Watershed Monitoring Projects

DRAFT
SAMPLING AND ANALYSIS PLAN

Assessment of Remediation of Fluvial Tailings Deposits in the Upper Arkansas River Basin

11-mile Reach Monitoring Project
Lake County, Colorado

Prepared by
U.S. Army Corps of Engineers
Omaha District
Omaha, Nebraska

In Partnership with

U.S. Geological Survey
Denver, Colorado

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LIST OF ACRONYMS & ABBREVIATIONS

AES	Atomic Emission Spectroscopy
APP	Acid Producing Potential
asap	As Soon As Possible
ASTM	American Society for Testing and Materials
bgs	below ground surface
$CaCO_3$	Calcium Carbonate
CEC	Cation Exchange Capacity
CENWD	U.S. Army Corps of Engineers – Northwestern Division
CENWO	U.S. Army Corps of Engineers – Omaha District
CEPOD	U.S. Army Corps of Engineers – Pacific Ocean Division
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
CESPD	U.S. Army Corps of Engineers – South Pacific Division
CESPA	U.S. Army Corps of Engineers – Albuquerque District
CESPK	U.S. Army Corps of Engineers – Sacramento District
CH	Fat Clay
CL	Lean Clay
cm	Centimeter
CN	Cyanide
COC	Chain of Custody
CSM	Colorado School of Mines
CVAA	Cold Vapor Atomic Absorption
DI	Deionized
DMG	Division of Minerals and Geology
DO	Dissolved Oxygen
DQCR	Daily Quality Control Report
DQO	Data Quality Objective
DRI	Desert Research Institute
ECB	Environmental Chemistry Branch
EE/CA	Engineering Evaluation/Cost Analysis
Eh	Redox or Oxidation Potential
EM	Electromagnetic
GC/MS	Gas Chromatography/Mass Spectroscopy
GPR	Ground-Penetrating Radar
GPS	Global Positioning System

GSSI	Geophysical Survey Systems, Inc.
HCN	Hydrogen Cyanide
H_2O_2	Hydrogen Peroxide
ICP	Inductively Coupled Plasma
ID	Identification
I.D.	Inner Diameter
IDW	Investigative-Derived Waste
IH	Industrial Hygienist
"J"	Estimate Code
K	Hydraulic Conductivity
LCS	Laboratory Control Sample
LCSD	Laboratory Control Sample Duplicate
LIMS	Laboratory Information Management System
LQMM	Laboratory Quality Management Manual
LRL	Laboratory Reporting Limit
MDL	Method Detection Limit
ML	Silt
mL	Milliliter
mm	Millimeter
MSL	Mean Sea Level
MS/MSD	Matrix Spike/Matrix Spike Duplicate
MW	Monitoring Well
MWMP	Meteoric Water Mobility Procedure
NaOH	Sodium Hydroxide
NAD	North American Datum
NGVD	National Geodetic Vertical Datum
NIST	National Institute for Standards and Technology
NTU	Nephelometric Turbidity Unit
O.D.	Outside Diameter
OSHA	Occupational Safety and Health Act
ORP	Oxidation Reduction Potential
pH	A measure of the Hydrogen Ion Concentration of materials
PM	Project Manager
ppm	Parts Per Million

PQL	Practical Quantitation Limit
psi	Pounds per square inch
PVC	Polyvinyl Chloride
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
QMP	Quality Management Plan
“R”	Unusable Code
R	Percent Recovery
RAMS	Restoration of Abandoned Mine Sites
RL	Reporting Limit
RPD	Relative Percent Difference
SB	Soil Boring
SB/MW	Soil Boring/Monitoring Well
SD	Sediment
SIR-2	Subsurface Interface Radar System-2
SOP	Standard Operating Procedure
SPLP	Synthetic Precipitation Leaching Procedure
SPT	Standard Penetration Test
SS	Surface Sample
SSA	Site Specific Addendum
SSHO	Site Safety and Health Officer
SSHP	Site Safety and Health Plan
SW-#	Solid Waste
SW	Surface Water
TB	Trip Blank
TCLP	Toxicity Characteristic Leaching Procedure
TDS	Total Dissolved Solids
TOC	Total Organic Carbon
USACE	United States Army Corps of Engineers
USCS	Unified Soil Classification System
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compounds
WAD	Weak Acid Dissociable
WB	Water Blank
WES	Waterways Experiment Station

WHC	Water Holding Capacity
WRDA	Water Resources Development Act

1. PROJECT/TASK ORGANIZATION

1.1 OVERVIEW

The project management organization is designed to provide a line of responsibility and authority, supported by a management control structure. Basically, this control structure provides for:

- Clearly identified lines of communication and coordination
- Project budget and schedule monitoring
- Key technical resources management
- Periodic financial management and progress reports
- QC

1.2 RESPONSIBILITIES

The United States Geological Survey (USGS) is the lead technical agency for the Eleven Mile Reach Monitoring Project. USGS has responsibility for coordinating all phases of the fieldwork performed by USGS with cooperating agencies. Where appropriate, USGS will provide project management, perform the field investigations, review and evaluate the data, and prepare draft and final reports. The project team will review all environmental data. All personnel involved in this project will adhere to Chain of Custody (COC) and field documentation protocols and will perform all activities in accordance with the Sampling and Analysis Plan (SAP) and the Site Safety and Health Plan (SSHP).

Technical Support for the Eleven Mile Reach Monitoring Project will be provided by Colorado Mountain College, Natural Resources Management Institute (CMC-NRMI). The United States Army Corps of Engineers (USACE), Omaha District will provide support through the development of work plans, SSHP's and field assistance in FY02. The Lead Project Sponsor of the project is the Lake County Soil Conservation District (LCSCD). In addition, financial support is provided by the United States Environmental Protection Agency (USEPA), USGS, and the cities of Aurora and Pueblo, Colorado. Data users may include all of the agencies listed above.

The various quality assurance (QA), field, laboratory and management responsibilities of key project personnel within the USGS are defined below.

1.3 MANAGEMENT RESPONSIBILITIES

The USGS Project Manager (PM) has overall funding responsibility for all phases of the investigation. The PM is responsible for coordinating the project QC reviews, scheduling, and data interpretation and has responsibility for implementing all phases of the investigation. In this capacity, the PM will coordinate with all project personnel during sampling activities and analyses of samples by ECB Laboratory and other laboratories for this work.

The PM's primary function is to ensure that technical, financial, and scheduling objectives are achieved. The PM will be the major point of contact internally and externally and control for all matters concerning the project.

1.4 QUALITY ASSURANCE RESPONSIBILITIES

The project team members will coordinate/implement the fieldwork to ensure that data collected will support the intent of the sampling effort, provide direction to the project field team and complete progress or other required management reports.

1.4.1 Project Chemist

The Project Chemist has primary responsibility for:

- writing the appropriate sections of the SAP,
- ongoing surveillance of project activities to help ensure conformance with this SAP,
- appropriate procedures, including strict QC and decisions about data acquisition,
- data quality issues,
- coordination of analytical requirements with laboratory analyses,
- initial data review of all sample results from the analytical laboratories,
- data review and evaluation as indicated in the SAP.

1.4.2 Project Geologist and/or Project Engineer

The Project Geologist and/or Project Engineer has primary responsibility for:

- writing the appropriate sections of the SAP,
- ongoing surveillance of project activities to help ensure conformance with this SAP, and
- oversight of the fieldwork as indicated in the SAP.

1.4.3 Project Industrial Hygienist

The Project IH has primary responsibility for:

- writing or reviewing any necessary modification to the SSHP,
- providing technical assistance to the field team, and
- ensuring that that the SSHP meets OSHA requirements.

The Project IH will also assist with reviewing analytical lab results for risk analysis purposes, if required by the SAP.

1.5 LABORATORY RESPONSIBILITIES

Samples for all analyses will be sent to the following laboratories:

- ECB Laboratory of the WES
- CSM
- Energy Laboratories

The laboratory will designate a Project or Program Manager, Operations Manager, QA Officer and Sample Custodian for the project. The functions of these individuals are explained in the respective laboratory QA manuals and are briefly described below. In some cases, titles other than those shown have been used by the laboratories.

1.5.1 Laboratory Program Manager

The Laboratory Program Manager will report to the Laboratory Director and will be responsible for:

- Ensuring all resources of the laboratory are available when required; and,
- Providing an overview of final analytical reports.

1.5.2 Laboratory Operations Manager

The Laboratory Operations Manager will report to the Laboratory Program Manager and will be responsible for:

- Coordinating laboratory analyses;
- Supervising in-house COC;
- Scheduling sample analyses;
- Overseeing data review;
- Overseeing preparation of analytical reports; and,
- Approving final analytical reports prior to submission to the USACE.

1.5.3 Laboratory Quality Assurance Officer

The Laboratory's QA Officer has overall responsibility for data after it leaves the bench. The Laboratory's QA Officer will be independent of the operating departments and will communicate data issues through the Laboratory's Program Manager to the Project Chemist. In addition, the Laboratory's QA Officer will:

- Overview laboratory QA,
- Overview QA/QC documentation,
- Conduct detailed data review,
- Determine whether to implement laboratory corrective actions if required,
- Notify the Project Chemist of data quality issues,
- Define appropriate laboratory QA procedures, and

- Prepare laboratory SOPs.

1.5.4 Laboratory Sample Custodian

Each Laboratory's Sample Custodian will report to the Laboratory's Operations Manager. Responsibilities of the Sample Custodian will include:

- Receiving and inspecting the incoming sample containers,
- Recording the condition of the incoming sample containers,
- Signing appropriate documents,
- Verifying COC reports and their accuracy,
- Notifying appropriate analytical staff of sample receipt and sample integrity issues (e.g., holding times),
- Assigning a unique identification number and customer number and entering each into the sample receiving log,
- With the help of laboratory staff, initiating and documenting transfer of the samples to appropriate lab sections, and
- Controlling and monitoring access/storage of samples and extracts.

Independent QA will be provided by the Laboratory's Program Manager and QA Officers prior to release of project data.

1.5.5 Laboratory Technical Staff

The Laboratories' Technical Staff will be responsible for continuance of COC, sample analysis, analytical documentation and identification of corrective actions, if necessary. Laboratory Technical Staff will report directly to the Laboratory Operations Manager or other appropriate Manager.

1.6 FIELD RESPONSIBILITIES

1.6.1 Field Team Leader

The Field Team Leader is responsible for the day-to-day field data collection and sampling activities of the various resource specialists under his/her supervision. The Field Team Leader is an experienced environmental professional (geologist, geological engineer, chemist, or other technical professional). Specific Field Team Leader responsibilities include:

- Day-to-day coordination of technical issues in specific areas of expertise,
- Implementation field-related portions of the SAP,
- Coordination and management of field staff during drilling, instrument installation and sampling,
- Implementation of QC measures for technical data provided by the field staff, including field measurement data,
- Adherence to work schedules provided by the PM,

- Identification of problems at the field team level, resolving difficulties in consultation with the PM, implementing and documenting corrective action procedures and providing communication between field sampling teams, PM, and the Laboratory,
- Participation in preparation of the draft and final reports,
- Input related to schedule and quality issues, and
- Preparation of documentation for the project, maintenance of copies of these documents at the site, and submittal of these documents.

1.6.2 Site Safety and Health Officer

The Site Safety and Health Officer (SSHO) will be responsible for:

- Updating equipment or procedures based on information gathered during the site inspection,
- Modifying the levels of protection based on site conditions,
- Determining and posting locations and routes to medical facilities and arranging for emergency transportation to medical facilities,
- Notifying local public emergency officers including police and fire departments of the nature of the team's operations and posting their telephone numbers,
- Examining work party members for symptoms of exposure or stress, and
- Providing emergency medical care and first aid as necessary.

1.7 REPORTING RESPONSIBILITY

The Eleven Mile Reach Monitoring Project team will be responsible for the preparation of the report.

2. PROJECT DEFINITION/BACKGROUND

The Eleven Mile Reach Monitoring Project addresses two water-quality priorities identified in the Mining Nonpoint Source Management Program:

- To prevent significant future threats to water-qulity from abandoned mine sites, and
- To develop and implement new and existing technologies for water quality restoration.

This project will assess the water quality of the unsaturated (vadose) zone and underlying ground water in an area affected by fluvial tailings deposits in the upper Arkansas River floodplain downstream from Leadville, Colorado. Ground waterUSACE has been provided authority for Restoration of Abandoned Mine Sites (RAMS) through the Water Resource Development Act (WRDA) 1999 section 560. This program is a regionally focused and stakeholder responsive program for the restoration of abandoned and inactive non-coal mines where water resources (ecosystem/habitat) have been degraded by past mining practices. This authority is intended to allow the Corps of Engineers to provide support to agencies that manage lands impacted by past mining. The scope of work for the Corps under RAMS will be developed in consultation with federal, state, and local government agencies and stakeholders to ensure that the stakeholder needs are being met and avoid duplication of effort and expenditures.

This Work Plan describes the field investigation activities, procedures, organization, objectives, functional activities and specific Quality Control (QC) activities to be used by the U.S. Army Corps of Engineers (USACE) RAMS program for Omaha District (CENWO), USACE Albuquerque District (CESPA), USACE Sacramento District (CESPK), and potentially other USACE districts within the boundaries of Northwestern Division (CENWD), South Pacific Division (CESPD), and Pacific Ocean Division (CEPOD). This Work Plan will provide the requirements to be followed in assessing the physical and environmental impacts from non-coal mining wastes.

Sites being investigated under the RAMS Program are not initially subject to the requirements of the Comprehensive Environmental Response Compensation and Liability Act (CERCLA), but may eventually come under the jurisdiction of the U.S. Environmental Protection Agency (USEPA) or Federal land management agencies. Therefore, work plans prepared for RAMS projects are of sufficient quality for use within the CERCLA process. The RAMS Work Plan is intended to provide standard information that will be applicable to most RAMS investigations. A Site-Specific Addendum (SSA) to this Work Plan will be prepared for each specific project. The SSA will reference the RAMS Work Plan and Site Safety and Health Plan (SSHP) and will include any site-specific requirements not included in the Work Plans.

2.1 PROJECT DESCRIPTION

The work described in the appendices includes the collection of surface soil and waste rock samples, advancement of soil borings for the collection of subsurface soil samples, the collection of surface water/sediment samples, the installation of monitoring wells for the collection of ground-water samples, performance of geophysical surveys, and performance of ground-water well pumping tests and slug tests to evaluate the vertical and lateral extent of potential contamination.
There are four appendices to this Work Plan:

- Appendix A – Standard Operating Procedures (SOPs)
- Appendix B – Field Equipment Operation Manuals
- Appendix C – American Society for Testing and Materials (ASTM) Methods
- Appendix D – Chemistry Quality Assurance Branch Laboratory Quality Management Manual (LQMM)

Field work will be conducted in accordance with the following Standard Operating Procedures (SOPs) (See Appendix A), if applicable.

A1	Surface Soil/Rock Sampling Equipment and Procedures
A2	Drilling Equipment and Procedures
A3	Subsurface Soil/Rock Sampling Equipment and Procedures
A4	Soil/Rock Homogenization Equipment and Procedures
A5	Lithologic Description of Surface and Subsurface Soil Samples
A6	Boring Log Completion

A7	Investigative Derived Waste Procedures
A8	Monitoring Well Design, Installation, and Abandonment Procedures
A9	Monitoring Well Development Equipment and Procedures
A10	Ground Water Sampling Equipment and Procedures
A11	Surface Water and Sediment Sampling Equipment and Procedures
A12	Equipment Decontamination Procedures
A13	Sample Handling, Documentation, and Tracking Procedures
A14	Field Documentation
A15	Geophysical Survey Equipment and Procedures
A16	Geotechnical Sampling Equipment and Procedures
A17	Percolation Test Equipment and Procedures
A18	Pumping Test Equipment and Procedures
A19	Slug Test Equipment and Procedures

These SOPs will be referenced by number as they apply to the areas discussed in the SSAs.

Additional information is included in the SSHP regarding procedures required to ensure the health and safety of personnel performing field investigation duties. These documents also include discussions of activities to be performed and the interpretation and use of the data obtained during investigations.

The site-specific projects may involve the following tasks:

- Preparation of Site Specific Addenda to this Work Plan,
- Preparation of Site Specific Addenda to the SSHP,
- Collection of surface soil environmental samples,
- Collection of waste rock samples,
- Collection of surface water/sediment environmental samples
- Completion of soil borings for the collection of surface and subsurface soil environmental samples,
- Installation and development of new monitoring wells,
- Collection of environmental samples from new and/or existing monitoring wells,
- Off-site laboratory analysis of environmental samples to quantitatively assess contamination,
- Collection of geotechnical samples in support of designs for mitigation,
- Performance of a percolation test,
- Performance of geophysical surveys,
- Performance of ground water well pumping tests and slug tests to quantify hydrologic parameters,
- Performance of topographical surveys of affected areas,
- Design of grading and drainage plans,
- Preparation of Engineering Evaluation/Cost Analysis (EE/CA) reports,
- Collection of data to populate a RAMS database,
- Evaluation from a “watershed” perspective,
- Pursuit and promotion of innovative technologies for mine waste characterization and remediation,
- Support for the efforts of other federal agencies,
- Soil geotechnical testing,

- Percolation and/or infiltration testing, and
- Preparation of Reports.

2.2 OVERALL PROJECT OBJECTIVES

Specific project objectives will be jointly determined by project partners, stakeholders, and the USACE virtual team for each project and stated in the Site Specific Addendum. The general objective of the RAMS program is to support federal, state, and local stakeholders in their objectives for investigation and/or restoration of abandoned mines and to avoid duplication of effort by all participants.

3. PROJECT/TASK DESCRIPTION

3.1 SAMPLING LOCATIONS

3.1.1 Surface Soil/Waste Rock Sampling Locations

The purpose of the surface soil/waste rock sampling is to determine contaminant concentrations the lateral extent of contamination in surface soils. (Surface soil sampling at soil boring locations is discussed under Soil Boring/Monitoring Well Sampling Locations in Section 3.1.2 below.) The selection of surface soil sampling locations will be based on the following criteria:

- locations within potential areas of contamination (lateral extent),
- locations down gradient topographically from potential areas of contamination (direction of migration), and
- locations in a topographic low area (following minor transportation by wind or water and/or evaporation).

3.1.2 Soil Boring/Monitoring Well Locations

The purpose of the soil borings/monitoring wells is to determine the vertical and lateral extent of surface and subsurface soil and/or ground-water contamination. The selection of soil boring/monitoring well locations will be based on the following criteria:

- locations within areas of potential contamination (vertical and lateral extent),
- locations down-gradient topographically from potential areas of contamination (direction of migration),
- locations up-gradient topographically from potential areas of contamination identified during previous investigations (up-gradient vertical and lateral extent), and
- locations within surface drainage ways or topographic lows (greater potential for ground water and area of concentration following minor transportation and/or evaporation).

3.1.3 Surface Water/Sediment Sampling Locations

The purpose of the surface water/sediment sampling is to determine the presence or absence of contamination related to mining activities. The selection of surface water sampling locations will be based on the following criteria:

- locations within surface drainage ways (potential presence of sediment and water),
- locations up-gradient topographically from potential areas of contamination identified during previous investigations (up-gradient vertical and lateral extent),
- locations in topographic low (greater potential for surface water during the dry, summer season), and

- locations down-gradient topographically from the source areas within the site (direction of migration).

3.2 SAMPLING REQUIREMENTS

3.2.1 Surface and Subsurface Soil Sampling Requirements for Soil Borings

Surface soil samples will be collected from the intervals indicated in the SSA. Soil analytical parameters are site-specific and are identified in the SSA.

3.2.2 Ground Water Sampling Requirements

Ground water analytical parameters are site-specific and are identified in the SSA. Lists of the potential analytes are presented in section 8 of this document.

3.2.3 Surface Water and/or Sediment Sampling Requirements

To prevent introduction of sampler-induced turbidity or sampler-caused sedimentation, surface water and sediments will be collected from downstream to upstream locations and the surface water sample will be collected prior to the collection of sediment samples.

3.2.4 Project Schedule

A project schedule will be provided in the SSA for each project.

4. DATA QUALITY OBJECTIVES FOR MEASUREMENT DATA

4.1 DATA USES

DQOs are qualitative and quantitative statements that specify the objectives of the project, define the types of decisions that will be made, identify the intended use of the data and design a data collection program which addresses the quantity and quality of data required to support the project objectives. The DQOs are based on the end uses of the data to be collected and may include:

- determining if detected compounds are site-related contamination rather than representative of naturally-occurring concentrations,
- determining the vertical and lateral extent of the contamination in surface soils, subsurface soils, surface water/sediments, and ground water,
- refining conceptual models that may be used to determine exposure pathways for biological/ecological receptors for each site,
- collecting data of sufficient quality to support a quantitative assessment of carcinogenic and non-carcinogenic risks to human receptors as well as support a quantitative assessment of risk to ecological receptors, if necessary,
- collecting data of sufficient quality to support fate and transport modeling of contamination, if necessary,
- collecting data of sufficient quality to support a feasibility study and selection of a remedial option or options, if necessary, and
- determining the need and scope for a pre-design investigation, if necessary.

4.2 DATA QUALITY NEEDS

Sites being investigated under the RAMS program usually are not initially subject to the requirements of CERCLA but may eventually become subject to CERCLA and under the jurisdiction of the USEPA. Therefore, the work plans being prepared for RAMS are intended to ensure that data of sufficient quality for use within the CERCLA process is being obtained during the RAMS investigations. All QA/QC procedures described herein are generally structured in accordance with applicable technical standards and the USEPA requirements, regulations and guidance.(duplication is very important for this info!)

Definitive data as defined by the EPA uses rigorous analytical methods with satisfactory QA/QC requirements such as approved EPA reference methods are required for these projects. Data will be analyte-specific, with confirmation of analyte identity and concentration. Proper methods provide the necessary guidelines to produce tangible raw data (e.g., chromatograms, spectra, digital values) in the form of paper printouts or computer-generated electronic files. Data may be generated at the site or at an off-site location, as long as the QA/QC requirements are satisfied. For these projects, data will generally be generated at an off-site laboratory.

Screening data are generated by rapid, less precise methods of analysis with less rigorous sample preparation. Screening data are often used for health and safety monitoring or initial site characterization to locate areas for subsequent analyses.

4.3 METHOD SPECIFIC DATA QUALITY OBJECTIVES

Precision, accuracy, representativeness, completeness and comparability goals for this project are described below. These data quality parameters are expressed as goals due to uncertainties regarding field conditions and the complexity of the sample matrices at the site. The ability of the laboratory to extract and quantify the target analytes is dependent on the matrix complexity. The variability of field conditions, such as soil type and contaminant deposition, also will affect the data representativeness and comparability.

4.3.1 Precision

Laboratory: Precision is a measure of the degree of mutual agreement among data that have been collected the same way under prescribed conditions. Precision is assessed by replicate measurements of known standards and analysis of duplicate field samples. Precision is expressed as relative percent difference (RPD) between duplicate samples. Site-specific matrix spike/matrix spike duplicate (MS/MSD) pairs will be used to assess analytical precision, and field duplicates will be used to assess both analytical and sampling precision. Data with detected concentrations greater than three times the method detection limit (MDL) will be used to assess precision. The number of MS/MSDs collected and analyzed will generally be 5 to 10% of the total number of samples. Field precision will be determined by the RPD of analyte in the original and duplicate samples: :

$$\text{RPD} = \frac{\text{(Amount in Field Sample - Amount in Duplicate)}}{0.5\text{ (Amount in Field Sample + Amount in Duplicate)}} \times 100$$

Field: Field sampling precision will be assessed through comparisons of field duplicate sample analytical results. The number of field duplicate samples collected will generally be equivalent to 10% of the number of original samples collected.

Precision for field measurements will be determined by performing replicate measurements on the same sample (i.e., a second measurement will be performed on 10% of the field samples collected). Comparison of consecutive measurements will be used to help determine the precision of the field sampling. When measurements are within 10% of each other, precision of field measurements will be considered adequate.

4.3.2 Accuracy

Laboratory: Accuracy is the measure of the proximity of an observed value to an accepted value. Accuracy is expressed as percent recovery for each analyte of the spike samples (MS/MSDs, LCS/LCSDs, surrogates, etc.).

$$\%R = [(\text{Spike sample result} - \text{sample result})/\text{Spike concentration added}] \times 100$$

where: %R = percent recovery

Field: Field accuracy is defined as the collection of a sample that truly reflects the quality of the media sampled, is adequately preserved and is not biased by field-induced contamination during sample collection, handling and shipment. Field accuracy will be assessed by analyzing trip blanks, laboratory checks of pH for preserved water samples, and the temperature of the samples when received by the laboratory. Samples will be maintained at a temperature of 4^oC +/- 2^oC.

Field Blanks

Field blank samples are not required with soil or sediment sampling.

New tubing and/or disposable bailers will be used for each ground-water well sampling event. This will reduce the probability of cross-contamination between wells and field blank samples will not be required with well water samples.

Trip Blanks

Trip blanks will accompany all sample shipments that contain water samples for Volatile Organic Compound (VOC) analysis. Trip blanks provide an indication of contamination attributable to sample collection, handling and shipment. Trip blanks will be prepared in the field from “carboys” of organic-free water provided by the USACE Environmental Chemistry Branch (ECB) Laboratory of Waterways Experiment Station. These blanks will be analyzed for all (VOC) analytes of concern. Trip blanks will not be required for soil samples.

Trip blanks will not contain detectable project analytes above the analytical laboratory reporting limits) (LRLs), and will have a proper pH and temperature when received by the laboratory. The sample LRL is the lowest concentration of an analyte that can be reported by the laboratory to be present in a sample with a specified level of confidence. Common contaminants arising from field sampling equipment, decontamination solutions and laboratory operations may be detected (these may include acetone, methylene chloride, toluene, 2-butanone, and/or common phthalates.) Trip blank samples will not contain these contaminant at concentrations greater than five times the LRL. Samples containing concentrations above these values will require the initiation of corrective action.

4.3.3 Representativeness

Laboratory: Representativeness expresses the degree to which data accurately and precisely represents the characteristics of a population of samples, parameter variations at a sampling point, a process or an environmental condition. Representativeness is a measure of how closely the measured results reflect the actual concentration or distribution of the chemical compounds in the sample. Representativeness of the analytical results can be assessed by comparing the results for field duplicate samples collected from a site. Some samples may require analysis of multiple phases to obtain representative results. To ensure representativeness in the laboratory, USACE will request that samples be prepared and analyzed together as much as possible so that the laboratory QC is applicable to this project's samples and laboratory variables are minimized.

Field: Under this Work Plan, field representativeness will be satisfied by ensuring that the Work Plan is followed, proper sampling techniques are used, proper sample handling and documentation procedures are followed, and proper analytical procedures are followed in the field. Proper documentation will establish that protocols have been followed and sample identification and integrity ensured.

4.3.4 Completeness

Laboratory: Completeness is defined as the amount of valid data obtained from the laboratory compared with the amount of data that would be expected under normal conditions. Completeness is presented in Table 4-1 as the percent of data that is valid. Data are considered valid if they are unqualified or if they are qualified as estimated. For analyses, the completeness of laboratory analytical data will be 90 percent or better. The goal for holding times is 100 percent.

The percent completeness for each set of samples can be calculated as follows:

Completeness = [valid data obtained/total data planned] x 100

where valid data are determined by the data acceptance criteria defined in this Work Plan.

Field: Completeness of field activities will be measured as the amount of field measurements (pH, conductivity, temperature, headspace analysis, etc.) that comply with SOPs for calibration and precision requirements compared to the whole population of field measurements attempted. The field data completeness objective for this project is a minimum of 95% of all samples.

Field sample collection completeness will be measured as the total number of field samples of sufficient volume collected for laboratory analysis compared to the total number of samples planned for collection in the SSA. Field sample collection completeness for this project is expected to exceed 95% for soil samples. Ground water may not be present at all proposed monitoring well locations, and this may have a significant effect on the completeness of the ground-water sampling.

4.3.5 Comparability

Laboratory: Comparability is an expression of the confidence with which one data set can be compared with another. Comparability of analytical data will be achieved through the use of accepted and documented analytical methods. The data will be reported in units consistent with Federal and State regulations, methods, and guidelines. LRLs for all analytes will be recorded on all lab data report sheets for all samples within the sample set. Comparability between databases will be achieved by using standardized sampling and analysis methods and data formats.

Field: Comparability of data obtained during this investigation is dependent upon the proper design of the sampling program and will be satisfied by ensuring the Work Plan is followed and proper sampling and handling techniques are used. The intent is that field data will be directly comparable to data obtained during subsequent phases of the project.

4.3.6 Sensitivity

Sensitivity broadly describes the method detection/quantitation/LRLs established to meet the project-specific DQOs. The sample LRL is the lowest concentration of an analyte that can be reported by the laboratory to be present in a sample with a specified level of confidence The LRLs are a function of the sample characteristics, method quantitation, and laboratory performance.

Method quantitation limits are determined by the laboratory and defined as the level at which the laboratory can reliably quantitate the concentration of an analyte on multiple analyses. The LRLs can be equal to the method quantitation limits, but often are above since method quantitation limit studies are performed using laboratory-prepared samples (spiked deionized [DI] water); whereas, environmental samples are naturally more variable. LRLs and/or Practical Quantitation Limits (PQLs) are provided in Section 6.0. For this project, data reported below the LRLs will be reported as estimated. Factors that may result in elevated LRLs are discussed below.

- High concentrations of target or non-target analytes may require that the sample extract be diluted to avoid saturation of the detector or to quantify the analyte concentration within the calibration range of the instrument. Consequently, LRLs are elevated in proportion to the dilution factor.

- Matrix interferences may require that the sample be diluted to reduce or eliminate the interference. Consequently, the LRLs are elevated in proportion to the dilution factor.

- Soil analytical results and LRLs are corrected for the moisture content of the sample. The LRLs listed Section 5.0 for soils are based on wet weight. LRLs calculated by the laboratory for soil on a dry weight basis will be higher. Because moisture content can vary from sample to sample, LRLs will vary accordingly.

- The physical characteristics of the matrix do not permit concentration to the required final volume during sample preparation resulting in a larger sample extract volume and consequently an elevation in LRLs.

- Matrix interference may require the LRLs be elevated because of the inability to quantify data below the elevated LRL

TABLE -1
COMPLETENESS GOALS

Analyte	Matrix	Completeness (%)
Holding Time for all analytes	Soil	90
Holding Time for all analytes	Water	90
VOCs	Soil	90
VOCs	Water	90
Metals	Soil	90
Metals	Water	90
Cyanide	Soil	90
Cyanide	Water	90
Water Quality Parameters	Water	90

Metals = Selected metals from Inductively Coupled Plasma – Atomic Emission Spectroscopy (ICP-AES) list
Water Quality Parameters/ = Alkalinity, Hardness (as $CaCO_3$), Conductivity, Total Dissolved Solids (TDS), Nitrate/Nitrite, Sulfate, Carbonate, Bicarbonate, Chloride and Ammonia

5. SAMPLING PROCESS DESIGN

5.1 SAMPLING LOCATIONS

5.1.1 Surface Soil/Waste Rock Sampling Locations

The purpose of the surface soil/waste rock sampling is to determine contaminant concentrations the lateral extent of contamination in surface soils. (Surface soil sampling at soil boring locations is discussed under Soil Boring/Monitoring Well Sampling Locations in Section 3.1.2 below.) The selection of surface soil sampling locations will be based on the following criteria:

- locations within potential areas of contamination (lateral extent),
- locations down gradient topographically from potential areas of contamination (direction of migration), and
- locations in a topographic low area (following minor transportation by wind or water and/or evaporation).

5.1.2 Soil Boring/Monitoring Well Locations

The purpose of the soil borings/monitoring wells is to determine the vertical and lateral extent of surface and subsurface soil and/or ground-water contamination. The selection of soil boring/monitoring well locations will be based on the following criteria:

- locations within areas of potential contamination (vertical and lateral extent),
- locations down-gradient topographically from potential areas of contamination (direction of migration),
- locations up-gradient topographically from potential areas of contamination identified during previous investigations (up-gradient vertical and lateral extent), and
- locations within surface drainage ways or topographic lows (greater potential for ground water and area of concentration following minor transportation and/or evaporation).

5.1.3 Surface Water/Sediment Sampling Locations

The purpose of the surface water/sediment sampling is to determine the presence or absence of contamination related to mining activities. The selection of surface water sampling locations will be based on the following criteria:

- locations within surface drainage ways (potential presence of sediment and water),
- locations up-gradient topographically from potential areas of contamination identified during previous investigations (up-gradient vertical and lateral extent),
- locations in topographic low (greater potential for surface water during the dry, summer season), and
- locations down-gradient topographically from the source areas within the site (direction of migration).

5.2 SAMPLING REQUIREMENTS

5.2.1 Surface and Subsurface Soil Sampling Requirements for Soil Borings

Surface soil samples will be collected from the intervals indicated in the SSA. Soil analytical parameters are site-specific and are identified in the SSA.

5.2.2 Ground Water Sampling Requirements

Ground water analytical parameters are site-specific and are identified in the SSA. Lists of the potential analytes are presented in section 8 of this document.

5.2.3 Surface Water and/or Sediment Sampling Requirements

To prevent introduction of sampler-induced turbidity or sampler-caused sedimentation, surface water and sediments will be collected from downstream to upstream locations and the surface water sample will be collected prior to the collection of sediment samples.

6. SAMPLING METHODS REQUIREMENTS

Brief description and table (see example)

7. SAMPLE HANDLING AND CUSTODY REQUIREMENTS

Sample containers and preservatives will be obtained through the laboratory from vendors. All sample containers will be certified as clean by the vendor, and a certificate of analysis will be supplied with each lot ordered. These certificates will be kept on file by the Field Team Leader and a record of the bottle lot numbers and preservatives used in the field will be made in the field sampling log; bottle lots and preservatives will be traceable to the fieldwork event. Sample containers and preservatives to be used are listed in Tables 7-1 and 7-2 and are grouped by analytes and matrix. These tables also identify the sample holding times by analytical parameter.

In general, sample collection order will be from locations surrounding the areas of concern which are expected to contain the least amount of contamination, to the locations that may contain the most contaminated soils; this determination will be based on the topography of the area, with sampling locations at higher elevations sampled first. Up-gradient wells will be sampled first (again, based on the topography of the site).

The order of sample collection at each location and sample interval will consist of obtaining samples for VOC analyses followed by VOC samples for on-site VOC headspace analysis, then samples for Metals and Design Parameters or Water Quality Parameters/Design Parameters (when appropriate).

7.1 SAMPLING IDENTIFICATION SCHEME

Samples will be uniquely identified by using a system as outlined below. If a different nomenclature system is used it shall be outlined in the SSA.

UU-VVVV-XXXX-YY-ZZ

where:

- **UU** = Project Designation
- **VVVV** = Designation of Sampling Area Location and an alphabetical letter may be inserted at the end of the VVVV character designation for the sub-site identification

- **XXXX** = 4 Character Designation for Sample Type/Location, where the first two X-characters indicate sample type:

  MW = Monitoring Well
  SB = Soil Boring
  SD = Sediment
  SS = Surface Sample
  SW = Surface Water
  TB = Trip Blank
  WB = Water Blank

  The next two X-characters, 01 through 99, further define the sample location based on the boring or sampling site number. Trip blanks will be marked with a MW or SW designation to prevent preferential treatment by the laboratory.
- **YY** = 2 Character Designation for Sample Depth, using the bottom depth of the soil sample interval, such as using -04, for the 2 to 4-foot interval. Water samples (MW, TB, WB, and SW) will not require a YY designation.
- **ZZ** = 2 Character Designation for Samples, where:

  01 = Normal Field Sample
  02 = QC Duplicate
  03 = Trip Blank
  04 = Confirmation Sample

7.2 SAMPLE CUSTODY

Documentation of sample custody will be maintained for all samples, from the time the samples are collected until analytical reports are received. A sample is under custody if:

- It is in a person's possession
- It is in a person's view, after being in one's possession
- It was in a person's possession and that person placed it in a secure area

The sample collector and/or sample packer will be responsible for initiating and filling out the COC form. The COC form will be signed by the sample collector when the samples are relinquished to anyone else (this includes relinquishing samples to a designated sample packer). The field team member packaging the samples for overnight shipment will sign the COC (if different from the sample collector). It is not necessary for the overnight shippers to sign the COC; however the shipping bill will be retained by the designated sample packer for tracking purposes. A COC form will be completed daily for each cooler. The following information will be included on the COC:

- Sampler's signature and affiliation

- Project name unique to the investigated site and a unique LIMS # xxxxxx. A unique LIMS number will obtained from the USACE project Chemist for each site investigated.
- Date and time of collection
- Sample identification, soil boring or monitoring well identification
- Sample type, matrix
- Preservatives used
- Internal temperature of the shipping container upon receipt at the laboratory when the shipping container is opened
- Analyses requested
- Number of containers
- Dates, times, and signature(s) of person(s) relinquishing custody
- Dates, times, and signature(s) of person(s) accepting custody
- Method of shipment
- Special instructions and/or Remarks

Upon receipt at the laboratory, the person receiving and unpacking the samples will sign the COC and it will be kept with the project records. The USACE Project Chemist will be notified if any noncompliance to set sample criteria occurs. The person receiving and unpacking the samples will also fill out a Cooler Receipt Form for each cooler received at the laboratory. A copy of the Cooler Receipt Form will be provided to the USACE Project Chemist.

Please refer to Chapter 4 of ECB Laboratory's LQMM (Appendix D) and Work Plan SOP A13 for corresponding information. Examples of a COC Form and a Cooler Receipt Form are provided in ECB Laboratory's LQMM (Appendix D).

TABLE 7-1
SAMPLE CONTAINERS, PRESERVATION, AND HOLDING TIMES FOR SOIL SAMPLES

Parameter	**Container**[1,2]	**Preservation**	**Maximum Holding Times**	
			Extraction	**Analysis**
Volatiles	2 X 2 oz Glass, Teflon Septa, no headspace.	Ice to 4°C	NA	14 days
Cyanide (total and WAD)	1 x 4 oz Glass	Ice to 4°C		14 days
Metals [3]	1 x 4 oz Glass	Ice to 4°C	6 mo. (Mercury - 28 days)	6 mo. (Mercury - 28 days)
Acid Base Accounting	16 oz glass container or plastic bag			NA [4]

Parameter	Container[1,2]	Preservation	Maximum Holding Times	
			Extraction	Analysis
	container			
TOC	4 ox glass	Ice to 4°C		ASAP

1 Three times the standard volume of sample is required at locations where QC and Matrix Spike/Matrix Spike Duplicate samples are collected.

2 Additional soil volume must be collected when leaching procedures are required.

3 Samples for metals need not be place in iced container.

4 If sample is kept in a closed to prevent contamination, no holding time is stated.

ASAP = As Soon As Possible
NA = Not Applicable

TABLE 7-2
SAMPLE CONTAINERS, PRESERVATION, AND HOLDING TIMES FOR WATER SAMPLES

Parameter	Container[1]	Preservation	Maximum Holding Times:	
			Extraction	Analysis
Volatiles	3 x 40 mL Glass, Septa vial, no headspace	Ice to 4°C HCl to pH <2	NA	14 days
Dissolved Metals[2]	1 x 1 Liter Plastic	Preservative added after filtering by ECB Lab	NA	6 months (Mercury - 28 days)
Total Metals[2]	1 x 1 Liter Plastic	HNO_3 to pH <2 Do not filter	NA	6 months (Mercury - 28 days)
Total and WAD Cyanide	2 x 500 mL plastic	NaOH to pH > 12		14 days
Alkalinity	1 x 1 Liter Plastic	Ice to 4°C	NA	14 days
Conductivity			NA	28 days
Sulfate			NA	28 days
Carbonate			NA	28 days
Bicarbonate			NA	28 days
Chloride			NA	28 days
Hardness	1 x 250 mL Plastic	HNO_3 to pH <2 Ice to 4°C	NA	6 months
Nitrate/Nitrite	1 x 250 mL Plastic	H_2SO_4 to pH <2 Ice to 4°C	NA	28 days
Sodium Adsorption Ratio (Ca, Mg, K, Na)	1 x 1 Liter Plastic	HNO_3 to pH <2 Do not filter	NA	6 months
Total Dissolved Solids (TDS)	1 x 1 Liter Glass	Ice to 4°C To be filtered by ECB Lab	NA	7 days
Total Organic Carbon (TOC)	1 x 1 Liter Glass	H_2SO_4 or HCl to pH <2 Ice to 4°C		28 days, if preserved
Ammonia	1 x 500 mL Plastic	H_2SO_4 to pH <2 Ice to 4°C	NA	28 days

1 Three times the standard volume of sample is required at locations where QC and Matrix Spike/Matrix Spike Duplicate samples are collected.

2 Samples for metals need not be place in iced container

NA = Not Applicable

8. ANALYTICAL METHODS REQUIREMENTS

This project will include the analysis of surface and subsurface soil, and sediment samples for volatile organic compounds (VOCs), selected Metals, and Cyanide (CN). It will also include the analysis of surface water and ground-water samples for VOCs, selected Metals, and Cyanide. Laboratory analysis of Water Quality Parameters/Design Parameters (which includes common ions) for surface water and ground-water samples may include some or all of the following: Alkalinity, Hardness (as calcium carbonate [$CaCO_3$]), Conductivity, Total Dissolved Solids (TDS), Total Organic Carbon (TOC), Sodium Adsorption Ratio (calculated), Nitrate/Nitrite, Sulfate, Carbonate, Bicarbonate, Chloride and Ammonia. Both Total and Dissolved Metals analyses may be performed on surface water and ground-water samples. A series of soil and sediment leaching procedures may be performed on these samples (see table 6-1 and section 6.2). Some other analyses may be performed on soil samples are given in table 6-1. All samples will be shipped to the ECB Laboratory for analyses (please see Section 3.7 for shipping address). The CSM may be used for specialty tests. The analytical methods are presented in Table 6-1 and a summary of internal QC checks is presented in Table 6-2. Specific analytes included in each analyte group and their LRLs, MDLs and QC Limits are presented in Tables 6-3 through 6-7 at the end of this section. Descriptions of internal QC checks are provided below.

8.1 LABORATORY ANALYTICAL METHODS

The analytical methods to be utilized by the ECB Laboratory and/or by CSM are summarized in the following subsections.

8.1.1 Volatile Organic Compounds (VOCs)

Surface soil, subsurface soil, and ground-water samples for VOCs will be analyzed by Third Edition SW-846 Final Update III (SW-846) 8260. Method 8260 is based upon a purge-and-trap, gas chromatographic/mass spectrometric (GC/MS) procedure.

8.1.2 Metals

In general, surface soil, subsurface soil, sediment samples, surface water, and ground-water samples will be analyzed for selected Metals by SW-846 6010. Method 6010 is based on the simultaneous or sequential, multi-elemental determination of elements by ICP-AES. ICP measures element-emitted spectra by optical spectrometry. Surface water and ground-water samples will analyzed for total recoverable and dissolved (Total and Dissolved) metals to assess the extent and potential for transport of metals through the surface water and ground water.

The soil and sediment samples will be digested by SW-846 3050A, while water samples will be digested using SW-846 3005A, prior to analysis.

8.1.3 Cyanide (CN)

Surface soil, subsurface soil, sediment samples, surface water, and ground-water samples will be analyzed for Cyanide by SW-846 9012 or by the Standard Method 4500. Total cyanide analysis is based on the decomposition of nearly all cyanides in the presence of strong acid, magnesium chloride, and heat during a one hr reflux distillation. The released cyanide in the form of hydrogen-cyanide (HCN) is captured in a sodium hydroxide (NaOH) trap where it is analyzed. The determination of Weak Acid Dissociable (WAD) Cyanide is based on the pretreatment of the sample with a week acid. Hydrogen cyanide is liberated from a slightly acidified sample (pH 4.5 to 6.0). The method does not recover the tightly bound cyanide complexes. The WAD cyanides that are captured in the NaOH trap are analyzed by a method the same as for total cyanide analysis. In many instances, stakeholders may prefer WAD Cyanide analysis that is generally considered to be more conservative with more reliable reported values. Stakeholderes will be consulted for preferred method.

8.1.4 Water Quality Parameters

Surface water and ground-water samples will be prepared and analyzed for the determination of some or all of the following:

- Alkalinity using EPA 310.2,
- Hardness (as $CaCO_3$) calculated using ASTM 2340D and the total calcium/magnesium results,
- Conductivity using SW-846 9050A, 1985,
- TDS using EPA 160.1,
- Nitrate/Nitrite as N using EPA 353.2,
- Sulfate using EPA 375.2,
- Carbonate using EPA 310.2,
- Bicarbonate using EPA 310.2,
- Chloride using EPA 325.2,
- Fluoride using EPA 340.1, 340.2 or 340.3,
- Ammonia using EPA 350.1.

8.1.5 Soil Analyses (misc)

Several miscellaneous soil analyses that may be used are given in Table 6.1.

8.1.6 Soils Geotechnical Tests

Various geotechnical tests that may be used are available in Appendix C.

8.1.6.1 Water Holding Capacity (WHC)

Water Holding Capacity is a measure of the amount of water can be contained in the soil and is directly related to the quantity of micropores within the soil, thus is influenced by the texture, structure, and organic matter content. The WHC is determined using a method adopted from the American Society of Agronomy, Methods of Soil Analysis, Part 1 - Physical and Mineralogical Properties.

8.2 SOLID/SEDIMENT AND LEACHATE SAMPLE PREPERATION PROCEDURES

Soils and rocks from the mine waste piles are collected and analyzed by two methods. The solid sample (grab sample or composite) are screened through a $^{1}/_{4}$ inch stainless steel sieve, then placed in pre-cleaned 125 mL glass jars. Sediment samples are obtained from the stream and placed in sample containers. See Table 7-1 and 7-2 for sample container, preservation, and holding time requirements. Specific sampling and analysis procedures will be given in the SSA to the Work Plan. Portions of the samples are sent to the laboratory for the following analyses.

- A portion of the samples is sent for solid sample analysis as is given in section 6.1 above.
- A portion is sent to the lab for leachate analysis. The analytical method is given above in section 6.1. The leachate preparation is as follows:

8.2.1 Mine Waste Pile Soils for Leachate Preparation.

8.2.1.1 Colorado Department of Minerals and Geology (DMG) Procedure

This extraction consists of combining a 2 : 1 mixture of deionized water and solid, and let set for a set period time. The filtered extract is then analyzed for metals.

The deionized leachate is collected as follows: 150 mL (dry volume) of the prescreened soil is placed in a 1-liter plastic beaker along with 300 mL of deionized water. This is vigorously mixed for 15 seconds; the top is wrapped in plastic, then let settle for 90 minutes. This time is the time it will generally take for the soils fraction to settle out. The liquid is then filtered through a fine grade soil filter (approximately 2 micron). A portion of the liquid is analyzed for total acidity, pH, and specific conductance. The remaining liquid sample is acidified with nitric acid and analyzed for selected total metals.

8.2.1.2 Meteoric Water Mobility Procedure (MWMP)

The purpose of MWMP is to evaluate the potential for dissolution and mobility of certain constituents from a mine rock sample by Meteoric water. The method is based upon data collected for wet depositions in Nevada, obtained from Desert Research Institute (DRI), University of Nevada Systems, Type II reagent water mostly simulates meteoric water in Nevada in terms of both composition and pH range, Meteoric Water Mobility Procedures, 9/19/90, and also Standard Methods for the Examination of Water and Wastewater, 1992.

8.2.2 Stream Sediment for Leachate Preparation.

Sediment samples are collected and analyzed by two methods. The sediment samples are analyzed as a solid by method as given in section 6.1. The leachate obtained from the sediment samples is analyzed for selected metals as shown in section 6.1. The leachate can be obtained by methods from mild dissolution to aggressive digestion on sediment of <80-mesh. The leachate methods are as follows:

8.2.2.1 DMG Procedure

This extraction is a 2:1 by volume deionized water extraction process as is used for the waste rock analysis in section 6.2.1.

8.2.2.2 Toxicity Characteristic Leaching Procedure (TCLP) (Modified EPA Method 1311)

The TCLP is a standard procedure used by the EPA to classify solid materials as hazardous wastes as designated for landfill disposal. The filtered leachate is then analyzed by method 6010.

The extraction solution is prepared by adding 5.7 mL of glacial acetic acid to 500 mL of water. To this is added 64.3 mL of 1 N NaOH and the volume is brought to 1 liter with water. The final solution should be pH 5. 2 grams of < 800-mesh sediment is added to 40 mL of the extraction solution in a 125 mL bottle. The bottle is agitated end over end using a rotary tumbler for 24 hrs. At the end of the 24 hrs the filtrate is filtered through a 0.45 micron filter, acidified with nitric acid and analyzed using ICP-AES.

8.2.2.3 Modified Synthetic Precipitation Leaching Procedures (SPLP) (EPA Method 1312).

The SPLP, in this unmodified form, is used by the USEPA to determine the potential mobility metals in a solid if exposed to rain or snowmelt and accounts to some extent for effects of acid rain.

The extraction fluid is prepared by adding a 60/40 weight percent mixture of sulfuric acid and nitric acid to reagent water until the pH is 5.00 +/- 0.05. 2 grams of < 80-mesh sediment is added to a 125 mL bottle containing 40 mL of the extraction solution. The bottle is then agitated end over end using a rotary tumbler for 18 hours. At the end of the 18 hrs the filtrate is filtered through a 0.45 micron filter, acidified with nitric acid and analyzed using ICP-AES.

8.2.2.4 Hydrogen Peroxide (H_2O_2) Acid Producing Potential (APP) Test (EPA Field and Lab Methods 3.2.11).

The H_2O_2 APP Test is a procedure that can be used to predict if a mine waste material will be an acid producer or a neutralizer. The APP releases sulfide material and the extraction fluid will indicate what metal can be found in a solid.

1 gram of < mesh sediment is placed in a Teflon beaker, 12 mL of 30 % hydrogen peroxide is added and heated to 40^0 C. The beaker is removed from the heat and the reaction is allowed to go to completion as is shown when bubbling has ceased. An additional 6 mL of 30 % hydrogen peroxide is added to the beaker and the reaction is once again allowed to go to completion. The beaker is then heated to 90^0C and allowed to react until any unreacted hydrogen peroxide in the beaker is destroyed. The beaker is not allowed to go to dryness. The sides of the beaker is then washed with 50 mL of distilled water, and then heated to boiling to drive of any dissolved carbon dioxide. The beaker is then cooled to room temperature and titrated with 0.0100 N NaOH, that is free of carbon dioxide, to a pH of 7.0 using a pH meter. The liquid is filtered through a 0.45 micron filter, acidified with nitric acid and analyzed using ICP-AES, Hageman, Phillip L, and Briggs, Paul H, 2000.

8.2.2.5 Amorphous Digestion

An amorphous digestion is carried out in order to determine if iron and manganese oxides are present in the sediments analyzed. Like the APP, this procedure tests for specific species within the sediment.

The extraction solution is prepared that contains equal volumes of 0.2 M $(NH_4)_2C_2O_4$, 0.2 M $H_2C_2O_4$ $2H_2O$, and 0.1 M Ascorbic Acid. 80 mL of the extraction solution is added to 2 grams of <80-mesh sediment in a teflon beaker. The beaker is heated to 90^0 C for 30 minutes. Samples are filtered with a 0.45 micron filter, acidified with nitric acid, and analyzed using ICP-AES, Duggan, Laura, Colorado School of Mines, Masters Thesis, 1993.

8.3 ACID BASE ACCOUNTING

Acid base accounting is a static procedure that can be used to predict if a sample mine overburden material will be an acid producer or a neutralizer. The acid producing potential in a rock is tied directly to the amount of sulfides bound up in the rock in various forms. When these sulfides minerals are exposed to water and air, the sulfur is oxidized to form more soluble oxygen containing anions resulting in the release of the metallic ions and acids. The lower pH can then result in additional metals release. Acid Base Accounting is an analytical test that can determine the potential of the sample to produce acid and release metallic ions. The analysis will be performed as the Acid Base Accounting which included acid-base potential, acid potential, neutralization potential, and sulfur forms (sulfide, sulfate, sulfite etc.). SMP buffer, which is a measure of the buffering capacity and exchangeable acidity can also be performed. See Table 6-1.

8.4 GROUND WATER AND SURFACE WATER SAMPLES

Water samples are obtained from monitoring wells and streams and sent to the laboratory for analysis. See Table 7-2 for sample container, preservation, and holding time requirements. Specific sampling procedures and required analyses are given in the Site Specific Addendum (SSA) to the Work Plan Portions.

9. QUALITY CONTROL REQUIRMENTS

Laboratory QC samples will be included in the analyses as are given in this section.

9.1.1 Laboratory Blank Samples

Blank samples are analyzed to check for potential contamination by constituents derived from a source other than the sample (i.e., sample handling or laboratory procedures). Method blank samples are deionized, distilled water that are prepared and analyzed as a sample. The detection of contaminants in the method blank indicates potential contamination from laboratory sources (i.e., contaminated reagents, cleaned laboratory equipment or persistent contamination due to the presence of contaminants in the ambient laboratory air). A method blank will be prepared and analyzed with each batch of 20 or fewer samples. If analytes are detected above the limits listed on Table 6-2, preparation and analysis will be stopped and the source of contamination found, documented and eliminated. All samples following the last contaminant-free method blank that contained the contaminant will be re-prepared and re-analyzed. Other blank samples (such as preparation blanks, instrument blanks, calibration blanks, etc.) will be run as required by specific methods.

9.1.2 Surrogate Standards for Organic Analysis

A surrogate is a compound that is chemically similar to the compounds of interest in the field or unknown sample, but which is not normally found in environmental samples. Surrogates are added to all blanks, samples and spiked samples prior to preparation and analysis. The surrogate percent recovery is a measure of the effectiveness of the preparation and analysis methods on the field or unknown sample. The surrogate recovery must fall within the accuracy limits established on Tables 6-2. Any sample with a surrogate recovery that exceeds the QC limits must be re-prepared and re-analyzed in accordance with the Laboratory's LQMM, with both sets of data reported unless otherwise approved by the Project Chemist.

9.1.3 Internal Standards

An internal standard compound (the peak of which is well separated from the peaks of the components of the sample, but close to the peak of the sample components) is introduced into each sample and standard. The ratio of analyte to internal standard peak area serves as the analytical parameter measurement. Internal standards ensure that Gas Chromatography/Mass Spectroscopy (GC/MS) sensitivity and response are stable during each analysis for VOCs. Internal standard counts must not vary by more than a factor of two (-50% to 100%) from the associated calibration standard and the retention time of the internal standard must not vary more than +/- 30 seconds from the retention time of the associated calibration standard. Samples with internal standards outside these limits must be re-analyzed.

9.1.4 Matrix Spike/Matrix Spike Duplicates (MS/MSD) - Organics

An MS sample is an aliquot of the environmental sample that has been spiked with known concentrations of analytes. The MS sample is prepared and analyzed by the same method as the unspiked field sample. An MSD sample is a duplicate of the MS, which is prepared and analyzed as described above. The percent recovery is used to evaluate the effect the sample matrix has on analytical bias. The RPD of the spike duplicates is calculated and used to assess the analytical precision. Limits for percent recovery/RPD are listed on the Tables at the end of this section. No action will be taken to re-extract or re-analyze samples if MS/MSD precision and/or accuracy results are outside these limits unless other quality control parameters so merit.

9.1.5 Matrix Spike/Matrix Spike Duplicates - Inorganics

If the spike recovery results exceed the limits on Tables 6-2, re-preparation and/or re-analysis will be performed as necessary to confirm matrix interference. If matrix interference is confirmed, the respective sample result will be qualified during data validation. For example, if the spike recovery result for an analyte is below the value listed on Tables 6-2, but above thirty percent (30%), the result will be qualified as estimated with a “J” (estimated) code. If the spike recovery result for an analyte is less than thirty percent (30%) and the respective sample result is reported as not detected at (or less than) the reporting limit, the associated samples will be qualified with an unusable code (“R”).

In instances where the sample concentration exceeds the spike concentration by a factor of four (4) or more, the limits on Table 6-2 may not apply and professional judgment will be used as to application of acceptance limits. However, no more than twenty percent (20%) of all spike recovery data reported for a given analyte may be reported where the sample concentration exceeds the spike concentration by a factor of four (4) or more. If the frequency exceeds twenty percent (20%), the MS and MSD samples will be prepared again at a higher spike concentration.

9.1.6 Laboratory Control Samples/Laboratory Control Sample Duplicates

LCS/ LCSD are samples which have been prepared in a matrix similar to that of the field samples and which have been spiked with known concentrations of analytes. The LCS/LCSD standard is prepared independently of calibration standards to provide a check of instrument calibration. The LCS and LCSD are prepared and analyzed by the same methods as the field sample. The percent recovery of the analytes in the LCS and LCSD indicate whether the analytical method is within established control limits. Control limits are presented on Table 6-2. If the control limits are exceeded, appropriate corrective actions will be taken in accordance with ECB Laboratory's LQMM.

9.2 FIELD QC SAMPLES

During the field activities for this project, QC samples will be collected/generated to assess the quality of the data resulting from the field sampling program and the analytical laboratory procedures. QC samples will consist of blanks (trip blanks, potable water supply blank, and/or source water supply blank), field duplicate samples and site-specific MS/MSD samples that will be sent to ECB Laboratory.

9.2.1 Blank Samples

Field blank samples are samples taken in the field of sources used in the field or samples to determine if any contamination has been put into the samples on transit.

Trip blanks samples will be submitted and analyzed to assess the quality of the data resulting from the field sampling program. Trip blanks will be used to assess the potential for VOC contamination of water samples due to contaminant migration during sample collection and handling, shipment and storage procedures. One VOC trip blank with deionized distilled ultra pure water will be included with each shipment of aqueous VOC samples. Trip blanks will be analyzed for all VOC analytes of concern. The objective is for the trip blanks to contain no detectable analytes above the analytical reporting limits and for all samples to be properly preserved when received at the laboratory.

Trip blanks will consist of containers (VOC vials) of reagent-grade deionized distilled ultra pure water filled in the field with the source water from Laboratory. Several 5-liter containers of trip blank source water obtained from ECB Laboratory will accompany the VOC containers (VOC vials) from the lab to the field. Trip blanks will be kept with the aqueous field samples for VOCs analysis and shipped with them to the lab for analysis. The source water for the trip blanks will also be used for the final rinse in the decontamination procedure.

9.2.2 Field Duplicate Samples

Field duplicate samples will be analyzed to assess the quality of the data resulting from the field sampling program. Field duplicate samples will be analyzed to provide an indication of precision with respect to sample collection procedures and analytical reproducibility. Field duplicates are samples taken in the field at the same time and in the same manner as the original sample for the purpose of verifying the sampling technique. Field duplicate soil samples will be prepared by mixing the original soil sample and dividing it into two subsamples, except for VOC analyses. Field duplicate soil samples requiring VOCs analyses will consist of separate grab samples taken from the same interval. The general level of the QC effort will be one field duplicate for every 10 primary samples. Three times the standard volume of sample is required at locations where QC and MS/MSD samples are collected.

Field duplicates (D1 and D2) are compared using the following RPD calculation:

$$RPD = [D1 - D2/(D1 + D2 /2)] \times 100$$

where: D1 is the measured concentration of the first sample aliquot
D2 is the measured concentration of the second sample aliquot

9.2.3 Matrix Spike/Matrix Spike Duplicate Samples

Matrix spikes provide information about the effect of the sample matrix on the digestion and measurement methodology; all matrix spikes will be performed in duplicate and are referred to as MS/MSD samples. MS/MSD samples are QC samples. Site-specific MS/MSD samples will be collected at a frequency of one per twenty (20) or fewer primary samples per sample matrix (i.e., surface soil, subsurface soil, ground water, etc.). Three times the standard volume of sample is required at locations where QC and MS/MSD samples are collected.

Table 6-1

ANALYTICAL METHODS

Analyte	Soil Method	Water Method
Volatile Organics[a]	8260	8260
Inorganics Metals/ (Metals)[a]		
Aluminum (Al)	3050A/6010	3005A/6010
Antimony (Sb)	3050A/6010	3005A/6010
Arsenic (As)	3050A/6010	3005A/6010
Barium(Ba)	3050A/6010	3005A/6010
Beryllium (Be)	3050A/6010	3005A/6010
Cadmium (Cd)	3050A/6010	3005A/6010
Calcium (Ca)	3050A/6010	3005A/6010
Chromium (Cr)	3050A/6010	3005A/6010
Cobalt (Co)	3050A/6010	3005A/6010
Copper (Cu)	3050A/6010	3005A/6010
Iron (Fe)	3050A/6010	3005A/6010
Lead (Pb)	3050A/6010	3005A/6010
Magnesium (Mg)	3050A/6010	3005A/6010
Manganese (Mn)	3050A/6010	3005A/6010
Mercury (Hg)	7471A	7470A
Nickel (Ni)	3050A/6010	3005A/6010
Potassium (K)	3050A/6010	3005A/6010
Selenium (Se)	3050A/6010	3005A/6010
Silver (Ag)	3050A/6010	3005A/6010
Sodium (Na)	3050A/6010	3005A/6010
Thallium (Tl)	3050A/6010	3005A/6010
Vanadium (V)	3050A/6010	3005A/6010
Zinc (Zn)	3050A/6010	3005A/6010
Infrequently Analyzed Metals: Bismuth, Boron, Gallium, Lithium, Molybdenum, Phosphorus, Scandium, Strontium, Tin, Titanium	3050A/6010 (This method is usable with some possible modifications)	3005A/6010 (This method is usable with some possible modifications)

Analyte	Soil Method	Water Method
Inorganic Analytes		
Cyanide (CN)	Standard Method 4500 or SW846 Method 9012	Standard Method 4500 or Sw846 Method 9012
Cyanide (WAD CN)*	Standard Method 4500 or SW846 Method 9012	Standard Method 4500 or Sw846 Method 9012
Water Quality Parameters/Design Parameters		
Alkalinity (total, reported as carbonate and bicarbonate)	NA	EPA 310.2
Hardness (as $CaCO_3$)	NA	ASTM 2340D
Sodium Adsorption Ratio (calculated)	NA	Bohn et al **
TDS	NA	EPA 160.1
Nitrate/Nitrite	NA	EPA 353.2
Sulfate	NA	EPA 375.2
Carbonate	NA	EPA 310.2
Bicarbonate	NA	EPA 310.2
Chloride	NA	EPA 325.2
Fluoride	340.1, 340.2, 340.3	340.1, 340.2, 340.3
Ammonia	NA	EPA 350.1
Conductivity	9050A	9050A
TOC	9060	9060
Leaching Procedures		
DMG Procedure	Section 6.2.1.1	
TCLP	Modified EPA 1311	
SPLP	EPA Method 1312	
H_2O_2 APP	EPA Method 3.2.11	
Amorphous Digestion	Section 6.2.2.5	
Meteoric Water Mobility Procedure	Section 6.2.1.2	
Other Soil Analyses		
Soil Conductivity	ASTM D1125	
Acid-Base Accounting	***	
SMP Buffering Capacity	***	
Cation Exchange Capacity	***	
Soil Water Holding Capacity (WHC)	Section 6.1.6.1	

Notes:
a = EPA SW-846 Methods
NA = Not Applicable
* = WAD - Weak Acid Dissociable

** = Bohn et al in Soil Chemistry, 1985 (calculated as described using Ca, Mg, K, Na results).
*** = Nevada Bureau of Mining Regulations and Reclamation, Waste Rock and Overburden Evaluation, Sept 14, 1990.

Table 6-2

INTERNAL QUALITY CONTROL CHECKS

Analytic Group	**Lab Blank**		**Field Split**		**LCS/LCSD**		**Surrogate Spike**		**Internal Standards**		**MS/MSD**		**Trip Blank**	
	F	**Limits**	**F**	**Limits**	**F**	**Limits**	**F**	**Limits**	**F**	**Limits**	**F**	**Limits**	**F**	**Limits**
Volatile Organics	1/20	<PQL[a]	1/10	50% RPD-Soil 30% RPD-Water	1/20	Table 6-3 and Table 6-4	Every Sample	Table 6-3 and Table 6-4	Every Sample	Section	1/20	Table 6-3 and Table 6-4	*	<PQL[a]
Total Cyanide and WAD Cyanide	1/20	< RL	1/10	50% RPD-Soil 30% RPD-Water	1/20	Table 6-7	Every Sample	Table 6-7	QC		1 /20	Table 6-7	NA	NA
Metals (soil) Metals (water)	1/20	<RL	1/10	50% RPD-Soil 30% RPD-Water	1/20	Table 6-5 and Table 6-6	NA	NA	NA	NA	1/20	Table 6-5 and Table 6-6	NA	NA

Notes:
PQL = Practical Quantitation Limit
RL = Reporting Limit
NA = Not Applicable
-- = Not available
F = Frequency
a = Lab solvents include acetone, methylene chloride, 2-butanone and toluene
b = Common Phthalate esters
* = One trip blank per every cooler containing water volatile organic samples
QC - Cyanide analysis requires an internal calibration curve and a midlevel continuing calibration

Table 6-3

Volatile Organic Compounds
Reporting and QC Limits
for Soil Samples
Method 8260

CAS No.	Analyte	MDL (µg/kg)	LRL (µg/kg)	Acceptance Range * (% Recovery)	RPD (%)
100-41-4	Ethylbenzene	1	5.0	60-140	25
100-42-5	Styrene	1	5.0	60-140	25
10061-01-5	cis-1,3-Dichloropropene	1	5.0	60-120	25
10061-02-6	trans-1,3-Dichloropropene	1	5.0	50-150	25
107-06-2	1,2-Dichloroethane	1	5.0	60-140	25
108-05-4	Vinyl Acetate	20	100	50-150	25
108-10-1	4-Methyl-2-pentanone	20	50	50-150	25
108-88-3	Toluene	1	5.0	59-139	25
108-90-7	Chlorobenzene	1	5.0	60-133	25
124-48-1	Dibromochloromethane	1	5.0	60-140	25
127-18-4	Tetrachloroethene	1	5.0	60-140	25
1330-20-7B	meta-/para-Xylenes	1	5.0	60-140	25
156-59-2	cis-1,2-Dichloroethene	1	5.0	60-140	25
156-60-5	trans-1,2-Dichloroethene	1	5.0	60-140	25
56-23-5	Carbon Tetrachloride	1	5.0	60-140	25
591-78-6	2-Hexanone	20	50	60-140	25
67-64-1	Acetone	20	50	50-150	25
67-66-3	Chloroform	1	5.0	60-140	25
71-43-2	Benzene	1	5.0	66-142	25
71-55-6	1,1,1-Trichloroethane	1	5.0	60-140	25
74-83-9	Bromomethane	1	5.0	50-150	25
74-87-3	Chloromethane	1	5.0	50-150	25

CAS No.	Analyte	MDL (µg/kg)	LRL (µg/kg)	Acceptance Range * (% Recovery)	RPD (%)
75-00-3	Chloroethane	1	10	50-150	25
75-01-4	Vinyl Chloride	1	5.0	50-150	25
75-09-2	Methylene Chloride	1	5.0	60-140	25
75-15-0	Carbon Disulfide	1	5.0	60-140	25
75-25-2	Bromoform	1	5.0	60-140	25
75-27-4	Bromodichloromethane	1	5.0	60-140	25
75-34-3	1,1-Dichloroethane	1	5.0	60-140	25
75-35-4	1,1-Dichloroethene	1	5.0	59-172	25
78-87-5	1,2-Dichloropropane	1	5.0	60-140	25
78-93-3	2-Butanone	20	50	50-140	25
79-00-5	1,1,2-Trichloroethane	1	5.0	60-140	25
79-01-6	Trichloroethene	1	5.0	62-137	25
79-34-5	1,1,2,2-Tetrachloroethane	1	5.0	60-140	25
95-47-6	ortho-Xylene	1	5.0	60-140	25
CAS No.	**Surrogates**			**Acceptance Ranges (%)**	**RPD (%)**
17060-07-0	1,2-Dichloroethane-d4			70-121	25
1868-53-7	Dibromofluoromethane			80-120	25
2037-26-5	Toluene-d8			81-117	25
460-00-4	4-Bromofluorobenzene			74-121	25

* Acceptable ranges are compound specific for the LCS/Spike Duplicate and MS/MSD

Table 6-4

Volatile Organic Compounds
Reporting and QC Limits
for Water Samples
Method 8260

CAS No.	Analyte	MDL (µg/L)	LRL (µg/L)	Acceptance Range * (% Recovery)	RPD (%)
100-41-4	Ethylbenzene	0.5	2.0	70-130	25
100-42-5	Styrene	0.5	2.0	70-130	25
10061-01-5	cis-1,3-Dichloropropene	0.5	2.0	70-130	25
10061-02-6	trans-1,3-Dichloropropene	0.5	2.0	60-140	25
107-06-2	1,2-Dichloroethane	0.5	2.0	70-130	25
108-05-4	Vinyl Acetate	10	50	60-140	25
108-10-1	4-Methyl-2-pentanone	10	25	60-140	25
108-88-3	Toluene	0.5	2.0	76-125	25
108-90-7	Chlorobenzene	0.5	2.0	75-130	25
124-48-1	Dibromochloromethane	0.5	2.0	70-130	25
127-18-4	Tetrachloroethene	0.5	2.0	70-130	25
1330-20-7B	meta-/para-Xylenes	0.5	2.0	70-130	25
156-59-2	cis-1,2-Dichloroethene	0.5	2.0	70-130	25
156-60-5	trans-1,2-Dichloroethene	0.5	2.0	70-130	25
56-23-5	Carbon Tetrachloride	0.5	2.0	70-130	25
591-78-6	2-Hexanone	10	25	70-130	25
67-64-1	Acetone	10	25	60-140	25
67-66-3	Chloroform	0.5	2.0	70-130	25
71-43-2	Benzene	0.5	2.0	76-127	25
71-55-6	1,1,1-Trichloroethane	0.5	2.0	70-130	25
74-83-9	Bromomethane	0.5	2.0	60-140	25
74-87-3	Chloromethane	0.5	2.0	60-140	25

CAS No.	**Analyte**	**MDL (µg/L)**	**LRL (µg/L)**	**Acceptance Range * (% Recovery)**	**RPD (%)**
75-00-3	Chloroethane	0.5	2.0	60-140	25
75-01-4	Vinyl Chloride	0.5	2.0	60-140	25
75-09-2	Methylene Chloride	0.5	2.0	70-130	25
75-15-0	Carbon Disulfide	0.5	2.0	70-130	25
75-25-2	Bromoform	0.5	2.0	70-130	25
75-27-4	Bromodichloromethane	0.5	2.0	70-130	25
75-34-3	1,1-Dichloroethane	0.5	2.0	70-130	25
75-35-4	1,1-Dichloroethene	0.5	2.0	61-145	25
78-87-5	1,2-Dichloropropane	0.5	2.0	70-130	25
78-93-3	2-Butanone	10	25	60-140	25
79-00-5	1,1,2-Trichloroethane	0.5	2.0	70-130	25
79-01-6	Trichloroethene	0.5	2.0	71-120	25
79-34-5	1,1,2,2-Tetrachloroethane	1	2.0	70-130	25
95-47-6	ortho-Xylene	0.5	2.0	70-130	25
CAS No.	**Surrogates**			**Acceptance Ranges (%)**	**RPD (%)**
17060-07-0	1,2-Dichloroethane-d4			76-114	25
1868-53-7	Dibromofluoromethane			80-120	25
2037-26-5	Toluene-d8			88-110	25
460-00-4	4-Bromofluorobenzene			86-115	25

* Acceptable ranges are compound specific for the LCS/Spike Duplicate and MS/MSD

Table 6-5

Selected Metals
Reporting and QC Limits for Soil Samples
ICP Trace

LCS, MS/MSD Acceptance Range: 80-120% RPD limit: 25%

Analyte	Method Detection Limit (mg/Kg)	Laboratory Reporting Limit (mg/Kg)
Aluminum (Al)	4	12
Antimony (Sb)	1.2	4
Arsenic (As)	0.6	3
Barium (Ba)	0.1	0.5
Beryllium (Be)	0.1	0.4
Boron (B)	0.8	4
Cadmium (Cd)	0.1	0.5
Calcium (Ca)	20	60
Chromium (Cr)	0.4	2
Cobalt (Co)	0.6	3
Copper (Cu)	0.4	2
Iron (Fe)	8	24
Lead (Pb)	0.4	2
Magnesium (Mg)	8	24
Manganese (Mn)	0.2	0.6
Mercury (Hg) (a)	0.002	0.01
Molybdenum (Mo)	0.4	2
Nickel (Ni)	0.6	2
Potassium (K)	20	60
Selenium (Se)	0.8	4
Silver (Ag)	0.2	1
Sodium (Na)	20	60
Thallium (Tl)	1	5

Analyte	Method Detection Limit (mg/Kg)	Laboratory Reporting Limit (mg/Kg)
Titanium (Ti)	0.2	1
Vanadium (V)	4	20
Zinc (Zn)	0.6	2
Infrequently Analyzed Metals: Bismuth, Gallium, Lithium, Phosphorus, Scandium, Strontium, Tin	Method Criteria	Method Criteria

(a) = Cold vapor method

Table 6-6

Selected Metals
Reporting and QC Limits for Water Samples
ICP Trace

LCS, MS/MSD Acceptance Range: 80-120% RPD limit: 25%

Analyte	Method Detection Limit (µg/L)	Laboratory Reporting Limit (µg/L)
Aluminum (Al)	20	60
Antimony (Sb)	3	15
Arsenic (As)	3	15
Barium (Ba)	0.5	2.5
Beryllium (Be)	0.5	2
Boron (B)	4	20
Cadmium (Cd)	0.5	2.5
Calcium (Ca)	100	300
Chromium (Cr)	2	10
Cobalt (Co)	3	15
Copper (Cu)	2	10
Iron (Fe)	40	120
Lead (Pb)	2	10
Magnesium (Mg)	40	120
Manganese (Mn)	1	3
Mercury (Hg) (a)	0.01	0.05
Molybdenum (Mo)	2	10
Nickel (Ni)	3	10
Potassium (K)	100	300
Selenium (Se)	4	20
Silver (Ag)	1	5
Sodium (Na)	200	400
Thallium (Tl)	5	25

Analyte	Method Detection Limit (µg/L)	Laboratory Reporting Limit (µg/L)
Titanium (Ti)	1	5
Vanadium (V)	4	20
Zinc (Zn)	3	10
Infrequently Analyzed Metals: Bismuth, Gallium, Lithium, Phosphorus, Scandium, Strontium, Tin	Method Criteria	Method Criteria

a = Cold Vapor

Table 6-7

Selected Inorganic Methods Reporting and QC Limits (LCS and MS/MSD Acceptance Limits) for Soil and Water Samples by Various Methods

Analyte	Soil MDL (mg/kg)	Soil LRL (mg/kg)	Water MDL (mg/L)	Water LRL (mg/L)	LCS,MS,MSD Acceptance Range	RPD Limit
Alkalinity, EPA 310.2	NA	NA	7	20	80-120%	20%
Hardness, ASPM 2340D	NA	NA	7	21	80-120%	25%
Total Dissolved Solids (TDS), EPA 160.1	NA	NA	5	15	80-120%	20%
Nitrate/Nitrite, EPA 353.2	NA	NA	0.01	0.10	80-120%	25%
Sulfate, EPA 375.2	NA	NA	6.0	20	80-120%	25%
Carbonate, EPA 310.2	NA	NA	7	20	80-120%	25%
Bicarbonate, EPA 310.2	NA	NA	7	20	80-120%	25%
Chloride, EPA 325.2	NA	NA	0.5	2	80-120%	25%
Fluoride, EPA 340.1, 340.2, or 340.3	NA	NA	0.5	2	80-120%	25%
Ammonia, EPA 350.1	NA	NA	0.02	0.10	80-120%	25%
Conductivity, 9050A and ASTM D1125	NA	NA	NA	NA	NA	NA
Sodium Adsorption Ratio, by Bohn et al	NA	NA	2 meq/L	6 meq/L	80-120%	25%
Total and WAD Cyanide	1	5	0.002	0.005	80-120 %	20 %
Soil pH, EPA 150.1	NA	NA	NA	NA	NA	NA

NA = Not Applicable

10. INSTRUMENT CALIBRATION AND FREQUENCY

10.1 FIELD INSTRUMENTS

Maintenance and proper calibration of field instruments are essential to the field sampling program. Before mobilization to the field, all equipment will be checked for malfunctions and cleaned. In addition, all equipment will be calibrated by the sampling team to ensure proper working order and to ensure the integrity to the measured values. Calibration will be performed on a daily basis or more frequently as required. Calibration procedures provided by the manufacturer will be followed and are contained in the Work Plan.

Calibration will be documented in the Field Log Book as described in the SOPs attached to the Work Plan(refer to SOPs A7, A9, A10 and A14).

The Field Team Leader is responsible for maintaining the Field Meter Calibration Log for field instruments as part of field documentation in the Field Log Book (SOP A14). This log contains the same information as that for permanent lab instruments (ID number, name and model of meter). The log also contains calibration results and notes for each day of equipment use. Documentation will include:

- Date of calibration
- Initials of person performing calibration
- Calibration results

Calibration will be performed daily prior to use for the multi-parameter probe and turbidity meter. In addition, the calibration will be checked any time the equipment is turned off during the day, any time there is a questionable response from the equipment and at the end of the day to determine if any drift has occurred. Changes in calibration will be noted on any boring logs or other sampling forms where field instrument readings were recorded that day. The thermometer will be calibrated prior to mobilization to the field.

10.2 LABORATORY INSTRUMENTS

Laboratory calibration procedures and frequency will be performed in accordance with the methods listed on Table 6-1. Documentation of calibration and maintenance is kept in bound notebooks. If equipment has been out of service for two weeks or longer, the equipment will be re-calibrated immediately prior to use and then at the frequencies prescribed below to ensure acceptable continual calibration while in use. Calibration procedures are summarized below (please refer to the LQMM in Appendix D for further information).

10.2.1 Volatile Organic Compounds (VOCs)

An instrument performance check solution must be performed at the beginning of each 12 hour period during which samples or standards are analyzed. The instrument performance checks, bromofluorobenzene for VOC analysis, must meet the criteria on Table 9-1.

A minimum of five concentrations of all compounds of interest is injected to determine response factors and define the linear range of the system. After an acceptable initial calibration has been performed, the calibration is verified at least once every 12 hours by analyzing a continuing calibration verification standard containing representative compounds from each fraction. The instrument is recalibrated (five standards) if the verification calibration check compounds are greater than ±25% of the initial calibration response.

10.2.2 **Metals**

For each analyte of interest, a calibration curve is prepared which covers the linear working range of the method. Two concentration levels and a blank are used to construct the calibration curve, including one near the upper limit of the concentration range and one near the lower limit of the concentration range with an equitable distribution of the remaining points.

The linear regression technique is used to find a straight line that best fits a set of calibration points. For a calibration curve to be acceptable, the correlation coefficient must be greater than or equal to 0.995 and the difference between the value observed for each calibration standard and the value predicted for that standard using the fitted calibration curve must be within ten percent.

A calibration verification check sample and calibration blank are analyzed after every ten samples and at the end of the analyses for the day. Recalibration is performed if the ten percent limit is exceeded and the ten samples preceding the out-of-control check standard and blank are reanalyzed.

10.2.3 **Cyanide**

Total and WAD cyanides are based on the acid distillation of HCN from the sample using strong and weak acid respectively. The HCN is captured in a NaOH trap. The concentration of cyanide can be determined by a Titrimetric, Colorimetric, or potentiometric procedure. The procedure must address any interfering substances such as chlorine and sulfides. A calibration curve is run and this curve is verified by independent calibration check standards. If the standards are not within 15 % of the expected value, a new recalibration curve is required. Verify the calibration curve with every sample batch by analyzing a mid-range standard. Run one matrix spike sample for every 10 samples to check the efficiency of sample distillation. A matrix spike should be prepared by adding cyanide from the working standard or intermediate standard to 500 mL of sample to obtain a concentration of approximately 40 ug/L. Both the matrix and matrix spike duplicate are brought through the entire sample preparation and analytical process.

10.2.4 **Total Dissolved Solids and other Water Quality Parameters/Design Parameters**

The analytical balance must be calibrated at least annually by a certified calibration service. Auto-zero the balance and check level at least once daily, before first use. Calibration must be verified daily using a series of at least two National Institute for Standards and Technology (NIST) class “S” weights. Results must be within the instrument manufacturer’s specifications. If results exceed the instrument specifications, the balance may not be used for analysis until it has been serviced and recalibrated. Please refer to the LQMM for further calibration information.

Water Quality Parameters/Design Parameters analyses vary in methodology and instrumentation, typically using ion chromatographs, spectrophotometers, analytical balances, etc. This leads to some variation in calibration for different analyses, but the general principles still apply. Calibration is always required, and consists of defining the working range by use of a series of standard solutions. A minimum of five standards is typically used, and is verified on an ongoing basis (every ten to twenty samples at a minimum and at the end of the analysis sequence). Continuing calibrations are not performed for non-instrumental methods such as total dissolved solids (i.e., gravimetric methods), but balance weights are checked daily and documented in appropriate log books.

TABLE 9-1

INSTRUMENT PERFORMANCE CHECK CRITERIA FOR VOCs

Bromofluorobenzene (BFB):	
Mass	Intensity Required (relative abundance)
50	15 to 40% of mass 95
75	30 to 60% of mass 95
95	base peak, 100% relative abundance
96	5 to 9% of mass 95
173	less than 2% of mass 174
174	greater than 50% of mass 95
175	5 to 9% of mass 174
176	greater than 95% but less than 101% of mass 174
177	5 to 9% of mass 176

11. ASSESSMENTS AND RESPONSE ACTIONS

The following sections discuss the Field Quality Control Procedures that will be utilized for these projects.

11.1 FIELD ANALYTICAL PROCEDURES

The procedures for field measurement of pH, conductivity, turbidity, water level, and temperature are described in the appropriate SOPs in Appendix A of this Work Plan.

11.2 FIELD QUALITY CONTROL CHECKS

During field activities, USACE personnel will collect soil, ground water, surface water, and sediment duplicate samples for laboratory analysis. The SSA will specify the number of duplicate samples to be collected for each project.

11.3 FIELD DATA REDUCTION AND VALIDATION PROCEDURES

All field measurements (e.g. pH, conductivity, and temperature) will be directly read from the equipment, and field data reduction procedures will be minimal. Calibration will be performed in accordance with the manufacturer's recommendation. The calibration data and sample measurement data will be recorded in field log books or on data sheets as described in the appropriate SOPs immediately after measurements are taken. If recording errors are made, the error will be crossed out using a single line, initialed, and dated by the field member, and the correct information will be written in the space adjacent to the original (erroneous) entry.

After completing the sampling, the field data package (field logs, chain-of-custody forms, etc.) will be reviewed by the project team for completeness and accuracy. Items included in the validation of field data are listed below:

- Review of completeness of field data recorded on sampling logs,
- Verification that field duplicates were properly prepared, identified, and collected at the required frequency,
- Review of field analyses, equipment calibration, and equipment condition,
- Review of chain-of-custody (COC) forms for proper completion, dates, and signatures of field personnel,
- Review of the boring logs for completeness and consistency with COC paperwork, and
- Review of all other logs and/or forms for completeness and consistency with COC paperwork.

11.4 FIELD DATA REPORTING

Field data reporting will be conducted principally through the transmission of boring logs, monitoring well construction diagrams, well development logs, water sampling logs, field log books, data sheets, and Daily Quality Control Reports (DQCR). Documentation of field calibration activities will be included in the field log books or on data sheets as described in the appropriate SOP. (Refer to SOP A14 of Appendix A).

11.5 FIELD PERFORMANCE AUDITS

If field performance audits are required in the SSA, they will meet the following requirements. A Quality Management Plan (QMP) will be prepared for each specific project and will indicate which performance audits will be performed and which project team member(s) will have those responsibilities. Audits are planned and documented evaluations of project operations that determine the adequacy and effectiveness of, as well as compliance with, the project plans. Performance and systems audits of both field and laboratory activities may be conducted to verify that field sampling and analyses, as well as off-site chemical analyses, are performed in accordance with the Work Plan.

Performance audits verify the laboratory's ability to correctly identify and quantify contaminants of concern in blind samples and as such, assess the accuracy of the measurement system. Laboratory performance audits will be performed by and at the discretion of USACE.

The objectives of performance audits are to:

- ensure all Work Plan and SSA requirements are being implemented,
- assess the effectiveness of the Work Plan and SSA
- verify that corrective actions are made in response to identified deviations

Systems audits evaluate the entire process of generating the environmental measurement from sample collection through entry of the analytical value into the project database. Systems audits are initially performed shortly after systems are operational and then on a schedule during the project lifetime.

The objectives of systems audits are to:

- ensure Work Plan and SSA are in use and understood,
- verify that required documentation is accurate and complete,
- assess the effectiveness of the Work Plans and identify necessary deviations, and
- verify the effectiveness of corrective actions, if required.

Field system audits will be conducted by the project team member(s) identified in the QMP who will be responsible for ensuring that corrective actions are complete and effective. The field team leader will be responsible for correcting all deficiencies cited as deviations from the Work Plans.

An initial field systems audit will be conducted at a frequency identified in the QMP.

The primary purpose of the field systems audit is to verify that the field team is complying with the DQOs and properly documenting field activities. Examination of field sampling records, field instrument calibration, proper log book or data sheet documentation, in-field custody procedures, sample container storage and labeling, packaging and shipping procedures, and observation of sample collection and handling will be included. All field systems audits will consist of the following:

- Pre-field mobilization preparation to familiarize the field team with the specific forms, field equipment calibration protocols, logs, and instrument records to be kept during field activities, and their importance,
- Inspection of field records with on-site identification of documentation gaps, inconsistencies, and deviations from the Work Plan,
- Observation of field sampling with immediate notification to the Project Geologist of deviations from the Work Plan,
- Discussions of the audit findings with the geologist at the site and notification of the audit findings to the USACE Project Manager, and
- Post-audit activities including preparation of an audit report detailing deviations, non-conformances, and corrective action recommendation.

11.6 SPECIFIC PROCEDURES

If identified in the QMP for each specific project, the following procedures will be used to assess field data precision, accuracy, and completeness.

11.6.1 Field Measurements

Accuracy of the field measurements will be assessed using daily instrument calibration and calibration checks.

11.6.2 Field Corrective Actions

If it is determined that a situation will result in nonconformance with the project plans and will require corrective action, a nonconformance report will be initiated by the project team. For RAMS projects, the project team will include the project manager, project technical staff, and project field team leader. The nonconformance report will document what the nonconformance consists of, what corrective action will be taken, and who is responsible for implementing and reporting the implementation of the corrective action.

The project team will be responsible for corrective actions that include:

- Evaluating all reported non-conformances,
- Controlling additional work on nonconforming items,
- Determining the corrective action to be taken,
- Directing the field staff to implement the corrective action,
- Maintaining a log of non-conformances,
- Reviewing nonconformance reports and corrective actions taken, and
- Ensuring nonconformance reports are included in the project files.

The project team will ensure that no additional work that is dependent on the nonconforming activity is performed until corrective actions are completed.

Corrective actions for field measurements may include:

- Repeating the measurement,
- Checking that proper adjustments have been made for ambient conditions such as temperature,
- Checking the batteries of the sampling equipment,
- Checking the calibration of the sampling equipment,
- Replacing the instrument or measurement devices, or
- Stopping the work.

The field team leader is responsible for all on-site activities, unless otherwise indicated in the SSA. The field team leader is required to implement corrective actions. The change in the program will be documented in the project files. The field team leader must agree with the change prior to field implementation. Actions taken prior to the change will be evaluated to determine the significance of the data obtained and its effect on the data quality objectives for the project.

The project team is responsible for controlling, tracking, and ensuring the implementation of the changes. Reports on all changes will be distributed to all affected parties. The USACE Project Manager will be notified within 24 hours that a field corrective action has occurred and the action taken.

11.7 OFF-SITE ANALYSES

Laboratories that will perform chemical analytical analyses associated with these projects include, but are not limited to:

U.S. Army Corps of Engineers
Chemical and Material Quality Assurance Branch Laboratory
420 South 18th Street
Omaha NE 68102
Telephone: (402) 444-4314
Point of Contact: Laura Percifield

Energy Laboratories
1120 So. 27th Street
Billings MT 59101
Telephone: (800) 735-4489
Point of Contact: John Standish

Colorado School of Mines (CSM)
(to be supplied in Site Specific Addendum if this laboratory will be utilized for the project)

Additional qualified analytical laboratories may be identified for use at specific sites. If a laboratory not identified in this plan will be used, information regarding the laboratory will be included in the SSA.

The following geotechnical laboratory will be involved with this project:
(to be supplied in Site Specific Addendum if geotechnical samples will be collected for the project)

An Environmental Chemistry Branch (ECB) Laboratory Information Management System (LIMS) number will be assigned to each sample submitted for analysis. A separate LIMS number will be assigned to each project and will be included in the SSA. The LIMS number must be added to the labels and COC records for all samples shipped to the ECB Laboratory for projects being performed under this Work Plan.

12. DATA REVIEW, VALIDATION AND VERIFICATION REQUIREMENTS

The Eleven Mile Reach field and laboratory data will be reviewed by xxxxx to determine if the data meet QAPP objectives. The xxxx will decide to qualify or reject the data.

13. DATA VALIDATION AND VERIFICATION METHODS

13.1 DATA REDUCTION

Upon completion of an analysis, the analyst will calculate the final sample results and associated QC results from the raw data. Additionally, for organic analyses, the analyst will review the scans of each sample and standard on the instrument terminal. The analyst will check for recovery of surrogate compounds, sample response within the linear range of the calibration curve and the integration of peaks in the chromatogram. Peaks that appear suspect may require re-integration by the analyst.

13.2 ANALYTICAL DATA PACKAGE REQUIREMENTS

The data will be submitted in both hard copy and on disk. For each analytical method run, the laboratory will report all analytes for each sample as a detected concentration or as less than the specific limits of quantitation. The data will be reported in units consistent with both Federal and State regulations, methods and guidelines. LRLs for all analytes will be recorded on all lab data report sheets for all samples within the sample set. Each analytical method run will be clearly identified as belonging to a specific analytical batch and will be reported with dates of collection, preparation and analysis; the laboratory also will report dilution factors for each sample. All soil samples will be reported on a dry-weight basis with percent moisture also reported. The laboratories will hold and make available all project raw data for a minimum period of ten years after samples have been analyzed.

A complete set of QC results, including calibration data, will be reported for each analytical batch. All required method QC procedures will be performed on project samples. A 45-calendar day turnaround time, from sample receipt of the last sample at the laboratory to data receipt by the Project Chemist, will be required for all samples.

13.2.1 Laboratory Blank Samples

All analytes will be reported for each laboratory blank. All sample results will be designated as corresponding to a particular laboratory blank in terms of analytical batch processing.

13.2.2 Surrogate Spike Samples

Surrogate spike recoveries will be reported with all organic method reports. Control limits for spike recoveries are identified on the Tables at the end of Section 6 and will be included with the analytical data package. The analytical data package also will specify the spiking concentration. Any out-of-control recoveries will result in the sample being re-prepared and re-analyzed as required by the analytical methods. Both sets of data will be reported, unless otherwise approved by the Project Chemist.

13.2.3 Matrix Spike/Matrix Spike Duplicate Samples

MS recoveries and RPDs will be reported for the samples. All sample results will be designated as corresponding to a particular MS/MSD pair. The report will indicate what field sample was spiked. MS/MSDs will be performed on project samples. The control limits for the MS/MSDs and RPD criteria are specified on the Tables at the end of Section 6 and will be included in the analytical data package.

13.2.4 Laboratory Control Samples/Laboratory Control Sample Duplicates

LCS results will be reported for the analyses. All sample results will be designated as corresponding to a particular LCS sample in terms of analytical batch processing. The control limits for the LCS/LCSDs and RPD criteria are specified on the Tables at the end of Section 6 and will be included in the analytical data package.

13.2.5 Other Method Quality Control

Additional QC checks, such as method of standard additions and serial dilutions for the analysis of metals, analytical spikes for metals, initial and continuing calibration data for all analytes, internal standard areas and tunes will be reported. Control limit ranges for all QC samples also will be reported in the analytical data package.

13.3 DATA PACKAGE ORGANIZATION

To aid data validation, separate data packages will be submitted for each type of analytical test as follows:

- VOCs;
- Metals;
- Cyanides;
- Water Quality Parameters.

Each data package will consist of the results for a maximum of 20 field samples. QC results discussed in Section 11.2 will be included for each batch. Laboratory Case Narratives, completed COC forms and cooler receipt forms will be submitted in the analytical data package.

13.4 FIELD DATA REDUCTION AND VALIDATION PROCEDURES

All field measurements (e.g. pH, conductivity, and temperature) will be directly read from the equipment, and field data reduction procedures will be minimal. Calibration will be performed in accordance with the manufacturer's recommendation. The calibration data and sample measurement data will be recorded in field log books or on data sheets as described in the appropriate SOPs immediately after measurements are taken. If recording errors are made, the error will be crossed out using a single line, initialed, and dated by the field member, and the correct information will be written in the space adjacent to the original (erroneous) entry.

After completing the sampling, the field data package (field logs, chain-of-custody forms, etc.) will be reviewed by the project team for completeness and accuracy. Items included in the validation of field data are listed below:

- Review of completeness of field data recorded on sampling logs,
- Verification that field duplicates were properly prepared, identified, and collected at the required frequency,
- Review of field analyses, equipment calibration, and equipment condition,
- Review of chain-of-custody (COC) forms for proper completion, dates, and signatures of field personnel,
- Review of the boring logs for completeness and consistency with COC paperwork, and
- Review of all other logs and/or forms for completeness and consistency with COC paperwork.

13.5 FIELD EQUIPMENT

The field equipment for this project includes thermometers, turbidity meter, and multi-parameter probe [for measurement of pH, conductivity, oxidation reduction potential (ORP) or Eh, and dissolved oxygen (DO)]. Specific preventive maintenance procedures recommended by the manufacturer will be followed for field equipment.

Critical spare parts such as pH probes, electrodes and batteries will be kept on-site to minimize instrument down time. Backup instruments and equipment will be available on-site or within one-day shipment to avoid delaying field activities.

13.6 LABORATORY INSTRUMENTS

Routine preventive maintenance programs will be conducted by laboratory to minimize the occurrence of instrument failure and other system malfunctions. Section supervisors and/or analysts will perform routine scheduled maintenance and coordinate with the vendor for the repair of all instruments. All laboratory instruments will be maintained in accordance with manufacturer's specifications and the requirements of the specific method employed; this maintenance will be carried out on a regular, scheduled basis and will be documented in the laboratory instrument service logbook for each instrument. Emergency repair or scheduled manufacturers maintenance will be provided under a repair and maintenance contract with factory representatives. Lists of equipment available at the laboratory are available in the LQMM.

14. RECONCILIATION WITH DATA QUALITY OBJECTIVES

A corrective action protocol that is both technically effective and administratively compatible is imperative to ensure accurate and timely correction of non-conformance with the Work Plan. To accomplish this, the organizational structure will be used (as described below) to initiate, implement and approve corrective actions.

14.1 FIELD PROCEDURES

The Field Team Leader is responsible for all site activities. In this role, the Field Team Leader at times is required to adjust the field program to accommodate site-specific needs. When it becomes necessary to modify the field program, the Field Team Leader will notify the PM (whom will notify the project team) of the anticipated change, document and implement the necessary changes after approval from the PM. Significant field changes may include: deleting a sampling location, moving a sample location, substituting different field equipment for that stated in the SSA or making any changes in the SSHP.

During the field investigation, each field team will be responsible for completing a DQCR. An example of a DQCR is provided in the appendices to this Work Plan. This report will include a description of any problems encountered and any corrective actions taken. These reports will be compiled and sent to the PM once every week if no problems or deviations from the schedule or Work Plan arise. However, should problems arise, the Field Team Leader will immediately notify the PM. DQCRs will be sent daily to the PM by fax or overnight delivery until the problem has been corrected.

Work may be stopped by the PM if corrective actions for significant problems are not effective and the problem remains unresolved.

14.2 LABORATORY PROCEDURES

Nonconformance is defined as any event which is beyond the limits established for laboratory performance, such as data which fall outside accepted bounds for accuracy and precision due to improper equipment calibration, maintenance operation or improper data verification. Any activity in the laboratory, which affects data quality, can result in a nonconformance.

Nonconformance associated with the statistical analysis and review of data is straightforward to identify. The Project Chemist will be responsible for the assessment of QC sample information. The PM will be notified of non-conformances that affect data quality to the degree that re-sampling may be necessary.

Corrective actions will be designed to correct the associated problems and to minimize the possibility of their recurrence. Examples of corrective actions include modifying nonconforming procedures; tagging, repairing or replacing deficient equipment; training or replacing unqualified personnel; re-analyzing affected samples; marking rejected data; and, reissuing affected reports.

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APPENDIX A

STANDARD OPERATING PROCEDURES

APPENDIX B

FIELD EQUIPMENT OPERATION MANUALS

(In the interest of saving trees and reducing costs, copies of the Field Equipment Operation Manuals will only be attached to USACE-CENWO Internal Copies that will be actually taken into the field.)

APPENDIX C

AMERICAN STANDARDS FOR TESTING AND MATERIALS (ASTM) METHODS

APPENDIX D

CHEMICAL QUALITY ASSURANCE BRANCH LABORATORY QUALITY MANAGEMENT MANUAL (LQMM)