for the trace elements follow the results of the ICP analyses, with lead having the greatest percentage of samples above the COPC limits for recreational visitors.

TABLE 7.1 TOTAL METAL CONCENTRATIONS FROM FIELD XRF RESULTS

COPCs	Average sample concentration from the Idora Mine project site (mg/kg)	Minimum sample concentration from the Idora Mine project site (mg/kg)	Maximum sample concentration from the Idora Mine project site (mg/kg)	COPCs limits (mg/kg) for recreational visitors	Percent of samples above COPC limits for recreational visitors
Arsenic	29 (18)	22	167	700	0 percent
Cadmium	122 (70)	90	623	19,500	0 percent
Copper	201 (174)	34	1301	27,100	0 percent
Lead	4,190 (5,988)	15	58,297	1,100	82 percent
Zinc	1,247 (1,455)	131	14,649	220,000	0 percent

Shading indicates exceedance of screening criteria.

7.1.2 Total Metals from Laboratory Results

Table 7.2 presents total metal concentration statistics for the soil/mine waste samples collected from the Idora Mine project site. The results show that lead is the major contaminant of concern in this system. Over three-quarters of all samples analyzed in the laboratory had lead levels above limits set for recreational visitors.

TABLE 7.2 TOTAL METAL CONCENTRATIONS FROM LABORATORY RESULTS

COPCs	Average sample concentration from the Idora Mine project site (mg/kg)	Minimum sample concentration from the Idora Mine project site (mg/kg)	Maximum sample concentration from the Idora Mine project site (mg/kg)	COPCs limits (mg/kg) for recreational visitors	Percent of samples above COPC limits for recreational visitors
Arsenic	21 (10)	9	48	700	0 percent
Cadmium	7 (5)	2	17	19,500	0 percent
Copper	207 (216)	28	896	27,100	0 percent
Lead	4,754 (5,252)	31	17,000	1,100	76 percent
Zinc	1,164 (908)	168	3,740	220,000	0 percent

Shading indicates exceedance of screening criteria.

7.1.3 Statistical Comparison of XRF Results and Laboratory Results

EPA Method 6200 stipulates that the correlation coefficient (R-squared) between ICP and XRF data needs to be greater than 0.7 for the XRF data to be considered screening level data. The method also stipulates that if the data range spans greater than one magnitude, a log scale shall be used for analysis. For the Idora samples, a least squares regression analysis was utilized to determine whether the apparent trend is statistically significant. As both data sets for all elements range across multiple magnitudes, a log-log correction was utilized. Least squares regression analysis, utilized to determine whether the apparent trend was statistically significant, is described in Appendix G. A comparison of the two, log-corrected data sets via least squares regression analysis indicates a strong, statistically significant relationship between results obtained by the two methods for lead and zinc concentrations (see Table 7.3). The regression relationship was not statistically significant for copper and there were too many readings below the laboratory's limit of detection for calculation of a regression between the laboratory and XRF results for arsenic and cadmium.

TABLE 7.3 LEAST SQUARES COMPARISON OF LOG-CORRECTED METAL CONCENTRATIONS VIA ICP AND FIELD XRF

COPCs	R² for regression line	p-Value of regression line	R for regression
Copper	0.407	0.1730	0.2035
Lead	0.897	<0.0001*	0.4485
Zinc	0.777	<0.0001*	0.3885

*Statistical significance at alpha = 0.05

The XRF analytic results for lead and zinc concentrations can be used as screening level data. This strongly supports the contention that a large proportion of the Idora Mine project site floodplains contain significantly elevated levels of lead.

7.1.4 Water-Extractable Metals Results for Soils and Mine Wastes

Table 7.4 presents water-extractable metal concentrations statistics for the soil/mine waste samples collected from the Idora Mine project site, as analyzed by EPA Method 200.7. Zinc had the highest concentration, which was expected given that it is among the most soluble of trace elements. Lead followed, reflecting the high concentrations of this metal found in the drainage. COPC concentrations in all of the samples, however, were well within the national threshold for human health concerns.

TABLE 7.4 WATER-EXTRACTABLE METAL CONCENTRATIONS OF SOILS AND MINE WASTES VIA ICP

COPCs	Average Sample Concentration from the Idora Mine Project Site (mg/kg)*	Minimum Sample Concentration from the Idora Mine Project Site (mg/kg)	Maximum Sample Concentration from the Idora Mine Project Site (mg/kg)	Surface Water Threshold Concentration (mg/kg) for Human Health Concerns
Arsenic	0 (0)	0.005	0.005	18
Cadmium	0.03 (0.04)	0.002	0.096	5
Copper	0.1 (0.2)	0.0068	0.605	1300
Lead	2.1 (3.7)	0.007	9.37	15
Zinc	4.3 (6.1)	0.0314	15.8	2000

* Mean and standard deviation are reported as #(#)

7.1.5 pH and Conductivity Results for Soils and Mine Wastes

Table 7.5 and Figures 5-A and 5-B present pH and conductivity statistics for the soil/mine waste samples collected from the Idora Mine project site. All samples had acidic values (i.e., less than 7.0 standard units). Fourteen of the 17 samples had pH values less than 5.8 standard units, an indication of significant acidity and low percentage base saturation. Four of the samples had pH values lower than 3.5 and 4.5, a level of high acidity at which exchangeable aluminum can be significantly phytotoxic.

TABLE 7.5 pH AND CONDUCTIVITY VALUES OF SOILS AND MINE WASTES

Analyses	Average sample values from the Idora Mine project site*	Minimum sample values from the Idora Mine project site	Maximum sample values from the Idora Mine project site
pH (standard units)	5.2 (0.7)	3.99	6.51
Conductivity ($\mu\text{mho/cm}$)	718.5 (576.3)	73.2	2690

* Mean and standard deviation are reported as #(#)

There are two major diagnostic thresholds that use soil electrical conductivity as a prime measure. Conductivity of greater than 2,000 $\mu\text{mho/cm}$ @ 25° C is one of the indications of an

Aridisol, while conductivity of greater than 4,000 $\mu\text{mho}/\text{cm}$ @ 25° C defines a saline soil (Boul and others, 1989). Only one sample from Idora Mine project site exceeds the 2,000 $\mu\text{mho}/\text{cm}$ threshold, indicating that soil salinity and/or excessive conductivity was not a significant problem in these soils.

7.1.6 Acid-Base Accounting Results for Soils and Mine Wastes

Table 7.6 presents ABA results for the soils and mine wastes from Idora Mine project site. The most significant results were the Acid-Base Potential values. Thirteen of 17 samples (76 percent) had values less than zero, indicating that they were acid generating. A significant proportion of the floodplain materials was acidic and had the potential to generate acidity.

Acid mine drainage is damaging to both aquatic and riparian life. Many forms of aquatic life cannot tolerate low pH levels caused by high acidity. Indirectly, the bio-availability of potentially phytotoxic metals increases in acidic water and soil, which limits plant growth (Pennsylvania Department of Environmental Protection, 1998).

TABLE 7.6 ACID-BASE ACCOUNTING RESULTS FOR SOILS AND MINE WASTES

Analyses	Average Sample Values from the Idora Mine Project Site*	Minimum Sample Values from the Idora Mine Project Site	Maximum Sample Values from the Idora Mine Project Site
Total sulfur (mg/kg)	0.3 (0.4)	0.005	1.19
Pyritic sulfur (mg/kg)	0.1 (0.2)	0.005	0.64
Sulfate sulfur (mg/kg)	0.1 (0.3)	0.005	1.04
Non-extractable sulfur (mg/kg)	0.0 (0.1)	0.005	0.21
Acid generating potential (TCaCO ₃ /1000T)	3.2 (5.0)	0.15	20
Acid neutralizing potential (TCaCO ₃ /1000T)	1.2 (1.8)	0.25	5.57
Acid-Base potential (TCaCO ₃ /1000T)	-2.1 (4.7)	-17.2	3.9

* Mean and standard deviation are reported as #(#)

7.2 Surface Water Quality

Seven water quality samples were collected and analyzed for total metals, pH, temperature, and hardness. The results of these analyses are shown in Table 7.7 and on Figures 6-A and 6-B.

TABLE 7.7 WATER SAMPLE RESULTS

Analyses	Average Sample Values from the Idora Mine Project Site*	Minimum Sample Values from the Idora Mine Project Site	Maximum Sample Values from the Idora Mine Project Site
Arsenic (dissolved metal mg/L)	<0.01 (0.0)	<0.01	<0.01
Cadmium (dissolved metal mg/L)	<0.002 (0.0)	<0.002	<0.002
Copper (dissolved metal mg/L)	<0.003 (0.0)	<0.003	<0.003
Lead (dissolved metal mg/L)	0.009 (0.0052)	<0.005	0.0144
Zinc (dissolved metal mg/L)	0.239 (0.908)	0.118	0.341

TABLE 7.7 WATER SAMPLE RESULTS (continued)

Analyses	Average Sample Values from the Idora Mine Project Site*	Minimum Sample Values from the Idora Mine Project Site	Maximum Sample Values from the Idora Mine Project Site
pH (standard units)	7.0 (0.05)	6.96	7.11
Temperature (° F)	47.8 (1.40)	46.22	48.92
Hardness (mg/L)	16.5 (0.3)	16.2	17

* Mean and standard deviation are reported as #/#)

Table 7.8 displays the percent of samples with values above the national drinking water standards. None of the analytes exceeded thresholds for water quality, although several samples contained lead concentrations near the EPA National Primary Drinking Water Standards. The proximity of the Beaver Creek arsenic levels to the EPA National Primary Drinking Water Standards was impossible to discern as the SVL Analytic detection limits for arsenic are 10 µg/L.

TABLE 7.8 WATER QUALITY SAMPLE COMPLIANCE WITH HUMAN HEALTH STANDARDS

COPC	Average Sample Values from the Idora Mine Project Site	EPA National Primary Drinking Water Standards	Percent of Samples Above EPA National Primary Drinking Water Standards: Beaver Creek
Arsenic (dissolved metal (µg/L))	<10	10 (as of 1/23/06)	0
Cadmium (dissolved metal µg/L)	<2	5	0
Copper (dissolved metal (µg/L))	<5	1,300	0
Lead (dissolved metal (µg/L))	8.9	15	0
Zinc (dissolved metal (µg/L))	239.4	N/A	N/A

As Table 7.9 illustrates, two analytes, lead and zinc, had values exceeding the aquatic life criteria. For lead, none of the values exceeded the aquatic life criterion acute levels, but 100 percent of the sample values surpassed the chronic values. Eighty-six (86) percent of the zinc sample values exceeded both the acute and chronic water quality criteria for aquatic life.

TABLE 7.9 WATER QUALITY SAMPLE COMPLIANCE WITH AQUATIC LIFE STANDARDS

COPC	Average Sample Values from the Idora Mine Project Site	National Recommended Water Quality Criteria for Aquatic Life		Percent of Samples Above the National Recommended Water Quality Criteria for Aquatic Life: Beaver Creek	
		Acute	Chronic	Acute	Chronic
Arsenic (mg/L)	<0.01	0.340	0.150	0	0
Cadmium (mg/L)	<0.002	0.002*	0.025*	0	0
Copper (mg/L)	<0.003	0.013*	0.009*	0	0
Lead (mg/L)	0.009	0.065*	0.0025*	0	100**
Zinc (mg/L)	0.239	0.120*	0.120*	86	86

Shading indicates exceedance of screening criteria.

* @ 100 mg/L hardness

** All samples (57%) that fell within the detection limits for zinc had levels above the recommended water quality criteria for aquatic life. Three samples (43%) fell below the detection limits.

Figure 4-A.

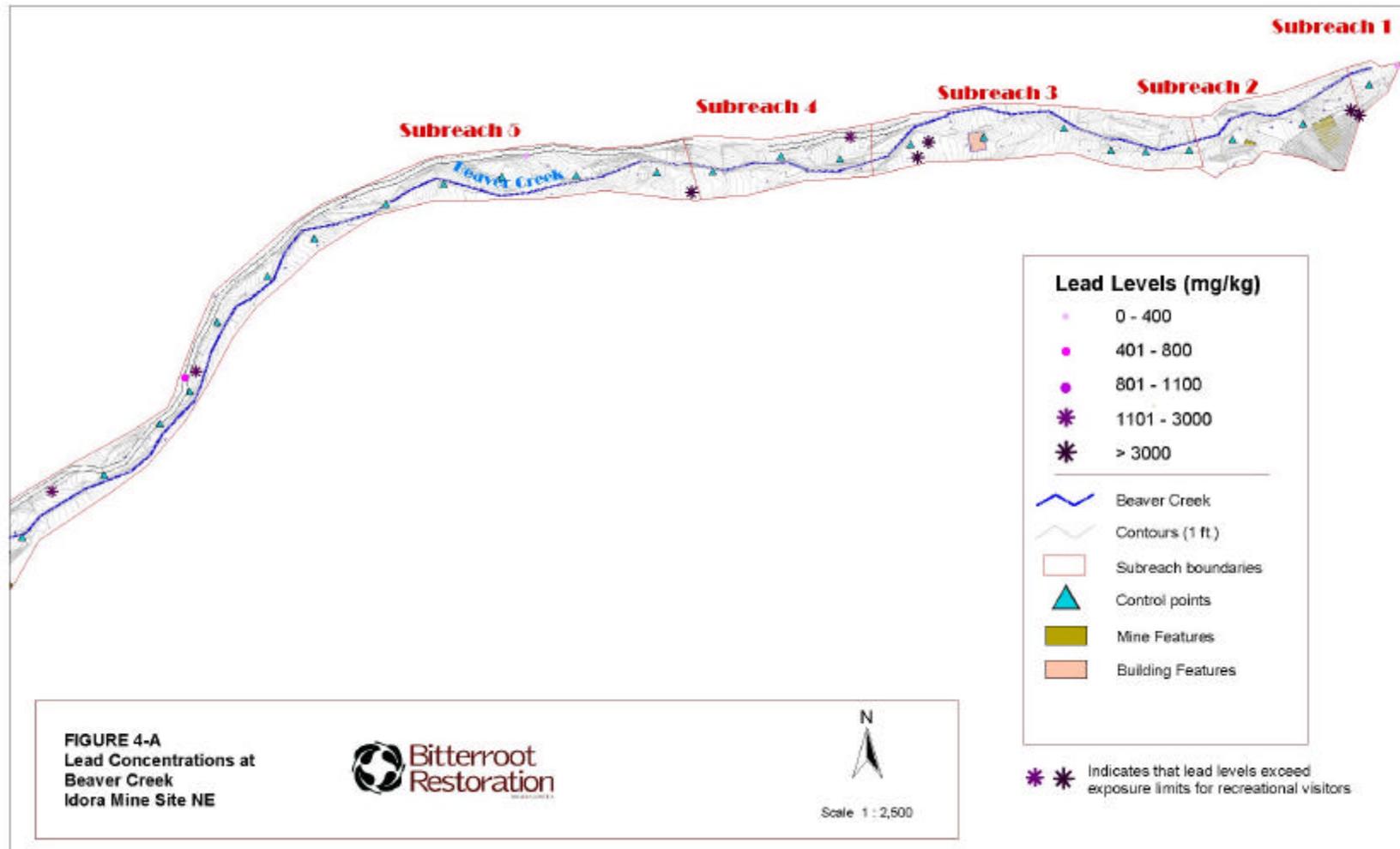


Figure 4-B.

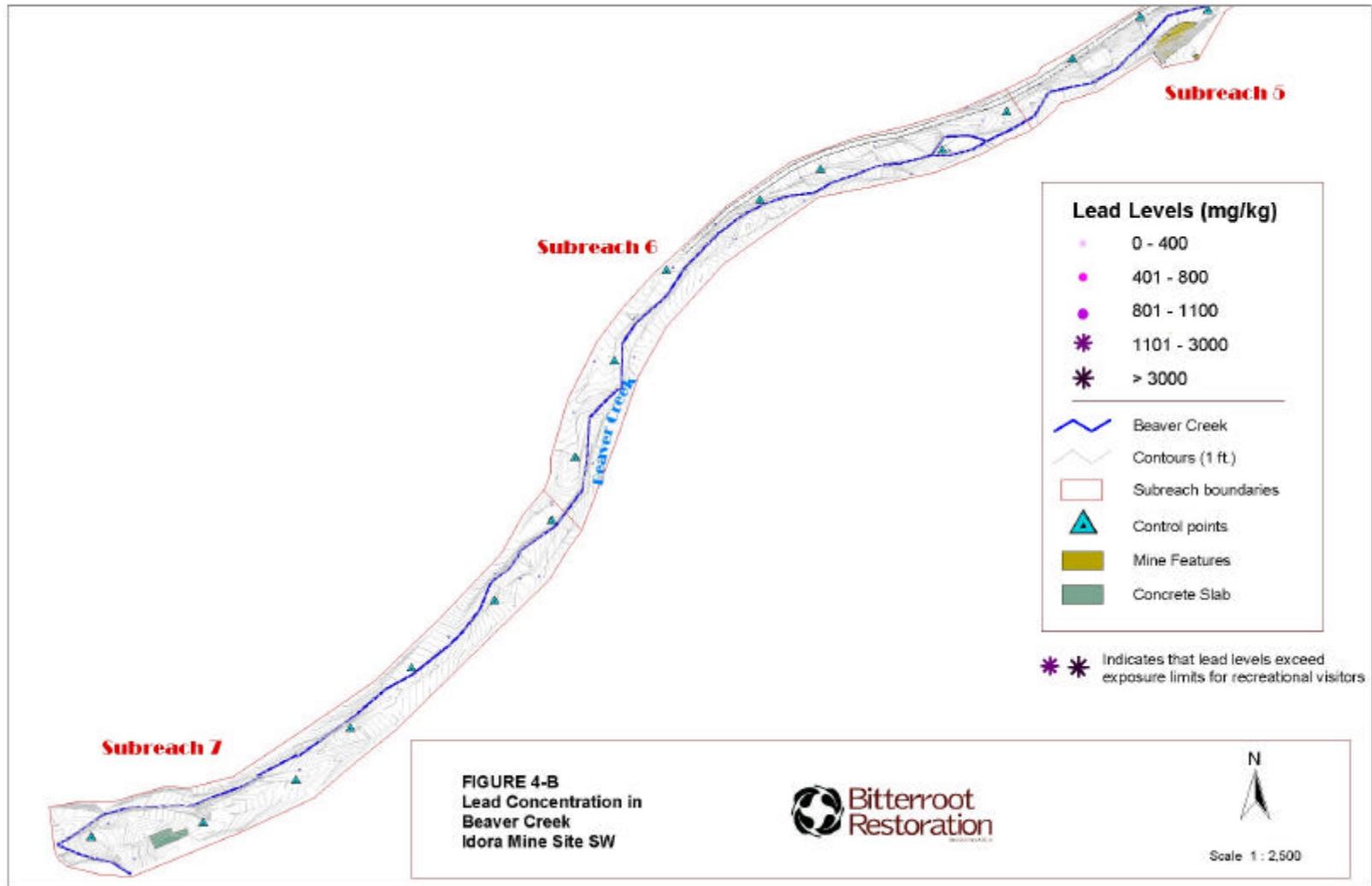


Figure 5-A.

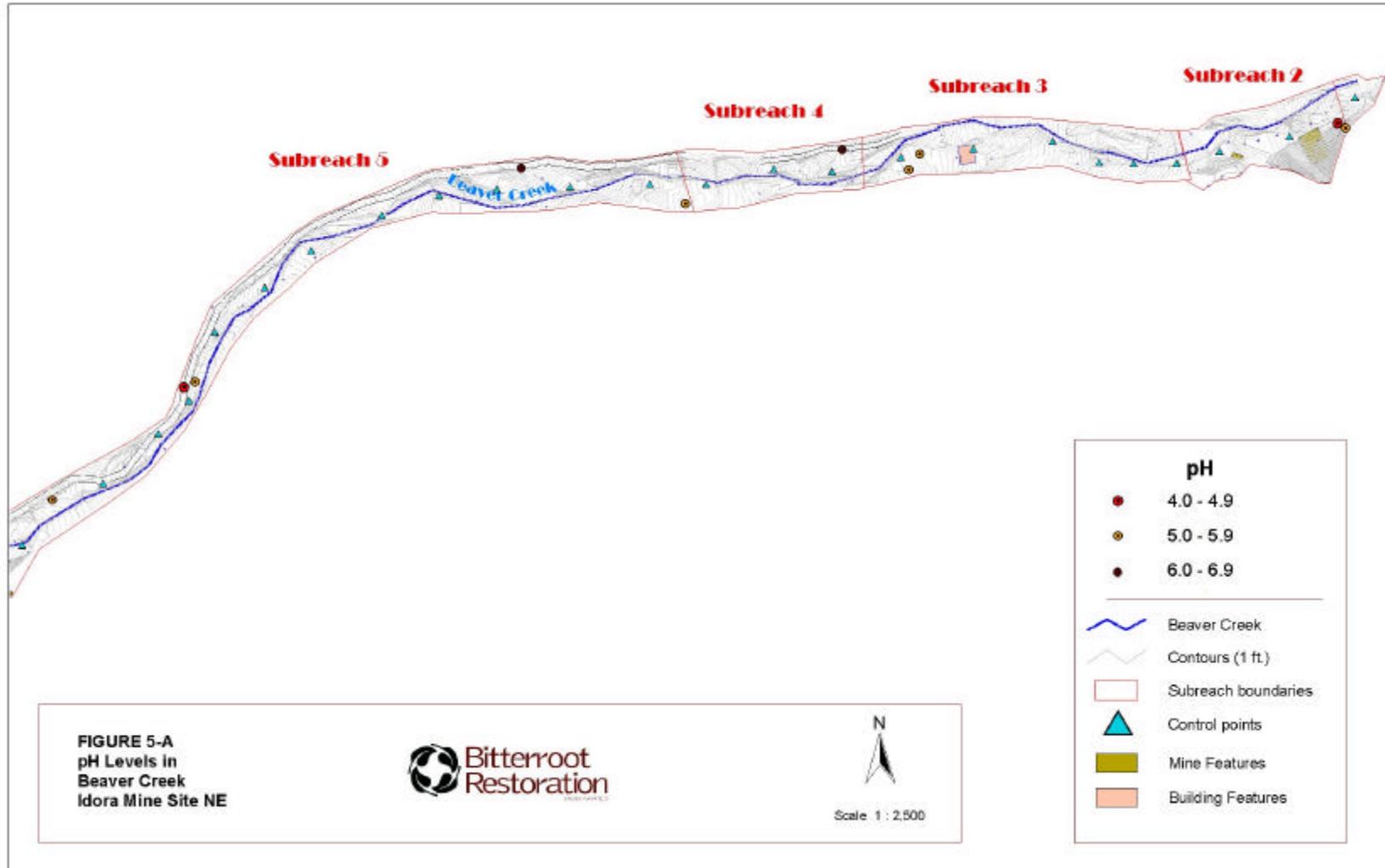


Figure 5-B.

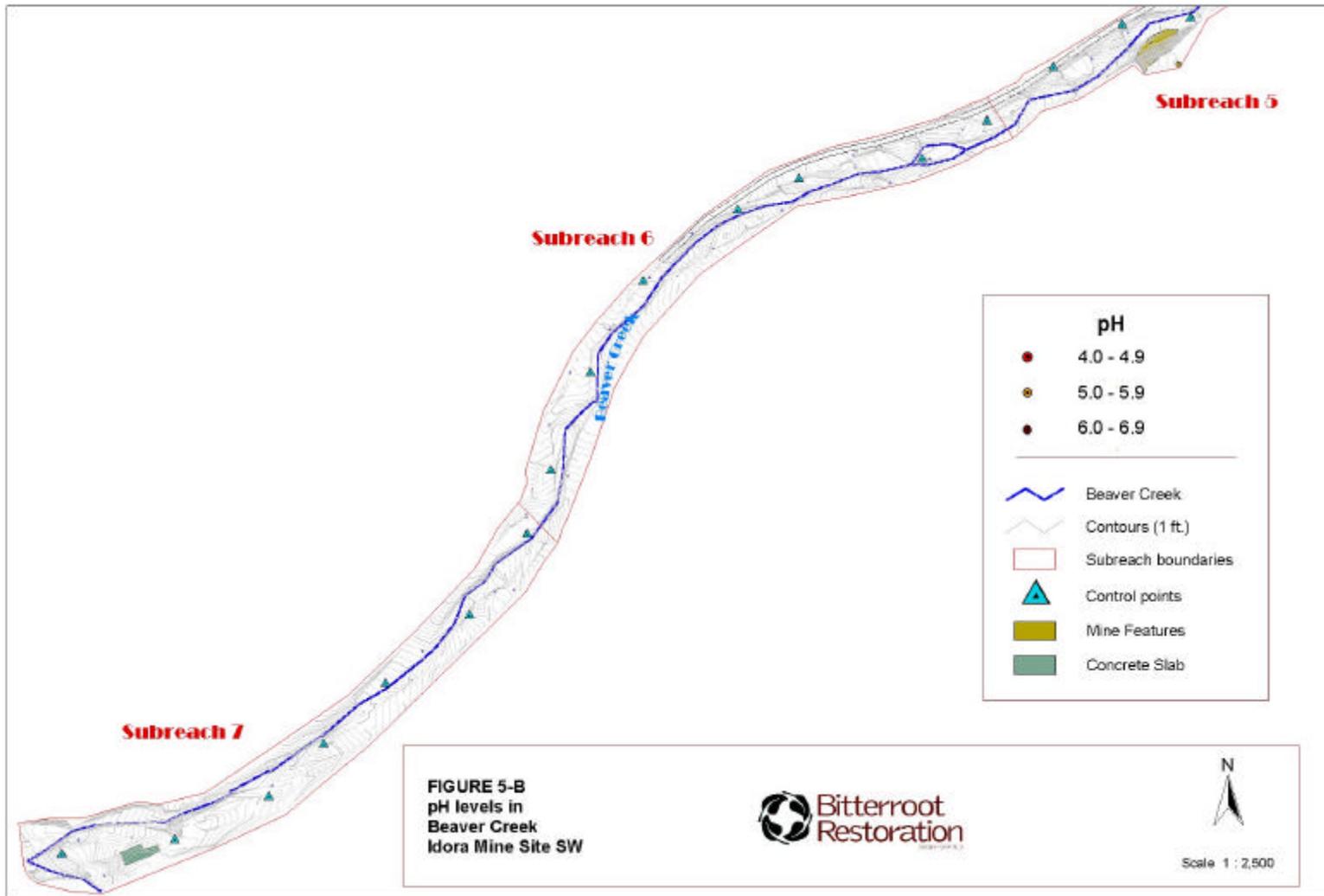


Figure 6-A.

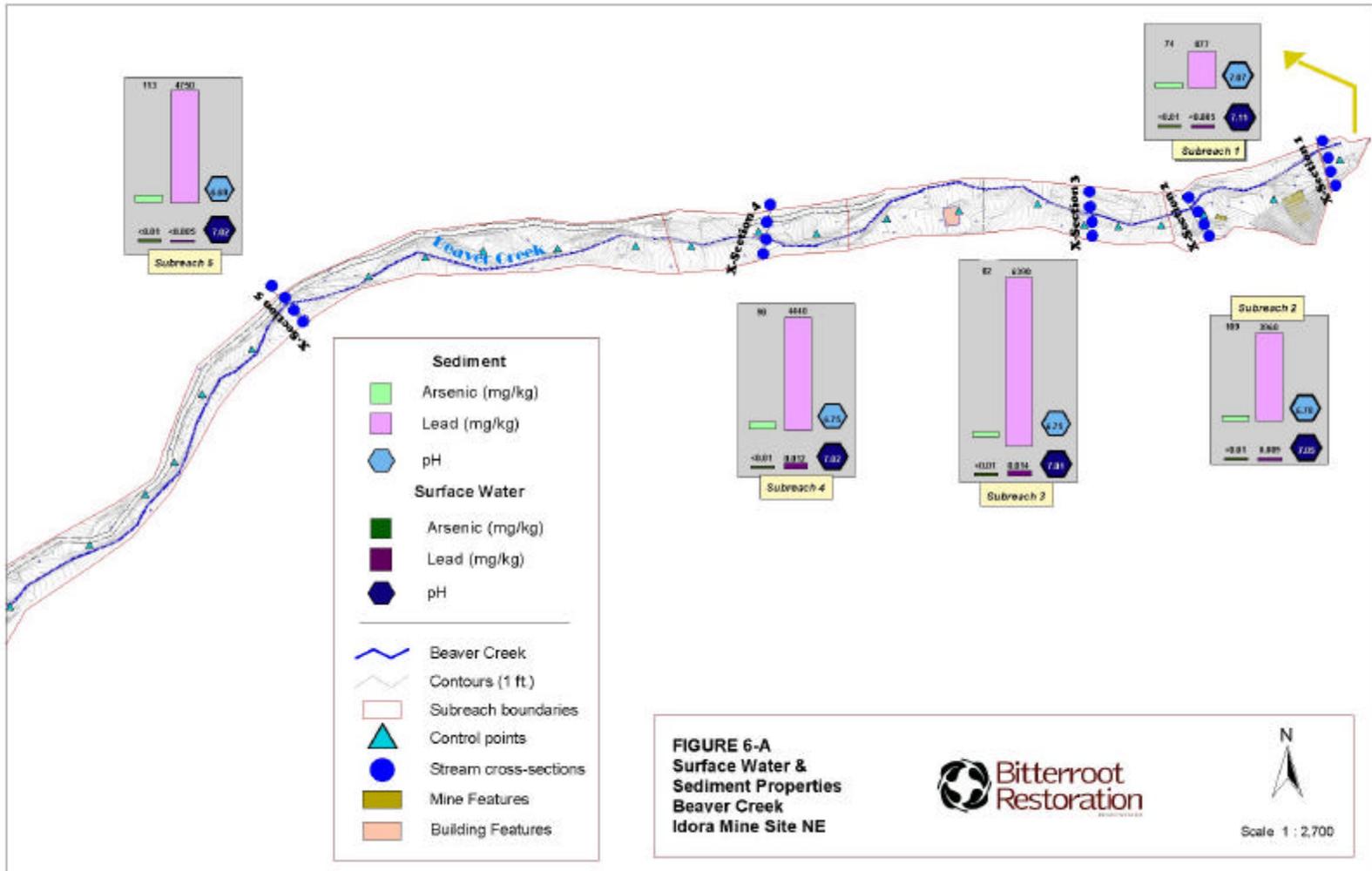
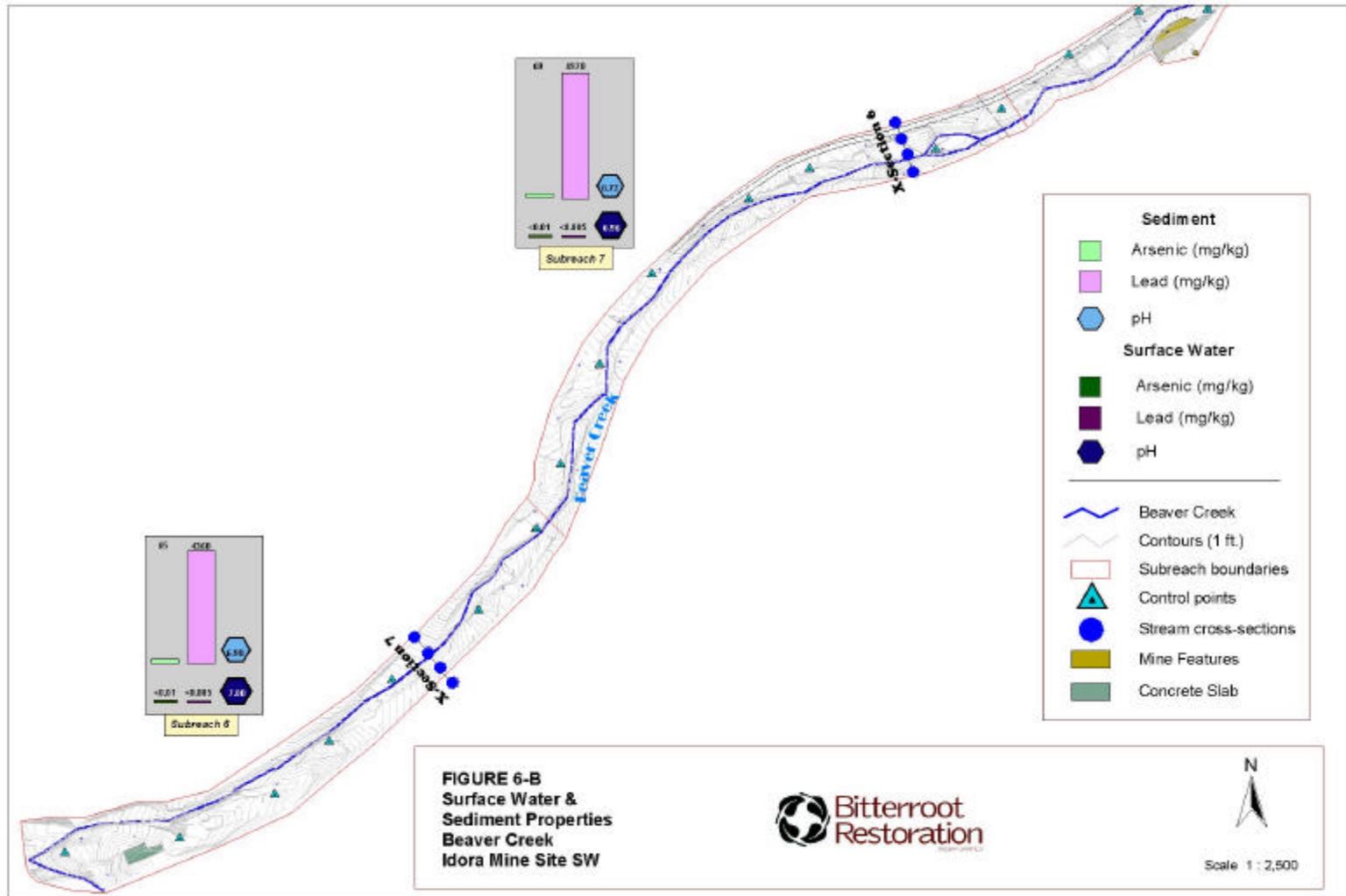


Figure 6-B.



7.3 Streambed Sediment

Seven sediment samples were collected and analyzed for total metals, pH and conductivity. These results (see Table 7.10 and Figures 6-A and 6-B) indicate that, like surface soil/mine waste samples, a significant percentage of streambed samples contained high concentrations of lead. Although other metal concentrations are elevated, they do not exceed the recommended thresholds for recreational users.

TABLE 7.10 SEDIMENT ANALYTICAL RESULTS

Analyses	Average Sample Values from the Idora Mine Project Site*	Minimum Sample Values from the Idora Mine Project Site	Maximum Sample Values from the Idora Mine Project Site	Screening Criteria for Recreational Visitors (mg/kg)	Percent of Samples above COPC Limits for Recreational Visitors
Arsenic (total metal mg/kg)	86 (19)	65	113	700	0 percent
Cadmium (total metal mg/kg)	24 (6)	18	37	19,500	0 percent
Copper (total metal mg/kg)	240 (74)	108	323	27,100	0 percent
Lead (total metal mg/kg)	4,250 (1,676)	877	6390	1,100	86 percent
Zinc (total metal mg/kg)	3,399 (1,256)	1770	5900	220,000	0 percent

Shading indicates exceedance of screening criteria.

* Mean and standard deviation are reported as #(#)

Illustrated in Table 7.11, sediment samples exhibit an essentially neutral pH.

TABLE 7.11 pH AND CONDUCTIVITY VALUES OF SEDIMENTS

Analyses	Average Sample Values from the Idora Mine Project Site*	Minimum Sample Values from the Idora Mine Project Site	Maximum Sample Values from the Idora Mine Project Site
pH (standard units)	7 (0)	6.7	7.1
Conductivity ($\mu\text{mho/cm}$)	253 (90)	157	358

* Mean and standard deviation are reported as #(#)

Conductivity of greater than 2,000 $\mu\text{mho/cm}$ @ 25° C is one of the indications of an Aridisol, while conductivity of greater than 4,000 $\mu\text{mho/cm}$ @ 25° C defines a saline soil (Boul and others, 1989). No samples from the Idora Mine project site exceeded the 2,000 $\mu\text{mho/cm}$ threshold; soil salinity was not a problem in these soils.

7.4 Riparian Health Assessment

Table 7.12 demonstrates the functional scores and habitat/community types found on the project site. Functional scores, ranging from zero to 100 percent, were derived by rating riparian vegetation and soil/hydrology conditions. A stream that scores between 100 and 80 percent is in proper functioning condition (healthy). Scores between 79 and 60 percent indicate that the stream is functional, but at-risk of degradation (healthy, but with problems). Nonfunctioning

(unhealthy) streams score below 60 percent. The vegetation and soil/hydrology factors assessed included diversity, cover, and regeneration of vegetation, as well as the amount of bare ground present, and the condition of the stream banks. A healthy stream system supports dense vegetation that is regenerating and has little to no exposed ground. The stream banks do not experience much erosion due to armoring from large rocks and binding root mass. This assessment/scoring system, developed by Dr. Paul Hansen, is thoroughly described on BRI's riparian and wetland website (<http://bitterrootrestoration.com/index.html>).

Vegetation within the Idora project site, with scores ranging from 78 to 63 percent, was functional, but at-risk of further degradation. Vegetation in the upper three subreaches was healthier than vegetation in the mid and lower sections of the stream. Upstream, the tailings were confined to areas in close proximity to the mill and mine. Downstream, however, contaminated materials and cobbles were spread over the entire flood prone area. So, although vegetation was absent near the mine/mill on the upstream riparian reaches, it was fairly healthy throughout most of the floodplain. Downstream, vegetation health was compromised throughout the floodplain.

The soils and hydrology in the upper two riparian reaches, with scores of 80 percent, were in proper functioning condition. In the two lower reaches, with scores of 67 to 60 percent respectively, they were functional, but at-risk of further degradation. The soils and hydrology were the poorest at the bottom of the injured area (Riparian Reach D) because the fine soil materials were washed away, leaving large accumulations of cobbles. This presents a particular challenge to restoration, as the re-establishment of plant life in this reach will require the addition of substantial amounts of fine soil materials and organics.

The only habitat type identified in the four Riparian Reaches was Western Red Cedar/Ladyfern. In other words, Western Red Cedar (*Thuja plicata*) is the dominant overstory species and Ladyfern (*Athyrium filix-femina*) is the dominant understory species. This is not to say that other overstory and understory species are not present. In fact, the site is diverse, containing 14 tree species, over 30 types of shrubs, nine grasses, and more than 30 forb species. Grand fir (*Abies grandis*) and Douglas fir (*Pseudotsuga menziesii*) are common trees on the site, typical shrubs include mountain alder (*Alnus incana*) Rocky Mountain maple (*Acer glabrum*), and thimbleberry (*Rubus parviflorus*). Two graminoid species – Bluejoint reedgrass (*Calamagrostis canadensis*) and redtop (*Agrostis stolonifera*) – are commonly found. A significant portion of Riparian Reach D is a sparsely vegetated cobble floodplain. Although grasses and sedges are found on the cobbled floodplain, the coverage is too sparse to qualify as a specific vegetation habitat or community class. This area is therefore categorized as an “Unclassified” Wetland habitat/community type. The riparian health assessments for the Idora project are contained in Appendix C.

TABLE 7.12 RIPARIAN HEALTH ASSESSMENT RESULTS, FUNCTIONAL SCORES, & HABITAT TYPES

Location	Vegetation	Soil/ Hydrology	Overall Health	Habitat/ Community Type 1	Habitat/ Community Type2
Riparian Reach A	78	80	79	Western Red Cedar/Ladyfern	N/A
Riparian Reach B	78	80	79	Western Red Cedar/Ladyfern	Cobble bars
Riparian Reach C	63	67	65	Western Red Cedar/Ladyfern	N/A
Riparian Reach D	78	60	68	Western Red Cedar/Ladyfern	Unclassified wetland

7.5 Hydrologic and Geomorphic Characteristics (Rosgen Stream Classification—Level II)

The hydrologic subreaches in the injured area are similar topographically and geomorphically. Using the Rosgen stream typing method, the upper five subreaches (correspond with Riparian Reaches A, B, and C) were rated as A3 systems, and the bottom reach, Subreach 7 (corresponds with Riparian Reach D) was an A4. A brief description of Rosgen Stream Types A3 and A4 follows.

- **Rosgen Stream Type A3:** The upstream sections of Beaver Creek (Subreaches 2 through 5) are A3 Rosgen stream types. An A3 stream is a cascading step/pool sequence that is steep, confined, and entrenched. These high-energy systems with low sinuosity are capable of heavy debris transport. The substrate materials are mainly composed of cobble.
- **Rosgen Stream Types A4:** Subreach 7 on Beaver Creek is rated as A4. Like the A3 stream type, an A4 stream is a cascading step/pool sequence that is steep, confined, and entrenched. It has low sinuosity and is capable of heavy debris transport. The substrate materials are mainly composed of gravel.

The stream gradient decreases as one moves downstream, from an average slope of eight percent on the upper reaches to five percent on the lower reaches. Sinuosity scarcely changes from the upper (1.05) to lower subreaches (1.03). The flood-prone width is narrow on Subreaches 2 through 6. It widens to 76 feet at the confluence of Beaver and Carbon Creeks on Subreach 7.

Stream discharge ranges from 0.74 cubic feet per second (cfs) on Subreach 5 to 2.61 cfs on Subreach 3. Differences in discharge rates are probably due to changes in gradient and bed materials. These two factors influence the amount of water flowing above ground in the channel versus underground. On Beaver Creek, the upper subreaches with steeper inclines have the highest discharges because water in the channel is flowing too fast to infiltrate into the bed materials and run underground. Midway down Beaver Creek, discharge rates decrease. The streambed gradient in this area begins to level off, allowing the channel water to infiltrate into the surrounding bed materials. Areas where this occurs tend to have large boulders and cobbles in the bed material, providing interstitial space for the water to flow underground. The discharge

rate increases in Subreach 7, probably due to changes in the underlying bed material. Analytical data are presented in Table 7.13.

TABLE 7.13 HYDROLOGIC AND GEOMORPHIC CHARACTERISTICS

Location	Discharge (ft ³ /sec)	Flood prone Width (ft.)	Slope (%)	Sinuosity	Rosgen Stream Type	Channel Materials
Subreach 1	0.96	17.7	---*	---*	---*	---*
Subreach 2	1.84	25.5	8	1.04	A3	Cobbles
Subreach 3	2.61	34.7	8	1.05	A3	Cobbles
Subreach 4	1.23	31.5	7	1.03	A3	Cobbles
Subreach 5	0.74	14.3	6	1.03	A3	Cobbles
Subreach 6	0.98	24.6	5	1.05	A3	Cobbles
Subreach 7	1.41	76.1	5	1.03	A4	Gravel

* Information not available

7.6 Volume Estimate of Contaminated Materials

Based upon methods previously discussed, the following field estimate of contaminated materials was developed at the Idora site. These figures were not calculated using formal engineering tools and are not intended to take the place of a thorough engineering estimate and cost analysis. They are an approximation of the volume of contaminated materials at the Idora project site. The soil depth to groundwater or bedrock was not computed due to the high amounts of cobbles and gravel throughout the site. Therefore, more detailed studies are needed to make accurate removal calculations.

The removal scenario presented in this report assumes that the materials under consideration for excavation will include all rock-based substances smaller than cobbles. Boulders and cobbles will not be removed from the site. It also assumes that the area of removal spans from the site boundaries on stream right and left (width) down to groundwater or bedrock (depth), extending from ground level to water's edge in the stream.

With these assumptions, it is estimated that approximately 2.3 million cubic feet of materials should be considered for removal. The volume of materials is spread fairly evenly across the site. The upper 1,100 feet of the site (accounting for 17 percent of the total injured area), however, contains 25 percent of the total volume of materials. A disproportionately high volume of materials is found in this area because it houses the Idora Mine and Mill.

As Table 7.14 illustrates, volume estimates were calculated for five size classes of material. Gravel is the most common material, with over 1 million cubic feet residing on the site. Boulders are the least common material, amounting to 141,857 cubic feet.

TABLE 7.14 VOLUME ESTIMATE OF CONTAMINATED MATERIALS

Volume (cu. ft.)	Boulders	Cobbles	Gravel	Sand	Fines
	141,857	700,354	1,084,354	706,785	555,246

8.0 CONCLUSIONS

The results from this site investigation indicate that the levels of contamination in and around the Idora Mine project site exceed established protective limits for recreational populations. Lead is the major COPC in the system. Over 75 percent of soil/mine waste samples and over 85 percent of sediment samples contained total lead concentrations above screening criteria for recreational visitors. In addition, all soil/mine waste samples were acidic in nature, with three-quarters of samples exhibiting continuing acid generating properties.

Nonetheless, the surface water in the Idora Mine project site does not contain metal levels elevated above water quality standards for human health. This is likely due to the neutral sediment and water chemistry, as well as to the low relative solubility of lead, the major metal in the system.

The riparian health assessments also indicate that the ecological integrity of the system is compromised. Many parts of the flood-prone zone are devoid of vegetation, likely due to a combination of soil chemistry and physical disturbance. In addition, the Beaver Creek channel is deeply entrenched with high levels of mobile cobbles and pebbles, reflecting probable historic changes in the hydrology of the system caused by mining and milling activities.

The Idora Mine project site is significantly impacted, with levels of COPCs in the floodplain materials and streambed sediments exceeding the limits for recreational exposure and human health. The removal of approximately 2.3 million cubic feet of contaminated tailings materials, the reconstruction of the impacted stream channel and floodplain areas, and the restoration of the impacted riparian zone are recommended.

9.0 REFERENCES

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APPENDICES

For

ABANDONED MINE SITE INVESTIGATION OF THE IDORA MINE SITE ALONG BEAVER CREEK, IDAHO

Prepared for:

U.S. Army Corps of Engineers, Sacramento District and
U.S. Army Corps of Engineers, Omaha District

Prepared By:

Bitterroot Restoration, Inc.
445 Quast Lane
Corvallis, MONTANA 59828



July 23, 2003

Appendix A.
Idora Investigative Field Notes

Appendix B.
Topographic/Site Features Survey
of the
Impacted Area at Idora Mine

LEGEND



- CONTROL POINT



- CROSS SECTION FLAGS



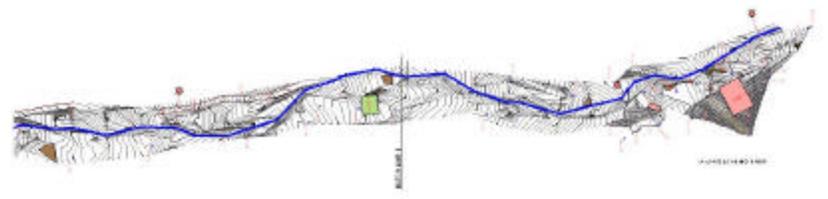
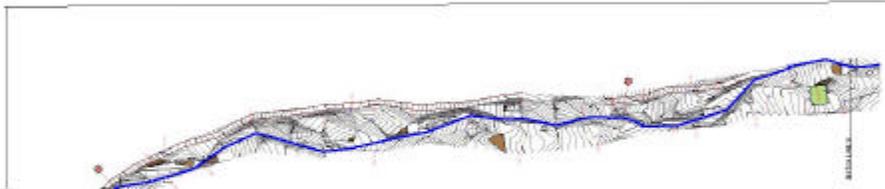
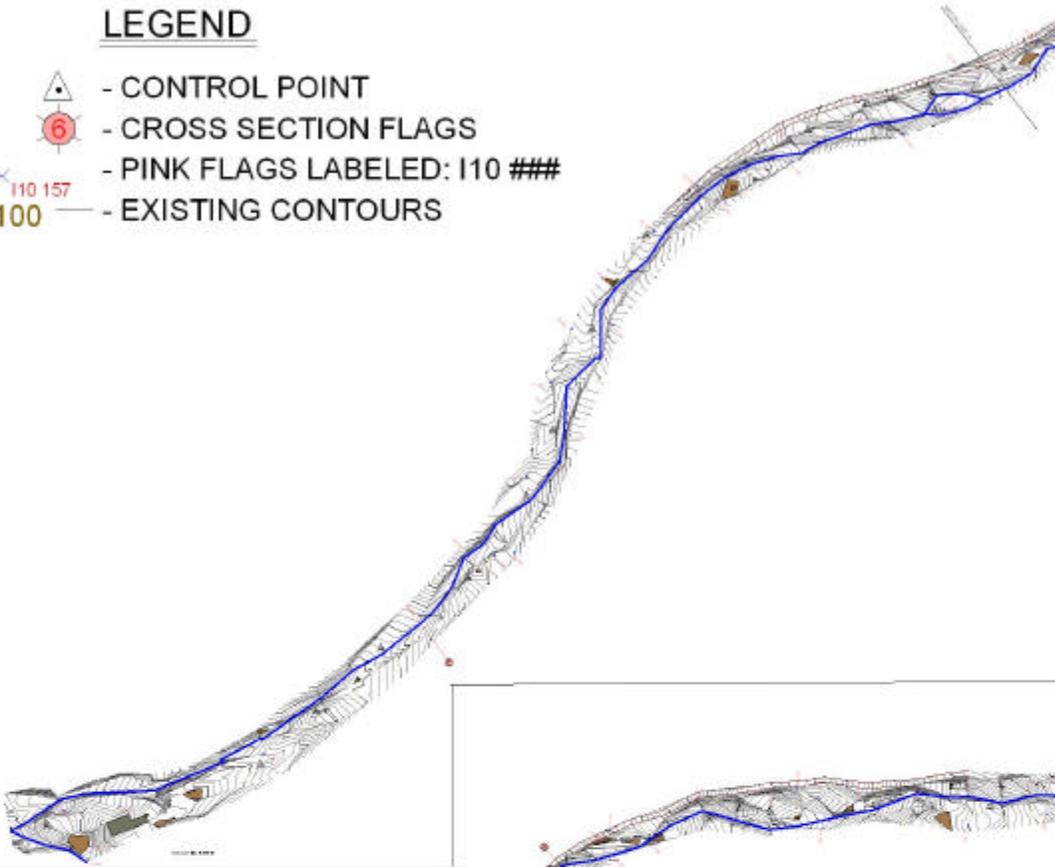
- PINK FLAGS LABELED: I10 ###



- EXISTING CONTOURS



0 100 200 300 Feet



**IDORA MINE SURVEY
SITE MAP
SHOSHONE COUNTY, IDAHO**

Appendix C.
Riparian Assessment Data
and
Rosgen Stream Classification Calculations

**SUMMARY OF
CROSS-SECTION DATA
IDORA MINE/MILL SITE**

Cross-Section	Channel Area (ft²)	Discharge (cfs)	Floodplain width (ft)	pH	Temperature	Gradient	Sinuosity
CS1	0.95	0.96	32.50	7.11	46.22	N/A	N/A
CS2	1.72	1.84	39.50	7.05	48.92	8%	1.04
CS3	1.99	2.61	44.75	7.01	48.2	8%	1.05
CS4	0.73	1.23	31.50	7.02	60.98	7%	1.03
CS5	1.08	0.74	15.00	7.02	n/a	6%	1.03
CS6	0.66	0.98	24.50	7.00	n/a	5%	1.05
CS7	2.02	1.41	76.50	6.96	n/a	5%	1.03

**SUMMARY OF
CROSS-SECTION DATA USED TO
DETERMINE THE ROSEN STREAM TYPE
IDORA MINE/MILL SITE**

Variable	Cross-section 1	Cross-section 2	Cross-section 3	Cross-section 4	Cross-section 5	Cross-section 6	Cross-section 7
bankfull width (ft)	8.58	15.67	15.33	3.27	9.42	14.42	28.50
bankfull mean depth (ft)	2.07	2.16	1.22	1.33	1.20	1.23	2.89
bankfull area (ft ²)	0.95	1.72	1.51	0.73	1.01	0.66	2.02
width/depth ratio	4.15	7.25	12.59	2.46	7.86	11.72	9.87
bankfull max. depth (ft)	2.30	2.45	1.50	1.55	1.45	1.40	3.10
flood-prone width (ft)	17.67	25.50	34.75	31.50	14.34	24.58	76.08
entrenchment ratio	2.06	1.63	2.27	9.63	1.52	1.70	2.67
channel materials (D50)	N/A	Small Cobbles	Small Cobbles	Small Cobbles	Small Cobbles	Small Cobbles	Course Gravel
water surface slope (rise/run)	N/A	8%	8%	7%	6%	5%	5%
channel sinuosity	N/A	1.04	1.05	1.03	1.03	1.05	1.03

Appendix D.

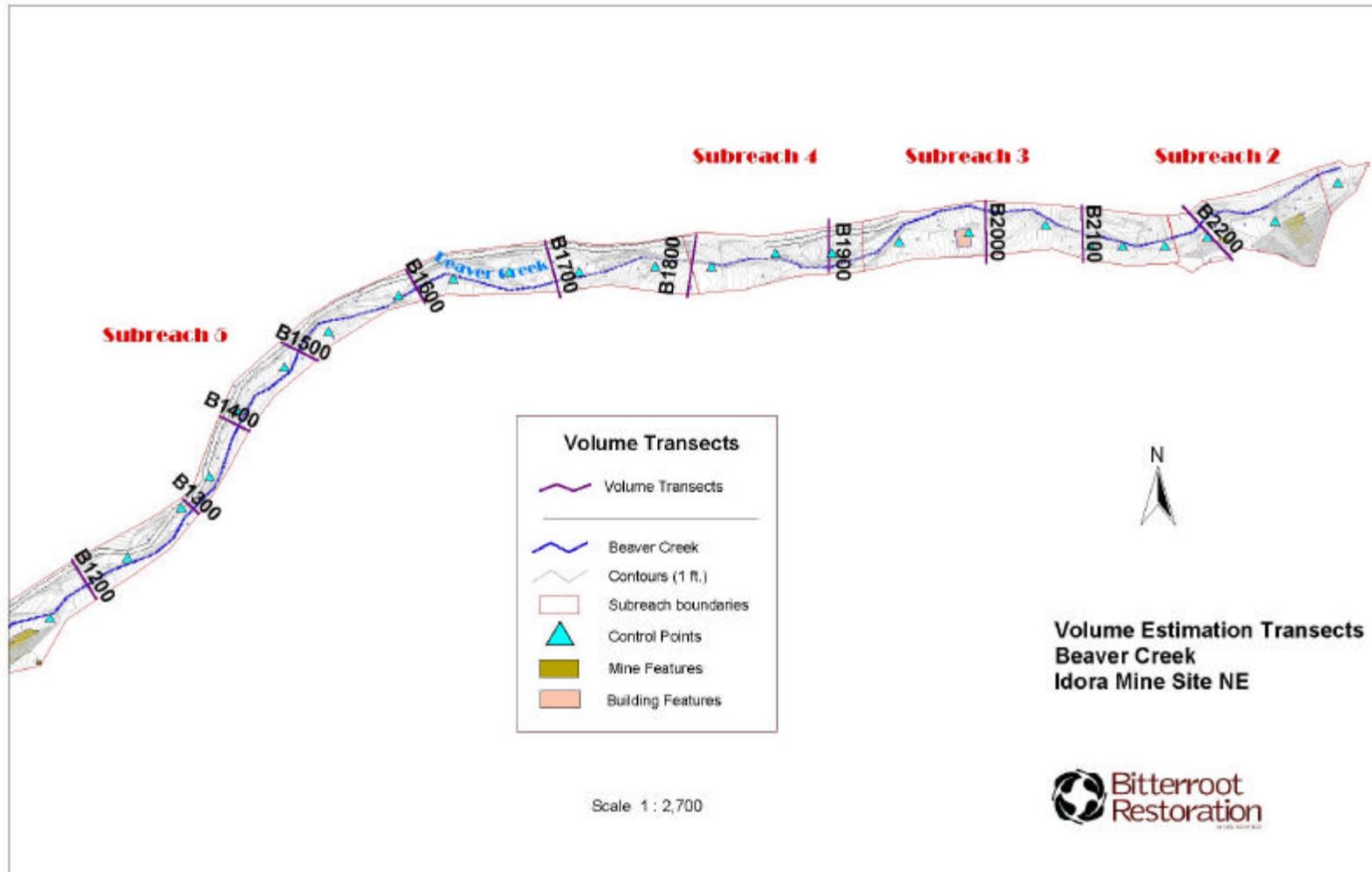
Volume of Contaminated Material Calculations

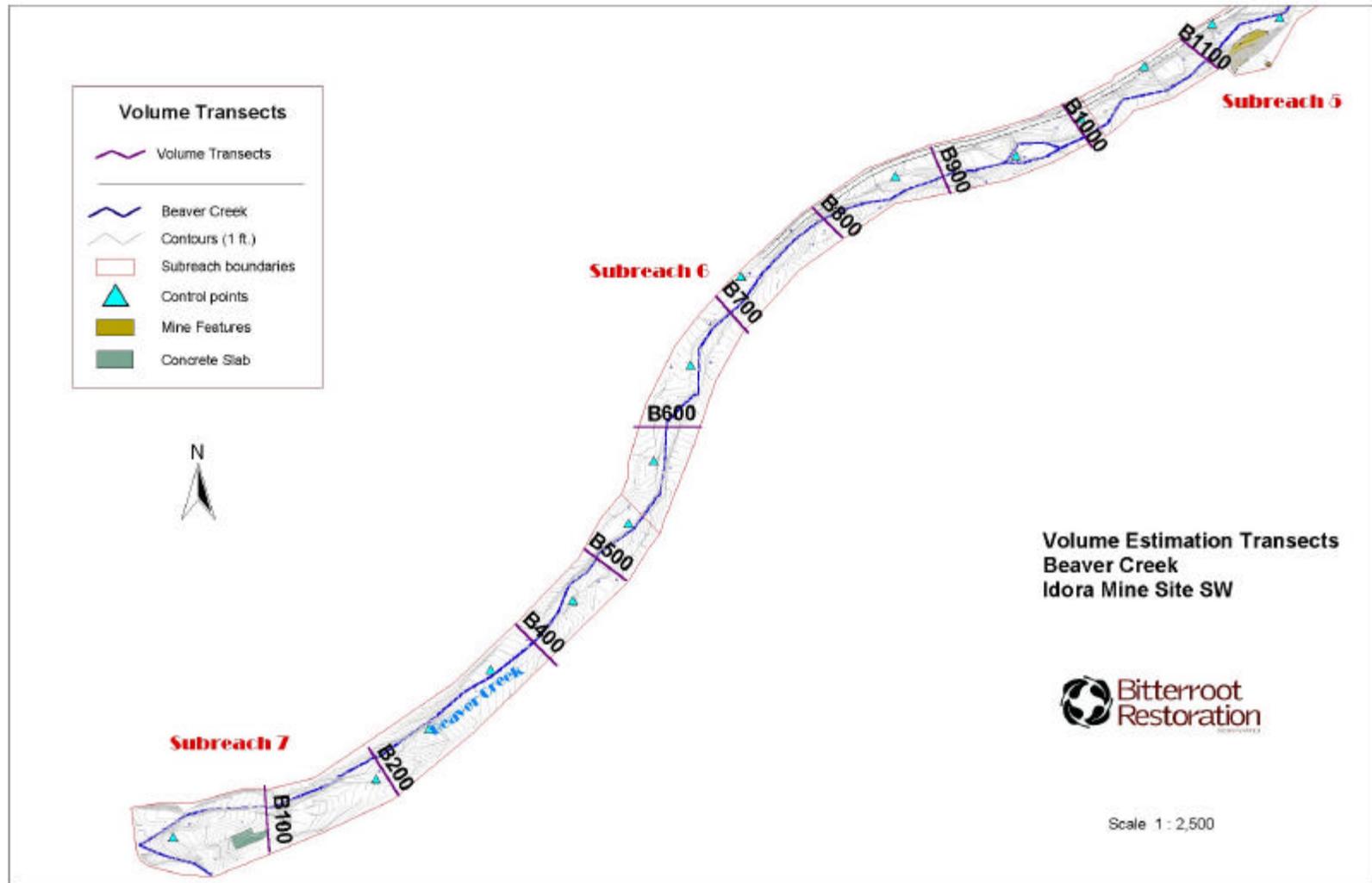
**VOLUME CALCULATIONS
BY REACH & BY
MATERIAL SIZE CLASS
AT
IDORA MINE/MILL**

Reach	Boulders	Cobbles	Gravel	Sand	Fines	Mill Tailings	Concrete
2300-2200	16323.48	30748.88	70861.62034	70861.62	44288.51	19993.00	0.00
2200-2100	7160.44	17453.57	26851.64	25732.82	34683.37	0.00	0.00
2100-2000	15904.35	27292.64	42215.24	45160.48927	64601.13	0.00	0.00
2000-1900	14489.82	45943.34	75394.19659	66847.96	33245.19	0.00	0.00
1900-1800	8055.17	94168.8087	102607.56	122937.28	57536.95	0.00	0.00
1800-1700						0.00	0.00
1700-1600	8488.56	43308.97	45041.33	17901.04	750.69	0.00	0.00
1600-1500						0.00	0.00
1500-1400	3050.15	10939.76	10609.23	7956.92	729.38	0.00	0.00
1400-1300	1888.15	27766.93	37763.02	19992.19	21658.23	0.00	0.00
1300-1200	1577.34	78649.23	162354.35	36954.60	43998.47	0.00	0.00
1200-1100						0.00	0.00
1100-1000	1440.54	69011.91	133667.69	73032.02	58291.61	0.00	0.00
1000-900						0.00	0.00
900-800	26310.98	75896.06	93605.38	53126.95	6071.77	0.00	0.00
800-700						0.00	0.00
700-600	21073.46	68154.48	91309.67	49635.00	2809.53	0.00	0.00
600-500						0.00	0.00
500-400	7034.13	35390.45	57152.28	41765.13	78035.84	0.00	0.00
300-200	2484.57	32643.95	66376.04	25389.74	54406.59	0.00	0.00
200-100						0.00	0.00
100-0	6575.62	42985.50	68544.44	49491.41	54138.49	0.00	10918.00
SUM	141856.76	700354.48	1084353.69	706785.16	555245.75	19993.00	10918.00
Grand Total	3219506.85						

Units of measurement are cubic feet.

The total volume of Gravel, Sand, Fines, Mill Tailings, and Concrete is 2,377,296 cubic feet.





Appendix E.
SVL Laboratory Raw Analytic Results

**Appendix E. SVL Laboratory Raw Analytic Results
for Idora Mine/Mill Site
Soil Analysis for Acid-Base Accounting and Soil/Mine Waste Results**

Sample Number	Sample Date	Job_Id	Arsenic (mg/kg)	Cadmium (mg/kg)	Copper (mg/kg)	Lead (mg/kg)	Zinc (mg/kg)	pH	Conductivity (umhos/cm)	S-Total (%)	S-Pyritic (%)	S-Sulfate (%)	S-Non-Extractable (%)	AGP (TCaCO ₃ /1000T)	ANP (TCaCO ₃ /1000T)	ABP (TCaCO ₃ /1000T)
I-01-01-00	10/8/02	105221	15.5	2.96	28	217	446	6.51	822	0.02	0.02	<0.01	<0.01	0.63	0.56	<0.07
I-04-01-04	10/8/02	105221	13.7	2.2	29.8	30.9	168	6.39	73.2	0.01	0.01	<0.01	<0.01	0.31	<0.5	-0.31
I-04-01-06	10/8/02	105221	24.4	14.6	896	17000	3740	3.99	2690	1.13	0.06	1.04	0.03	1.88	0.56	-1.32
I-04-01-13	10/8/02	105221	48.4	5.46	267	7570	1160	4.35	639	0.55	0.24	0.23	0.08	7.5	<0.5	-7.5
I-04-01-17	10/8/02	105221	22.6	7.17	329	16900	1760	5.31	660	1.19	0.64	0.34	0.21	20	2.78	-17.2
I-04-01-39	10/8/02	105221	26.9	6.8	136	8560	1520	4.87	315	0.29	0.09	0.17	0.03	2.81	<0.5	-2.81
I-04-01-42	10/8/02	105221	39.1	10.7	524	6890	2180	5.15	857	0.63	0.29	0.21	0.13	9.06	5.57	-3.49
I-04-01-45	10/8/02	105221	11	4.53	90.1	1370	487	6	890	0.03	0.03	<0.01	<0.01	0.94	4.45	3.51
I-04-01-58	10/8/02	105221	9.3	2.39	30	146	217	5.76	443	<0.01	<0.01	<0.01	<0.01	<0.3	3.9	3.9
I-04-01-70	10/8/02	105221	12.9	6.19	113	2060	1170	5.11	1150	0.2	0.12	0.08	<0.01	3.75	<0.5	-3.75
I-04-01-71	10/8/02	105221	17.9	2.03	71.6	741	196	4.43	390	0.04	0.04	<0.01	<0.01	1.25	<0.5	-1.25
I-04-01-75	10/8/02	105221	14.4	4.99	191	2410	780	5.45	194	0.06	0.03	0.02	0.01	0.94	<0.5	-0.94
I-04-01-83	10/8/02	105221	14.6	4.52	99.2	1920	831	5.29	589	0.13	0.03	0.08	0.02	0.94	<0.5	-0.94
I-04-02-01	10/8/02	105221	20.1	17.1	184	3450	1890	5.63	431	0.05	0.05	<0.01	<0.01	1.56	<0.5	-1.56
I-04-02-05	10/8/02	105221	23.4	11.2	177	3450	1300	5.07	704	0.04	0.02	0.01	0.01	0.63	<0.5	-0.63
I-04-02-15	10/8/02	105221	16.1	14.6	167	4230	1390	5.25	809	0.05	0.04	<0.01	0.01	1.25	<0.5	-1.25
I-04-01-52	10/8/02	105221	23.4	3.21	190	3870	550	4.49	559	0.12	<0.01	0.09	0.03	<0.3	<0.5	<0.3

Appendix E. SVL Laboratory Raw Analytic Results for the Idora Mine Site Water Extractable Analysis								
Sample Number	Sample Date	Comments	Job_Id	Arsenic (mg/kg)	Cadmium (mg/kg)	Copper (mg/kg)	Lead (mg/kg)	Zinc (mg/kg)
I-01-01-00	10/8/02	EXTRACTION 1:10 RATIO	105220	<0.01	0.0035	0.0092	0.014	0.254
I-04-01-13	10/8/02	EXTRACTION 1:10 RATIO	105220	<0.01	0.096	0.605	9.37	15.8
I-04-01-39	10/8/02	EXTRACTION 1:10 RATIO	105220	<0.01	0.0341	0.0846	2.85	5.43
I-04-01-58	10/8/02	EXTRACTION 1:10 RATIO	105220	<0.01	<0.002	0.0068	0.007	0.0314
I-04-01-71	10/8/02	EXTRACTION 1:10 RATIO	105220	<0.01	0.0079	0.012	0.184	0.265
I-04-01-83	10/8/02	EXTRACTION 1:10 RATIO	105220	<0.01	0.0259	0.0264	0.183	4.06

**Appendix E. SVL Laboratory Raw Analytic Results
for the Idora Mine Site
Stream Sediment Sample Results**

Sample Number	Sample Date	Comments	Job_Id	Arsenic (mg/kg)	Cadmium (mg/kg)	Copper (mg/kg)	Lead (mg/kg)	Zinc (mg/kg)	pH	Conductivity (umhos/cm)
ID-CS1-SED	10/5/02		105185	74.4	22.5	108	877	1770	7.07	159
ID-CS2-SED	10/5/02		105185	109	24.4	210	3960	3660	6.78	358
ID-CS3-SED	10/5/02		105185	81.6	36.9	279	6390	5900	6.75	350
ID-CS4-SED	10/5/02		105185	89.7	23.8	217	4440	3370	6.75	263
ID-CS5-SED	10/5/02		105185	113	18.3	313	4750	2810	6.68	312
ID-CS6-SED	10/5/02		105185	65.1	20	229	4360	3080	6.9	170
ID-CS7-SED	10/5/02		105185	68.9	23.2	323	4970	3200	6.72	157

**Appendix E. SVL Laboratory Raw Analytic Results
for the Idora Mine Site
Surface Water Sample Results**

Sample Number	Sample Date	Job_Id	Calcium (mg/L)	Magnesium (mg/L)	Hardness (mg/L)	Arsenic (mg/L)	Cadmium (mg/L)	Copper (mg/L)	Lead (mg/L)	Zinc (mg/L)
ID-CS1-H2O	10/5/02	105186	4.7	1.28	17	<0.01	<0.002	<0.003	<0.005	0.118
ID-CS2-H2O	10/5/02	105186	4.68	1.27	16.9	<0.01	<0.002	<0.003	0.0094	0.126
ID-CS3-H2O	10/5/02	105186	4.61	1.24	16.6	<0.01	<0.002	<0.003	0.0144	0.209
ID-CS4-H2O	10/5/02	105186	4.48	1.23	16.2	<0.01	<0.002	<0.003	0.0105	0.321
ID-CS5-H2O	10/5/02	105186	4.51	1.2	16.2	<0.01	<0.002	<0.003	<0.005	0.264
ID-CS6-H2O	10/5/02	105186	4.58	1.18	16.3	<0.01	<0.002	<0.003	<0.005	0.297
ID-CS7-H2O	10/5/02	105186	4.58	1.2	16.4	<0.01	<0.002	<0.003	0.0128	0.341

QUALITY CONTROL REPORTS - SOIL

SVL ANALYTICAL, INC.

Quality Control Report

Part I Prep Blank and Laboratory Control Sample

Client :BITTERROOT RESTORATION INC					SVL JOB No: 103571				
Analyte	Method	Matrix	Units	Prep Blank	True	LCS	Found	LCS %R	Analysis Date
Arsenic	6010B	SOIL	mg/kg	<1.0	192		186	96.9	10/21/02
Cadmium	6010B	SOIL	mg/kg	<0.20	125		123	98.4	10/21/02
Copper	6010B	SOIL	mg/kg	<0.30	93.9		96.4	102.7	10/21/02
Lead	6010B	SOIL	mg/kg	<0.50	160		156	97.5	10/21/02
Zinc	6010B	SOIL	mg/kg	<0.50	246		228	92.7	10/21/02

LEGEND:

LCS = Laboratory Control Sample

LCS %R = LCS Percent Recovery

N/A = Not Applicable

QUALITY CONTROL REPORTS - SOIL

SVL ANALYTICAL, INC.

**Quality Control Report
Part I Prep Blank and Laboratory Control Sample**

Client :BITTERROOT RESTORATION INC				SVL JOB No: 105221				Analysis Date
Analyte	Method	Matrix	Units	Prep Blank	True—LCS—Found	LCS %R		
pH	9045	SOIL		5.42	9.02	8.52	94.5	3/19/03
Spec. Cond.	120.1	SOIL	umhos/cm	1.30	465	449	96.6	3/20/03
ABP	EPA600	SOIL	TCaCO3/k	N/A	42.0	42.9	102.1	3/26/03
Acid Neut. Pot.	EPA600	SOIL	TCaCO3/k	N/A	52.0	52.6	101.2	3/26/03
Pyritic Sulfur,S	LECO	SOIL	%	N/A	0.298	0.310	104.0	3/26/03

LEGEND:

LCS = Laboratory Control Sample

LCS %R = LCS Percent Recovery

N/A = Not Applicable

3/27/03 9:30

QUALITY CONTROL REPORTS - SOIL

SVL ANALYTICAL, INC.

Quality Control Report Part II Duplicate and Spike Analysis

Client :BITTERROOT RESTORATION INC						SVL JOB No: 105221			
Test Method Matrix	QC SAMPLE ID	Result	Duplicate or MSD Pound	RPD%	Matrix Spike Result	SPK ADD	%R	Analysis Date	
pH	9045 SOIL	1	6.51	6.55	0.6	N/A	N/A	N/A	3/19/03
COND	120.1 SOIL	1 umhos/c	822	609	29.8	N/A	N/A	N/A	3/20/03
ABP	EPA600 SOIL	1 TCaCO3/	-0.07	-0.07	0.0	N/A	N/A	N/A	3/26/03
AGP	EPA600 SOIL	1 TCaCO3/	0.63	0.63	0.0	N/A	N/A	N/A	3/26/03
ANP	EPA600 SOIL	1 TCaCO3/	0.56	0.56	0.0	N/A	N/A	N/A	3/26/03
S-N-EX	LECO SOIL	1 %	<0.010	<0.010	UDL	N/A	N/A	N/A	3/26/03
S-PYR	LECO SOIL	1 %	0.020	0.020	0.0	N/A	N/A	N/A	3/26/03
S-SO4	LECO SOIL	1 %	<0.010	<0.010	UDL	N/A	N/A	N/A	3/26/03
S-TOT	LECO SOIL	1 %	0.020	0.020	0.0	N/A	N/A	N/A	3/26/03

LEGEND:

$RPD\% = (|SAM - DUP| / ((SAM + DUP) / 2)) * 100$ UDL = Both SAM & DUP not detected. *Result or *Found: Interference required dilution.

$RPD\% = (|SPK - MSD| / ((SPK + MSD) / 2)) * 100$ M in Duplicate/MSD column indicates MSD.

SPIKE ADD column, A = Post Digest Spike; %R = Percent Recovery N/A = Not Analyzed; R > 4S = Result more than 4X the Spike Added

QC Sample 1: SVL SAM No.: 327055 Client Sample ID: I10100

3/27/03 9:27

QUALITY CONTROL REPORTS – WATER EXTRACTABLE

SVL ANALYTICAL, INC.

**Quality Control Report
Part I Prep Blank and Laboratory Control Sample**

Client :BITTERROOT RESTORATION INC					SVL JOB No: 105220			
Analyte	Method	Matrix	Units	Prep Blank	True—LCS—Found	LCS %R	Analysis Date	
Arsenic	200.7	ESOIL	mg/L Ext	<0.010	1.25	1.29	103.2	3/20/03
Cadmium	200.7	ESOIL	mg/L Ext	<0.0020	1.25	1.30	104.0	3/20/03
Copper	200.7	ESOIL	mg/L Ext	<0.0030	1.25	1.17	93.6	3/20/03
Lead	200.7	ESOIL	mg/L Ext	<0.0050	1.25	1.27	101.6	3/20/03
Zinc	200.7	ESOIL	mg/L Ext	<0.0050	1.25	1.30	104.0	3/20/03

LEGEND:

LCS = Laboratory Control Sample

LCS %R = LCS Percent Recovery

N/A = Not Applicable

3/21/03 9:04

QUALITY CONTROL REPORTS – WATER EXTRACTABLE

SVL ANALYTICAL, INC.

Quality Control Report Part II Duplicate and Spike Analysis

Client :BITTERROOT RESTORATION INC						SVL JOB No: 105220			
Test Method	Matrix	QC SAMPLE ID		Duplicate or MSD		Matrix Spike			Analysis Date
		Units	Result	Found	RPD%	Result	SPK ADD	%R	
As	200.7 ESOIL	2 mg/L Ex	<0.010	<0.010	UDL	1.01	1.00	101.0	3/20/03
Cd	200.7 ESOIL	2 mg/L Ex	<0.0020	<0.0020	UDL	0.967	1.00	96.7	3/20/03
Cu	200.7 ESOIL	2 mg/L Ex	0.0068	<0.0030	200.0	0.961	1.00	95.4	3/20/03
Pb	200.7 ESOIL	2 mg/L Ex	0.0070	<0.0050	200.0	0.975	1.00	96.8	3/20/03
Zn	200.7 ESOIL	2 mg/L Ex	0.0314	0.0075	122.9	0.975	1.00	94.4	3/20/03

LEGEND:

RPD% = $\left(\frac{|SAM - DUP|}{(SAM + DUP)/2} \right) * 100$ UDL = Both SAM & DUP not detected. *Result or *Found: Interference required dilution.

RPD% = $\left(\frac{|SPK - MSD|}{(SPK + MSD)/2} \right) * 100$ M in Duplicate/MSD column indicates MSD.

SPIKE ADD column, A = Post Digest Spike; %R = Percent Recovery N/A = Not Analyzed; R > 4S = Result more than 4X the Spike Added

QC Sample 1: SVL SAM No.: 327047 Client Sample ID: I10100

QC Sample 2: SVL SAM No.: 327050 Client Sample ID: I40158

3/21/03 9:04

QUALITY CONTROL REPORTS – WATER

SVL ANALYTICAL, INC.

Quality Control Report Part I Prep Blank and Laboratory Control Sample

Client :BITTERROOT RESTORATION INC				SVL JOB No: 105186					
Analyte	Method	Matrix	Units	Prep Blank	True	LCS	Found	LCS %R	Analysis Date
Arsenic	200.7	WATER	mg/L	<0.010	1.00		0.996	99.6	3/20/03
Calcium	200.7	WATER	mg/L	<0.040	20.0		19.9	99.5	3/20/03
Cadmium	200.7	WATER	mg/L	<0.0020	1.00		0.997	99.7	3/20/03
Copper	200.7	WATER	mg/L	<0.0030	1.00		1.04	104.0	3/20/03
Hardness	200.7	WATER	mg/L	<0.265	132		131	99.2	3/20/03
Magnesium	200.7	WATER	mg/L	<0.040	20.0		19.8	99.0	3/20/03
Lead	200.7	WATER	mg/L	<0.0050	1.00		1.01	101.0	3/20/03
Zinc	200.7	WATER	mg/L	<0.0050	1.00		1.00	100.0	3/20/03

LEGEND:

LCS = Laboratory Control Sample

LCS %R = LCS Percent Recovery

N/A = Not Applicable

3/21/03 9:01

QUALITY CONTROL REPORTS – WATER

SVL ANALYTICAL, INC.

Quality Control Report
Part II Duplicate and Spike Analysis

Client :BITTERROOT RESTORATION INC				SVL JOB No: 105186					
Test Method Matrix	QC SAMPLE ID		Duplicate or MSD			Matrix Spike			Analysis Date
	Units	Result	Found	RPD%	Result	SPK ADD	%R		
As	200.7 WATERS	1 mg/L	<0.010	<0.010	UDL	0.919	1.00	91.9	3/20/03
Ca	200.7 WATERS	1 mg/L	4.70	4.75	1.1	24.2	20.0	97.5	3/20/03
Cd	200.7 WATERS	1 mg/L	<0.0020	<0.0020	UDL	0.960	1.00	96.0	3/20/03
Cu	200.7 WATERS	1 mg/L	<0.0030	<0.0030	UDL	1.01	1.00	101.0	3/20/03
Hdns	200.7 WATERS	1 mg/L	17.0	17.1	0.6	143	132	95.5	3/20/03
Mg	200.7 WATERS	1 mg/L	1.28	1.28	0.0	20.1	20.0	94.1	3/20/03
Pb	200.7 WATERS	1 mg/L	<0.0050	<0.0050	UDL	0.966	1.00	96.6	3/20/03
Zn	200.7 WATERS	1 mg/L	0.118	0.119	0.8	1.05	1.00	93.2	3/20/03

LEGEND:
 RPD% = (|SAM - DUP| / ((SAM + DUP) / 2)) * 100 UDL = Both SAM & DUP not detected. *Result or *Found: Interference required dilution.
 RPD% = (|SPK - MSD| / ((SPK + MSD) / 2)) * 100 M in Duplicate/MSD column indicates MSD.
 SPIKE ADD column, A = Post Digest Spike; %R = Percent Recovery N/A = Not Analyzed; R > 4S = Result more than 4X the Spike Added
 QC Sample 1: SVL SAM No.: 326791 Client Sample ID: ID-CS1-H20

QUALITY CONTROL REPORTS – SEDIMENT

MAR-25-03 09:44 From:SVL ANALYTICAL

+2087830891

T-118 P.09/13 Job-122

SVL ANALYTICAL, INC.

Quality Control Report
Part I Prep Blank and Laboratory Control Sample

Client :BITTERROOT RESTORATION INC				SVL JOB No: 105185					
Analyte	Method	Matrix	Units	Prep Blank	True	LCS	Found	LCS %R	Analysis Date
Arsenic	6010B	SOIL	mg/kg	<1.0	283		310	109.5	3/21/03
Cadmium	6010B	SOIL	mg/kg	<0.20	50.7		52.5	103.6	3/21/03
Copper	6010B	SOIL	mg/kg	0.55	169		183	108.3	3/21/03
Lead	6010B	SOIL	mg/kg	<0.50	84.7		89.6	105.8	3/21/03
Zinc	6010B	SOIL	mg/kg	<0.50	149		156	104.7	3/21/03
pH	9045	SOIL		5.42	9.07		8.52	93.9	3/19/03
Spec. Cond.	120.1	SOIL	umhos/cm	1.30	465		449	96.6	3/20/03

LEGEND:

LCS = Laboratory Control Sample

LCS %R = LCS Percent Recovery

N/A = Not Applicable

3/25/03 8:40

QUALITY CONTROL REPORTS – SEDIMENT

MAR-25-03 09:44 From:SVL ANALYTICAL

+2087830891

T-118 P.10/13 Job-132

SVL ANALYTICAL, INC.

Quality Control Report
Part II Duplicate and Spike Analysis

Client :BITTERROOT RESTORATION INC										SVL JOB No: 105185	
Test Method	Matrix	QC SAMPLE ID		Duplicate or MSD			Matrix Spike			Analysis Date	
		Units	Result	Found	RPD%	Result	SPK ADD	%R			
As	6010B SOIL	1 mg/kg	74.4	281	M	2.5	288	200	106.8	3/21/03	
Cd	6010B SOIL	1 mg/kg	22.5	208	M	3.3	215	200	96.3	3/21/03	
Cu	6010B SOIL	1 mg/kg	108	315	M	6.2	335	200	113.5	3/21/03	
Pb	6010B SOIL	1 mg/kg	877	970	M	1.7	987	200	R >4S	3/21/03	
Zn	6010B SOIL	1 mg/kg	1770	1790	M	4.4	1870	200	R >4S	3/21/03	
pH	9045 SOIL	1	7.07	7.03		0.6	N/A	N/A	N/A	3/19/03	
COND	120.1 SOIL	1 umhos/c	159	151		5.2	N/A	N/A	N/A	3/20/03	

LEGEND:

RPD% = $(|SAM - DUP| / ((SAM + DUP)/2)) * 100$ UDL = Both SAM & DUP not detected. *Result or *Found: Interference required dilution.

RPD% = $(|SPK - MSD| / ((SPK + MSD)/2)) * 100$ M in Duplicate/MSD column indicates MSD.

SPIKE ADD column, A = Post Digest Spike; %R = Percent Recovery N/A = Not Analyzed; R > 4S = Result more than 4X the Spike Added

QC Sample 1: SVL SAM No.: 326782 Client Sample ID: ID-CS1-SED

3/25/03 8:40

CHAIN OF CUSTODY RECORDS - SOIL



Client: Bitterroot Restoration, Inc.
 Contact: Grant Massey
 Address: 445 Quast Lane
 Corvallis, MT 59822
 Phone Number: 406-962-4991
 FAX Number: 406-961-4626

CHAIN OF CUSTODY RECORD

Page 1 of 2

NOTES:

- 1) Ensure proper container packaging.
- 2) Ship samples promptly following collection.
- 3) Designate Sample Reject Disposition

Table 1 -- Matrix Type
 1 = Surface Water, 2 = Ground Water
 3 = Soil/Sediment, 4 = Rinsate, 5 = Oil
 6 = Waste, 7 = Other (Specify)

FOR SVL USE ONLY
 SVL JOB #
10357

PO#: _____
 Project Name: Idora (24400)

Samplers Signature: [Signature]

Sample ID	Collection		Miscellaneous			Preservative(s)					Other (Specify)	Analyses Required	Comments	
	Date	Time	Collected by: (Init.)	Matrix Type From Table 1	No. of Containers	Sample Filtered ? Y/N	Unpreserved (See Only)	HNO3	HCL	H2SO4				NAOH
1. I40100	10/08/02	9:45	SFB	3	1	N	✓							
2. I40104		9:55		3	1		✓							
3. I40106		10:05		3	1		✓							
4. I40113		10:19		3	1		✓							
5. I40117		10:15		3	1		✓							
6. I40139		10:30		3	1		✓							
7. I40142		10:37		3	1		✓							
8. I40145		11:02		3	1		✓							
9. I40158		11:30		3	1		✓							
10. I40170	10/08/02	11:45	SFB	3	1	N	✓							

Received by: [Signature]
 Date: 10-8-02
 Time: 3:15 PM

White: LAB COPY Yellow: CUSTOMER COPY SVL-COC 12/95

* Sample Reject: | | Return | | Dispose | | Store (30 Days)

CHAIN OF CUSTODY RECORDS - SOIL

Page 2 of 2

CHAIN OF CUSTODY RECORD

CLIENT NOTES:

- 1) Ensure proper container packaging.
- 2) Ship samples promptly following collection.
- 3) Designate Sample Reject Disposition

Client: Bithervod Restoration, Inc.
 Contact: Grant Massey
 Address: 445 Quavast Lane
Carrollis, MT 59828
 Phone Number: 406-961-4991
 FAX Number: 406-961-4626

FOR SVL USE ONLY
 SVL JOB #
103571

Table 1. -- Matrix Type
 1 = Surface Water, 2 = Ground Water
 3 = Soil/Sediment, 4 = Rinssate, 5 = Oil
 6 = Waste, 7 = Other (Specify)
 Samplers Signature: JTB

Project Name: Idora (724400)

Sample ID	Collection		Miscellaneous			Preservative(s)					Other (Specify)	Analyses Required	Date	Time	
	Date	Time	Collected by: (Init.)	Matrix Type	From Table 1	No. of Containers	Sample Filtered ? Y/N	Unpreserved (free-Galv)	HNO3	HCL					H2SO4
1. I40171	10/08/02	12:07	JFB	3	N	1	N	✓	✓	✓	✓	✓	Metals (As, Pb, Cu, Zn)	10-8-02	3:15
2. I40175		12:20						✓	✓	✓	✓	✓			
3. I40183		12:45						✓	✓	✓	✓	✓			
4. I40201		13:02						✓	✓	✓	✓	✓			
5. I40205		13:35						✓	✓	✓	✓	✓			
6. I40215	10/08/02	13:45	JFB	3	Y	1	Y	✓	✓	✓	✓	✓			
7. I40152	10/08/02	12:00	JFB	3	N	1	N	✓	✓	✓	✓	✓			
8.															
9.															
10.															

As = Arsenic
 Pb = Lead
 Cu = Copper
 Cd = Cadmium
 Zn = Zinc
 Comments

Requisitioned by: James F. B...
 Requisitioned Date: 10/08/02
 Date: 10/08/02
 Time: 3:15 PM
 Received by: JTB
 Received Date: 10-8-02
 Time: 3:15

White: LAB COPY Yellow: CUSTOMER COPY SVL-COC 12/95

* Sample Reject: | Return | | Dispose | | Store (30 Days)

CHAIN OF CUSTODY RECORDS - SURFACE WATER & SEDIMENT

MAR-21-03 10:11 From:SVL ANALYTICAL +2087830891 T-078 P.02/13 Job-088

Do Not Analyze Until Given Notice to Proceed by BHE. Continue to archive, per 2/27/03

CHAIN OF CUSTODY RECORD

Client: Bitterroot Restoration, Inc (BHE)

Contact: Gart Massey

Address: 445 Quinst Lane

Corvallis, MT 59828

Phone Number: 406-961-4991

FAX Number: 406-961-2626

1) Ensure proper container packaging.

2) Ship samples promptly following collection.

3) Designate Sample Reject Disposition

POB:

Project Name: RAMS- IDORA

FOR SVL USE ONLY
SVL JOB# _____

Table
1 = Surface Water, 2 = Ground Water
3 = Solid Sediment, 4 = Rinse, 5 = Oil
6 = Waste, 7 = Other (Specify)

Samplers Signature: Class Stapp
David Coffey

Sample ID	Collection		Collected by: (Ink)	Matrix Type	No. of Containers	Preservative(s)				Other (Specify)	Comments	
	Date	Time				HNO3	HCL	H2SO4	NAOH			
1. ID-C51-SED	10-5-02	1:40 PM	CF/DC	3	1	N	✓					
2. ID-C52-SED	10-5-02	2:30 PM	CF/DC	3	1	N	✓					
3. ID-C53-SEP	10-5-02	3:30 PM	CF/DC	3	1	N	✓					
4. ID-C54-SEP	10-5-02	4:05 PM	CF/DC	3	1	N	✓					
5. ID-C55-SEP	10-5-02	4:30 PM	CF/DC	3	1	N	✓					
6. ID-C56-SEP	10-5-02	5:40 PM	CF/DC	3	1	N	✓					
7. ID-C57-SEP	10-5-02	6:20 PM	CF/DC	3	1	N	✓					
8. ID-C51-12D	10-5-02	8:40 PM	CF/DC	1	1	N						
9. ID-C92-12D	10-5-02	2:25 PM	CF/DC	1	1	N						
10. ID-C55-12D	10-5-02	3:30 PM	CF/DC	1	1	N						

Lab Name: SVL Analytical, Inc. (208) 784-1258 FAX (208) 783-0891
Address: One Government Gulch, Kellogg, ID 83837-0927

Sample Reject: | | Return | | Dispose | | Store (30 Days)

White: LAB COPY Yellow: CUSTOMER COPY

SVL-COC 12/95

Appendix F.
XRF Field Analytical Results for Total Metals



7220 North 16th Street, Suite E
Phoenix, AZ 85020
(602) 331-3859
Fax (602) 331-4104

May 21, 2003

1034-1 & 1034-2

Ms. Clare Fitzgerald
Bitterroot Restoration, Inc.
445 Quast Lane
Corvallis, Montana 59828

X-Ray Fluorescence (XRF) Instrument Details – Response to United States Forest Service (USFS) Comments for Bullion and Idora Site Characterization Reports

Dear Clare:

As discussed during our telephone conversation on Friday, May 9, 2003 the USFS commented on the Bullion and Idora Site Characterization Reports and requested additional information regarding the XRF instrument used in the field. Information regarding the USFS' XRF comment, "To be consistent with the other sections below (e.g. pH, flow meters, etc.) this should state what type of XRF instrument was used, it's approximate upper and lower detection limits, precision, accuracy and limitations," is discussed below. I've included as attachments the XRF summary brief text for the Bullion and Idora sites submitted to BRI in March 2003 and EPA's Method 6200 – 'Field Portable X-Ray Fluorescence Spectrometry for the Determination of Elemental Concentration in Soil and Sediment' for your reference.

- The type of XRF instrument used: Spectrace 9000 portable XRF
- The approximate upper detection limits or quantitation limits is determined as 10 times the sample result's associated standard deviation, which is reported by the instrument. This quantitation limit varies from sample to sample. Typically, an average would be used to determine upper detection limits; however, because the XRF instrument was being used to characterize the site and site-specific characterization samples were not available the above method was employed.
- The approximate lower detection limits is determined as 3 times the sample result's associated standard deviation, which is reported by the instrument. This detection limit varies from sample to sample. Typically, an average would be used to determine lower

detection limits; however, because the XRF instrument was being used to characterize the site and site-specific characterization samples were not available the above method was employed. Additionally, the EPA Method 6200 includes a guide for lower detection limits based on no interference, 600 counts per source and quartz soil, they are as follows:

- Arsenic (As) 40 ppm
 - Lead (Pb) 20 ppm
 - Copper (Cu) 50 ppm
 - Cadmium (Cd) 100 ppm
 - Zinc (Zn) 50 ppm
- Precision: The precision for the XRF instrument is based on site-specific conditions and is discussed in detail in the Quality Assurance/Quality Control section of the XRF summary briefs submitted to BRI for Bullion and Idora sites on March 20, 2003 and March 24, 2003, respectively.
 - Accuracy: The accuracy for the XRF instrument is based on site-specific conditions and is discussed in detail in the Quality Assurance/Quality Control section of the XRF summary briefs submitted to BRI for Bullion and Idora sites on March 20, 2003 and March 24, 2003, respectively.
 - Limitations: The XRF instrument limitations are discussed in detail in EPA's Method 6200 Section 4.0 – 'Interferences'.

Sincerely,
EMC²

(sent via email)

Lisa N. Gonzales
Principal

Enclosures

cc: Joe Flynn, EMC²

Appendix G.
**Statistical Procedures (Student's t-Test,
Least Squares Regressions)**

Regression Summary
L_XRF_COPPER vs. L_ICP_Copper

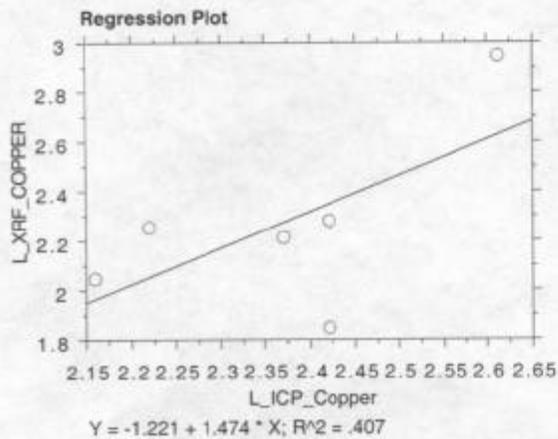
Count	8
Num. Missing	10
R	.638
R Squared	.407
Adjusted R Squared	.258
RMS Residual	.320

ANOVA Table
L_XRF_COPPER vs. L_ICP_Copper

	DF	Sum of Squares	Mean Square	F-Value	P-Value
Regression	1	.281	.281	2.743	.1730
Residual	4	.409	.102		
Total	5	.690			

Regression Coefficients
L_XRF_COPPER vs. L_ICP_Copper

	Coefficient	Std. Error	Std. Coeff.	t-Value	P-Value
Intercept	-1.221	2.111	-.1221	-.578	.5941
L_ICP_Copper	1.474	.890	.638	1.656	.1730



Regression Summary
L_XRF_LEAD vs. L_ICP_Lead

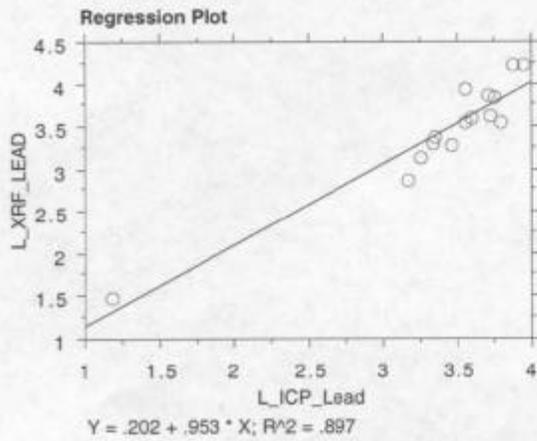
Count	15
Num. Missing	1
R	.947
R Squared	.897
Adjusted R Squared	.889
RMS Residual	.221

ANOVA Table
L_XRF_LEAD vs. L_ICP_Lead

	DF	Sum of Squares	Mean Square	F-Value	P-Value
Regression	1	5.542	5.542	113.057	<.0001
Residual	13	.637	.049		
Total	14	6.179			

Regression Coefficients
L_XRF_LEAD vs. L_ICP_Lead

	Coefficient	Std. Error	Std. Coeff.	t-Value	P-Value
Intercept	.202	.312	.202	.649	.5278
L_ICP_Lead	.953	.090	.947	10.633	<.0001



Regression Summary

L_XRF_ZINC vs. L_ICP_Zinc

Count	16
Num. Missing	0
R	.882
R Squared	.777
Adjusted R Squared	.761
RMS Residual	.192

ANOVA Table

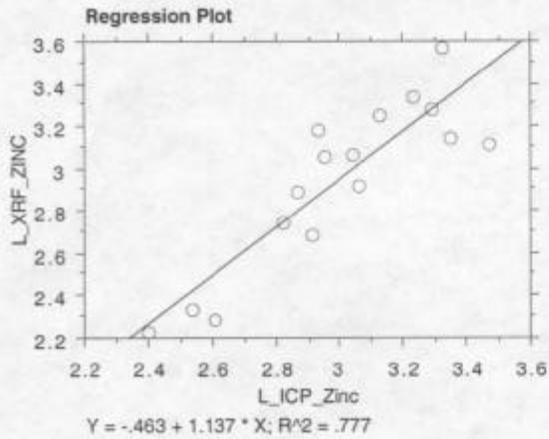
L_XRF_ZINC vs. L_ICP_Zinc

	DF	Sum of Squares	Mean Square	F-Value	P-Value
Regression	1	1.802	1.802	48.887	<.0001
Residual	14	.516	.037		
Total	15	2.318			

Regression Coefficients

L_XRF_ZINC vs. L_ICP_Zinc

	Coefficient	Std. Error	Std. Coeff.	t-Value	P-Value
Intercept	-.463	.490	-.463	-.945	.3606
L_ICP_Zinc	1.137	.163	.882	6.992	<.0001



t-STATISTIC & P-VALUE DESCRIPTION

The **t statistic** is used for small samples (less than 30 samples) to determine the probability whether a sample mean is not equal to the expected population mean. In general terms, the greater the value of a t statistic for a given sample size, the stronger the probability a sample mean does not follow the expected population mean (i.e., the sample and population means are different). The **p-value** indicates this probability. The smaller the p-value, the greater the likelihood that the sample mean does not follow the expected population mean.

LEAST SQUARES REGRESSION DESCRIPTION

Least squares regression describes how two measurement variables are related. Most importantly for the purpose of this exercise, the least squares regression method describes how accurately we can predict the value of one variable (the cause) if we know the value of another variable (the response). The coefficient of determination (R^2) is interpreted as the proportion of the total variation of the response that can be explained by the cause. The rule of thumb for interpreting the R^2 and the correlation coefficient (R) is that there is a strong relationship between the cause and effect if $R^2 > 0.64$ ($|R| > 0.8$), a moderate relationship if $R^2 > 0.25$ ($|R| > 0.5$), and a weak relationship if $R^2 > 0.04$ ($|R| > 0.2$). In this test, the p-value indicates the probability that the observed relationship between the two variables is not false or artificial. The smaller the p-value, the greater the likelihood that the observed relationship is not false.