From: DHONT, JEFF
To: Natalia.Raykhman@CH2M.com
Subject: FW: IKM updated field work plan
Date: Thursday, November 7, 2013 12:56:00 PM
Attachments: IKM_FWP draft_r3.1.docx

Latest – it is different than the last one – use this one.

From: Bussey, Donald
Sent: Thursday, November 07, 2013 11:28 AM
To: Johnson, Terrence; DHONT, JEFF
Cc: Newell, Duane; Gerard, Henry; Ledbetter, Ray
Subject: FW: IKM updated field work plan

With title change.

From: Aloysius, David L [mailto:david.l.aloysius@lmco.com]
Sent: Thursday, November 07, 2013 11:21 AM
To: Bussey, Donald
Subject: RE: IKM updated field work plan

Attached

From: Bussey, Donald [mailto:Bussey.Don@epa.gov]
Sent: Thursday, November 07, 2013 2:14 PM
To: Aloysius, David L; Johnson, Terrence
Cc: Grossman, Scott C; Richards, Sandra L; Leuser, Richard M; Miller, Dennis A
Subject: EXTERNAL: RE: IKM updated field work plan

Supplemental Field Investigation Work Plan.

From: Aloysius, David L [mailto:david.l.aloysius@lmco.com]
Sent: Thursday, November 07, 2013 10:46 AM
To: Bussey, Donald; Johnson, Terrence
Cc: scott.c.grossman@lmco.com; sandra.l.richards@lmco.com; richard.m.leuser@lmco.com; dennis.a.miller@lmco.com
Subject: IKM updated field work plan

Updated file attached FYI

DRAFT
SUPPLEMENTAL FIELD INVESTIGATION
WORK PLAN
Iron King Mine Site
Dewey-Humboldt, Arizona

Prepared for:
United States Environmental Protection Agency/Environmental Response Team
Las Vegas, Nevada

By:
Lockheed Martin/Scientific Engineering Response & Analytical Services (SERAS)
Work Assignment Number: SERAS-146

November 7, 2013

Table of Contents

1.0 INTRODUCTION

The Environmental Protection Agency (EPA) Region 9 (the Region) has requested assistance from the EPA/Environmental Response Team (ERT) in conducting a data gap assessment at the Iron King Mine (IKM) - Humboldt Smelter Superfund Site in Dewey-Humboldt, Yavapai County, Arizona. Lockheed Martin personnel from the Scientific, Engineering, Response and Analytical Services (SERAS) contract will assist the EPA/ERT in completing this work.

This Supplemental Field Investigation Work Plan (FWP) outlines the objectives, approaches, and methods that will be used to address field tasks in source and potentially impacted areas, and further evaluate site-wide groundwater and surface water impacts. It was developed from information gathered from a recent draft Data Gap Analysis Report (CH2M Hill, 2013), conference calls between the Region, ERT, SERAS, CH2M Hill (Region 9 contractor), and site reconnaissance. The source areas include the IKM property and main tailings pile (MTP), the Humboldt Smelter Area (smelter dross, smelter slag, and smelter tailings), lower Chaparral Gulch, Chaparral Gulch Dam, and the Agua Fria River (Figure 1). Potentially impacted areas include peripheral or undeveloped areas around the IKM property, Galena Gulch, upper and middle sections of Chaparral Gulch, and in-town residential parcels.

1.1 Work Scope Overview

In addition to the site-specific tasks and general site assessment methods outlined in this plan, a number of supporting tables (pertaining to sample types, approximate number of samples, and types of analyses) and figures (showing approximate or proposed sampling locations) are also attached. Sample matrix tables (Tables 1 through 3) include information for geotechnical laboratory testing, analytical laboratory testing, and bioassessment sampling and analysis. A fourth table (Table 4) outlines the sample identification protocol for this project.

The detailed quality assurance and quality assurance protocols for the analytical and testing methods are outlined in a site-specific Uniform Federal Policy-Quality Assurance Project Plan (UFP-QAPP; SERAS, 2013).

Prior to initiating intrusive sampling at the site, a subset of sampling locations (excluding residential properties) will be field-marked with labeled pin flags. As the sampling proceeds, additional locations will be added to meet each specific task objective. During field activities, SERAS personnel will work with ERT and/or Region personnel to assure that the proper number of samples have been acquired from each area of interest.

An attached schedule chart (Attachments section) presents the estimated task-specific timelines. The bulk of the work is projected to be completed from December 2013 through mid May 2014; however, tasks such as groundwater and surface water sampling and monitoring are expected to continue through March 2015.

2.0 SITE BACKGROUND

The Iron King-Humboldt-Smelter Superfund site is located in Dewey-Humboldt, Yavapai County, Arizona (Figure 1). The Site is a combination of sources and releases from two areas: the Iron King Mine (IKM) and the Humboldt Smelter. A portion of the Town of Dewey-Humboldt is situated between the Mine and the Smelter. Three waterways (Chaparral Gulch, Galena Gulch, and Agua Fria River) also transect the Iron King-Humboldt-Smelter Superfund site.

The IKM occupies approximately 153 acres and is bordered by Chaparral Gulch to the north, Galena Gulch to the south, Highway 69 to the east, and undeveloped land to the west. The IKM is comprised of the Iron King Mine proper area, the operations area, and the former fertilizer plant. The mine was periodically operated from 1906 to 1969 for extraction of gold, silver, copper, lead, and zinc. The Main Tailing Pile (MTP) on the property covers over 55 acres, is over 100 feet high, and contains over 6,000,000 cubic yards of tailings.

The Humboldt Smelter area, located east of Highway 69, occupies approximately 182 acres along Chaparral Gulch including property at the east end of Main Street in the Town of Dewey-Humboldt around the old smelter stack. This area is covered in approximately 763,800 square feet of yellow-orange tailings, 653,000 square feet of grey smelter ash, and 456,000 square feet of slag. These mine and smelter wastes are sources of lead and arsenic contamination to neighboring residential soils through air transport, surface deposition, and use as yard fill material in some cases. In addition to nearby residential areas, the investigation area around the smelter also includes sections of Chaparral Gulch, the Agua Fria River, and adjoining drainage channels and outfalls.

3.0 PROJECT PLANNING AND SUPPORT ACTIVITIES

3.1 Health and Safety Plan

During work at the site, SERAS personnel may be exposed to a number of occupational and environmental hazards. These will be covered in detail in a site-specific health and safety plan (HASP). All SERAS personnel will be required to read, understand, and sign the HASP prior to initiating any work at the site. SERAS personnel will adhere to the following SERAS Health & Safety SOPs for all site-related activities:

#3001 *SERAS Health and Safety Program Policy and Implementation*
#3012 *SERAS Health and Safety Guidelines for Field Activities*
#3020 *Inclement Weather and Temperature Extremes*

3.2 Quality Assurance Project Plan

Project management, measurement, assessment, and usability elements applicable to this Site-Specific Work Plan are included in a corresponding site-specific Uniform Federal Policy-Quality Assurance Project Plan (UFP-QAPP).

3.3 Subcontractor Procurement

A number of *Requests for Proposals* (RFPs) will be prepared and subsequently transmitted to qualified subcontractors for the following services. These include:

- Drilling and subsurface sampling
- Field surveying (dam, slag pins, new monitor wells)
- Dust control
- Monitor well installation
- Borehole geophysics

Pre-bid meetings and area walkovers will take place at the site with prospective subcontractors prior to submittal of final bids for the various work elements above.

Additionally, arrangements will be made with qualified geotechnical and analytical laboratories for analysis/testing of select parameters on a number of soil and other environmental samples as requested by the Region.

3.4 Field Support Facilities and Site Access

Arrangements will be made to mobilize a large office trailer to the site, which will remain in place for an extended period of time (tentatively, mid November 2013 through May 2014). It is anticipated that the trailer will reside on the Iron King Mine property and therefore, unrestricted site access will be required for the duration of the project. Arrangements for on-site power over the extended period will also be made (i.e., utility pole hook-up). Necessary office furniture, related office supplies and materials, and at least two porta-johns will be rented from local suppliers.

ERT West in Las Vegas, Nevada will transport a mobile laboratory to the site, which will be dedicated to sample analysis using field portable x-ray fluorescence (XRF) analyzers. The lab will be co-located with the office trailer.

Note: Additional, unrestricted site access will also be required for the smelter tailings area (i.e., through the locked gate at the end of Sweat Pea Lane).

3.5 Mark Outs of Proposed Sampling Locations

Prior to initiating field activities, most of the proposed sampling locations (excluding residential properties) will be marked and identified with either flagged stakes or pin flags. During this activity, representatives from ERT and/or the Region will be on site to provide direction, guidance, and concurrence with the mark-outs. It is assumed that this effort will occur as a separate mobilization to the site, which will be tied into the field support facilities and site access arrangements (above). Based on timing, this work may be linked to one or more pre-bid meetings with prospective subcontractors (especially, the drilling and subsurface sampling work element). This initial field work will also serve as an orientation to a number of SERAS staff that will work on the various field tasks.

3.6 Project Staffing

A number of SERAS staff will participate in field and/or office-related activities, including: hydrogeologists, chemists, environmental scientists, environmental technicians, GIS and AutoCAD specialists, data validation chemists, and subcontracting personnel. Other SERAS technical and/or administrative personnel and subcontractors may work on this project as needed.

4.0 SITE-SPECIFIC TASKS

4.1 Site Aerial, Topographic & Parcel Data

Objective: Obtain available data from Yavapai County, which will be useful for volume estimations of mine wastes, identification of parcels (requiring property access) where future sampling efforts and removal activities are planned, and future site restoration activities (e.g., site grading plans, stormwater routing, and waste consolidation & capping evaluations).

- The Yavapai County Geographic Information Systems (GIS) Department will be contacted to obtain 2010 aerial imagery and 2-foot topographic contour coverage for the entire site and surrounding areas. Parcel data will also be acquired for identifying property boundaries and owners. All data will be in electronic format (shape and image files), compatible with ArcGIS version 9.0 (or later versions).

4.2 Property Access and Data Management

Objective: To ensure that EPA obtains signed property access agreements for all residential properties to be sampled prior to sampling.

- ERT will conduct the research to determine the owners of all parcels to be sampled - i.e., parcels designated for both area-based risk screening and yard-specific risk characterization. Property owners will be determined through a combination of county records, utility companies' databases, public meetings, door-to-door visits, telephone calls, and internet searches.

Property access will be requested mainly through door-to-door visits; however, mass mailings of the access agreements will also be conducted. Multiple teams will be deployed to conduct door-to-door visits. Each team will consist of at least one EPA representative and a SERAS contractor. Each team member will wear appropriate identification clothing, and EPA personnel will also have their EPA identification. EPA personnel will explain the need for access and present occupants with a copy of the access agreement and the site Fact Sheet provided by the Region. If the property is not owner-occupied, signed access agreement will be required from both owner and occupant. If additional information is required by an owner/occupant that is not covered by the Fact Sheet, that individual will be referred to a Regional contact, such as the Regional Community Coordinator. Properties that are held by holding companies, trust and out-of-state registered owners will be referred back to the Region.

The signed access agreement shall be scanned and backed up electronically and the original will be filed accordingly for easy access. ERT's Scribe software will be used as an electronic repository for all access agreement data. The Scribe property access database will contain the following fields: property sampling identifier; property address (sub division); property owner(s) name; property owner(s) address(es), if different from property address; contact information (telephone and email); occupant/tenant name(s), if property not owner-occupied; access-request date; status of access (approved; denied; or nonresponsive); approval/denial date; sampling date; an electronic copy of signed access agreements; and comments. Biweekly updates of the Scribe access agreement database will be made available to the Region and other stakeholders identified by the Region.

4.3 Construction Materials Survey

Objective: Determine local off-site sources of natural materials that can be used for future site restoration efforts (e.g., erosion protection, low permeability soil cover, drainage material, and engineered fill).

- Suppliers local to the site will be contacted by phone to inquire as to what types of products are available. Materials of interest include riprap (quarried rock), angular gravel, bank-run gravel, pea gravel, sand (various grain sizes), clayey and non-cohesive backfill materials, road base material (mixed soil & gravel), and organic topsoil. Supplier names, phone numbers, addresses, and available product will be documented in an electronic spreadsheet.

4.4 IKM Main Tailings Pile (MTP)

Overview and Objectives:

1. Bedrock Integrity: Assess bedrock characteristics beneath pile (rock quality, fracturing, etc.).

2. Geotechnical Properties of Tailings: Assess moisture conditions with depth; stability analysis of the pile; liquefaction potential.

3. Acid Mine Drainage Potential: Assess buffering capacity of tailings and acid mine drainage potential.

4. Perched Groundwater Level Monitoring: Assess seasonal groundwater level fluctuations in the pile.

5. Mine Waste Rock Characterization: Assess durability, chemical properties, and degradation characteristics of waste rock for evaluation of use as cover material.

6. Bioaccessibility Analysis: Refine bioaccessibility values to be used in the site risk assessment.

- **Bedrock Integrity**: Sonic drilling will be used to advance three borings into the MTP and the underlying bedrock. Two borings will be drilled on the Upper MTP and one on the Lower MTP (Figure 2). Borings on the Upper MTP will be drilled to approximately 110 feet and the one on the Lower MTP will be drilled to approximately 50 feet (estimated depths to bedrock). The borings will be advanced an additional 20 feet into the underlying bedrock. Rock core samples will be collected to assess the bedrock integrity.

- **Geotechnical Properties:** During drilling in unconsolidated materials, Standard Penetration Tests (SPTs) will be conducted at 5-foot intervals. In addition, undisturbed samples of unconsolidated materials will be collected at 10-foot intervals. The following geotechnical tests will be performed on unconsolidated samples: moisture-density, saturated hydraulic conductivity, specific gravity, soil-water characteristic curve, gradation, Atterberg limits, consolidation tests, direct shear tests, and consolidated triaxial shear tests with pore pressure measurements. Table 1 provides a summary of the number of samples per test.

- **Acid Mine Drainage (AMD) Potential:** Four unconsolidated samples will be collected per boring and analyzed for AMD potential. Samples will be collected at or near ground surface, at perched water zones (where present), in the saturated tailings, and in native material below the tailings. AMD analyses will include Target Analyte List (TAL) metals, acid base accounting (ABA) measurements (rinse and paste pH, sulfur species, neutralization potential, and acid generation potential), hexavalent chromium, and synthetic precipitation leaching procedure (SPLP; EPA Method 1312) followed by metals analysis of the leachate extract.

- **Perched Groundwater Level Monitoring:** The three boreholes will be backfilled to the base of the tailings and completed as monitor wells. The wells will be constructed with 4-inch diameter, Schedule 80 PVC riser pipe and 20-foot, 10-slot screens (positioned at the base of the tailings). Pressure transducers (with data logging capability) will be installed in the wells to monitor water level fluctuations in the MTP over a one year period. These wells will be included in the area-wide monitoring well network and will be sampled on two occasions for analysis of the groundwater.

- **Mine Waste Rock Characterization:** During a field reconnaissance of the area, visual observations will be made to determine a median size of the waste rock (Figure 3). The volume of the waste rock will be estimated using a combination of field measurements and digital topographic contour data. Field measurements will employ a Global Positioning System (GPS) for measuring total area and distances, a survey rod (or similar device) for measuring material thickness, and a Brunton compass (or similar device) for measuring slope angles (where applicable).

  The total rock volume will be estimated from a series of total thickness and footprint measurements, and then assuming a particular geometric shape; for example, a hexagonal prism. The waste rock footprint will be mapped using a handheld GPS and total thicknesses will be measured at a minimum of six locations throughout the area. Assuming a relatively flat, level surface beneath the waste rock, digital topographic contour data may be useful for both refining volume estimates and comparing the results to those derived from manual measurements.

  Five (5) waste rock samples (i.e., fine-grained material) will be collected for the following tests/analyses: slake durability (ASTM D4644), TAL metals, ABA measurements, and SPLP metals.

- **Bioaccessibility Analysis:** Ten surface samples of tailings material will be collected from the MTP for *in vitro* bioaccessibility (IVBA) testing for lead and arsenic. The samples will be sent to the EPA Region 9 Laboratory for analysis.

4.5 IKM Peripheral Areas

Objectives:

1. Determine the extent of contamination beyond the MTP.

2. Refine bioaccessibility values to be used in the site risk assessment.

- **Soil Borings (up to 20 feet):** A minimum of 11 borings will be drilled in two areas (Figure 2) to depths ranging from 5 and 20 feet using a small, track-mounted sonic or direct-push drilling rig. The borings will be logged for lithology, moisture conditions, presence of perched water, and depth of the tailings. Sampling intervals will be determined from field observations; however, a minimum of two samples will be collected per boring for XRF field analysis (one from the top and one from the bottom). Soil samples will be collected from the borings in accordance with SERAS SOP #2012, *Soil Sampling*. A minimum of 22 bag samples will be analyzed for lead and arsenic using a field portable XRF (Table 2). Two XRF shots per bag sample will be performed. All analyses will be conducted in conformance with SERAS SOP# 1720, *Operation of the Niton XLt792YW Field Portable X-Ray Fluorescence Unit*. Sampling tools will be decontaminated between locations as per SERAS SOP #2006, *Sampling Equipment Decontamination*. The borings will be backfilled with hydrated bentonite chips after the soil sampling is completed.

The areas and approximate number of borings for each are as follows:

- Area west of MTP, in native (?) material: 5 borings
- Area southwest of main retention ponds (below blowout area): 6 borings

Additional step-out sample borings may be required to define the three-dimensional extents of visibly impacted soil and/or until XRF lead and arsenic concentrations are below site action levels. Locations and spacing of step-out samples will require adjustment in the field based on visual observations. Where samples indicate impact from tailings (based on XRF field screening), deeper samples will be collected to delineate the impacted area. Step-out sampling will continue both laterally and vertically until tailings and contaminated native materials are not encountered. Hand augers will be used to collect samples around or near perceived boundaries or where the tailings are thought to be less than four feet in thickness.

- **Hand Augering (up to 4.5 feet):** In each area of interest, discussed below (Figure 3), shallow borings will be hand-augered to a maximum depth of 4.5 feet. Soil samples will be collected from each boring location in accordance with SERAS SOP #2012, *Soil Sampling*. A minimum of 152 bag samples will be analyzed in the field for lead and arsenic using a field portable XRF (Table 2). Two XRF shots per bag sample will be performed. All analyses will be conducted in conformance with SERAS SOP# 1720, *Operation of the Niton XLt792YW Field Portable X-Ray Fluorescence Unit*. The hand auger will be decontaminated between locations as per SERAS SOP #2006, *Sampling Equipment Decontamination*. The borings will be backfilled with clean fine sand after sampling is completed and capped to match the existing grade.

The areas are listed below indicating the minimum number of borings and proposed sampling depths:

- Areas northeast of main retention ponds: 2 hand borings (samples from surface and 1-foot); 2 hand borings (samples from surface, 1-foot and 3 feet).
- Area immediately north of the MTP: 15 hand borings (samples from surface, 1-foot and 3 feet)
- Area north of the MTP – around or near to property boundary: 18 hand borings (samples from surface and 1-foot)
- Galena Gulch: 13 hand borings (samples from surface, 1-foot and 3 feet; possibly up to 4.5 feet)
- Areas south of former Fertilizer Plant and MTP - north of Galena Gulch: 11 hand borings (samples from surface and 1-foot)

Additional step-out sample borings may be required to define the three dimensional extents of visibly impacted soil and/or until XRF lead and arsenic concentrations are below site action levels. Locations and spacing of step-out samples will require adjustment in the field based on visual observations. Where samples indicate impact from tailings (based on XRF field screening), deeper samples will be collected to delineate the impacted area. Step-out sampling will continue both laterally and vertically until tailings and contaminated native materials are not encountered. Hand augers will be used to collect samples around or near perceived boundaries or where the tailings are thought to be less than four feet in thickness.

- **Galena Gulch - Bioaccessibility Analysis:** Five surface samples will be collected from Galena Gulch for *in vitro* bioaccessibility (IVBA) testing for lead and arsenic. The samples will be sent to the EPA Region 9 Laboratory for analysis.

4.6 Undeveloped Areas

Objectives:

1. Characterize the extent and distribution of lead and arsenic in shallow soil within areas that have not been previously sampled.

2. Estimate the extent of aerial deposition of dust generated from the MTP

- **Hand Augering:** In each area of interest, discussed below (Figure 4), shallow borings will be hand-augered to a maximum depth of one foot. The hand auger will be decontaminated between locations as per SERAS SOP #2006, *Sampling Equipment Decontamination*. The borings will be backfilled with clean fine sand after sampling is completed and capped to match the existing grade. The areas and approximate number of borings for each are as follows:

    - Barren-undeveloped areas west of Waste Rock area: 4 hand borings

    - Undeveloped area south of Galena Gulch: 11 hand borings

    - Legion Field: 11 hand borings

    - Undeveloped areas north of the IKM and Smelter area: 8 to 10 hand borings

    - Area east of the Chaparral Gulch Dam and Agua Fria River: 4 hand borings

  Soil samples will be collected from the ground surface and one-foot depth at each boring location in accordance with SERAS SOP #2012, *Soil Sampling*. A minimum of 76 bag samples will be analyzed in the field for lead and arsenic using a field portable XRF (Table 2). Two XRF shots per bag sample will be performed. All analyses will be conducted in conformance with SERAS SOP# 1720, *Operation of the Niton XLt792YW Field Portable X-Ray Fluorescence Unit*.

4.7 Smelter Plateau: Dross Material, Slag, and Plateau Soils

Overview and Objectives:

1. Dross Material: Determine depth and volume of material; asses extent of lead and arsenic contamination; assess AMD potential and the presence of dioxins/furans.

2. Plateau Soils: Characterize the nature and extent of contamination on the plateau and secondarily, the basic geotechnical properties of soils in the area where a future containment cell for the dross material might be built. Data from the geotechnical testing will be used in the future Feasibility Study (FS) for conceptual design of the containment cell.

3. Slag: Evaluate the stability of the main slag pile given that cracks are present. Confirm differences in the chemical characteristics between the main and satellite slag piles, as identified in the previous Remedial Investigation (RI) report for the site.

- **Dross Material Investigation:** A 50-by-50-foot sampling grid (Figure 4) will be established over the major dross area using labeled pin flags, which will produce approximately 200 sampling locations (Figure 5). At each grid location, soil auger hand borings will be advanced through the dross to one-foot into the underlying native material. Samples will be collected at the surface, at one-foot intervals, and at final depth (expected to be no greater than 4.5 feet). Initially, a maximum of four samples will be submitted for XRF analysis of lead and arsenic from each location. Additional depth samples will be collected at locations where lead or arsenic concentrations at total depth are above 400 and 200 milligrams per kilogram (mg/kg), respectively. Two of the four samples will be the surface sample and the final depth sample. To capture the extent of contamination beyond the visible dross material, step-out samples will be collected to define the total impacted source area in three-dimensional space. Step-out sampling will be performed, both horizontally and vertically, until lead and arsenic concentrations in samples are below 400 and 200 mg/kg, respectively. Horizontal step-out sampling locations will be added to be consistent with the 50-by-50-foot grid (Figure 4). Horizontal coordinates of all step-out locations will be determined using a handheld GPS. The horizontal coordinates and final depth information for each boring will be imported into geographic information system (GIS) software, which will be used to interpolate the data and estimate the volumes of both dross and impacted (contaminated) native material. Upon completion, the borings will be backfilled with clean fine sand and capped to match the existing grade.

  Within the major dross area, there are a number of randomly scattered smaller dross piles. The volume of the smaller piles will be determined individually and independent of the grid sampling effort. First, all the smaller piles will be identified using pin flags; secondly, the volume of each pile will be determined by assuming a particular geometric shape (for example, a hexagonal prism or a cone) and its basic dimensions: areal foot print, length, width, height, and average side slope. Basic dimensions will be determined using a GPS for measuring total area and distances, a survey rod (or similar device) for measuring material thickness, and a Brunton compass (or similar device) for measuring slope angles (where applicable). The total volume of dross impacted material will be determined as the sum of the major dross impacted area and the individual smaller piles.

Dross Sampling and Analysis: Up to four unconsolidated samples will be collected from the dross material for laboratory analysis. Samples will be collected at or near ground surface. Analyses will include Target Analyte List (TAL) metals, acid base accounting (ABA) measurements (rinse and paste pH, sulfur species, neutralization potential, and acid generation potential), and synthetic precipitation leaching procedure (SPLP; EPA Method 1312) followed by metals analysis of the leachate extract. Two samples of the dross material will also be collected for analysis of dioxins/furans.

- **Plateau Soils - Shallow Borings:** Approximately 15 borings will be drilled in the Plateau soils to a maximum depth of six feet using a small, track-mounted sonic or direct-push drill rig (Figure 5). Soil samples for XRF field analysis will be collected from the borings at ground surface, at some intermediate depth (based on visual observations), and at the bottom of the hole (6 feet) in accordance with SERAS SOP #2012, *Soil Sampling*. Approximately 45 bag samples will be analyzed for lead and arsenic using a field portable XRF (Table 2). Two XRF measurements (or shots) will be performed per bag sample. All analyses will be conducted in conformance with SERAS SOP # 1720, *Operation of the Niton XLt792YW Field Portable X-Ray Fluorescence Unit*. The core barrel will be decontaminated between samples as per SERAS SOP #2006, *Sampling Equipment Decontamination*. Six soil samples for geotechnical analysis will also be collected from the range of materials encountered in the borings (Table 1). The geotechnical samples will be analyzed for gradation, moisture content, and Atterberg limits. The borings will be backfilled with hydrated bentonite chips after the soil sampling is completed.

- **Slag Wall Stability Measurements:** The slag pile at Humboldt Smelter consists of a vitrified mass that has properties similar to a massive rock formation. There are large cracks in the top of the slag materials that may be the result of cooling of the slag pile rather than tension cracks from slag pile deformation. To confirm that the cracks are not opening further, the coordinates and elevations of stainless steel pins installed on each side of three cracks (total of six pins) will be surveyed twice using differential leveling with sub-millimeter accuracy over a 10-month period. The slag will expand and contract with temperature differences; therefore, contemporaneous temperature and weather conditions will be recorded along with the survey measurements to assist in interpretation of the data. A local benchmark will be established by a subcontracted surveyor at the slag pile for these measurements.

  Transects along cracks through the most critical sections of the slag pile will additionally be surveyed by the subcontracted surveyor and the crack locations will be plotted on detailed planimetric maps (also prepared by the surveyor). The cracks will be identified by Lockheed Martin/SERAS in advance of the surveying activities to assist the subcontractor with the surveying. Critical sections for stability will be where the slag pile is tallest or steepest.

- **Main and Satellite Slag Pile Sampling**: Surficial samples of fine-grained materials will be collected from the Main and Satellite Slag Piles in accordance with SERAS SOP ##2012, *Soil Sampling*. One sample will be collected from the Main Slag Pile and two samples will be collected from the Satellite Slag Pile. Clean, dedicated sampling equipment will be used at each location. The samples (total of three) will be analyzed for TAL metals, ABA measurements, SPLP metals, and specific gravity (refer to Tables 1 and 2).

4.8 Smelter Tailings Swale

Objectives:

1. Use borings and surface geophysics to evaluate the depth and volume of tailings and impacted native material within this area.

2. Assess AMD potential of the tailings.

3. Generate chemical and geotechnical data that will be used in the FS to evaluate the potential to move or consolidate tailings in this area, and prepare a conceptual design for in-place closure of the tailings material in this area.

- **Shallow Borings with XRF Field and Geotechnical Analyses:** A minimum of 16 borings will be drilled in the tailings swale to depths between 5 and 25 feet (average of 15 feet) using a small, track-mounted sonic or direct-push drilling rig (Figure 6). The borings will be logged for lithologic layering, presence of perched water, depth of the tailings, and depth to bedrock, where present. Soil samples for XRF field analysis will be collected from the borings at the ground surface and at 5-foot intervals in accordance with SERAS SOP #2012, *Soil Sampling*. A minimum of 64 bag samples will be analyzed for lead and arsenic using a field portable XRF (Table 2). Two XRF shots per bag sample will be performed. All analyses will be conducted in conformance with SERAS SOP# 1720, *Operation of the Niton XLt792YW Field Portable X-Ray Fluorescence Unit*.

  Based on visual observations, two samples will be collected from two borings for laboratory analysis. One sample will be collected from the upper portion of the tailings, corresponding to the oxidized zone, and one sample will be collected from the lower portion in the reduced zone. A total of four samples will be analyzed for TAL metals, ABA measurements, SPLP metals, and hexavalent chromium (Table 2). The core barrel will be decontaminated between samples as per SERAS SOP #2006, *Sampling Equipment Decontamination*. Two soil samples will also be collected from the borings for geotechnical analysis (Table 1). The geotechnical samples will be analyzed for gradation, moisture content, and Atterberg limits. The borings will be backfilled with hydrated bentonite chips after the soil sampling is completed.

Additional step-out samples may be required in order to define the extent of the tailings and contaminated native materials. Locations and spacing of step-out samples will require adjustment in the field based on visual observations. Where samples indicate impact from tailings (based on XRF field screening), deeper samples will be collected to delineate the impacted area. Step-out sampling will continue both laterally and vertically until tailings and contaminated native materials are not encountered. Hand augers will be used to collect samples around or near perceived boundaries or where the tailings are thought to be less than four feet in thickness.

- **Surface Geophysical Investigation:** The smelter tailings swale will be investigated using surface geophysics (i.e., electrical resistivity) to determine the thickness of the tailings and the topography of the underlying native material. An Iris Instruments Syscal Pro Resistivity Meter may be used for the investigation, which provides pseudo-geological cross sections based on varying electrical resistance of materials in the subsurface. An array of electrodes are inserted into the ground and electricity is transmitted between a pair of electrodes while a second pair of electrodes measures voltage and current that are used to internally calculate resistance (via Ohms Law). This process is repeated along the array to determine the thickness and lateral variations of the tailings (including the edges of the tailings) along with the topography of the underlying native material.

  Assuming the tailings are less than 20 feet thick, a dipole-dipole array will be employed using a one-meter spacing. The assumption that this array will penetrate the full thickness of the tailings will be tested by collecting data on two arrays: one on the north end of the investigation area and the other on the southern end. This should represent both the thinnest and thickest sections of the tailings. Any adjustments in the array parameters can be made based on these two lines.

  To cover the investigation area, data will be collected both perpendicular and parallel to gullied areas filled with tailings. A main gully runs north-south and has a tributary from the northeast entering in the northern portion of the investigation area. Ten arrays of data will be collected perpendicular to the gullies at approximately 100-foot spacings, with the lengths being adjusted to match the gully widths. Five additional arrays will be collected parallel to the gullies: two in the north, two in the south, and one along the tributary. Adjustments will be made in the field based on field conditions. GPS coordinates will be collected along each array at regular intervals and at changes in slope. Initial processing of the data will be completed in the field to confirm that robust and sufficient data is collected. Note the rough terrain at the site may result in processing artifacts, which may preclude effective interpretation.

  Profiles of apparent resistivity will be generated by software that runs an inversion model. Variations in resistivity will be interpreted based on the local geology (calibrated to borehole data), where a sharp contrast is expected between the tailings and the underlying native material. GPS coordinates and topographic relief (from digital contour data) will be included in the model.

The volume of the tailings material, as estimated from the geophysical survey, will be adjusted upwards (possibly by 10 percent or more) using XRF data from borehole samples to provide a better estimate as to the total volume of "contaminated materials" (including native materials) that reside above site actions levels for both lead and arsenic. Additional information pertaining to material volume estimates is presented under General Site Assessment Methods.

Note: The viability of using geophysics in this area, along with the most appropriate method(s), will be determined during a site visit in November 2013. A separate Technical Memorandum will be prepared subsequent to the site visit discussing any change in approach.

4.9 Chaparral Gulch Floodplain (below Smelter Tailings Swale)

Objectives:

1. Evaluate the depth and horizontal extent of tailings material in the floodplain below the smelter tailings swale.

2. Assess layering and moisture content of alluvium, perched groundwater zones, AMD potential, and metal concentrations.

3. Generate geotechnical data that will be used in the FS to evaluate the erosive nature of the tailings and for design of a potential conveyance channel.

4. Refine bioaccessibility values to be used in the site risk assessment.

- **Shallow Borings with XRF Field and Geotechnical Analyses:** Approximately 50 borings will be drilled within the Chaparral Gulch floodplain below the swale to depths between 5 and 25 feet (average of 15 feet) using a small, track-mounted sonic or direct-push drilling rig (Figure 6). The borings will be logged for lithologic layering, presence of perched water, moisture content, and depth of tailings. Soil samples for XRF field analysis will be collected from the borings at the ground surface and at 5-foot intervals in accordance with SERAS SOP #2012, *Soil Sampling*. Up to 200 bag samples will be analyzed for lead and arsenic using a field portable XRF (Table 2). Two XRF shots per bag sample will be performed. All analyses will be conducted in conformance with SERAS SOP# 1720, *Operation of the Niton XLt792YW Field Portable X-Ray Fluorescence Unit*.

  Based on visual observations, two samples (one in the upper oxidized zone and one in the lower reduced zone) will be collected from four borings and analyzed for TAL metals, ABA measurements, SPLP metals, and hexavalent chromium (Table 2). A total of ten samples will also be collected between depths of two and four feet for analysis of gradation, moisture content, and Atterberg limits (Table 1). The borings will be backfilled with hydrated bentonite chips after the soil sampling is completed.

Additional step-out samples may be required in order to define the extent of the tailings and contaminated native materials. Locations and spacing of step-out samples will require adjustment in the field based on visual observations of the depositional environment, with the objective of delineating lenses of impacted material. Where samples indicate impact from tailings (based on XRF field screening), deeper samples will be collected to delineate the impacted area. Step-out sampling will continue both laterally and vertically until tailings and contaminated native materials are not encountered. Hand augers will be used to collect samples around or near perceived boundaries or where the tailings are thought to be less than four feet in thickness.

- **Bioaccessibility Analysis:** Five surface samples of tailings material will be collected from the floodplain for IVBA testing for lead and arsenic. The samples will be sent to the EPA Region 9 Laboratory for analysis.

4.10 Dam and Area behind the Dam

Overview and Objectives:

1. Borings: Soil borings will be drilled and sampled to determine the batter (slope angle) of the upstream surface of the concrete tailings dam. That surface is currently buried under mine tailings and cannot be inspected. Observations made during the drilling and analytical results for samples collected from the borings will be used to assess the total depth and volume of the mine tailings, concentrations of metals, loading on the dam, groundwater levels, and acid mine drainage potential of the tailings behind the dam.

2. Physical Measurements: Physical measurements of the tailings dam will be used to assess its structural stability in relation to the imposed loads.

- **Upstream Surface Batter of Dam:** A total of six soil borings will be drilled behind the tailings dam with three borings located along each of two transects aligned perpendicular to the dam (Figure 6). The borings will be advanced to an estimated maximum depth of 25 feet using a small track-mounted sonic or direct-push drilling rig. The depth to dam concrete and presence of groundwater will be noted in each boring. The borings will be backfilled with hydrated bentonite chips and surveyed to determine their horizontal and vertical locations by an Arizona professional land surveyor.

- **Concentrations of Metals:** Soil samples will be collected for XRF field analysis of lead and arsenic from five depths at each of the six borings. A total of 30 XRF bag samples will be collected in accordance with SERAS SOP #2012, *Soil Sampling*. Two duplicate XRF shots per bag sample will be taken.

- **Geotechnical Properties:** Two soil samples will be collected in conformance with SERAS SOP #2012 for geotechnical analysis from each of three borings. The samples will be collected from the middle and bottom of the borings. The six soil samples will be analyzed for moisture content, gradation, and Atterberg limits.

- **AMD Potential:** Two soil samples will be collected from each of three borings per SERAS SOP #2012 for analysis of AMD potential. The samples will be obtained from the upper oxidized zone and lower reduced zone in the borings. The six soil samples will be analyzed for TAL metals, ABA measurements, and SPLP metals.

- **Physical Measurements of Dam:** The dam is more or less a retaining wall for overburden on the upstream side. The downstream side of the dam is fully exposed; whereas, the upstream side of the dam is completely obscured by overburden. The dam is currently not showing any signs of distress. However, an analysis of the overall stability of the dam is required to evaluate the long-term stability of the structure. The stability analysis will require knowledge of the dimensions, particularly the width at the base, of the dam. The exposed top, apron, and base of the dam on the downstream side will be professionally surveyed by a local, subcontracted engineering firm. Horizontal and vertical measurements will be to sub-centimeter accuracy at each survey location.

  The depth of the contact between the concrete dam and the retained materials will be identified in the six boreholes by a Lockheed Martin/SERAS geologist. The depth data, combined with the surveyed borehole locations, will be used to determine the batter of the dam on the upstream side. The subcontractor will prepare up to three scaled drawings showing the size, height, and thickness of the tailings dam.

4.11 Upper Chaparral Gulch (near 3rd Street)

Objectives:

1. Evaluate the depth and extent of contaminated native materials and tailings and assess layering within the alluvium found in that area.

2. Generate geotechnical data that will be used in the FS to evaluate the erosive nature of the tailings and for design of a potential conveyance channel in this area.

- **Shallow Borings with XRF Field and Geotechnical Analyses:** A minimum of 15 borings will be drilled in the Upper Chaparral Gulch near 3rd Street to depths between 5 and 15 feet (average of 10 feet) using a small track-mounted sonic or direct-push drilling rig (Figure 7). The borings will be logged for lithologic layering, presence of perched water, depth of the tailings, and depth to bedrock, where present. Soil samples for XRF field analysis will be collected from the borings at the ground surface and at 5-foot intervals in accordance with SERAS SOP #2012, *Soil Sampling*. A minimum of 45 bag samples will be analyzed for lead and arsenic using a field portable XRF (Table 2). Two XRF shots per bag sample will be performed. All analyses will be conducted in conformance with SERAS SOP# 1720, *Operation of the Niton XLt792YW Field Portable X-Ray Fluorescence Unit*. The core barrel will be decontaminated between samples as per SERAS SOP #2006, *Sampling Equipment Decontamination*. Six (6) soil samples for geotechnical analysis will also be collected between depths of 2 and 4 feet from the range of materials encountered in the borings (Table 1). The geotechnical samples will be analyzed for gradation, moisture content, and Atterberg limits. The borings will be backfilled with hydrated bentonite chips after the soil sampling is completed.

Additional step-out samples may be required in order to define the extent of the tailings and contaminated native materials. Locations and spacing of step-out samples will require adjustment in the field based on visual observations of the depositional environment, with the objective of delineating lenses of impacted material. Where samples indicate impact from tailings (based on XRF field screening), deeper samples will be collected to delineate the impacted area. Step-out sampling will continue both laterally and vertically until tailings and contaminated native materials are not encountered. Hand augers will be used to collect samples around or near perceived boundaries or where the tailings are thought to be less than four feet in thickness.

- **Bioaccessibility Analysis:** Two surface samples of tailings material will be collected for *in vitro* bioaccessibility (IVBA) testing for lead and arsenic. The samples will be sent to the EPA Region 9 Laboratory for analysis.

4.12 Chaparral Gulch (between 3rd Street and Smelter)

Objectives:

1. Evaluate the depth and extent of contaminated native materials and tailings and assess layering within the alluvium found in that area.

2. Generate geotechnical data that will be used in the FS to evaluate the erosive nature of the tailings and for design of a potential conveyance channel in this area.

- **Shallow Borings with XRF Field and Geotechnical Analyses:** Approximately 29 initial soil borings will be drilled in Chaparral Gulch, between 3rd Street and the smelter, to depths ranging from 5 to 15 feet (average of 10 feet) using a small, track-mounted sonic or direct-push drilling rig (Figure 7). The borings will be logged for lithologic layering, presence of perched water, depth of the tailings, and depth to bedrock, where present. Soil samples for XRF field analysis will be collected from the borings at the ground surface and at 5-foot intervals in accordance with SERAS SOP #2012, *Soil Sampling*. A minimum of 69 bag samples will be analyzed for lead and arsenic using a field portable XRF (Table 2). Two XRF shots per bag sample will be performed. All analyses will be conducted in conformance with SERAS SOP# 1720, *Operation of the Niton XLt792YW Field Portable X-Ray Fluorescence Unit*. The core barrel will be decontaminated between samples as per SERAS SOP #2006, *Sampling Equipment Decontamination*. Six (6) soil samples for geotechnical analysis will also be collected between depths of 2 and 4 feet from the range of materials encountered in the borings (Table 1). The geotechnical samples will be analyzed for gradation, moisture content, and Atterberg limits. The borings will be backfilled with hydrated bentonite chips after the soil sampling is completed.

Additional step-out samples may be required in order to define the extent of the tailings and contaminated native materials. Locations and spacing of step-out samples will require adjustment in the field based on visual observations of the depositional environment, with the objective of delineating lenses of impacted material. Where samples indicate impact from tailings (based on XRF field screening), deeper samples will be collected to delineate the impacted area. Step-out sampling will continue both laterally and vertically until tailings and contaminated native materials are not encountered. Hand augers will be used to collect samples around or near perceived boundaries or where the tailings are thought to be less than four feet in thickness.

- **Bioaccessibility Analysis:** One surface sample of tailings material will be collected for *in vitro* bioaccessibility (IVBA) testing for lead and arsenic. The samples will be sent to the EPA Region 9 Laboratory for analysis.

4.13 Site-Wide Groundwater: Installation of New Monitor Wells

Objectives:

1. Better define groundwater flow directions and gradients in the water table and bedrock aquifers north and south of the IKM site.

2. Develop a better understanding of vertical movement of groundwater and contaminants and further define the lateral and vertical extent of contamination.

3. Further define the hydrogeology and hydrostratigraphy such that reliable cross sections can be constructed, including north-south cross sections. The lithologic information from these wells will also be used for identifying possible preferential pathways for groundwater flow and the contaminant migration routes.

4. Assist in developing a robust conceptual site model (CSM) for groundwater fate and transport.

- **Drilling:** Three deep wells in bedrock (250 to 350 feet) and eight shallow wells in unconsolidated deposits (30 to 75 feet) will be drilled by an Arizona-licensed driller in accordance with local and State regulations and SERAS SOP #2048, *Monitor Well Installation*. The proposed well locations are shown in Figure 8.

  Sonic drilling will be used to install pilot boreholes through the unconsolidated deposits to targeted depths (for overburden wells) or into competent bedrock (for bedrock wells). A 9- to 10-inch diameter surface casing and sonic drill-through tub will be installed at each location so any fluids that may overtop the casing will be captured and contained. A 6-inch diameter core barrel and 7-inch diameter override casing will be used to continuously core through the overburden to the target depth or competent bedrock. An 8-inch diameter override casing will be drilled over the 7-inch casing to provide the necessary annular space in the overburden or weathered bedrock for the well installation.

Subsequent to reaching competent bedrock at the three bedrock well locations, flush-joint steel casing will be installed into each borehole and grouted in-place using an appropriate cement-bentonite grout mixture. To simplify the casing installation, the following procedure may be used: 1) a temporary cement plug can be placed at the bottom of each casing; 2) the borehole can be filled with grout (to some calculated level) prior to casing insertion; 3) after the casing has been inserted into the borehole and the grout has cured, the plug can then be drilled out and the borehole advanced. Sonic drilling or a downhole air-hammer will be used to complete the pilot boreholes for the deep wells. All downhole drilling equipment will be decontaminated using high-pressure steam between well locations.

- **Borehole Geophysics:** Prior to well construction borehole geophysical logging in the three open bedrock holes will be completed by a subcontractor. The logs will include: borehole caliper, fluid conductivity, natural gamma, electromagnetic-induction, groundwater temperature, heat pulse flow meter, borehole direction/deviation, optical televiewer, and acoustic televiewer.

- **Well Installation:** After the drilling is completed, the pilot boreholes will be converted into monitor wells. Four-inch inner diameter (ID), Schedule 80 PVC casing and 10-slot well screen will be installed at each location. Screen lengths will be 30 feet for the bedrock wells and 15 feet for the overburden wells. A filter pack consisting of 10/20 sieve-size silica sand will be placed around each well screen. The filter pack will be emplaced in lifts as the override casing is removed from the boreholes at the shallow well locations. A hydrated bentonite seal will be placed above the filter pack at each well. The remainder of the annular space will be backfilled with cement-bentonite grout using a tremie pipe. A flush-mounted vault or monument cover encased in a concrete apron will be installed over the wellhead at each location.

- **Well Development**: The completed monitor wells will be developed using a combination of air lifting, surging, and pumping in accordance with SERAS SOP #2044, *Well Development*. The open bedrock interval for the three deep wells will be developed prior to installation of the well materials. The shallow wells will be developed no sooner than 48 hours after installation.

- **Slug Testing:** Slug tests, to estimate horizontal hydraulic conductivities, will be performed in accordance with SERAS SOP #2046, *Slug Tests,* on either all or a select number of the new wells following installation. The tests will be performed by monitoring the changes in water level in a well after the instantaneous addition/removal (slugin-slugout) of a 5-foot long, 3-inch diameter PVC slug. Water levels will be measured on a logarithmic scale during the tests, using an electronic pressure transducer with onboard data-logger (Level Troll® 700). Up to three slugin-slugout tests will be performed at each well to ensure the results are reproducible. Slug test data will be processed using AQTESOLV™ Pro (ver. 4.0) or similar software and analyzed using the appropriate aquifer solution for each well.

4.14 Groundwater Sampling: New and Existing Wells

Objectives:

1. Further evaluate contaminant distributions in groundwater beneath the site and surrounding areas.

2. Develop a detailed knowledge of the groundwater chemistry for assessing the chemical signatures of the groundwater and understanding the chemical reactions that are occurring along the groundwater flow paths.

- Two rounds of groundwater sampling and water level measurements will be conducted at the 11 new and 11 existing wells (Figure 8). All sampling and monitoring equipment will be decontaminated before use at each well as per SERAS SOP #2006, *Sampling Equipment Decontamination*. Prior to placement of the pump, precise and accurate static water levels will be measured in the wells using an electronic indicator in conformance with SERAS SOP #2043, *Water Level Measurement*. The wells will be purged and sampled using a Grundfos Rediflo3 submersible pump in accordance with SERAS SOP #2007, *Groundwater Well Sampling*. Indicator parameters will be monitored in the field during well purging. The indicator parameters are pH, Eh, dissolved oxygen, specific conductivity, temperature, turbidity, and ferrous iron (Fe^{2+}). All of the indicator parameters, except for Fe^{2+}, will be measured using a Horiba U-52 with flow chamber. Calibration procedures recommended by the manufacturer for the Horiba meter will be followed and documented in the project field logbook including calibration solutions used, expiration date(s), lot numbers, and calibration results. Ferrous iron will be measured by the 1,10-phenanthrolene method using a Hach test kit. Groundwater samples for TAL metals analysis will be sent under chain-of-custody to the EPA Region 9 Laboratory. Groundwater samples will be sent under chain-of-custody to an outside, subcontracted laboratory for the following analyses: alkalinity, chloride, fluoride, nitrate, phosphate, silica, sulfate, dissolved organic carbon (DOC), and total dissolved solids (TDS).

4.15 Biological Survey

Objective: Assess riparian corridors and upland areas within the site boundaries that would provide suitable habitat for wildlife.

- A reconnaissance-level survey of the plants and wildlife in upland habitats and riparian corridors will be performed at each sampling location, as outlined in the Bioassessment Sampling. Additional locations within the area of concern may be selected in the field based on unique habitats or data gaps. At each location, sufficient time will be spent quietly at the sampling location to allow local fauna to return to normal behavior and activity and therefore become visible. Completion of appropriate EPA Checklists (EPA, 1997) will occur at each sampling location as well as any relevant observations in the surrounding area. Photographic documentation of the local habitat at each sampling location will be recorded. Plant species, vegetation type, and vegetative coverage will be photographed and recorded. Representative voucher specimens of plants will be collected for record and for later taxonomic identification and verification. In addition, any incidental wildlife observed while traveling from one area to another will be carefully recorded. All observations during field and laboratory efforts will be documented in accordance with SERAS SOP #4001, *Logbook Documentation* and SERAS SOP #2002, *Sample Documentation*.

Additional analysis for benthic community observations and fish observations may be recorded within the streams and corridors at each of the sampling locations, as outlined in the Bioassessment Sampling. The details have yet to be determined. The physical characteristics association with each area will also be carefully recorded (e.g. water depth, presence of vegetation or boulders, etc.).

4.16 Bioassessment Sampling

Objective: Estimate bioaccessibility for ecological risk assessment.

- A bioassessment sampling effort will occur at the Iron King Mine Site in order to generate data that may be used in an Ecological Risk Assessment for the Site at a later date. Pre-selected locations for analysis will be sampled during the field effort. Plant material, soil, sediment, and surface water will be collected and analyzed for TAL Metals. Select sediment samples from the Agua Fria River will also be analyzed for dioxin/furans and total organic carbon (TOC). Selected water samples from the Agua Fria River will be analyzed for the water quality parameters as outlined in Table 3.

  Plant material and soil will be collected as part of the bioassessment sampling effort. Ten sampling points will be randomly generated within the designated areas of interest (Figure 9). Artificial structures and unvegetated areas will be eliminated prior to selection of the actual locations. If a sampling point falls within an area void of vegetation it may be moved to include the nearest area with vegetative cover. For each sampling location, a 1.0 meter (m) by 1.0 m quadrat will be centered at the sampling point. The quadrat will be divided into four quarters. Plant density (number of plants per unit area), plant community (species), and soil coverage by vegetation will be evaluated for each quarter independently according to SERAS SOP #2037, *Terrestrial Plant Community Sampling*. The mean of each parameter calculated with the data from the four quarters of the sampling point will represent the vegetative coverage at the sampling point.

  After completion of the site vegetation assessment, one-half or one-quarter of the above ground biomass (SERAS SOP #2034, *Plant Biomass Determination*) within the 1.0 m by 1.0 m quadrat will be collected depending on the density of the plants at the sampling point. The plants will be cut at 1.0 centimeter (cm) above the soil surface and, if necessary, washed with deionized (DI) water and blotted dry with paper towels. The fresh weight of the plant samples will be determined in the field or as soon as possible after the samples are collected. Samples will be placed in Ziploc bags and preserved at 4 degrees Celsius on ice.

Soil sampling will begin after the vegetation assessment is completed. For each sampling point, a composite of four surface soil points will be collected from the same quadrat as the vegetation sampling (collocated). Each composite soil sample will be mixed thoroughly before being placed into a 4-ounce glass jar. Samples will be shipped to predetermined laboratories for chemical analysis. All samples will be collected in accordance with SERAS SOP #2012, *Soil Sampling*.

Sediment and sediment/surface water pairs will be collected at the 24 approximate sampling locations indicated in Figure 9 and outlined in Table 3. Locations on the figure are generalized and actual locations will be recorded by a handheld GPS in the field at the time of sampling. Sediment will be collected according to SERAS SOP# 2016 *Sediment Sampling* and SERAS SOP # 2013 *Surface Water Sampling*. Sediment and water samples will be analyzed for TAL metals. A select group of subsamples from the Agua Fria will also be subject to additional analysis (Table 3). All observations during field and laboratory efforts will be documented in accordance with SERAS SOP #4001, *Logbook Documentation* and SERAS SOP #2002, *Sample Documentation*.

4.17 Sampling Downstream of Dam

Overview and Objectives:

1. Groundwater Seeps: Groundwater seeps will be sampled at the base of the dam to determine if AMD is being produced by tailings that reside behind the dam.

2. Sediment Sampling: Sediment samples will be collected in Chaparral Gulch (over a distance of approximately 1,600 feet) to determine (1) sediment depth to bedrock; (2) lead and arsenic concentration levels in sediment; and (3) compare sediment concentration levels to existing data.

- **Groundwater Seeps:** A weighted tape will be used to determine the total depth of the water column at the base of the dam, which will be noted in a field logbook. Based on the depth of the water column, a minimum of two water samples will be collected using a subsurface grab sampling device or peristaltic pump. A water quality meter will be used measure water quality parameters (pH, specific conductivity, dissolved oxygen, Eh, temperature, turbidity) with depth. Water samples will be sent under chain-of-custody to the EPA Region 9 Laboratory for analysis of TAL metals. Additional samples will be sent under chain-of-custody to an outside, subcontracted laboratory for the following analyses: alkalinity, chloride, fluoride, nitrate, phosphate, silica, sulfate, DOC, and TDS.

- **Sediment Sampling:** Beginning at the base of the dam and at every 25-foot interval downstream, a hand auger (or tile probe) will be advanced through the sediment down bedrock. The depth to bedrock at each location will be noted in a field logbook. A handheld GPS will be used to record the horizontal coordinates of each location. A minimum of two sediment samples (surface and total depth) will be collected at each location for XRF analysis of lead and arsenic concentrations. Sediment samples will be collected in accordance with SERAS SOP #2016, *Sediment Sampling*.

4.18 Hydrologic Monitoring and Surface Water Sampling

Objective: To assess the impact of site sources on surface water quality in the Chaparral Gulch and the Agua Fria River, particularly during flow from seasonal storm events

- Surface water monitoring and sampling will be conducted in Chaparral Gulch downstream of the dam and in the Agua Fria River (both upstream and downstream of the confluence with the Chaparral Gulch) over a one-year period. A total of four monitoring and sampling stations will be placed along these waterways: two within the Chaparral Gulch (one at the base of the dam and the other immediately upstream of the Agua Fria River confluence) and two within the Agua Fria River (one upstream of the confluence with the Chaparral Gulch and the other downstream of the confluence). Each station will be equipped to continuously monitor basic water quality and flow parameters: hydraulic head, pH, turbidity, and specific conductivity. From the turbidity measurements, the suspended sediment load will be estimated based on a site-specific turbidity-suspended sediment concentration (SSC) calibration curve.

  At each monitoring location, the stream cross section, as a function of depth, will be measured. Using the wetted cross-sectional area (based on the hydraulic head measurements), estimated channel slope (from topographic data) and estimated channel roughness (i.e., Manning's n), variable flows at the four monitoring locations will be estimated over time. Estimated channel flows will be compared to flows at a U.S. Geological Survey (USGS) gauging station along the Agua Fria River, located downstream of the proposed new stations.

  A USGS-developed automated water sampler will also be deployed at each station. The automatic samplers will collect discrete, flow-triggered water samples during base flow, but more so during seasonal storm flow conditions when sediment loads are high. Surface water samples will retrieved periodically and analyzed for total and dissolved lead and arsenic, and sediment load. ERT will contract with the USGS, through an Inter-Agency Agreement (IAG), to deploy the samplers.

  Two rain gauges will also be deployed: one at one of the four stations and the other within upper Chaparral Gulch, located west of Highway 69. To enable real-time data transmission from the four monitoring stations and the upper Chaparral Gulch rain gauge, five Mini-SAT™ satellite-receiving units will be interfaced to the monitoring devices (excluding the USGS samplers) for real-time uploading of data to an internet server site. This data can be accessed routinely and any problems with data acquisition can be identified for subsequent corrective actions.

  Additional tasks that will be performed in support of a conceptual design of stormwater control and management include: gathering local historical precipitation records; delineation of sub-basin areas within and surrounding the Site area for estimating runoff contribution; determining rainfall-runoff relationships base on topography and surface runoff coefficients; estimating 100-year storm runoff; and constructing a hydrograph for the Agua Fria River based on flow conditions at the nearby USGS gauging station.

4.19 Site Dust Control: Smelter Dross Area

Objectives: Temporarily suppress the dust that is periodically generated during high wind events.

- A subcontractor will be retained to apply a soil stabilization and dust suppression agent over the entire Dross Area (approximately 15 acres) at the Humboldt Smelter. An environmentally safe and biodegradable liquid copolymer will be uniformly sprayed on the area. Once cured, the product will form a transparent, wind resistant, and flexible surface. An application rate will be selected to provide up to two years of dust suppression in the area. It is anticipated that this work will be scheduled for April 2014.

4.20 Residential Property Sampling

- The residential sampling objectives and approach that were developed by the Region (Attachments section) will be followed.

5.0 GENERAL SITE ASSESSMENT METHODS

5.1 Site Action Levels

The primary contaminants of concern in soils and unconsolidated deposits at the site include lead and arsenic. Their site action levels are as follows:

- Lead: 400 mg/kg or parts per million (ppm)
- Arsenic: 200 ppm

5.2 Sample Collection, Handling and Shipment

- **Soil and Sediment Samples:** Soil and sediment samples will be collected in accordance with SERAS SOP #2012, *Soil Sampling* and SERAS SOP #2016, *Sediment Sampling*. Samples will be collected over discrete sampling intervals: surface samples will be collected from the top two inches of soil; one-foot depth samples will be collected from 10 to 12 inches below grade; two-foot depth samples from 22 to 24 inches; and so on. Organic surface layers, where present - such as dead leaves, roots and sticks - will be removed to expose surface mineral soil for sampling.

  Soil samples will be transferred directly into strong, zip-lock plastic baggies having an average size of 6- to 8-square inches. Excess stones, rocks, and other debris will be removed from the samples. Each baggie will be labeled, at a minimum, with a unique sample number, date, time, and sampling team. A field log with observations and notations will be prepared for each sample.

  All samples will be brought to the on-site laboratory for XRF analysis. Saturated samples will either be dried in an oven at a temperature up to 60 degrees Celsius prior to XRF analysis or submitted directly to a laboratory for metals analysis. A minimum of 10 percent of the samples will be sent to a fixed laboratory for confirmation of the XRF results. SERAS personnel will manage and ship samples in accordance with SERAS SOP #2003, *Sample Storage, Preservation and Handling* and SERAS SOP #2004, *Sample Packing and Shipment*.

Leftover samples after XRF analysis and confirmation sample selection will be shipped to a location specified by the Region for storage.

- **Surface Water Samples:** All sampling and monitoring equipment will be decontaminated before use at each sampling location in accordance with SERAS SOP #2006, *Sampling Equipment Decontamination*. Surface water samples will be collected in accordance with SERAS SOP #2013, *Surface Water Samples*. Prior to sample collection, indicator parameters will be measured in the field using a calibrated multi-sonde water quality monitoring instrument. Indicator parameters will include pH, Eh, dissolved oxygen, specific conductivity, temperature, and turbidity. Field measurements will be documented in a field logbook. Water samples will be sent under chain-of-custody to the EPA Region 9 Laboratory for TAL metals analysis. Additional samples will be sent under chain-of-custody to an outside, subcontracted laboratory for the following analyses: alkalinity, chloride, fluoride, nitrate, phosphate, silica, sulfate, dissolved organic carbon (DOC), and total dissolved solids (TDS).

5.3 Sample Identification

Each sample collected for during the field investigation will be assigned a unique alphanumeric code. Sample codes will be recorded in field logbooks, on sample bags or sample labels affixed to containers, and on chain-of-custody (COC) forms. The field team leader will be responsible for maintaining a master database or spreadsheet of samples to be collected and samples obtained to ensure that all planned samples are collected during the field investigation, sample designation codes are not used twice for different locations, and the correct analytical parameters or geotechnical tests are identified on laboratory documentation. The sample identification scheme for this project is outlined in Table 4.

5.4 XRF Field Analysis

A Niton XLt792YW XRF field portable XRF analyzer will be used to analyze the lead and arsenic concentrations in surface and subsurface soil samples. The XRF will be operated in accordance with SERAS Standard Operating Procedure (SOP) #1720, *Operation of the Niton XLt792YW Field Portable X-Ray Fluorescence Unit.*

Soil samples for XRF analysis will be collected using a combination of trowels, spoons, hand augers, and drilling/sampling tools. Vegetation, rocks, and other debris will be removed from each sample prior to transferring the sample to a self-sealing plastic bag. The samples will be thoroughly shaken and mixed back and forth while in the baggie for 15 to 30 seconds. The baggie will be squeezed repeatedly between thumb and forefinger to break up any colloidal or semi-consolidated materials. Cohesive materials will be crushed, smeared, crumbled, and tumbled again within the baggie to achieve as much mixing as is practicable. The samples will be brought to a central processing area and pertinent sampling information will be entered into a Scribe database prior to XRF analysis.

Once the samples are received by the XRF chemist they will be assessed for moisture content. Saturated samples will either be dried in an oven at a temperature up to 60 degrees Celsius prior to XRF analysis or submitted directly to a laboratory for metals analysis.

The Niton measurement times (instrument live-time) will be set at 120 seconds for measurement condition 1 (Filt1 for lead, arsenic) and 30 seconds for measurement condition 2 (Filt2). Each sample, without being removed from the bag, will be placed on the test stand above the Niton analyzer; the safety shield will be closed; and then the analysis will be initiated. If the XRF results for lead or arsenic exceed 400 mg/kg or 200 mg/kg, respectively, a second measurement will be made for the sample. For samples where two XRF measurements are collected, both readings will be recorded separately. For these cases, an "A" suffix will be added to the sample ID for the first analysis and "B" suffix will be added to the sample ID for the second analysis, but only the average lead and arsenic concentrations will be reported. If one measurement is below the reporting limit (RL), the RL will be used to calculate the average concentration for the sample.

XRF analysis results for each sample will be saved in the Niton XLt792YW internal data logger and the data will be downloaded and archived on a USB drive on a daily basis. Target element (arsenic and lead) results for each analyzed sample and standard will also be logged in a field logbook. Target element results will be qualified using the field method detection limits (MDLs) and RLs; the results are considered preliminary or screening data (SD) data only.

The reliability of the Niton XLt792YW XRF unit and application model will be evaluated on a daily basis for the duration of the project. The detector calibration (energy calibration and detector resolution check) will be performed at the beginning of each day to ensure that proper instrument calibration is maintained and that the detector resolution is adequate for producing reliable X-ray intensity measurements. The Niton XLt792YW Standard Soil application will be verified at the beginning of the day for the target elements using sand and silicon dioxide (SiO_2) blanks, and National Institute of Standards and Technology (NIST) Standard Reference Materials (SRMs) #2709A, #2710A, #2711A, and #2586. All daily energy calibration checks, detector resolution checks, and application verification results will be recorded in a field logbook.

A low concentration standard, NIST SRM #2709A, will be analyzed at the beginning of each day and periodically throughout the day to establish statistically-derived MDLs for the target elements. The sample standard deviation for these analyses is used to calculate the Niton's MDL for each target element. The MDL is calculated as:

$$MDL = t(n - 1,99) * \sigma$$

where,

$t(n - 1,99)$ = student's t-value for a 99% confidence level and a standard deviation estimate with n–1 degrees of freedom

σ = sample standard deviation (n - 1 degrees of freedom).

Typically, the RL is two to five times the statistical MDL. The project-specific XRF RLs are estimated to be approximately 50 mg/kg for lead and 35 mg/kg for arsenic, and results below the RL will be qualified as non-detect (U). Due to severe spectral overlap between lead and arsenic, the arsenic RL will be raised to 1/10 of the lead concentrations in samples where the lead concentration exceeded 10 times the arsenic RL (estimated to be around 350 mg/kg).

After the samples are analyzed by XRF, a minimum of 10 % the samples will be selected for confirmation analysis at a fixed laboratory. These samples will be transferred to 8-ounce glass jars and then will be sent to the laboratory for TAL metals analyses.

XRF results will be evaluated by a SERAS statistician on a routine basis to confirm there is an ongoing and consistent correlation between the XRF results and the confirmation samples results. A classical OLS regression analysis will be used to assess the XRF data and the resulting coefficient of determination (R^2) must be ≥ 0.70, as specified in SERAS SOP #1720, for the XRF data to be considered valid. If the data fails to achieve this criterion, changes in XRF methodology and/or analyses types and methodologies will be evaluated in conjunction with EPA personnel.

5.5 Material Boundary Delineation

This approach pertains to the following areas:

- Waste rock area, west of MTP (waste rock)
- Lower bench area of the MTP – below blowout area (tailings)
- IKM property (beyond the MTP, including Galena Gulch)
- Smelter plateau area (dross material)
- Smelter tailings swale
- Sections of Chaparral Gulch – up to the dam (tailings)

To the extent possible, the lateral (areal) and vertical extents of mine tailings, dross material, and impacted native materials will be determined by visual observations and XRF field analysis. The areal extent of the waste rock will be solely determined by visual observations and mapped out using a handheld GPS. Visual observations will include changes in material color and composition; absence of ground cover; type, quantity, and diversity of plant species; edges of the floodplain (Chaparral Gulch); and erosion features.

Step-out sample borings (both deep and hand-augered) will be used to define the three-dimensional extents of visibly impacted soil and/or until XRF lead and arsenic concentrations are below site action levels. Locations and spacing of step-out samples will require adjustment in the field based on visual observations of both surface and subsurface samples. The horizontal spacing of step-out sampling locations may range from 5 to 20 feet. Where subsurface samples indicate impact from tailings (based on XRF field screening), deeper samples will be collected to define the extent of contamination. Borehole depths will be confirmed or deepened (in 5-foot increments) according to contamination levels recorded with the portable XRF. Final boring depths will be recorded in a field logbook in accordance with SERAS SOP #4001, *Logbook Documentation*. Step-out sampling will continue both laterally and vertically until mine wastes and contaminated native materials are not encountered. Hand augers will be used to collect samples around or near perceived boundaries or where the mine wastes are thought to be less than four feet in thickness. Horizontal coordinates for all borings will be obtained with handheld GPS device.

5.6 Material Volume Estimates

Material volumes will be estimated for the following areas:

- Waste rock area, west of MTP (waste rock)
- Lower bench area of the MTP – below blowout area (tailings)
- Galena Gulch (a small tailings pile)
- Smelter plateau area (dross material)
- Smelter tailings swale
- Behind Dam (tailings)

Volume determination of the waste rock was previously discussed under the Site-Specific Tasks (IKM Main Tailings Pile). It is anticipated that this method will be used to estimate the volume of a small tailings pile along Galena Gulch and for a number of randomly scattered piles throughout the dross material area (refer to the Smelter Plateau section under Site-Specific Tasks).

For other areas, including major portions of the dross material, the horizontal coordinates and final depth information for each boring will be imported into ArcGIS and then *Spatial/3D Analyst* tools within the software will be used to interpolate the data and estimate material volumes. Kriging will be used as the primary interpolation method, which uses an interpolation algorithm based on the geospatial distribution and variance of the data points. Kriging produces best linear unbiased estimates with a minimization of the estimation error.

The software will determine the net volume of material between defined upper and lower surfaces. The upper surface is the digital landscape topography (2-foot contour intervals), which was recently acquired from the Yavapai County GIS Department. The lower surface is the interpolated depth data acquired from multiple borings within each area of interest.

5.7 Surveying and Station Positioning

Horizontal coordinates of all tailings/waste rock field delineation locations, sample locations, and monitor wells will be surveyed using a mapping-grade GPS device. Coordinates of a number planned sample locations will be determined prior to mobilization and programmed into the GPS units as waypoints to facilitate the navigation to all planned sample locations. Coordinates will be recorded using a Trimble GeoXT or GeoXH series or equivalent handheld GPS device. Anticipated horizontal accuracy will be contingent on conditions encountered in the field. GPS data will be differentially corrected as necessary to maximize accuracy. Post-processing of coordinate data may allow sub-meter horizontal accuracy to be achieved.

A subcontracted Arizona-registered land surveyor will survey the vertical coordinates of newly installed monitor wells. Well elevations will be surveyed to within the nearest 0.1 foot. The land surveyor will also survey the physical dimensions of the dam (and ultimately provide a scaled, construction detail in digital format), locations of major cracks in the slag material (linear transects), and positions of monitoring pins in the slag (both horizontal coordinates and vertical elevations of ground surface and top of pins).

5.8 Deviations from the Field Work Plan

Deviations from the FWP are inevitable. Deviations may arise from changed field conditions, adjustment of sampling methods, inability to obtain samples from a planned location, and other circumstances. All deviations to the FWP will be carefully documented by the field team leader using the SERAS Work Assignment Field Change Form (Attachments section), which will document the nature and reason(s) for specific deviations.

6.0 DATA MANAGEMENT & COMMUNICATION

Documentation of environmental sampling and monitoring performed for this project will be provided in an electronic data deliverable (EDD) form, compatible with Scribe.

Scribe is a software tool developed by the ERT to assist in the process of managing environmental data. Scribe captures sampling, observational, and monitoring field data. Examples of Scribe field tasks include soil sampling, water sampling, and biota sampling. Scribe can import electronic data deliverable (EDD) files including analytical lab result EDD files and sampling location EDD data files. Scribe outputs include labels for collected samples, chain-of-custody generation, and analytical lab result data reports. Scribe provides a flexible user interface to manage, query, and view all this information. Scribe supports exporting electronic data for user services such as geographic information system (GIS) tools and spreadsheets so sampling data may be further analyzed and incorporated into report writing and deliverables.

All deliverables and other relevant project information will be submitted in electronic format to the site-specific folder on the ERT-Information Management System (IMS) website.

Field notes and data for this project will be recorded in accordance with SERAS SOP #4001, *Logbook Documentation*. Site logbooks and other sampling related worksheets will be electronically scanned on a periodic basis and additionally posted to the site-specific folder on the ERT-IMS website.

7.0 PROJECT DELIVERABLES

The following deliverables will be provided as Technical Memorandums:

- GPS coordinates for all sampling locations (including ground elevations estimated from 2-foot topographic contour data)
- Borehole logs showing coordinates, estimated elevations (from contour data), drilling and sampling methods, drill rig model/type, etc.
- Construction details for the new monitor wells
- Top of casing and ground surface elevations for the new wells (as provided by a professional surveyor)
- Laboratory and other data/results (as delivered by subcontracted geotechnical and analytical labs)
- Scribe data file
- Sampling summary matrix tables showing sample number (location/depth) vs. analyses performed - sorted by area
- A list of local suppliers of raw construction materials (riprap, sand, gravel, etc.)
- As-built construction detail of the on-site dam (as provided by a professional surveyor)
- Horizontal coordinates and elevations of the slag pins, and transect data for major cracks within the slag (as provided by a professional surveyor)
- Volume estimates of mine-related wastes and impacted materials for various areas of the site
- Results from the biological survey, surface and borehole geophysical surveys, and the hydrologic monitoring study.

8.0 PROJECT SCHEDULE

A tentative project schedule is attached to this plan (generated with Microsoft© Project software, 2010).

9.0 PROJECT ASSUMPTIONS

Revisions to the approach and schedule proposed in this Site-Specific Work Plan may result from the acquisition of new or additional information and data, additional tasks requested by ERT and the Region, and other circumstances that may arise that are outside or beyond SERAS program control. Changes in the project schedule, SERAS project priorities, and resource availability may affect the specific details of the proposed scope of work. Also, the total estimated cost to complete this project (including but not limited to, labor, travel and materials) may change as the project evolves.

A number of SERAS staff (hydrogeologists, chemists, environmental scientists, and environmental technicians) will travel to the site on multiple occasions with extended stays. At present, it is anticipated that the majority of field activities will occur from early December 2013 through mid May 2014.

10.0 REFERENCES

CH2M Hill, 2013. *Data Gap Analysis Report (draft): Iron King Mine – Humboldt Smelter Superfund Site, Dewey-Humboldt, Yavapai County, Arizona*. Prepared for the U.S. Environmental Protection Agency, Region 9. April 2013.

Environmental Protection Agency (EPA), 1997. Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments, Interim Final. Office of Solid Waste and Emergency Response. EPA/540-R-97-006. June 1997.

TABLES (4 Tables)
FIGURES (9 Figures)

<u>Attachments</u>

Project Schedule
EPA Region 9 Sampling Procedure for Residential Properties
SERAS Work Assignment Field Change Form