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13 September 2008

Ms. Leah Butler
Task Order Monitor
U.S. Environmental Protection Agency (EPA)
75 Hawthorne Street SFD-8-2
San Francisco, CA 94105

Subject: **Sampling and Analysis Plan, Revision 01**
Iron King Mine - Humboldt Smelter Superfund Site
Remedial Investigation/Feasibility Study
EPA Region 6 Remedial Action Contract 2
Contract: EP-W-06-004
Task Order: 0034-RICO-09MX

Dear Ms. Butler:

EA Engineering, Science, and Technology, Inc. (EA) is enclosing one original hard copy and three electronic copies on compact disc of the Sampling and Analysis Plan for the above-referenced Task Order. An electronic copy of this document was transmitted via e-mail on the 13 September 2008.

If you have any questions regarding this submittal, please call me at (972) 459-5046.

Sincerely,

Doug McReynolds

Doug McReynolds
Project Manager

Enclosure

cc: Michael Pheeny, EPA Contracting Officer (letter only)
Rena McClurg, EPA Project Officer (letter only)
Fritz Meyer, EA Program Manager (letter only via e-mail)
Jeff Hills, EA Financial Manager (letter only via e-mail)
File

TRANSMITTAL OF DOCUMENTS FOR ACCEPTANCE BY EPA	DATE: **13 September 2008**	TRANSMITTAL NO.: **0000010**

TO: **Ms. Leah Butler** **U.S. Environmental Protection Agency Region 9**	FROM: **Mr. Doug McReynolds** **EA Engineering, Science, and Technology, Inc.**

SUBTASK NO.	DELIVERABLE		NO. OF COPIES	
1	Samplng and Analysis Plan, Rev. 01 Iron King Mine - Humboldt Smelter Superfund Site Remedial Investigation/Feasibility Study		1 Hard Copy 3 Electronic Copies on Compact Disc	

ACCEPTANCE ACTION

DOCUMENTS FOUND ACCEPTABLE (LIST BY SUBTASK NO.)	NAME/TITLE/SIGNATURE OF REVIEWER DATE

Sampling and Analysis Plan

Remedial Investigation/Feasibility Study
Iron King Mine – Humboldt Smelter Superfund Site
Dewey-Humboldt, Yavapai County, Arizona
EPA Identification No. AZ0000309013

Remedial Action Contract 2 Full Service
Contract: EP-W-06-004

Prepared for

U.S. Environmental Protection Agency
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September 2008
Revision: 01
EA Project No. 14342.34

Sampling and Analysis Plan

Remedial Investigation/Feasibility Study
Iron King Mine – Humboldt Smelter Superfund Site
Dewey-Humboldt, Yavapai County, Arizona
EPA Identification No. AZ0000309013

Remedial Action Contract 2 Full Service
Contract: EP-W-06-004

13 September 2008

Fritz Meyer, P.E. Date
EA Program Manager

13 September 2008

David S. Santoro, P.E., L.S. Date
EA Quality Assurance Officer

Leah Butler Date
U.S. Environmental Protection Agency Region 9 Task Order Monitor

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LIST OF ACRONYMS AND ABBREVIATIONS

95UCLM	95% Upper Confidence Limit of the Mean
ACM	Asbestos-containing material
ADEQ	Arizona Department of Environmental Quality
AOI	Area of Interest
bgs	Below ground surface
BTV	Background level threshold values
Cd-109	Cadmium 109
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
COPC	Contaminant of potential concern
CRDL	Contract-required Detection Limit
CRQL	Contract-required Quantitation Limit
CSM	Conceptual Site Model
CUS	Conceptual Understanding of the Site
DESR	Data Evaluation Summary Report
DMA	Demonstration of Methods Applicability
DMP	Data Management Plan
DQA	Data quality assessment
DQO	Data quality objective
EA	EA Engineering, Science, and Technology, Inc.
EDD	Electronic data deliverable
EPA	U.S. Environmental Protection Agency
ERA	Ecological risk assessment
F	Fahrenheit
FS	Feasibility Study
FSP	Field Sampling Plan
ft^2	Square foot (feet)
GPS	Global positioning system
H_o	Null hypothesis
H_a	Alternative hypothesis
HHRA	Human health risk assessment
HSP	Health and Safety Plan
IDW	Investigation-derived waste
LCS	Laboratory control spike
MD	Matrix duplicate
MDL	Method detection limit
mg/m^3	Milligram(s) per cubic meter
mm	Millimeter(s)
MS	Matrix spike
MSD	Matrix spike duplicate
NHPA	National Historic Preservation Act
NIOSH	National Institute for Occupational Safety and Health
NIST	National Institute of Standards and Technology

LIST OF ACRONYMS AND ABBREVIATIONS
(CONTINUED)

NPL	National Priorities List
ORNL	Oak Ridge National Laboratory
ORD	Office of Research and Development
OSHA	Occupational Safety and Health Administration
PARCC	Precision, accuracy, representativeness, completeness, and comparability
PCB	Polychlorinated biphenyl
PEL	Permissible Exposure Limit
PM	Particulate matter
PM_{10}	Particulate matter less than 10 microns in diameter
ppm	Part(s) per million
ppb	Part(s) per billion
PRP	Potentially Responsible Party
PRG	Preliminary Remediation Goal
PSQ	Principal study question
QA	Quality assurance
QAPP	Quality Assurance Project Plan
QC	Quality control
RAC	Remedial Action Contract
RACA	Remedial Alternatives Comparative Analysis
RAGS	Risk Assessment Guidance for Superfund
RAO	Remedial action objective
RI	Remedial Investigation
ROD	Record of Decision
RPD	Relative percent difference
SAP	Sampling and Analysis Plan
SHSO	Site Health and Safety Officer
Site	Iron King Mine – Humboldt Smelter Superfund Site
SMP	Site Management Plan
SOP	Standard operating procedure
SOW	Statement of Work
SPLP	Synthetic Precipitation Leaching Procedure
SVOC	Semivolatile organic compound
TAL	Target Analyte List
TAT	Turnaround time
TCLP	Toxicity Characteristic Leaching Procedure
TOC	Top of casing
TOM	Task Order Monitor
TSP	Total suspended particulates
µm	Micron(s)
VOC	Volatile organic compound
VSP	Visual Sample Plan
XRF	X-ray fluorescence

DISTRIBUTION LIST

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1. PROJECT DESCRIPTION AND MANAGEMENT

EA Engineering, Science, and Technology, Inc. (EA) has been authorized by the U.S. Environmental Protection Agency (EPA), under Remedial Action Contract (RAC) Number EP-W-06-004, Task Order 0034-RICO-09MX, to conduct a Remedial Investigation/Feasibility Study (RI/FS) at the Iron King Mine – Humboldt Smelter Superfund Site (Site). EA has prepared this Sampling and Analysis Plan (SAP) in accordance with: (1) specifications provided in the EPA Statement of Work (SOW), dated 3 March 2008 (EPA 2008a); and (2) the EPA-approved EA Work Plan (Revision 01), dated 22 May 2008 (EA 2008b).

This SAP is a combination Quality Assurance Project Plan (QAPP) and Field Sampling Plan (FSP). It details the field sampling schedule, sample collection procedures, and analytical methods required to collect sufficient data to perform a RI/FS for the Site. Combining the QAPP and FSP into the SAP allows allow a streamlining of the planning process, while ensuring that data collected is of sufficient quality for its intended use.

This SAP was prepared in conjunction with the following independent site-specific plans, which together, present the overall approach for implementing the RI field program:

- Health and Safety Plan (HSP) (EA 2008b) specifies employee training, protective equipment, personal air monitoring procedures, medical surveillance requirements, standard operating procedures, and contingency planning procedures; and

- Site Management Plan (SMP) (EA 2008c) addresses Site access, security, contingency procedures, management responsibilities, data management, and waste disposal.

In accordance with the EPA-approved RI/FS Work Plan (Revision 01) (EA 2008a), EA has incorporated the following technical documents into this SAP:

- Conceptual Understanding of the Site (CUS) Technical Memorandum (Appendix A);

- Interim Measures Technical Memorandum (Appendix B);

- *Uniform Federal Policy for Quality Assurance Project Plans* Worksheets (Appendix C); and

- Air Quality Monitoring Plan (Appendix D).

This SAP was prepared in accordance with EA's Quality Management Plan (EA 2005a) and meets requirements set forth in *EPA Requirements for Quality Assurance Project Plans for Environmental Data Operation (QA/R-5)* (EPA 2001a) and *Guidance for Quality Assurance Project Plans (QA/G-5)* (EPA 2002a).

This SAP describes procedures to assure that the project-specific data quality objectives (DQOs) are met, and that the quality of data (represented by precision, accuracy, completeness, comparability, representativeness, and sensitivity) is known and documented. The SAP presents the project description, project organization and responsibilities, and quality assurance (QA) objectives associated with the sampling and analytical services to be provided in support of the RI/FS. Table 1 demonstrates how this SAP complies with elements of a QAPP currently required by EPA guidance (EPA 2001a, 2002a).

TABLE 1 ELEMENTS OF EPA QA/R-5 IN RELATION TO THIS SAP

EPA QA/R-5 QAPP Element	EA SAP (QTRAK # 08-056)
A1 Title and Approval Sheet	Title and Approval Sheet
A2 Table of Contents	Table of Contents
A3 Distribution List	Distribution List
A4 Project/Task Organization	1.0 Project Description and Management
A5 Problem Definition/Background	1.1 Problem Definition and Background
A6 Project/Task Description	1.2 Description of Project Objectives and Tasks
A7 Quality Objectives and Criteria	1.3 Data Quality Objectives 1.4 Quality Assurance Objectives for Measurement Data
A8 Special Training/Certification	1.5 Special Training and Certification
A9 Documents and Records	1.6 Documents and Records
B1 Sampling Process Design	2.1 Sampling Process Design 2.2 Consent for Property Access
B2 Sampling Methods	2.3 Sampling Methodology 2.4 Sample Processing 2.7 Sample Designation
B3 Sample Handling and Custody	2.8 Sample Container, Volume, Preservation, and Holding Time Requirements 2.9 Sample Handling and Custody
B4 Analytical Methods	2.10 Analytical Methods Requirements
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D1 Data Review, Verification, and Validation	4.1 Data Review and Reduction Requirements
D2 Validation and Verification Methods	4.2 Validation and Verification Methods
D3 Reconciliation with User Requirements	4.3 Reconciliation with Data Quality Objectives

The overall QA objectives are as follows:

- Attain quality control (QC) requirements for analyses specified in this SAP;
- Obtain data of known quality to support goals set forth for this project; and
- Document aspects of the quality program including performance of the work and required changes to work at the Site.

The EPA Region 9 Task Order Monitor (TOM), Ms. Leah Butler, and the Alternate TOM, Mr. David Seter, are responsible for the project oversight. The Project Officer for EPA Region 6 is Ms. Rena McClurg. The Contracting Officer for EPA Region 6 is Mr. Michael Pheeny. EA will perform tasks under this Task Order in accordance with this SAP. The EA Project Manager, Mr. Doug McReynolds, is responsible for implementing activities required by this Task Order. Figure 1 presents the proposed project organization for this Task Order.

1.1 PROBLEM DEFINITION AND BACKGROUND

This section describes the following:

- Purpose of the investigation and sampling events (Section 1.1.1); and
- Site background and description (Section 1.1.2).

1.1.1 Purpose of the Investigation and Sampling Events

The purpose of this investigation is to collect airborne particulates, ground water, surface water, surface soils, subsurface soils, and sediment data to support a RI/FS. The RI/FS process will allow the EPA to select a remedy that eliminates, reduces, or controls risks to human health and the environment. The goal is to develop the minimum amount of data necessary to support the selection of an approach for the Site's investigation, and then to use the data to support a Record of Decision (ROD). The EPA RI/FS SOW (EPA 2008a) and EPA approved Work Plan (EA 2008a) sets forth the framework and requirements for this effort.

1.1.2 Site Background and Description

The Site is located in Dewey-Humboldt, Yavapai County, Arizona (Figure 2). The Site is a combination of sources and releases from two separate facilities: the Iron King Mine property and the Humboldt Smelter property. A portion of the Town of Humboldt is situated between the mine and the smelter (Figure 3).

During the site visit that was conducted on 19 March 2008, the following Areas of Interest (AOI) were identified:

- Iron King Mine – The Iron King Mine Proper Area, Iron King Operations Area, Former Fertilizer Plant Area, and ancillary associated properties;
- Humboldt Smelter and ancillary associated properties;

- Off-Site Soil in the vicinity of the Site;

- Waterways - Including the Chaparral Gulch, Galena Gulch, Aqua Fria River, and adjoining drainage channels and outfalls; and

- Ground Water - Shallow alluvial and deep bedrock ground water.

These five AOIs were combined into a single Operational Unit for the purpose of conducting the RI/FS because: (1) ore from the Iron King Mine may have been processed at Humboldt Smelter; (2) off-site migration of particulates from the Iron King Mine and Humboldt Smelter may have overlapping air-depositional areas; (3) mine tailings from the Iron King Mine may have migrated onto the Humboldt Smelter property via the Chaparral Gulch; (4) the Aqua Fria River and its contributing waterways (e.g., Chaparral Gulch and Galena Gulch) may have impacts from both the Iron King Mine and Humboldt Smelter; and (5) ground water may be impacted from both the Iron King Mine and Humboldt Smelter.

The Iron King Mine property, located west of Highway 69, occupies approximately 153 acres. The Iron King Mine property is bordered by Chaparral Gulch, to the north, Galena Gulch to the south, Highway 69 to the east, and undeveloped land to the west. The Iron King Mine was a periodically active gold, silver, copper, lead, and zinc mine from 1906 (when the mine produced fluxing ore for the Humboldt Smelter) until 1969. Ore from the Iron King Mine may have been processed at the Humboldt Smelter, which operated from the late 1800s until 1969.

The Humboldt Smelter property, located at the east end of Main Street, occupies approximately 189 acres. The smelter is situated less than 1-mile east of the Iron King Mine property. The Humboldt Smelter property is bordered by the Town of Humboldt to the west and north, the Agua Fria River to the east, and the Chaparral Gulch to the south.

The Iron King Mine property includes the following three subordinate properties:

- The Iron King Mine Proper Area, which consists of a large tailings pile and a plant area. In addition, there are 5 retention ponds or impoundments: Main Retention Pond, Pond 40-01A, Pond 40-02A, Pond 100-003F, and Pond 200-5S.
- The Iron King Operations Area, which historically contained at least 11 buildings, including the assay laboratory office, main office, change rooms, and the mechanical room. This property also contains multiple mine shafts, and the former Glory Hole; the latter of which has more recently been used as a landfill.
- The Former Fertilizer Plant Area includes several abandoned buildings, concrete pads, sumps, tanks, and an ore bin.

The Humboldt Smelter property consists of several abandoned buildings, a smelter stack, a tailings pile (763,000 square feet), a smelter ash pile (1,041,200 square feet), and a slag pile (456,000 square feet). On-site ponds, pits, and lagoons were reportedly used for the leaching of minerals from mined ore.

Chaparral Gulch, a natural drainage channel, flows from northwest to southeast along the border of the Iron King Mine property. The gulch crosses under Highway 69, passes through a residential area, and then enters the northeast boundary of the Humboldt Smelter property, flowing through the southwest corner. A tailings dam located on the smelter property within the Chaparral Gulch has retained tailings from both the Iron King Mine and Humboldt Smelter properties. The Chaparral Gulch flows into the Agua Fria River approximately ¼ mile downstream of the Chaparral Gulch dam. The Aqua Fria River also flows from the north to the south along the eastern boundary of the Humboldt Smelter property.

Presently, the full extent of off-site soil contamination and possible ground water contamination has not been assessed. Arsenic and other metals have impacted on-site soil, sediments, surface water, and ground water at concentrations significantly above background levels. The 2006 Expanded Site Inspection revealed arsenic concentrations in ground water ranging from 1.2 parts per billion (ppb) to 306 ppb. The Federal Maximum Contaminant Level for arsenic in public drinking water is 10 ppb. At this point, the data are inconclusive regarding the Site's contribution to the arsenic concentrations detected in ground water samples, due to elevated levels of naturally-occurring arsenic in this area. Additional investigation of the ground water is required to identify possible sources of arsenic contamination.

A Potentially Responsible Party (PRP) lead removal action was completed in 2006 to remove contaminated soil from four off-site residential properties. Staff from EPA's Office of Emergency Response supervised the sampling and removal of the contaminated soil conducted by the PRP's contractor.

Portions of this Site were regulated under the Arizona Department of Environmental Quality (ADEQ)'s Voluntary Remediation Program. In September 2007, EPA received a response from Arizona Governor Napolitano consenting to the placement of the Site on the National Priorities List (NPL). On 19 March 2008, EPA formally proposed the Site to the NPL.

1.2 DESCRIPTION OF PROJECT OBJECTIVES AND TASKS

This section describes the project objectives and tasks for this SAP.

1.2.1 Project Objectives

The primary objectives of the RI/FS are to determine the nature and extent of contamination and to gather sufficient information so that the EPA can select a remedy that eliminates, reduces, or controls risks to human health. Specifically, the RI/FS involves multimedia environmental sampling of the Site AOIs. EA will implement the following key components during the RI/FS for the Site:

- Area Reconnaissance—Reconnaissance activities will be performed for the following purposes:
    - Establish background multimedia sample locations,
    - Establish on- and off-site soil sampling locations,
    - Identify outfalls and surface water pathways and establish surface water/sediment sampling locations,
    - Identify private and municipal drinking wells for tap water sampling,
    - Establish monitoring well locations, and

  - Perform a radiological screening survey.

- Data Collection—During the field program, the following data and samples will be collected:
  - Demonstration of Methods Applicability (DMA) Study to evaluate the effectiveness of field x-ray fluorescence (XRF) analysis over a range of solid matrices,
  - Meteorological data to support the ambient air sampling program,
  - Ambient air samples for inorganic analysis to determine sources and evaluate potential off-site migration of airborne contamination,
  - Surface and subsurface soil samples for nature and extent characterization,
  - Ground water samples from 1 deep (bedrock) and 5 shallow (alluvial) newly-installed monitoring wells,
  - Tap water samples from private and municipal wells,
  - Sediment and surface water samples from the Site waterways, outfalls/washes, and the dam,
  - Sediment and surface water samples from five on-site impoundments at Iron King Mine and retention pond at Humboldt Smelter,
  - Volumetric estimates of the mine tailings,
  - Storm water evaluation of Iron King Mine drainage pathways,
  - Geotechnical testing data from soil borings,
  - Historical Section 106 review,
  - Ecological habitat survey, and
  - Ancillary investigatory activities necessary for the RI/FS.

- Risk Assessment
  - Baseline human health risk assessment (HHRA) to evaluate commercial/industrial, residential, construction worker, recreational, and trespasser exposure scenarios for the five AOIs and additional areas identified during this investigation, as appropriate. AOIs may be further subdivided into individual exposure areas based on the historical use, presence of contaminants, potential reuse, etc. An unrestricted reuse (i.e., residential) exposure scenario will be evaluated for source areas so that a ‘no action’ alternative may be evaluated in the FS.
  - Screening-level and refined screening-level ecological risk assessment (ERA) to characterize and quantify, where appropriate, the current and potential ecological risks that would prevail if no further remedial action is taken. The ERA will also incorporate the habitat survey that will be conducted as part of the field investigation.

- RI Report—RI Report will accurately establish the site characteristics, such as contaminated media, nature and extent of contamination, and the physical boundaries of the contamination for the five AOIs, as well as additional areas identified during the course of the investigation.

- Remedial Alternatives Technical Memorandum—Appropriate remedial alternatives will be developed that will undergo full evaluation, and will establish remedial action objectives (RAOs), general response actions, screening of applicable remedial technologies, development of remedial alternatives, screening of the remedial alternatives for effectiveness, implementability and cost, summarize the alternatives as they relate to applicable or relevant and appropriate requirements, and summarize the screening process in relation to RAOs. Individual alternatives will be assessed against each of the nine criteria and a comparative analysis of options will be performed against the evaluation criteria.

- FS Report—Following screening and evaluation of the remedial alternatives, the FS Report will be prepared to provide a detailed analysis of alternatives and cost-effectiveness analysis.

- Post-RI/FS Support—Technical and administrative support will be provided that is required for preparation of the Proposed Plan and ROD.

- Project Close-out—Necessary activities will be performed to close out the Task Order in accordance with contract requirements.

1.2.2 Project Tasks

To complete the Site RI/FS site activities, EA will perform the following tasks (with subtasks), which are generally outlined in the Task Order SOW (EPA 2008a) and detailed in Sections 2, 3, and 4 of this SAP:

- Project planning and support;
- Community involvement;
- Field investigation/data acquisition;
- Sample analysis;
- Analytical support and data validation;
- Data evaluation;
- Risk assessment;
- RI Report preparation;
- Remedial alternatives screening and evaluation;
- FS Report preparation; and
- Post-RI/FS support.

EA's field activities will be conducted in accordance with this SAP to ensure proper sample management, including accurate chain-of-custody procedures for sample tracking, protective sample packaging techniques, and proper sample preservation techniques, as well as EA's site-specific HSP (EA 2008b) and SMP (EA 2008c). Sample management will be conducted using the EPA-approved Forms II Lite software. Data management will be conducted in accordance with EA's Data Management Plan (DMP; Appendix C to the SMP [EA 2008c]).

EA will perform field-generated waste (e.g., investigation–derived waste [IDW]) characterization and disposal in accordance with local, State, and Federal regulations. EA will also incorporate best management practices of green remediation; whereby solid IDW generated during monitoring well installation and direct-push investigations of source areas (e.g., tailings piles, ash piles, etc.) may be returned to their place of origin to minimize waste generation requiring off-site disposal. Non-source area IDW (e.g., Off-site Soil) and aqueous IDW (e.g., decontamination) will be subject to disposal, as appropriate.

1.3 DATA QUALITY OBJECTIVES

The following sections present the DQOs for this project. Much of the information used to develop DQOs was obtained from the SOW issued by the EPA (2008a) and the EPA-approved Work Plan (EA 2008a). The CUS technical memorandum, which is presented in Appendix A, also forms the basis for the DQO assessment as it functions as the preliminary Conceptual Site Model (CSM). This DQO assessment follows EPA's 7-step DQO process (Table 2), which is outlined in *Guidance on Systematic Planning Using the Data Quality Objectives Process (QA/G-4)* (EPA 2006a) and *Systematic Planning: A Case Study for Hazardous Waste Site Investigations (QA/CS-1)* (EPA 2006b).

Additional information is referenced, as appropriate, in the following sections:

- Section 1.3.1 Purpose and Goal;
- Section 1.3.2 Step 1 – State the Problem;
- Section 1.3.3 Step 2 – Identify the Goal of the Study;
- Section 1.3.4 Step 3 – Identify Information Inputs;
- Section 1.3.5 Step 4 – Define the Boundaries of the Study;
- Section 1.3.6 Step 5 – Develop the Analytical Approach;
- Section 1.3.7 Step 6 – Specify the Performance or Acceptance Criteria; and
- Section 1.3.8 Step 7 – Develop the Plan for Obtaining Data.

1.3.1 Purpose and Goal

The purpose of defining the DQOs for the Site is to support decision making by applying a systematic planning and statistical hypothesis testing methodology to decide between alternatives. The goal was to develop an analytic approach and data collection strategy that was effective and efficient.

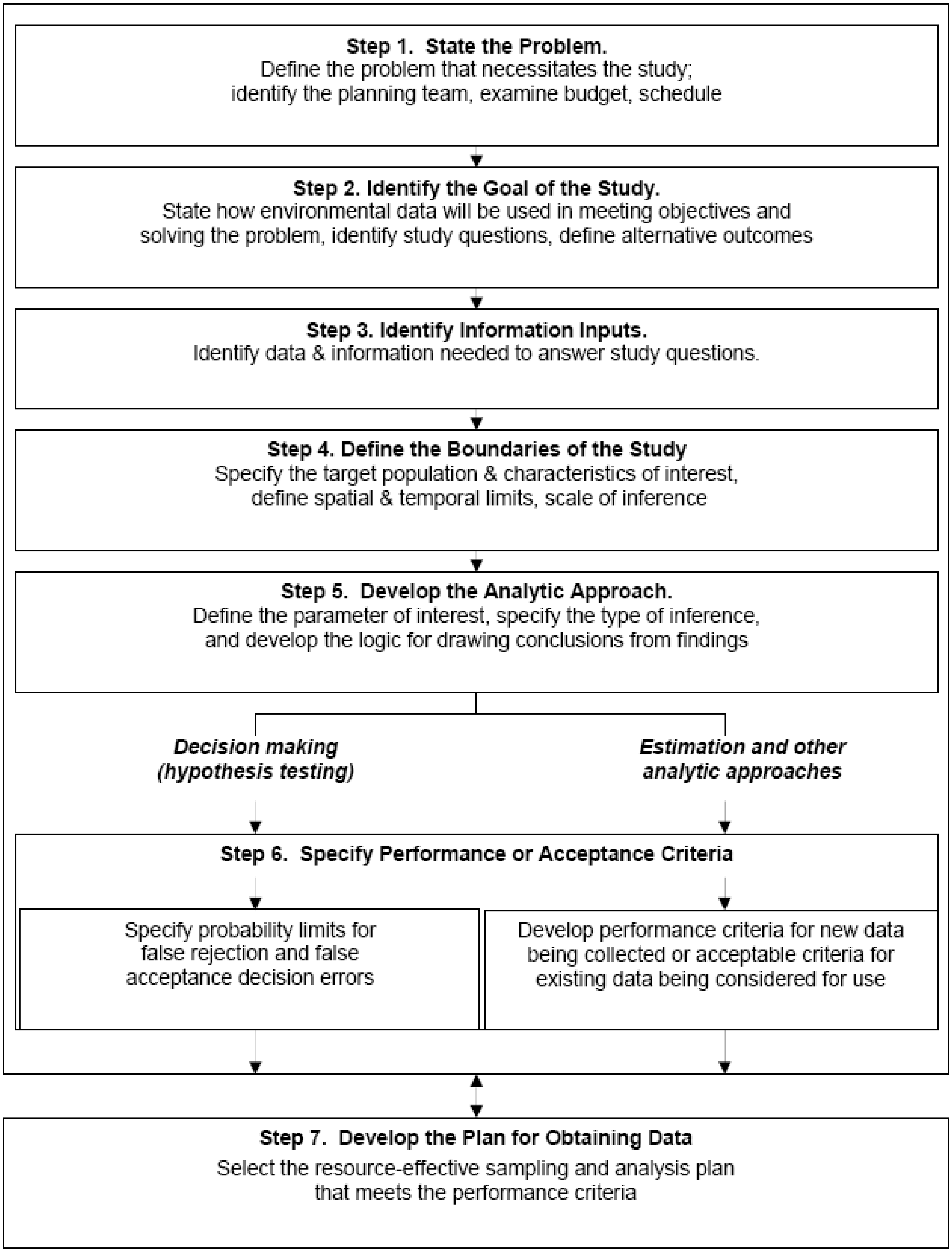
1.3.2 Step 1 – State the Problem

The first step in systematic planning process, and therefore the DQO process, is to define the problem that has initiated the study. As environmental problems are often complex combinations of technical, economic, social, and political issues, it is critical to the success of the process to separate each problem, define it completely, and express it in an uncomplicated format.

The most important activities in DQO Step 1 are as follows:

- Give a concise description of the problem;
- Identify leader and members of the planning team;
- Develop a CSM of the environmental hazard to be investigated; and
- Determine resources (i.e., budget, personnel, and schedule).

TABLE 2 DATA QUALITY OBJECTIVE PROCESS



Step 1. State the Problem.
Define the problem that necessitates the study;
identify the planning team, examine budget, schedule

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

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

Step 4. Define the Boundaries of the Study
Specify the target population & characteristics of interest,
define spatial & temporal limits, scale of inference

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

Step 6. Specify Performance or Acceptance Criteria

Specify probability limits for
false rejection and false
acceptance decision errors

Develop performance criteria for new data
being collected or acceptable criteria for
existing data being considered for use

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

1.3.2.1 Problem Description

The soil at Iron King Mine and Humboldt Smelter has high concentrations of contaminants of potential concern (COPCs) (primarily lead and arsenic) that may be being transported off-site via: (1) surface water runoff to the Waterway AOI; and (2) air particulate migration to the Off-site Soil AOI. It is unknown whether either the Iron King Mine or Humboldt Smelter AOIs are impacting the shallow alluvial or deeper bedrock ground water aquifers. Potential unacceptable risk to human health or ecological receptors as a result of exposure to COPCs in site-related media (i.e., air, soil, sediment, surface water, or ground water) at the five AOIs has not been estimated.

1.3.2.2 Planning Team Members and Stakeholders

A proven effective approach to formulating a problem and establishing a plan for obtaining information that is necessary to resolve the problem is to involve a team of experts and stakeholders that represent a diverse, multidisciplinary background. Such a team provides the ability to develop a concise description of complex problems, and multifaceted experience and awareness of potential data uses. Planning team members (including the leader) and stakeholders are presented below.

Planning Team Members

- Leah Butler, EPA TOM
- David Seter, EPA Alternate TOM
- Sophia Serda, EPA Human Health Risk Assessor
- Ned Black, EPA Ecological Risk Assessor
- Brian Stonebrink, ADEQ Project Manager

Stakeholders

- EPA Region 9 Superfund Division Management
- EPA Headquarters
- EPA’s Lead Sites and Technical Review Workgroups
- United States Bureau of Land Management
- ADEQ Remediation Division
- Arizona Game and Fish Department
- Town of Dewey-Humboldt Management and citizenry
- National Resource Damage Assessment Trustees
- Stephen Schuchardt, President North American Industries
- Clayton Kuhles, Kuhles Capital, LLC
- Warren Kuhles, Greenfields Enterprises
- Terry Nolan, Humboldt Precast
- Other interested parties

If additional planning team members and/or stakeholders are identified as the RI progresses, they will be incorporated into the decision-making process as appropriate.

1.3.2.3 Conceptual Site Model

It is critical to carefully develop an accurate conceptual site model (CSM) of the environmental problem, as this model will serve as the basis for subsequent inputs and decisions.

The soil at Iron King Mine and Humboldt Smelter has high concentrations of COPCs (primarily lead and arsenic) that may be being transported off-site via: (1) surface water runoff to the Waterway AOI; and (2) air particulate migration to the Off-site Soil AOI. It is unknown whether either the Iron King Mine or Humboldt Smelter AOIs are impacting the shallow alluvial or deeper bedrock ground water aquifers.

Historically, the Iron King Mine and Humboldt Smelter were used for mining related or other industrial activities. It is likely, that future reuse will remain commercial or industrial at these two AOIs. However, future reuse that would include construction worker, recreational, trespasser, or residential exposure is possible. The Off-site Soil AOI includes residential or commercial/industrial exposure as appropriate for the designated land use. Potential receptors for the Waterways AOI may include recreationalists or trespassers. Ground water is being used by residents and the municipality for drinking water, so residential and commercial/industrial exposure is likely.

Ecological receptor exposure at the Iron King Mine and Humboldt Smelter is expected to be limited due to the lack of natural resources, habitat, and vegetation. The Galena and Chaparral Gulches provide a more suitable environment for ecological receptors, especially during periods when the gulches retain water. However, the most sensitive and valuable habitat is the Agua Fria River, which contains water throughout the year. Off-site Soil and Ground Water AOIs do not provide a significant exposure for ecological receptors.

Additional details pertaining to the CSM are provided in the CUS Technical Memorandum presented in Appendix A, and are not repeated here for brevity.

1.3.2.4 Determine Resources

Resources should be identified by the planning team so that constraints (e.g., budget, time, etc.) associated with collecting/evaluating data can be anticipated during the project life cycle. To assist in this evaluation, the DQO process (e.g., developing performance or acceptance criteria) and the SAP (i.e., for collecting and analyzing samples, and interpreting and assessing the collected data) should be completed.

EPA has tasked EA to perform the investigation and prepare the deliverables required for the Site RI/FS. EA will utilize the services of the EPA's Region 9 Laboratory or EPA Contract Laboratory Program (CLP), depending on the needs of the RI/FS and the availability of the laboratory's services.

The EPA will perform a review of each required deliverable and provide comments as necessary. EPA will also solicit comments from other planning team members or stakeholders as appropriate. EPA anticipates that a RI/FS Report will be submitted to the EPA prior to 18 May 2009, which is 11 months after the Task Order approval date of 18 June 2008. Additional details pertaining to the schedule of events and deliverables necessary to meet this milestone are provided in the RI/FS Work Plan (EA 2008a).

1.3.3 Step 2 – Identify the Goal of the Study

Step 2 of the DQO process involves identifying the key questions that the study attempts to address, along with alternative actions or outcomes that may result based on the answers to these key questions. These two items are combined to develop a decision statement, which is critical for defining decision performance criteria later in Step 6 of the DQO process.

The most important activities in DQO Step 2 are as follows:

- Identify principal study question(s).
- Consider alternative actions that can occur upon answering the question(s).
- Develop decision statement(s) and organize multiple decisions.

1.3.3.1 Principal Study Question

The principal study question(s) (PSQ) define the question(s) to be answered by the HHRA, ERA, and RI. The PSQs are as follows:

> ***What are the nature and extent of air, soil, sediment, surface water, and ground water contamination at the AOIs?***
>
> ***What are the migration pathways for these contaminants to be transported to other AOIs?***
>
> ***Are concentrations of AOI COPCs significantly greater than background?***
>
> ***What is the potential risk to human health and ecological receptors from exposure to Site related COPCs at the AOIs?***

1.3.3.2 Alternative Actions

The alternative actions provide PSQ alternatives in the FS, as follows. Potential alternative actions, which will be evaluated in the FS, include, but are not limited to, the following:

- Remediate the source areas at Iron King Mine and Humboldt Smelter;

- Restrict access to the Iron King Mine or Humboldt Smelter properties to limit exposure;

- Mitigate the air and surface water migration pathways from the Iron King Mine and Humboldt Smelter;

- Remediate Off-site Soil areas impacted by other AOIs;

- Prevent further migration of COPCs from/within the Waterway AOIs;
- Remove the material from behind the dam located near the confluence of Chaparral Gulch and the Agua Fria River;
- Prevent exposure to COPCs in ground water by installing (point-of-use) filtration systems; and
- Address other migration/exposure pathways impacting receptors by employ engineering or institutional controls.

An Interim Measures Technical Memorandum, which addresses some potential alternative actions, is provided in Appendix B; details of that evaluation are not repeated here for brevity.

1.3.3.3 Decision Statement

For decision-making problems, the PSQs and alternative actions are combined to develop decision statements, which are critical for defining decision performance criteria later in DQO Step 6.

The decision statements are as follows:

> ***Determine the nature and extent of air, soil, sediment, surface water, and ground water contamination at the AOIs.***
>
> ***Determine the migration pathways for these contaminants to be transported to other AOIs.***
>
> ***Determine whether the concentrations of AOI COPCs are significantly greater than background.***
>
> ***Determine if exposure to Site related COPCs at the AOIs pose a potential unacceptable risk to human health and ecological receptors.***

1.3.4 Step 3 – Identify Information Inputs

Step 3 of the DQO process determines the types and sources of information needed to resolve: (1) the decision statement or produce the desired estimates; (2) whether new data collection is necessary; (3) the information basis the planning team will need for establishing appropriate analysis approaches and performance or acceptance criteria; and (4) whether appropriate sampling and analysis methodology exists to properly measure environmental characteristics for addressing the problem.

The most important activities in DQO Step 3 are as follows:

- Identify types and sources of information needed to resolve decisions or produce estimates;

- Identify the basis of information that will guide or support choices to be made in later steps of the DQO process; and

- Select appropriate sampling and analysis methods for generating the information.

The EPA RI/FS SOW (EPA 2008a) and EPA approved Work Plan (EA 2008a) sets forth the framework and requirements for this effort.

1.3.4.1 Necessary Information and Sources

A variety of sources and types of information form the basis for resolving the decision statements. The following information and sources are necessary to resolve this step of the DQO process.

The decision statements are supported by the following:

Determine the nature and extent of air, soil, sediment, surface water, and ground water contamination at the AOIs.

- A Historical Section 106 review will be conducted for the Iron King Mine and Humboldt Smelter to identify historic properties, assess adverse effects on identified historic properties, resolve any adverse effects, and consult with the public throughout the Section 106 Review process.

- An evaluation of previous investigation data will shape the field investigation by narrowing or broadening the data needs. A preliminary data quality assessment was conducted (see Worksheet #13 in Appendix C). These data will be subject to further evaluation, when available electronically, in the Remedial Investigation.

- Additional air, soil, sediment, surface water, and ground water data for the five AOIs will be collected to augment the historical dataset.

- Geologic and hydrogeologic information (e.g., soil borings, new monitoring wells, etc.) coupled with physical/chemical property data will be collected to evaluate the Iron King Mine and Humboldt Smelter impacts to the shallow alluvial and deeper bedrock aquifers.

Determine the migration pathways for these contaminants to be transported to other AOIs.

- A weather station will be constructed at the Site to collect meteorological data for the evaluation of off-site migration of airborne particulates from the Iron King Mine and Humboldt Smelter to Off-site Soil.

- An evaluation of the surface water transports will be conducted to aid in understanding the transport of contamination via surface water flow from the Iron King Mine and Humboldt Smelter to the adjoining waterways.

- An evaluation of source material leaching to ground water will evaluated by the collection of synthetic precipitation leaching procedure and geotechnical data.

Determine whether the concentrations of AOI COPCs are significantly greater than background.

- Geology and media data will be collected to evaluate the potential anthropogenic contributions of contaminants above background.

Determine if exposure to Site related COPCs at the AOIs pose a potential unacceptable risk to human health and ecological receptors.

- An ecological habitat survey will be conducted to narrow or broaden the potential receptors of concern at the Site.

1.3.4.2 Basis of Information

The basis of information will guide or support choices to be made in later steps of the DQO process.

The basis of information is supported by the following:

Determine the nature and extent of air, soil, sediment, surface water, and ground water contamination at the AOIs.

- During the RI field program, EA will oversee subcontractor performance of a historical properties review in accordance with Section 106 of the National Historic Preservation Act (NHPA 1966).

- For the Iron King and Humboldt Smelter properties, Visual Sample Plan Version 5.0 (Pacific Northwest National Laboratory 2007) was used to establish a virtual random-start systematic grid for selecting systematic random samples (see Appendix E). Biased or judgmental sample locations will be based on evaluation of historical data, photographs, or visual cues.

- An evaluation of previous investigation data will utilize EPA guidance documents including, but not limited to: Guidance for Data Usability in Risk Assessment (EPA 1992); Data Quality Assessment - Statistical Methods for Practitioners (EPA 2006d); Guidance for Data Quality Assessment (EPA 2000b); Guidance on Systematic Planning Using the Data Quality Objectives Process (EPA 2006a).

- Geologic and hydrogeologic information (e.g., soil borings, new monitoring wells, etc.) coupled with physical/chemical property data will be collected to evaluate the Iron King Mine and Humboldt Smelter impacts to the shallow alluvial and deeper bedrock aquifers.

Determine the migration pathways for these contaminants to be transported to other AOIs.

- The Interim Final Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (EPA 1988) describes the process for evaluating migration pathways.

Determine whether the concentrations of AOI COPCs are significantly greater than background.

- Statistical approaches, including the background evaluation, will be consistent with EPA guidance, including, but not limited to: ProUCL 4.0 User Guide (Singh, Singh, and Maichle 2007); EPA Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites (EPA 2002b); and Role of Background in CERCLA Cleanup Program (EPA 2002e).

Determine if exposure to Site related COPCs at the AOIs pose a potential unacceptable risk to human health and ecological receptors.

- A HHRA will be conducted in accordance with the EPA's guidance which includes, but is not limited to:
    - Risk Assessment Guidance for Superfund (RAGS), Volume I: Human Health Evaluation Manual (EPA 1989);
    - EPA's Superfund Lead-Contaminated Residential Sites Handbook (June 2003b);
    - RAGS for Superfund Volume I: Human Health Evaluation Manual. Supplemental Guidance: Standard Default Exposure Factors (EPA 1991);
    - RAGS, Volume I, Human Health Evaluation Manual, Part D, Standardized Planning, Reporting, and Review of Superfund Risk Assessments (EPA 2001b);
    - Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites (EPA 2002c);
    - Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites, Interim Guidance (EPA 2002d); and
    - RAGS, Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) (EPA 2004a).
- A Screening Level ERA will be conducted in accordance with the EPA's guidance which includes, but is not limited to:
    - RAGS, Volume II: Environmental Evaluation Manual (EPA 1997a); and
    - Ecological RAGS: Process for Designing and Conducting Ecological Risk Assessments (EPA 1997b, 1999).

To determine the nature and extent of contamination at the Site, an extensive field investigation has been proposed to collect air, soil, sediment, surface water, and ground water data. Details pertaining to this effort are contained in Section 2.0 and will not be repeated here for brevity.

1.3.4.3 Sampling and Analysis Methods

An extensive field investigation has been proposed to collect air, soil, sediment, surface water, and ground water data. Details pertaining to this effort are contained in Section 2.0 and will not be repeated here for brevity.

1.3.5 Step 4 – Define the Boundaries of the Study

In Step 4 of the DQO process, the target population of interest and spatial/temporal features pertinent for decision making should be identified. The most important activities in DQO Step 4 are as follows:

- Define the target population of interest.
- Specify temporal or spatial boundaries and other practical constraints associated with sample/data collection.

1.3.5.1 Target Population

Five AOIs (Iron King Mine, Humboldt Smelter, Waterways, Ground Water, and Off-site Soil) were identified for the Site. These AOIs were further subdivided into subordinate properties or potential exposure areas as described in Section 1.1.2. These subdivisions were based on historic use, potential future reuse, potential regulatory issues, or other factors that were identified after reviewing historical documents and data included in previous studies.

The target population consists of soil, sediment, surface water, ground water, and air in proximity to the five AOIs. The following descriptions of the target population are segregated by media below.

Generally soil is not considered mobile because ground cover or vegetation often precludes migration. However, large portions of the Iron King Mine and Humboldt Smelter AOIs are denuded or are subject to particulate and/or storm water migration. Although these factors can lead to a slight temporal aspect to characterization, soil is not considered to be mobile enough to have a significant temporal aspect. The distribution of soil is from the surface to either: the bottom of impacted soil, native soil below source material, or to 10-feet bgs, which is generally considered the deepest depth interval for risk assessment.

Sediment in the Waterways and adjoining properties are considered mobile during heavy rain events. The fine grain materials are routinely subject to storm water migration and may be transported some distance from the source. Therefore, a minor temporal aspect to the concentration of sediments in a particular location may occur over time. The distribution of sediments in the Waterways is thought to be from several inches to several feet thick in most areas. However, the sediments behind the dam near the confluence of Chaparral Gulch and Agua Fria River are thought to be tens of feet thick. Typically sediments are contained within the banks of the waterway are often have higher deposition rates near bends or where surface water flow is reduced.

Surface water in the Waterways and adjoining properties is highly mobile, especially during heavy rain events. The residence time for surface water is expected to be short because surface water runoff is high and soil retention, due to the sandy substrate, is low. Surface water has a high temporal aspect and is dependent on the entrained material (e.g., sediments) which can be transported long distances in surface water. Sampling will occur during the monsoon season when likelihood of encountering surface water is much higher.

Ground water is found in the upper alluvial and deeper bedrock aquifers in the vicinity of the Site. The mobility of ground water is unknown because it is dependent on preferential pathways, the type of aquifer (e.g., alluvial or bedrock), and other site-specific parameters. For example, the ground water beneath the tailings material, which is considered alluvial ground water, may be more or less mobile than the deeper bedrock aquifer. Nevertheless, both aquifers are likely to have a temporal aspect related to season, when infiltration, water usage, or other factors vary.

Air concentrations in the vicinity of the Site are affected by humidity, soil concentrations, topography, soil surface conditions, soil moisture content, wind speed, wind direction, and various other factors. Therefore, air concentrations are expected to have a high temporal aspect. Generally, air concentrations are expected to be highest during high wind events when the weather has been dry for extended periods of time and when soil particulate migration is greater; this typically occurs from March through May, but can vary from season to season. The boundaries for air are larger than for other media because of the potential for increased migration. However, for this evaluation, air in the vicinity of the Site is of paramount importance because air concentrations are expected to be higher near the Site source areas and because there are human health receptors immediately downwind of the Site.

1.3.5.2 Temporal or Spatial Boundaries

The horizontal study boundary for the Site RI/FS includes five AOIs discussed in Section 1.1.2:

- Iron King Mine – The Iron King Mine Proper Area, Iron King Operations Area, Former Fertilizer Plant Area, and ancillary associated properties;
- Humboldt Smelter and ancillary associated properties;
- Off-site Soil in the vicinity of the Site;
- Waterways - Including the Chaparral Gulch, Galena Gulch, Aqua Fria River, and adjoining drainage channels and outfalls; and
- Ground Water - Shallow alluvial and deep bedrock ground water.

This investigation will evaluate the five AOIs and additional areas identified during this investigation, as appropriate. It is likely that these AOIs will be further subdivided into individual exposure areas based on the historical use, presence of contaminants, potential reuse, available receptors, etc.

The Site is located in a mountainous region of Arizona and has an average high temperature of approximately 50-degrees Fahrenheit (F) in the winter and 90-degrees F in the summer. The wind direction tends to come from the south-southwest and is slightly calmer during the summer months. Precipitation tends to fall during the monsoon season (i.e., July and August) and again during the winter (e.g., December). Because of this variation, there is a temporal aspect to exposure and migration of site contaminants. Exposure to site-related contaminants will tend to be greater during the summer when receptors are more active. Off-site migration of air-borne particulates may tend to be lower in the summer months, when average wind speeds are decreased. However, off-site migration of contaminated soil and water would likely be higher during the summer monsoon season. These temporal variances are considered minor and are not considered a significant source of uncertainty.

1.3.6 Step 5 – Develop the Analytical Approach

Step 5 of the DQO process involves developing an analytic approach that will guide how to analyze the study results and draw conclusions from the data. It is the intention of this step to integrate the outputs from the previous four steps with the parameters developed in this step.

The most important activities in DQO Step 5 are as follows:

- Specify the appropriate population parameters for making decisions.
- Choose a workable action level and generate an "If … then … else" decision rule which involves it.

The air monitoring DQOs are provided in the Air Quality Monitoring Plan (see Appendix D).

1.3.6.1 Population Parameters

The population parameter is defined as the value used in the decision statement to evaluate a decision point. The population parameter will be used as an exposure point concentration in the HHRA and Screening Level ERA. A population parameter will be determined for each chemical (e.g., arsenic); in each exposure area (e.g., Small Tailings Pile); for each sample group (e.g., surface soil from 0 to 2-feet below ground surface [bgs]). In this example, the population is arsenic in Small Tailings Pile surface soil from 0 to 2-feet bgs. The population parameter for site comparisons will be the 95% Upper Confidence Limit of the Mean (95UCLM), which will be calculated using ProUCL version 4.0 (Singh, Singh, and Maichle 2007), or the maximum detected concentration if lower.

Background statistical evaluations for soil, ground water, surface water, and sediment will also be conducted. Two-population tests will be used to determine if an exposure area is significantly greater than background. Also, background level threshold values (BTV) may be used to evaluate some datasets (e.g., property specific Off-site Soils).

1.3.6.2 Action Level Decision Rule

The action levels for the Site will likely be either: (1) risk-based screening criteria developed during the HHRA or Screening Level ERA; or (2) site-specific background concentrations (i.e., BTVs). Site-specific background concentrations will be developed during the course of the investigation.

The following risk-based screening criteria were used to evaluate whether analytical data will be of sufficient quality for risk assessment (see Worksheet #15 of Appendix C).

Human Health

- Soil or Sediment – Residential and Industrial Regional Screening Levels for Chemical Contaminants at Superfund Sites (Oak Ridge National Laboratory [ORNL] 2008); and
- Surface Water or Ground Water – Tap Water Screening Levels for Chemical Contaminants at Superfund Sites (ORNL 2008) or Maximum Contaminant Levels (EPA 2008b).

Ecological

- Soil – EPA Ecological Soil Screening Levels; ORNL Preliminary Remediation Goals (PRG);
- Sediment – Threshold Effects Levels; Effects Range – Low; Sediment Quality Benchmarks based on Equilibrium Partitioning;
- Surface Water - ORNL PRGs.

As observed by the comparisons in Appendix C Worksheet #15, there are several analyte sample quantitation limits that are greater than their respective risk-based screening values. If these analytes are not detected in an exposure area and sample quantitation limits are greater than risk-based values, then they may be a source of potential risk underestimation or additional sampling may be conducted to mitigate the uncertainty.

The decision rule for the Site is as follows:

- If Site concentrations are not significantly greater than background and are less than risk based criteria, then the remedial actions are generally not recommended;
- Else, if Site concentrations are significantly greater than background or greater than risk based criteria, then a risk evaluation is generally recommended.

1.3.7 Step 6 – Specify the Performance or Acceptance Criteria

Step 6 of the DQO process specifies the tolerable limits on decision errors. Data are subject to various types of errors (e.g., how samples were collected, how measurements were made, etc.). As a result, estimates or conclusions that are made from the collected data may deviate from what is actually true within the population. Therefore, there is a chance that an erroneous conclusion could be made or that the uncertainty in the estimates will exceed what is acceptable.

The performance or acceptance criteria for collected data will be derived to minimize the possibility of either making erroneous conclusions or failing to keep uncertainty in estimates to within acceptable levels. Performance criteria and QA practices will guide the design of new data collection efforts. Acceptance criteria will guide the design of procedures to acquire and evaluate existing data.

The most important activities in DQO Step 6 are as follows:

- Recognizing the total study error and devising mitigation techniques to limit error.
- Specify the decision rule as a statistical hypothesis test, examine consequences of making incorrect decisions from the test, and place acceptable limits on the likelihood of making decision errors.

1.3.7.1 Total Study Error

Even though unbiased data collection methods may be used, the resulting data will still be subject to random and systematic errors at different stages of the collection process (e.g., from field sample collection to sample analysis). The combination of these errors is called the "total study error" (or "total variability") associated with the collected data. There can be many contributors to total study error, but there are typically two main components, sampling error and measurement error.

Sampling Error

Sampling error, sometimes called statistical sampling error, is influenced by the inherent variability of the population over space and time, the sample collection design, and the number of samples collected. It is usually impractical to measure the entire population space, and limited sampling may miss some features of the natural variation of the measurement of interest. Sampling design error occurs when the data collection design does not capture the complete variability within the population space, to the extent appropriate for making conclusions. Sampling error can lead to random error (i.e., random variability or imprecision) and systematic error (bias) in estimates of population parameters. In general, sampling error is much larger than measurement error and consequently needs a larger proportion of resources to control.

Measurement Error

Sometimes called physical sampling error, measurement error is influenced by imperfections in the measurement and analysis protocols. Random and systematic measurement errors are introduced in the measurement process during physical sample collection, sample handling, sample preparation, sample analysis, data reduction, transmission, and storage.

The potential for measurement error will be mitigated by using accurate measurement techniques. As described in Sections 2.3 and 2.4, sampling techniques were selected to limit the measurement error, including the following:

- Sample collection procedures, sample processing, and field sample analysis protocols are fairly standard. This will ensure that the methodology remains consistent and limits the potential for measurement error.

- Field teams will be trained and will perform specific tasks (e.g., sample collection or processing) throughout the field sampling effort to limit the potential for measurement error.

- Potential for measurement error in the sample analysis will be limited by the analysis of QC samples (e.g., duplicates), as described in Sections 1.3.2 through 1.3.4.

- Data management procedures, which are outlined in the DMP (Appendix C of the SMP [EA 2008c]), will limit the potential for data reduction, transmission, and storage errors.

1.3.7.2 Statistical Hypothesis Testing and Decision Errors

Decision-making problems are often transformed into one or more statistical hypothesis tests that are applied to the collected data. Data analysts make assumptions on the underlying distribution of the parameters addressed by these hypothesis tests, in order to identify appropriate statistical procedures for performing the chosen statistical tests.

Due to the inherent uncertainty associated with the collected data, the results of statistical hypothesis tests cannot establish with certainty whether a given situation is true. There will be some likelihood that the outcome of the test will lead to an erroneous conclusion (i.e., a decision error).

When a decision needs to be made, there are typically two possible outcomes: either a given situation is true, or it is not. Although it is impossible to know whether an outcome is really true, data are collected and statistical hypothesis testing is performed to make an informed decision. In formulating the statistical hypothesis test, one of the two outcomes is labeled the "baseline condition" and is assumed to represent the *de facto*, true condition going into the test, and the other situation is labeled the "alternative condition." The baseline condition is retained until the information (data) from the sample indicates that it is highly unlikely to be true.

The statistical theory behind hypothesis testing allows for defining the probability of making decision errors. However, by specifying the hypothesis testing procedures during the design phase of the project, the performance or acceptance criteria can be specified.

There are four possible outcomes of a statistical hypothesis test. Two of the four outcomes may lead to no decision error; there is no decision error when the results of the test lead to correctly adopting the true condition, whether it is the baseline or the alternative condition. The remaining two outcomes represent the two possible decision errors. The first is a false rejection decision error, which occurs when the data leads to decision that the baseline condition is false when, in reality, it is true. The second is a false acceptance decision error, which occurs when the data are insufficient to change the belief that the baseline condition is true when, in reality, it is false.

In the statistical language of hypothesis testing, the baseline condition is called the "null hypothesis" (H_o) and the alternative condition is called the "alternative hypothesis" (H_a). A false rejection decision error, or a Type I error, occurs when you reject the null hypothesis when it is actually true. The probability of this error occurring is called alpha (α) and is called the hypothesis test's level of significance. A false acceptance decision error, or a Type II error, occurs when you fail to reject the null hypothesis when it is actually false. The probability that this error will occur is called beta (β). Frequently, a false rejection decision error is the more severe decision error, and therefore, criteria placed on an acceptable value of alpha (α) are typically more stringent than for beta (β). Statisticians call the probability of rejecting the null hypothesis when it is actually false the statistical power of the hypothesis test. Statistical power is a measure of how likely the collected data will allow you to make the correct conclusion that the alternative condition is true rather than the default baseline condition and is a key concept in determining DQOs for decision-making problems. Note that statistical power represents the probability of "true rejection" (i.e., the opposite of false acceptance) and, therefore, is equal to $1-\beta$.

Decision errors can never be totally eliminated when performing a statistical hypothesis test. However, the primary aim of this step is to arrive at the upper limits on the probabilities of each of these two types of decision errors that the planning team finds acceptable.

Background Evaluation

Inorganics in soil, sediment, surface water, and ground water will be subject to a background evaluation to determine whether Site concentrations are significantly greater than background. Two-population tests will be used to determine if an exposure area is significantly greater than background. Because the Site is heavily impacted by inorganics (i.e., lead and arsenic), the null hypothesis is the mean concentration of a contaminant does exceed (i.e., is greater than or equal to) the mean background concentration and the alternative hypothesis is the mean concentration does not exceed the mean background concentration as follows:

H_o = Mean Media Analyte Concentration $\geq$ Mean Media Analyte Background

H_a = Mean Media Analyte Concentration < Mean Media Analyte Background

Also, BTVs may be used to evaluate some datasets (e.g., property specific Off-site Soils). The null hypothesis is the mean concentration of a contaminant does exceed (i.e., is greater than or equal to) the action level or background dataset and the alternative hypothesis is the mean concentration does not exceed the action level as follows:

H_o = Mean Media Analyte Concentration $\geq$ Action Level

H_a = Mean Media Analyte Concentration < Action Level

For the statistical evaluations conducted for the Site, the probability of a Type I error occurring will be established at 5 percent and a Type II error will be established at 10 percent.

The Type I error rate was set more conservatively because this type of error would result in finding the site uncontaminated when it actually was contaminated. Type I error is considered more serious than Type II error because it would leave contamination in place for continuing exposure to receptors. By comparison, a higher Type II error rate of 10 percent was tolerable because this type of error would result in considering the site contaminated when it is actually not contaminated.

1.3.8 Step 7 – Develop the Plan for Obtaining Data

In the Steps 1 through 6 of the DQO process, performance or acceptance criteria were developed. The goal of Step 7 is to develop a resource-effective sampling design for collecting and measuring environmental samples, or for generating other types of information needed to address the PSQ. In addition, this sampling design will lead to data that will achieve the performance and acceptance criteria.

The most important activity in DQO Step 7 is as follows:

- Use the information from Steps 1 through 6 of the DQO process to identify a sampling and analysis design that will answer the PSQ and achieve the performance or acceptance criteria.

Normally, this step would require compiling a few different sampling and analysis designs, which could be evaluated to determine the best approach to answer the PSQ and achieve the performance or acceptance criteria. However, the sampling and analysis design was largely dictated by the SOW issued by EPA on 3 March 2008 (EPA 2008a); the scoping meeting that was conducted on 10 March 2008; the site visit that was conducted on 19 March 2008; the negotiation meetings conducted on 12 and 14 May 2008; the comments received from EPA via e-mail dated 14 May 2008; the EPA-approved EA Work Plan dated 22 May 2008 (EA 2008a); and subsequent conference calls and E-mail correspondence.

Visual Sample Plan

A random-start systematic sampling approach using Visual Sample Plan (VSP) Version 5.0 will be used to select some sample locations. A nonparametric distribution was assumed because environmental data typically do not exhibit a normal distribution in smaller datasets. The equation used to calculate the number of sample locations was based on a Wilcoxon Signed Ranks test (see Appendix E).

VSP can provide a statistical output based on the comparison of two populations (e.g., Site versus background) or based on the comparison of a population against a fixed value (e.g., background level or screening level). Because much of the Site is highly impacted, it was determined that comparing the Site population against a fixed value (i.e., background) would be appropriate. This is the same approach that was used at two EPA Region 6 Superfund Sites (i.e., Petro-Chemical Systems, Inc. Superfund Site and Many Diversified Interests Superfund Site).

Arsenic and lead were the most widespread contaminants of potential concern in historic samples. Because arsenic is more potentially deleterious, it was chosen for the VSP evaluation. The following locations were used to determine the average background concentration (21.6 mg/kg) and standard deviation (5.84 mg/kg): IK-S16, IK-S17, IK-S30, IK-S31, IK-SB16, IK-SB17, 01-BG-0, and 01-BG-1.5. Background locations HS-47SS and HS-48SS were not selected because their respective concentrations (63 mg/kg and 53.7 mg/kg) were significantly higher than the remaining background dataset, which may indicate that they originate from a different background population. The average and standard deviation were then used to determine the appropriate number of random sample locations using VSP.

VSP used a systematic sampling approach to discern a difference of 1 to 2 standard deviations between a mean arsenic concentration and its background value; this "gray region" is the concentration range in which site decisions cannot be made at the specified Type I or Type II error rates. The smaller the tolerable gray region, the greater the numbers of samples that are required. A gray region of less than 1 standard deviation are more difficult to resolve unless a larger number of measurements are available and relative differences of more than three standard deviations are easier to resolve, but may lack statistical robustness (EPA 2002b and Pacific Northwest National Laboratory 2007). Therefore the use of 1 to 2 standard deviations for the gray region was considered appropriate for the Site.

A virtual random-start systematic sampling approach using VSP (Pacific Northwest National Laboratory 2007) was used to establish the random sample locations for the Iron King Mine and Humboldt Smelter AOIs. These AOIs were further subdivided into areas/subareas based on historical use, contaminant characteristics, or potential regulatory differences. The VSP evaluations are contained in Appendix E.

- Iron King Mine – Iron King Operations Area, Glory Hole, Iron King Proper Area, Small Tailings Pile; and Former Fertilizer Plant; and
- Humboldt Smelter – Tailings Pile, Ash Pile, Black Slag Pile, and entire property.

Biased or Judgmental Samples

The soil, sediment, and surface water sampling approach also contains biased or judgmental samples. Soil samples will be biased toward impacted areas using historical site evidence (e.g., photographic documentation, previous sampling results, etc.). Sediment and surface water samples will be collected from areas with higher sediment deposition or where surface water is present. This does introduce bias and potential sampling error; however, the bias is likely to increase the sample concentration, which will likely result in a more protective remedial decision. Sampling error that is considered more protective of human health or the environment is acceptable for this evaluation.

Additional details pertaining to the sampling and analysis design are detailed throughout this document and will not be repeated here for brevity.

Soil Sampling Strategy Summary

The soil sampling strategy for the Site includes both randomly selected sample locations using VSP and biased or judgmental sample locations. The biased or judgmental samples were selected based on historic activities, historic data, visual field cues, or other ancillary information. New data will be combined with the historic dataset to evaluate the nature and extent of contamination in the Remedial Investigation. Only historic data suitable for risk assessment will be combined with the new data to evaluate potential unacceptable risk for ecological and human health receptors. A summary of the randomly selected and biased or judgmental samples is provided on Table 6.

1.4 QUALITY ASSURANCE OBJECTIVES FOR MEASUREMENT DATA

A well-defined QA/QC process is integral to the generation of analytical data of known and documented quality. The QC process includes those activities required during data collection to produce data of sufficient quality to support the decisions that will be made based on the data (e.g., decisions to be made prior to, during, and after site remedial actions) (EPA 2006a). After environmental data are collected, QA activities focus on evaluating the quality of the data in order to determine the data usability with respect to support for remedial or enforcement decisions. Table 3 presents the acceptance criteria for definitive on-site and off-site laboratory data for chemical analyses of investigation samples only.

1.4.1 Data Categories

In order to produce data suitable for decision-making, an appropriate analytical technique must be selected. The EPA Superfund program has developed two descriptive categories of analytical techniques: (1) field-based techniques; and (2) fixed-laboratory techniques. The type of data generated depends on the qualitative and quantitative DQOs developed for a project. Regardless of whether the data was analyzed utilizing field or laboratory techniques, it must be of adequate quality for the decision-making process for which it was collected. For this project, data from both types of techniques will be collected. Section 2 discusses the methods that will be used to analyze the samples. Both field-based and definitive analytical data will be used to support decisions made for this project.

Rigorous analytical methods (e.g., EPA CLP methods) are used to generate analyte-specific, definitive data. The definitive quality of the data is assured by: (1) using Standard Operating Procedures (SOP) and QC processes during data collection; (2) documented control and traceability of reference standards, calibrations, and instrument performance; and (3) acceptable performance of field and laboratory QC procedures within the defined limits established for these procedures.

TABLE 3 QUALITY ASSURANCE INDICATOR CRITERIA

Indicator Parameter	Analytical Parameter [b]	QC Sample	Acceptance Criteria for Laboratory Analysis
Accuracy (percent recovery)	VOCs, SVOCs, pesticides, dioxins	MS, MSD Blanks	50 to 150 percent recovery Less than CRQL
	TAL Metals and cyanide	MS LCS Blanks [a]	75 to 125 percent recovery 80 to 120 percent recovery Less than CRDL
	Field-based XRF (metals)	Teflon ™ blank Standard	Less than the MDL 90 to 100 percent recovery
Precision (RPD)	VOCs, SVOCs, pesticides, dioxins	MS, MSD Field duplicates	30 percent RPD 50 percent RPD
	Metals and cyanide	MS, MD Field duplicates	20 percent RPD (aqueous) 35 percent RPD (solid) 50 percent RPD

Indicator Parameter	Analytical Parameter [b]	QC Sample	Acceptance Criteria for Laboratory Analysis
	Field-based XRF (metals)	Field duplicates	50 percent RPD
Sensitivity (quantitation limits)	Analytical tests	MS, MD, MSD Field duplicates	Not applicable
Completeness	The objective for data completeness is 90 percent.		
Representativeness	The sampling network analytical methods for this site are designed to provide data that are representative of site conditions.		
Comparability	The use of standard published sampling and analytical methods, and the use of QC samples, will ensure data of known quality. These data can be compared to other data of known quality.		

Notes:

[a] May include method blanks, reagent blanks, instrument blanks, calibration blanks, and other blanks collected in the field (such as field blanks)

b EPA approved methods and quality assurance indicator criteria are provied in Appendix C.

CRDL = Contract-required detection limit
CRQL = Contract-required quantitation limit
LCS = Laboratory control sample
MD = Matrix duplicate
MDL = Method detection limit
MS = Matrix spike
MSD = Matrix spike duplicate
QC = Quality control
RPD = Relative percent difference
SVOC = Semivolatile organic compound
TAL = Target analyte list
VOC = Volatile organic compound
XRF = X-ray fluorescence.

The majority of the fixed-laboratory analysis for samples collected during the RI/FS sampling event will be conducted by the EPA Region 9 Laboratory and/or an EPA-designated CLP laboratory. A subcontracted, non-CLP laboratory will provide the following analytical support:

- Total suspended particulates (TSP), particulate matter less than 10 microns (µm) in diameter (PM-$_{10}$), and inorganics in ambient air samples;
- Arsenic and lead speciation in soil/source samples;
- Dioxins in soil/source samples;
- Personal air samples for TSP and metals to evaluate worker protection;
- Baseline and follow-up blood-lead screening in a clinical setting to evaluate worker protection; and
- Geotechnical testing of soil/source samples.

EPA approved methods and quality assurance indicator criteria are provided in Appendix C.

1.4.2 Measurement Quality Objectives

Soil analytical results will be evaluated in accordance with precision, accuracy, representativeness, completeness, and comparability (PARCC) parameters to document the quality of the data and to ensure that the data are of sufficient quality to meet the project objectives. Of these PARCC parameters, precision and accuracy will be evaluated quantitatively by collecting the QC check samples listed in Table 3.

The sections below describe each of the PARCC parameters and how they will be assessed within this project.

1.4.2.1 Precision

Precision is the degree of mutual agreement between individual measurements of the same property under similar conditions. Usually, combined field and laboratory precision is evaluated by collecting and analyzing field duplicates and then calculating the variance between the samples, typically as a relative percent difference (RPD).

RPD is calculated as follows:

$$\mathrm{RPD} = \frac{|\mathrm{A} - \mathrm{B}|}{(\mathrm{A} + \mathrm{B})/2} \times 100\%$$

where: A = first duplicate concentration
B = second duplicate concentration

Field sampling precision is evaluated by analyzing field duplicate samples. For every 10 samples collected, one soil blind duplicate sample will be collected. Field measurements will be collected using the field-portable XRF analyzer. The XRF analyzer will be calibrated each day following manufacturer recommendations prior to, and following daily field use (see Section 2.12.1). If calibration readings deviate 20 percent or more from the concentration of the calibration standard, the unit will be recalibrated.

Laboratory analytical precision is evaluated by analyzing laboratory duplicates (also called matrix duplicates [MDs]) or matrix spikes (MSs) and matrix spike duplicates (MSDs). For this project, MS/MSD and MS/MD samples will be generated for analytes. The results of the analysis of each MS/MSD or MS/MD pair will be used to calculate the RPD as a measure of lab precision. In addition, laboratory control spikes and laboratory control spike duplicates are also used for laboratory precision. The RPD acceptance criteria are listed in Table 3.

1.4.2.2 Accuracy

A program of sample spiking will be conducted to evaluate laboratory accuracy. This program includes analysis of the MS and MSD samples, laboratory control spikes (LCSs) or blank spikes, surrogate standards, and method blanks. MS and MSD samples will be prepared and analyzed at a frequency of 5 percent for soil samples. LCSs or blank spikes are also analyzed at a frequency of 5 percent. Surrogate standards, where available, are added to every sample analyzed for inorganic constituents. The results of the spiked samples are used to calculate the percent recovery for evaluating accuracy.

$$\text{Percent Recovery} = \frac{S - C}{T} \times 100\%$$

where: S = measured spike sample concentration
C = sample concentration
T = true or actual concentration of the spike

The objective for accuracy of field measurements is to achieve and maintain factory specifications for the field equipment. The field-portable XRF analyzer will be calibrated using calibration standards at the start, midpoint, and end of each field day.

1.4.2.3 Representativeness

Representativeness expresses the degree to which sample data accurately and precisely represent the characteristics of a population, variations in a parameter at a sampling point, or an environmental condition that they are intended to represent. For this project, representative data will be obtained through careful selection of sampling locations and analytical parameters. Representative data will also be obtained through proper collection and handling of samples to avoid interference and minimize contamination.

Representativeness of data will also be ensured through the consistent application of established field and laboratory procedures. Field blanks (if appropriate) and laboratory blank samples will be evaluated for the presence of contaminants to aid in evaluating the representativeness of sample results. Data determined to be non-representative, by comparison with existing data, will be used only if accompanied by appropriate qualifiers and limits of uncertainty.

1.4.2.4 Completeness

Completeness is a measure of the percentage of project-specific data that are valid. Valid data are obtained when samples are collected and analyzed in accordance with QC procedures outlined in this SAP, and when none of the QC criteria that affect data usability are exceeded. When data validation is completed, the percent completeness value will be calculated by dividing the number of useable sample results by the total number of sample results planned for this investigation.

As discussed further in Section 4.2, completeness will also be evaluated as part of the data quality assessment process (EPA 2006c; 2006d). This evaluation will help determine whether limitations are associated with the decisions to be made based on the data collected.

1.4.2.5 Comparability

Comparability expresses the confidence with which one data set can be compared with another. Comparability of data will be achieved by consistently following standard field and laboratory procedures and by using standard measurement units in reporting analytical data. Standard EPA analytical methods and QC will be used to support the comparability of analytical results with those obtained in other testing. Calibrations will be performed in accordance with EPA or manufacturer's specifications and will be checked with the frequency specified in the EPA CLP SOW(s).

1.4.3 Detection and Quantitation Limits

The analytical parameters and their quantitation limits for use on this project are determined under the EPA CLP SOW(s). The Contract-required Detection Limit (CRDL) is the minimum concentration of an analyte that can be reliably distinguished from background noise for a specific analytical method. The quantitation limit represents the lowest concentration of an analyte that can be accurately and reproducibly quantified in a sample matrix. Contract-required Quantitation Limit (CRQLs) are contractually specified maximum quantitation limits for specific analytical methods and sample matrices, such as soil or water, and are typically several times the method detection limit (MDL) to allow for matrix effects.

For this project, analytical methods have been selected so that the CRQL for each target analyte is below the applicable regulatory screening criteria, wherever practical. For this project, samples results will be reported as estimated values if concentrations are less than CRQLs but greater than CRDLs. The CRDL for each analyte will be listed as the detection limit in the laboratory's electronic data deliverable (EDD).

1.5 SPECIAL TRAINING AND CERTIFICATION

This section outlines the training and certification required to complete the activities described in this SAP. The following sections describe the requirements for the EA team and subcontractor personnel working on-site.

1.5.1 Health and Safety Training

EA field team personnel who work at hazardous waste project sites are required to meet the Occupational Safety and Health Administration (OSHA) training requirements defined in 29 Code of Federal Regulations (CFR) 1910.120(e). These requirements include: (1) 40 hours of formal off-site instruction; (2) a minimum of 3 days of actual on-site field experience under the supervision of a trained and experienced field supervisor; and (3) 8 hours of annual refresher training. Field personnel who directly supervise employees engaged in hazardous waste operations also receive at least 8 additional hours of specialized supervisor training.

Copies of the field team's health and safety training records, including course completion certifications for the initial and refresher health and safety training, and specialized supervisor training are maintained in project files.

For more health and safety details, see EA's site-specific HSP (EA 2008b).

1.5.2 Subcontractor Training

Subcontractors who work on site will certify that their employees have been trained for work on hazardous waste project sites. Training will meet OSHA requirements defined in

29 CFR 1910.120(e). Before work begins at the project site, subcontractors will submit copies of the training certification for each employee to EA.

Employees of associate and professional services firms and technical services subcontractors will attend a safety briefing and complete the Safety Meeting Sign-Off Sheet before they conduct on-site work (EA 2008b). This briefing is conducted by the EA Site Health and Safety Officer (SHSO) or other qualified person.

Subcontractors are responsible for conducting their own safety briefings; EA personnel may audit these briefings. Alternatively, the subcontractors may elect to attend the EA safety briefings.

1.6 DOCUMENTS AND RECORDS

The following sections discuss the requirements for documenting field activities and for preparing laboratory data packages. This section also describes reports that will be generated as a result of this project.

1.6.1 Field Documentation

Field personnel will use permanently bound field logbooks with sequentially numbered pages to record and document field activities and will follow SOP 016 for completing field logbooks (Appendix F). The logbook will list the contract name and number; site name; and names of subcontractors, service client, and Project Manager. At a minimum, the following information will be recorded in the field logbook:

- Name and affiliation of on-site personnel or visitors;
- Weather conditions during the field activity;
- Summary of daily activities and significant events;
- Notes of conversations with coordinating officials;
- References to other field logbooks or forms that contain specific information;
- Discussions of problems encountered and their resolution;
- Discussions of deviations from the SAP or other governing documents; and
- Description of photographs taken.

1.6.2 Laboratory Documentation

This section describes the data reporting requirements for EA field personnel and laboratories (e.g., EPA CLP laboratories, EPA Region 9 laboratory, or subcontracted non-CLP laboratories) that submit field and laboratory measurement data under the EPA Region 6 RAC II program.

EA will require fixed off-site non-CLP laboratories to prepare and submit data packages in accordance with the EPA CLP protocols (2004b,c,d; 2005a; 2006e; 2007) for hardcopy and EDD format of lead data. Data packages will include applicable documentation for independent validation of data and verification of the DQOs. The following documentation will be required for full data validation, if applicable:

- Case narratives, which will describe QC non-conformances that are encountered during the analysis of samples in addition to corrective actions that are taken:
  - Statement of samples received,
  - Description of deviations from the specified analytical method,
  - Explanations of data qualifiers that are applied to the data, and
  - Other significant problems that were encountered during analysis.

- Tables that cross-reference field and laboratory sample numbers;

- Chain-of-custody forms, which pertain to each sample delivery group or sample batch that is analyzed;

- Laboratory reports, which must show traceability to the sample analyzed and must contain specified information:
  - Project identification,
  - Field sample number,
  - Laboratory sample number,
  - Sample matrix description,
  - Dates and times of sample collection, receipt at the laboratory, preparation, and analysis,
  - Description of analytical method and reference citation,
  - Results of individual parameters, with concentration units, including second column results, second detector results, and other confirmatory results, where appropriate,
  - Quantitation limits achieved, and
  - Dilution or concentration factors;

- Data summary forms and QC summary forms showing analytical results, if applicable:
  - Samples,
  - Surrogates,
  - Blanks,
  - Field QC samples,
  - LCS,
  - Initial and continuing calibrations, and
  - Other QC samples;

- Laboratory control charts:
  - Raw data,
  - Instrument printouts, and
  - Laboratory bench sheets for preparation of samples; and

- MDL study results.

EA's Project Manager, in cooperation with the QA Officer, will define site-specific requirements for data reporting. Requests for analytical services define these requirements, the turnaround time for receipt of the data deliverables specified, and requirements for retaining samples and laboratory records. Laboratory QA managers are responsible for ensuring that laboratory data reporting requirements in this SAP are met.

1.6.3 Full Data Package

When a full data package is required, the laboratory will prepare data packages in accordance with the instructions provided in the EPA CLP SOWs (EPA 2004b,c,d; 2005a; 2006e; 2007). Full data packages will contain the information from the summary data package and associated raw data. Full data packages are due to EA within 35 days after the last sample in the sample delivery group is received. Unless otherwise requested, the subcontractor will deliver one copy of the full data package.

1.6.4 Reports Generated

Following the completion of the RI field program and receipt of validated data, EA will prepare the following reports associated with the Site RI/FS:

- Data Evaluation Summary Report (DESR);
- Baseline HHRA Report;
- Screening-Level ERA Report;
- RI Report;
- Remedial Alternatives Comparative Analysis (RACA) Report; and
- FS Report.

The specific requirements and elements of each of these reports are discussed in detail in the EPA-approved RI/FS Work Plan (EA 2008a).

2. DATA GENERATION AND ACQUISITION

This section describes the requirements for the following:

- Sampling process design (Section 2.1);
- Consent for property access (Section 2.2);
- Sampling methodology (Section 2.3);
- Sample processing (Section 2.4);
- Decontamination (Section 2.5);
- Management of investigation-derived waste (Section 2.6);
- Sample designation (Section 2.7);
- Sample container, volume, preservation, and holding time requirements (Section 2.8);
- Sample handling and custody (Section 2.9);
- Analytical methods requirements (Section 2.10);
- Quality control requirements (Section 2.11);
- Instrument calibration and frequency (Section 2.12);
- Requirements for inspection and acceptance of supplies and consumables (Section 2.13);

- Data acquisition requirements (Section 2.14); and
- Data management (Section 2.15).

2.1 SAMPLING PROCESS DESIGN

For the activities associated with this Task Order and SAP, main elements of the sampling design include the numbers and types of samples to be collected, sampling locations, sampling frequencies, and sample matrices.

As stated in the DQOs (Section 1.3), the following principle study questions were formulated for the RI:

> ***What are the nature and extent of air, soil, sediment, surface water, and ground water contamination at the AOIs?***
>
> ***What are the migration pathways for these contaminants to be transported to other AOIs?***
>
> ***Are concentrations of AOI COPCs significantly greater than background?***
>
> ***What is the potential risk to human health and ecological receptors from exposure to Site related COPCs at the AOIs?***

The primary objective of the sampling design is to collect data of sufficient quantity and quality to resolve the study question and support risk assessment and remedy evaluation. The purpose of the RI/FS is to determine the nature and extent of contamination and to gather sufficient information so that the EPA can select a remedy that eliminates, reduces, or controls risks to human health or the environment, as follows:

> ***Determine the nature and extent of air, soil, sediment, surface water, and ground water contamination at the AOIs.***
>
> ***Determine the migration pathways for these contaminants to be transported to other AOIs.***
>
> ***Determine whether the concentrations of AOI COPCs are significantly greater than background.***
>
> ***Determine if exposure to Site related COPCs at the AOIs pose a potential unacceptable risk to human health and ecological receptors.***

The goal is to develop the minimum amount of data necessary to support the selection of an approach for the Site's investigation, and then to use the data to support a ROD. To achieve this goal, soil, sediment, surface water, ground water, and air will be sampled during the RI/FS at the Site.

Table 4 and 5 summarize the historical soil data that are available and its suitability for use to either: (1) qualitatively evaluate the nature and extent of contamination; or (2) definitively evaluate potential risk to human health and ecological receptors. In addition, the tables detail the number of samples that are recommended for this investigation as well as the number that will be suitable for risk assessment after the field investigation.

Tables 6 through 8 summarize the type and quantities of soil, sediment, surface water, and ground water samples to be collected during the RI field program. The type and quantities of ambient air to be collected during the RI field program are presented in the Air Quality Monitoring Plan (Appendix D).

Table 9 summarizes the allocated and unallocated proposed sample quantities with respect to the EPA-approved Work Plan (EA 2008a). Allocated samples are the minimum quantity of samples required to evaluate human health and ecological risk. Unallocated samples may be incorporated into the field investigation based on site conditions with EPA approval.

2.2 CONSENT FOR PROPERTY ACCESS

Off-site Soil sampling activities will be performed on privately-owned properties located within the City of Dewey-Humboldt, Arizona. EPA will obtain consent for property access agreements from the private property owners that have been identified for investigation under the RI/FS. For properties where the property owner cannot be identified and/or the property owner is not responsive, other properties may be identified for characterization as appropriate.

2.3 SAMPLING METHODOLOGY

This section describes the procedures for sample collection. Table 10 lists the SOPs that will be implemented during this field program. The SOPs are provided in Appendix F.

Sample collection and handling procedures for samples that will be analyzed using the CLP will follow CLP protocols in accordance with EPA's *Contract Laboratory Program Guidance for Field Samplers* (EPA 2004c).

During sample collection, preparation, and field analysis, chain of custody will be maintained and documented as required in Section 2.9. Sample locations will be documented photographically and sketched in the field logbook; an accompanying photograph log will be completed in the field logbook (see Section 1.6.1).

TABLE 4 SOIL SAMPLE DATA ANALYSIS AND PROPOSED SAMPLES
Iron King Mine - Humboldt Smelter Superfund Site Remedial Investigation and Feasibility Study

Area	Sampling Unit	Historical Qualitative Soil Dataset for General Nature and Extent		Historical Definitive Soil Dataset for Risk Assessment		Sampling Category [2]	Proposed Number of Additional Samples		
		Surface Soil (0 to 2-Feet BGS)	Subsurface Soil (4 to 7-Feet BGS)	Surface Soil (0 to 2-Feet BGS)	Subsurface Soil (4 to 7-Feet BGS)		Surface Soil (0 to 2-Feet BGS)	Subsurface Soil (4 to 7-Feet BGS)	Deep Soil (Greater than 10-Feet BGS)
Iron King Mine	Iron King Operations Area	11	0	6	3	VSP Systematic Random Start	12	6	0
						Minimum Biased/Judgmental	6	3	0
						Total	**18**	**9**	**0**
	Glory Hole	7	0	0	0	VSP Systematic Random Start	5	3	0
						Minimum Biased/Judgmental	5	3	2
						Total	**10**	**6**	**2**
	Former Drum Area	0	0	0	0	VSP Systematic Random Start	0	0	0
						Minimum Biased/Judgmental	10	6	0
						Total	**10**	**6**	**0**
	Former Fertilizer Plant	0	0	4	3	VSP Systematic Random Start	5	3	0
						Minimum Biased/Judgmental	3	1	0
						Total	**8**	**4**	**0**
	Iron King Proper Area Large Tailings Pile	0	0	3	0	VSP Systematic Random Start	10	5	0
						Minimum Biased/Judgmental	6	3	3
						Total	**16**	**8**	**3**
	Iron King Proper Area Mine Plant	0	0	2	0	VSP Systematic Random Start	2	1	0
						Minimum Biased/Judgmental	6	5	0
						Total	**8**	**6**	**0**
	Small Tailings Piles	0	0	0	0	VSP Systematic Random Start	5	3	0
						Minimum Biased/Judgmental	5	3	0
						Total	**10**	**6**	**0**
	Totals	**18**	**0**	**15**	**6**	**Iron King Mine Totals**	**80**	**45**	**5**
Humboldt Smelter	Yellow Tailings Pile	4	0	4	0	VSP Systematic Random Start	5	4	0
						Minimum Biased/Judgmental	3	2	0
						Total	**8**	**6**	**0**
	Ash Pile	3	0	2	0	VSP Systematic Random Start	5	4	0
						Minimum Biased/Judgmental	3	2	0
						Total	**8**	**6**	**0**
	Black Slag	2	0	1	0	VSP Systematic Random Start	5	4	0
						Minimum Biased/Judgmental	4	2	0
						Total	**9**	**6**	**0**
	Miscellaneous Areas	7	0	3	0	VSP Systematic Random Start	12	6	0
						Minimum Biased/Judgmental	4	2	0
						Total	**16**	**8**	**0**
	Smelter	0	0	0	0	Minimum Biased/Judgmental	6	3	0
	Drum Pile	1	0	0	0	Minimum Biased/Judgmental	4	2	0
	Metal Shed	0	0	0	0	Minimum Biased/Judgmental	2	1	0
	Assay Laboratory	1	0	3	0	Minimum Biased/Judgmental	5	3	0
	Office Building	0	0	0	0	Minimum Biased/Judgmental	2	1	0
	Dam Borings	0	0	0	0	Minimum Biased/Judgmental	3	3	3
	Totals	**18**	**0**	**13**	**0**	**Humboldt Smelter Totals**	**63**	**39**	**3**
Background	Background Soil	Background Dataset Subject to Evaluation for Appropriateness				Soil Type No. 1	10	0	0
						Soil Type No. 2	10	0	0
						Soil Type No. 3	10	0	0
		Totals				**Background Totals**	**30**	**0**	**0**
Off-Site	Private Property [3]	15	0	10	2	**Off-Site Soil Totals**	**100**	**0**	**0**
						Proposed Totals [1]	**273**	**84**	**8**

Notes:

1	Totals do not include quality assurance/quality control samples.
2	Additional biased/judgmental samples are necessary for an adequate dataset and to characterize nature and extent of contamination; selection will be based on historical information (e.g., photographic documentation) and visual cues. Additional unallocated samples will be collected as appropriate based on Site conditions and EPA concurrence. Volatile organic compound, semi-volatile organic compound, and pesticides/ poly-chlorinated biphenyls analyses will be biased toward areas with likely waste disposal activities or where visually impacted soil is observed.
3	The estimate is based on sampling four depth intervals per 2,500-square foot area. Typically, two 2,500-square foot areas encompass a single property so the estimate is for approximately 10 properties.
VSP	Visual Sample Plan Version 5.0. Pacific Northwest National Laboratory. U.S. Department of Energy. PNNL-16936. September 2007.
BGS	Below ground surface

TABLE 5 SEDIMENT, SURFACE WATER, AND GROUND WATER SAMPLE DATA ANALYSIS AND PROPOSED SAMPLES

Iron King Mine - Humboldt Smelter Superfund Site Remedial Investigation and Feasibility Study

Area	**Sampling Unit**	**Historical Qualitative Soil Dataset for General Nature and Extent**		**Historical Definitive Soil Dataset for Risk Assessment**		**Proposed Number of Additional Samples**	
		Surface Water	**Sediment**	**Surface Water**	**Sediment**	**Water (Surface or Ground)**	**Sediment**
Iron King Mine	Impoundments/ Ponds	2	0	0	3	18	18
	Outfall/Wash	0	0	0	0	17	17
	Totals	**2**	**0**	**0**	**3**	**35**	**35**
Humboldt Smelter	Impoundments/ Ponds	0	0	0	0	3	3
	Outfall/Wash	0	0	0	0	4	4
	Totals	**0**	**0**	**0**	**0**	**7**	**7**
Waterways	Chaparral Gulch	0	2	1	3	21	21
	Galena Gulch	0	0	0	2	14	14
	Aqua Fria River	0	0	4	3	15	15
	Dam Effluent	0	0	1	1	2	2
	Totals	**0**	**2**	**6**	**9**	**52**	**52**
Background	Chaparral Gulch	Background Dataset Subject to Evaluation for Appropriateness		Background Dataset Subject to Evaluation for Appropriateness		10	10
	Galena Gulch					10	10
	Aqua Fria River					10	10
	Totals					**30**	**30**
Ground Water or Tap Water	Alluvial	2 Background Dataset Subject to Evaluation for Appropriateness		32 Background Dataset Subject to Evaluation for Appropriateness		**46**	**0**
	Bedrock						
	Alluvial Background						
	Bedrock Background						

Proposed Totals [1]	**170**	**124**

Notes:

[1] Totals do not include quality assurance/quality control samples. Additional unallocated samples will be collected as appropriate based on Site conditions and EPA concurrence.

TABLE 6 PROPOSED SOIL SAMPLES
Iron King Mine - Humboldt Smelter Superfund Site Remedial Investigation and Feasibility Study

Area	Sampling Unit	Sampling Category [4]	Surface Soil (0 to 2-Feet BGS)	Subsurface Soil (4 to 7-Feet BGS)	Deep Soil (Greater than 10-Feet BGS)	TAL Metals (including Mercury and Cyanide)	Volatile Organic Compounds	Semi-Volatile Organic Compounds	Pesticides/ Poly-Chlorinated Biphenyls	pH	Nitrate/ Sulfate/ Perclorate [5]	Dioxins	Geotech Parameters	Asbestos	Synthetic Precipitation Leaching Procedure	Lead/ Arsenic Speciation	DMA XRF [2]
Iron King Mine	Iron King Operations Area	VSP Systematic Random Start	12	6	0	27	8	8	8	8	6	0	0	0	0	0	**30 Locations - In situ and Ex situ (Sieved and Unsieved)**
		Minimum Biased/Judgmental	6	3	0												
		Total	**18**	**9**	**0**												
	Glory Hole	VSP Systematic Random Start	5	3	0	18	6	6	6	6	3	0	2	0	3	0	
		Minimum Biased/Judgmental	5	3	2												
		Total	**10**	**6**	**2**												
	Former Drum Area	VSP Systematic Random Start	0	0	0	16	6	6	6	6	3	0	0	0	2	0	
		Minimum Biased/Judgmental	10	6	0												
		Total	**10**	**6**	**0**												
	Former Fertilizer Plant	VSP Systematic Random Start	5	3	0	12	6	6	6	6	3	0	0	0	3	0	
		Minimum Biased/Judgmental	3	1	0												
		Total	**8**	**4**	**0**												
	Iron King Proper Area Large Tailings Pile	VSP Systematic Random Start	10	5	0	27	0	0	0	0	4	0	6	0	3	3	
		Minimum Biased/Judgmental	6	3	3												
		Total	**16**	**8**	**3**												
	Iron King Proper Area Mine Plant	VSP Systematic Random Start	2	1	0	14	2	2	2	2	2	0	0	0	2	0	
		Minimum Biased/Judgmental	6	5	0												
		Total	**8**	**6**	**0**												
	Small Tailings Piles	VSP Systematic Random Start	5	3	0	16	0	0	0	0	2	0	2	0	2	0	
		Minimum Biased/Judgmental	5	3	0												
		Total	**10**	**6**	**0**												
		Totals	**80**	**45**	**5**	**130**	**28**	**28**	**28**	**28**	**23**	**0**	**10**	**0**	**15**	**3**	
Humboldt Smelter	Yellow Tailings Pile	VSP Systematic Random Start	5	4	0	14	0	0	0	2	2	3	2	0	2	1	
		Minimum Biased/Judgmental	3	2	0												
		Total	**8**	**6**	**0**												
	Ash Pile	VSP Systematic Random Start	5	4	0	14	0	0	0	2	2	3	2	0	2	1	
		Minimum Biased/Judgmental	3	2	0												
		Total	**8**	**6**	**0**												
	Black Slag	VSP Systematic Random Start	5	4	0	15	0	0	0	2	2	3	2	0	2	1	
		Minimum Biased/Judgmental	4	2	0												
		Total	**9**	**6**	**0**												
	Miscellaneous Areas	VSP Systematic Random Start	12	6	0	24	0	0	0	2	2	8	2	0	0	0	
		Minimum Biased/Judgmental	4	2	0												
		Total	**16**	**8**	**0**												
	Smelter	Minimum Biased/Judgmental	6	3	0	9	0	--	--	1	1	5	1	5	0	0	
	Drum Pile	Minimum Biased/Judgmental	4	2	0	6	2	2	2	1	1	1	1	0	0	0	
	Metal Shed	Minimum Biased/Judgmental	2	1	0	3	0	--	--	1	1	0	1	0	0	0	
	Assay Laboratory	Minimum Biased/Judgmental	5	3	0	8	2	2	2	1	1	1	1	0	0	0	
	Office Building	Minimum Biased/Judgmental	2	1	0	3	0	--	--	1	1	0	1	0	0	0	
	Dam Borings	Minimum Biased/Judgmental	3	3	3	9	0	--	--	1	1	0	1	0	0	0	
		Totals	**63**	**39**	**3**	**105**	**4**	**4**	**4**	**14**	**14**	**24**	**14**	**5**	**6**	**3**	
Background	Background Soil	Soil Type No. 1 (BgD)	10	0	0	10	0	0	0	2	2	10	0	0	0	2	
		Soil Type No. 2 (MkF)	10	0	0	10	0	0	0	2	2	0	0	0	0	2	
		Soil Type No. 3 (SnD)	10	0	0	10	0	0	0	2	2	0	0	0	0	2	
		Totals	**30**	**0**	**0**	**30**	**0**	**0**	**0**	**6**	**6**	**10**	**0**	**0**	**0**	**6**	
Off-Site	Private Property[3]	**Totals**	**300**	**0**	**0**	**300**	**0**	**0**	**0**	**2**	**2**	**0**	**0**	**0**	**0**	**4**	
		Proposed Totals [1]	**473**	**84**	**8**	**565**	**32**	**32**	**32**	**50**	**45**	**34**	**24**	**5**	**21**	**16**	**30**

Notes:

1	Totals do not include quality assurance/quality control samples.
2	Demonstration of Methods Applicability (DMA) X-ray fluorescence (XRF) analysis will be conducted on up to 30 samples to evaluate whether XRF would be beneficial to use as a screening tool for sample location determination and potential delineation of source areas.
3	The estimate is based on sampling four depth intervals per 2,500-square foot area. Typically, two 2,500-square foot areas encompass a single property so the estimate is for approximately 10 properties.
4	Additional biased/judgmental samples are necessary for an adequate dataset and to characterize nature and extent of contamination; selection will be based on historical information (e.g., photographic documentation) and visual cues. Additional unallocated samples will be collected as appropriate based on Site conditions and EPA concurrence. Volatile organic compound, semi-volatile organic compound, and pesticides/ poly-chlorinated biphenyls analyses will be biased toward areas with likely waste disposal activities or where visually impacted soil is observed.
VSP	Visual Sample Plan Version 5.0. Pacific Northwest National Laboratory. U.S. Department of Energy. PNNL-16936. September 2007.
BgD	Balon gravelly sandy clay loam
BGS	Below ground surface
MkF	Moano very rocky loam, 15 to 60
SnD	Springerville-Cabezon complex, 3 to 30 percent slopes.
TAL	Target analyte list metals

TABLE 7 PROPOSED SEDIMENT, SURFACE WATER, AND GROUND WATER SAMPLES
Iron King Mine - Humboldt Smelter Superfund Site Remedial Investigation and Feasibility Study

Area	Sampling Unit	Proposed Number of Samples		Surface Water or Ground Water				Sediment				
		Water (Surface or Ground)	Sediment	TAL Metals (including Mercury and Cyanide)	Nitrate/ Nitrite/ Sulfate/ Perclorate	Anions/ Cations and Total Dissolved Solids	Volatile and Semi-Volatile Organic Compounds	TAL Metals (including Mercury and Cyanide)	Nitrate/ Sulfate/ Perclorate	Geotech Parameters	Synthetic Precipitation Leaching Procedure	Lead/ Arsenic Speciation
Iron King Mine	Impoundments/ Ponds	18	18	18	4	1	0	18	4	0	0	0
	Outfall/Wash	17	17	17	4	0	0	17	4	0	0	0
		35	**35**	**35**	**8**	**1**	**0**	**35**	**8**	**0**	**0**	**0**
Humboldt Smelter	Impoundments/ Ponds	3	3	3	1	0	0	3	1	0	0	0
	Outfall/Wash	4	4	4	1	0	0	4	1	0	0	0
		7	**7**	**7**	**2**	**0**	**0**	**7**	**2**	**0**	**0**	**0**
Waterways	Chaparral Gulch	21	21	21	2	1	0	21	2	2	2	1
	Galena Gulch	14	14	14	2	0	0	14	2	0	0	0
	Aqua Fria River	15	15	15	3	1	0	15	3	0	0	0
	Dam Effluent	2	2	2	1	1	0	2	1	0	0	1
		52	**52**	**52**	**8**	**3**	**0**	**52**	**8**	**2**	**2**	**2**
Background	Chaparral Gulch	10	10	10	2	1	0	10	2	0	0	1
	Galena Gulch	10	10	10	2	0	0	10	2	0	0	1
	Aqua Fria River	10	10	10	2	1	0	10	2	0	0	1
		30	**30**	**30**	**6**	**2**	**0**	**30**	**6**	**0**	**0**	**3**
Ground Water or Tap Water	Alluvial	**46**	**0**	**46**	**12**	**4**	**6**	**0**	**0**	**0**	**0**	**0**
	Bedrock											
	Alluvial Background											
	Bedrock Background											
	Proposed Totals [1]	**170**	**124**	**170**	**36**	**10**	**6**	**124**	**24**	**2**	**2**	**5**

Notes:

1	Totals do not include quality assurance/quality control samples. Additional unallocated samples will be collected as appropriate based on Site conditions and EPA concurrence.
TAL	Target analyte list metals

TABLE 8 SUMMARY OF PROPOSED GROUND WATER SAMPLE LOCATIONS
Iron King Mine - Humboldt Smelter Superfund Site Remedial Investigation and Feasibility Study

Sample Location	Address	Registration ID	Water Use	Casing Type/Information	Well Depth (feet)	Casing Diameter (inches)	Screened Interval (feet)
GW-200293	1265 S Dewey Rd	200293	Domestic	Steel - Perforated Or Slotted Casing	305	5	--
GW-500167	219 E Navajo Dr	500167	Domestic	Steel - Perforated Or Slotted Casing	460	7	--
GW-502562	PO Box 205	502562	Domestic	Plastic Or PVC	220	7	139-220
GW-502888	2925 S Holiday Drive	502888	Domestic	Steel - Perforated Or Slotted Casing	165	6	--
GW-507388	--	507388	Domestic	--	--	--	--
GW-509113	2342 S Sierra Drive	509113	Domestic	Other - Black Steel - Iron - Seamless	183	7	--
GW-511246	1722 S. River Dr	511246	Domestic	Other - Black Steel - Iron - Seamless	64	7	--
GW-512734	--	512734	Domestic	--	125	5	60-120
GW-533639	13502 Burten Rd	533639	Municipal	Steel - Perforated Or Slotted Casing	305	8	200-305
GW-550566	PO Box 41	550566	Domestic	Steel - Perforated Or Slotted Casing	340	7	260-340
GW-551142	13680 Deer Pass	551142	Domestic	Steel - Perforated Or Slotted Casing	105	7	--
GW-551459	PO Box 218	551459	Industrial	Steel - Perforated Or Slotted Casing	400	8	--
GW-551874	--	551874	Domestic	--	125	--	65-125
GW-558708	PO Box 582	558708	Domestic	Steel - Perforated Or Slotted Casing	220	7	120-220
GW-566350	PO Box 68	566350	Domestic	Plastic Or PVC	100	4	60-100
GW-567387	20327 N 106th Ave	567387	Domestic	Plastic Or PVC	325	7	225-325
GW-575380	300 E Willis Ste B	575380	Domestic	Plastic Or PVC	261	4	161-261
GW-576555	12150 Turquoise Circle	576555	Domestic	Plastic Or PVC	260	4	--
GW-586144	PO Box 948	586144	Domestic	--	--	--	--
GW-586482	PO Box 26	586482	Domestic	Plastic Or PVC	600	5	--
GW-592720	PO Box 218	592720	Industrial	Plastic Or PVC	1000	5	--
GW-599489	PO Box 1670	599489	Domestic	Steel - Perforated Or Slotted Casing	60	--	40-60
GW-623784	PO Box 206	623784	Municipal	Steel - Perforated Or Slotted Casing	170	6	--
GW-633890	PO Box 73	633890	Domestic	--	40	--	--
GW-634755	13608 N 17th Dr	634755	Domestic	Other - Black Steel - Iron - Seamless	90	9	--
GW-635665	13825 E Henderson Road	635665	Domestic	Plastic Or PVC	115	5	--
GW-636442	2820 Azurite	636442	Domestic	Plastic Or PVC	140	6	--
GW-638661	44 Quail Run Ct	638661	Domestic	Steel - Perforated Or Slotted Casing	150	6	--
GW-639385	PO Box 367	639385	Stock	--	238	6	--
GW-639493	2013 Dana St	639493	Irrigation	--	35	--	--
GW-639494	2450 Sierra Dr	639494	Domestic	--	--	--	--
GW-639818	409 1/2 Campbell	639818	Domestic	--	200	--	--
GW-801122	11680 Manzanita Tr.	801122	Domestic	Plastic Or PVC	140	5	--
GW-801570	13788 E Ridge Way	801570	Domestic	Plastic Or PVC	130	5	--
GW-805189	PO Box 334	805189	Domestic	Steel - Perforated Or Slotted Casing	77	8	--
GW-SW-09	219 E Navajo Dr	SW-09	Mining	--	--	--	--
GW-808303	13621 E Deer Pass	808303	Domestic	--	--	--	--
GW-808582	2270 S Sierra Dr	808582	Domestic	--	--	--	--
GW-900344	PO Box 67	900344	Domestic	Plastic Or PVC	800	5	700-800
GW-900905	--	900905	Domestic	--	225	5	125-225

-- = Unknown or undetermined because information is not available.
PVC = Polyvinyl chloride

TABLE 9 SUMMARY OF PROPOSED SAMPLES
Iron King Mine - Humboldt Smelter Superfund Site Remedial Investigation and Feasibility Study

Area	Sampling Unit	TAL Metals (including Mercury and Cyanide)	Volatile Organic Compounds	Semi-Volatile Organic Compounds	Pesticides/ Poly-Chlorinated Biphenyls	pH	Nitrate/ Nitrite/ Sulfate/ Perclorate	Dioxins	Geotech Parameters	Asbestos	Synthetic Precipitation Leaching Procedure	Lead/ Arsenic Speciation	Anions/ Cations and Total Dissolved Solids
Iron King Mine	Soil	130	28	28	28	28	23	0	10	0	15	3	0
Humboldt Smelter	Soil	105	4	4	4	14	14	24	14	5	6	3	0
Background	Soil	30	0	0	0	6	6	10	0	0	0	6	0
Off-Site	Soil	300	0	0	0	2	2	0	0	0	0	4	0
Iron King Mine	Sediment	35	0	0	0	0	8	0	0	0	0	0	0
Humboldt Smelter	Sediment	7	0	0	0	0	2	0	0	0	0	0	0
Background	Sediment	30	0	0	0	0	6	0	0	0	0	3	0
Waterways	Sediment	52	0	0	0	0	8	0	2	0	2	2	0
Proposed Soil/Sediment Totals[1]		**689**	**32**	**32**	**32**	**50**	**69**	**34**	**26**	**5**	**23**	**21**	**0**
EPA Approved WP Soil/Sediment[1]		**745**	**49**	**49**	**49**	**50**	**82**	**49**	**NS**	**5**	**23**	**21**	**0**
Unallocated Soil/Sediment Totals[1]		**56**	**17**	**17**	**17**	**0**	**13**	**15**	**0**	**0**	**0**	**0**	**0**
Iron King Mine	Surface Water	35	0	0	0	0	8	0	0	0	0	0	1
Humboldt Smelter	Surface Water	7	0	0	0	0	2	0	0	0	0	0	0
Background	Surface Water	30	0	0	0	0	6	0	0	0	0	3	2
Waterways	Surface Water	52	0	0	0	0	8	0	0	0	0	2	3
Ground Water	Ground Water	46	6	6	0	0	12	0	0	0	0	0	4
Proposed SW/GW Totals[1]		**170**	**6**	**6**	**0**	**0**	**36**	**0**	**0**	**0**	**0**	**5**	**10**
EPA Approved WP SW/GW Totals[1]		**226**	**8**	**8**	**0**	**0**	**37**	**0**	**0**	**0**	**0**	**10**	**10**
Unallocated SW/GW Totals[1]		**56**	**2**	**2**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**5**	**0**

Notes:

1	Totals do not include quality assurance/quality control samples. Additional unallocated samples will be collected as appropriate based on Site conditions and EPA concurrence.
NS	Not specified
TAL	Target analyte list metals

TABLE 10 STANDARD OPERATING PROCEDURES

SOP Number	SOP Title
001	Labels
002	Chain-of-Custody Form
003	Subsurface/Utility Clearance
004	Sample Packing and Shipping
005	Field Decontamination
007	Surface Water Sampling
008	pH Measurement
009	Temperature Measurement
010	Water Level and Well Depth Measurements
012	Specific Conductance Measurements
013	Monitoring Well Sample Collection
014	Collection of Production Well Samples
016	Surface Water, Groundwater, and Soil/Sediment Logbooks
019	Monitoring Well Installation
021	Sediment Sampling
022	Sediment and Benthic Sampling
025	Soil Sampling
028	Well Boring and Abandonment
030	Radioactive Surveys
036	Turbidity Measurements
037	Dissolved Oxygen Measurements
038	Redox Potential Measurements
039	Sample Preservation and Container Requirements
042	Disposal of Investigation-Derived Material
047	Direct-Push Technology Sampling
048	Low-Flow Sampling
051	Low-Flow Purge and Sampling With Dedicated Pumps

2.3.1 Soil Sampling

During the RI field program, EA will collect surface and subsurface soil samples from the Iron King Mine, Humboldt Smelter, Off-Site Soil AOIs, and background areas in accordance with SOPs 025 and 047 (Appendix F) as projected in Table 4. Figures 4 through 6 illustrate the proposed random-start systematic grid VSP soil sampling locations associated with these three AOIs. Biased or judgmental sample are not depicted on the figures because they will be selected based on historical site evidence (e.g., photographic documentation, previous sampling results, etc.) during the Site reconnaissance with EPA concurrence. A higher percentage of the biased or judgmental samples that will be analyzed for organic compounds will be concentrated in areas where there is expected to be variability in the analyte concentrations or where the nature and extent of impacts is unknown (e.g., Iron King Operations Area); the tailings piles, ash piles, and slag piles are expected to present less variability so a lower percentage of the biased or judgmental samples that will be analyzed for organic compounds will be collected in those areas.

Biased or judgmental samples may be collected in the following areas based on previous site visits or information provided by the EPA:

- Historical information indicates that a mill may have operated near the confluence of the Chaparral Gulch and Agua Fria River.

- An unnamed gulch flows through surface water conduits under 3rd Street. Sulfo-salts may appear in the dry riverbed.

- A riparian habitat may exist east of Highway 69 near 3rd Street.

- Liquid waste was observed on the ground surface near the entrance to the Former Fertilizer Plant.

- The ADEQ observed two piles of drums north of the glory hole in 1998, which may have contained cyanide. During a 2001 site visit by ADEQ, these drums were no longer present.

- The ADEQ observed small containers, which apparently contained laboratory waste, on the ground near the laboratory in the Iron King Mine Operations Area. The 2001 Phase I Assessment reported that the laboratory waste was stockpiled, graded, and spread out over a 250 foot by 100 foot area. During a 2001 site visit by ADEQ, the stockpile was not observed.

- Underground Storage Tanks were removed from the Former Fertilizer Plant in 1992; these tanks formerly contained diesel, gasoline, or other unknown substances.

2.3.1.1 Demonstration of Methods Applicability Study

At the onset of the field program, EA will implement a DMA Study on several samples representing the range of material (e.g., tailings, ash, and slag) and soil (i.e., on-site and off-site) types across the study area, which may include the following:

- Tailings material from the Iron King Mine tailings piles, Humboldt Smelter tailings pile, and/or Chaparral Gulch tailings deposits;

- Ash and slag material from the Humboldt Smelter AOI;

- Exposed surface soil from the Iron King Mine and Humboldt Smelter; and

- Sediments from the Chaparral Gulch, Galena Gulch, and/or Agua Fria River.

The DMA Study will be completed using a field-portable Niton® XL3t XRF analyzer and various sample collection and preparation methods (*in situ, ex situ*, grinding, drying, and sieving). EA will submit up to 33 (including QA/QC) split samples to the EPA's CLP and/or Region 9 Laboratory for Target Analyte List (TAL) metals analysis based on an estimated 7-day turnaround time (TAT), with preliminary data provided within a 72-hour TAT. EA will evaluate the correlation between XRF data and fixed laboratory data for site-related metals. The DMA Study will assist in determining the effectiveness of the XRF instrument as a screening tool or if the XRF instrument can be utilized for more definitive analysis. The XRF instrument normally provides a good correlation with fixed laboratory data for lead, but its effectiveness on other inorganics (e.g., arsenic) is uncertain.

The following method parameters will be evaluated under the DMA Study and will be refined throughout the RI:

- Site- and matrix-specific instrument practical quantitation limits (reporting limits);
- Various sample preparation techniques and their impacts on observed precision of results relative to decision-making (i.e., the utility of *in situ* XRF measurements versus *ex situ* XRF measurements);
- Instrument count times and analytical measurement conditions and their impact on precision, bias, and decision-making;
- Sample matrices and their impact on precision, bias, and decision-making (i.e., tailings material versus soil);
- Presence of potential interference that might affect method performance for analysis of the site-related metals and require method modification;
- Correlation of XRF results using various preparation techniques with fixed laboratory analyses using CLP and/or EPA SW-846 Methods for site-related metals;
- XRF sample population distribution, summary statistics, statistical plots, and correlation evaluation; and
- Sample throughput, supporting equipment and supply needs, and approximate analysis costs.

The use of *in situ* XRF may provide screening-level quality data with minimal sample preparation. In the *in situ* mode of operation, the analyzer is placed in direct contact with the soil surface to be tested; within seconds, a value of ± 50 to 60 parts per million (ppm) lead (for example) is displayed for a low-resolution standard (www.niton.com). Bagged sample testing (*ex situ*) will also help to better characterize the metals-impacted areas.

The *ex situ* XRF mode (prepared samples) is more involved than the *in situ* mode, requiring that a sample be collected, homogenized, and dried prior to analysis. Homogenization procedures can range from minimal (manual removal of rocks, organic matter, and large soil grains) to rigorous (involving grinding, sieving, and blending). *Ex situ* XRF can also be compared to *in situ* XRF to determine if the soil conditions allow the *in situ* method to meet DQOs. A combination of both methods will be applied during the DMA Study and compared with fixed laboratory results for split samples from both methods to determine the optimum method for subsequent investigatory activities, as appropriate.

2.3.1.2 On-site Soil Sampling

A virtual random-start systematic sampling approach using VSP (Pacific Northwest National Laboratory 2007) was used to establish the random sample locations for the Iron King Mine and Humboldt Smelter AOIs. These AOIs were further subdivided into areas/subareas based on historical use, contaminant characteristics, or potential regulatory differences. The VSP evaluations are contained in Appendix E.

- Iron King Mine – Iron King Operations Area, Glory Hole, Iron King Proper Area, Small Tailings Pile; and Former Fertilizer Plant; and

- Humboldt Smelter – Tailings Pile, Ash Pile, Black Slag Pile, and entire property.

Biased or judgmental samples will be selected based on historical site evidence (e.g., photographic documentation, previous sampling results, etc.) during the Site reconnaissance with EPA concurrence.

Direct-push methodology will be used to collect on-site surface soil samples (from 0 to 2 feet bgs) and subsurface soil samples (from 4 to 7 feet bgs). Subsurface soil collection will be biased towards those locations that indicate potential anthropogenic impacts/contamination. Deeper samples will be collected in the tailings areas and near Chaparral Gulch dam to evaluate subsurface soils impacts greater than 10 feet bgs. A field geologist will log the material types within each boring to assist in the understanding of Site geology and for the nature and extent evaluation.

Coordinates for the soil boring locations will be obtained after sampling using a hand-held global positioning system (GPS) device. Boring locations may be adjusted based on existing field conditions to accommodate the existence of buried debris, concrete slabs, buried utilities, and permanent structures, as necessary. Following completion of sampling activities, borings will be abandoned in accordance with SOP 028 (Appendix F).

Soil samples will be analyzed for TAL Metals including mercury and cyanide. The analysis of volatile organic compounds (VOCs); semi-volatile organic compounds (SVOCs); pesticides/ poly-chlorinated biphenyls (PCB); and nitrates, sulfates, and perclorate analyses will be biased towards locations that indicate impacts (e.g., strong odor, visual staining, etc.).

In addition to the routine chemical characterization analysis, EA will analyze soil samples for Synthetic Precipitation Leaching Procedure (SPLP) to evaluate leachability of source material. EA will collect geotechnical samples (e.g., from the tailings piles) using direct-push or drilling methodology to evaluate the structural integrity of the underlying material and for remedy evaluation during the FS. A small number of samples from the Humboldt Smelter AOI and background samples will be analyzed for dioxins to determine whether dioxins at the Site are significantly greater than background.

Lead/arsenic speciation will be utilized to determine if the material at the Humboldt Smelter and Off-Site Soil areas are consistent with the material at the Iron King Mine; this information will primarily be utilized to evaluate an operational link between the Iron King Mine and Humboldt Smelter. The potential contribution of anthropogenic sources of arsenic (e.g., in residential yards) will be evaluated using lead/arsenic speciation analysis in Off-Site Soil areas. The EPA Office of Research and Development (ORD) will be consulted prior to the lead/arsenic speciation evaluation to provide assistance/guidance.

Using the existing dataset in conjunction with VSP, on-site soil sampling methodology has been tailored for each of the following sampling units associated with the two AOIs (see Appendix A Figures 3 and 4):

- Iron King Mine AOI
    - Iron King Mine Operations Area,
    - Glory Hole,
    - Former Fertilizer Plant Area,
    - Iron King Mine Proper Area, and
    - Small Tailings Pile;

- Humboldt Smelter AOI
    - Ash Pile,
    - Yellow Tailings Pile,
    - Black Slag Pile,
    - Miscellaneous Areas, and
    - Humboldt Smelter Process Areas.

Additional biased/judgmental soil sample locations may be selected based upon field observations/conditions, at the discretion of EPA.

2.3.1.3 Background Surface Soil Sampling

Up to three off-site surface soil types will be sampled to evaluate whether on-site soil concentrations are significantly greater than background concentrations. EA anticipates collecting a minimum of 10 surface soil samples (0 – 2 feet bgs) from three different areas/soil types, for a minimum total of 30 background soil samples (Table 6). A Background Workgroup has been setup to establish appropriate background locations. Electronic Geology Information for the area is contained in Appendix H.

2.3.1.4 Off-Site Soil Sampling

Residential and commercial properties located in the Off-site Soil AOI will be sampled to evaluate air deposition of metals from suspected source areas (Figure 6). These parcels were selected because the predominant wind direction is from the south-southwest and they appear to contain occupied structures.

EA proposes to collect up to 300 surface soil samples from up to approximately 30 off-site properties (Table 6). Each property will have approximately two 2500-square-foot [ft^2] areas to evaluate potential impacts from airborne particulates. EA will manually collect nine discrete samples from the 0 to 2-inch depth interval and one discrete sample from the 10 to 12-inch depth interval. The deeper depth interval was selected at random from beneath one of the nine surface sample locations. The nine surface sample locations were evenly distributed across the yard, except for targeted placement near play structures or discolored or texturally different soil.

Soil samples will be collected using slide-hammers or other similar technology. The XRF analyzer and/or visual cues may be utilized as a screening tool, as appropriate. Additional sampling may be conducted at EPA's request following review and statistical analysis of the initial analytical data. This additional sampling would require EPA approval.

EPA chose properties for the initial off-site soil sampling program based on proximity to contaminant source areas. The distribution of these properties across the site will depend, in part, on landowner access approval.

2.3.1.5 Radiological Survey

EA will conduct a preliminary radiological survey of the potential source areas associated with Iron King Mine and Humboldt Smelter to determine the need for additional radiological investigation (see SOP 030 in Appendix F). EPA radiological evaluation resources may also be utilized if additional investigation is required.

EA will survey potential source areas with a radiation survey meter to evaluate if radiation levels are greater than three times the background radiation level, which will be established in a background area.

2.3.1.6 Synthetic Precipitation Leaching Procedure

An evaluation of source material leaching to ground water will be evaluated by the collection of synthetic precipitation leaching procedure and geotechnical data. Although there are no regulatory criteria for evaluating these results, these data may be compared to regulatory ground water criteria (e.g., MCLs) to provide an estimate of the leaching potential of source material to the underlying ground water. EA will sample potential sources/source areas for analysis. If directed by EPA, these results may also be incorporated into a fate and transport model. However, often the best way to evaluate the potential leaching of source material to groundwater is to sample the underlying ground water. Both methodologies (direct and indirect measurements) are being employed at the Site.

2.3.1.7 Other Samples

Samples from the Humboldt Smelter will be collected to characterize the material for suspect asbestos-containing materials (ACM). A certified asbestos inspector will evaluate and collect samples from suspect ACM that are visible and easily accessible at the Humboldt Smelter and Glory Hole. These areas will not be disturbed during the site investigation and will be marked as such. Because of the unique risks associated with asbestos, asbestos will not be quantitatively included as a COPC in the risk assessments if confirmed present on site. Instead, it will be considered during debris removal options for the FS. Worker protection issues associated with conducting the RI in and around the ACM are outlined in the site-specific HASP (EA 2008b).

2.3.2 Surface Water and Sediment Investigation

During the RI field program, EA will collect surface water and sediment samples from various areas of the Site as projected in Table 5. Surface and sediment samples will be collected approximately every 400 to 500 linear feet along the Chaparral Gulch, Galena Gulch, and Agua Fria River. Sample locations will be chosen to provide a good spatial distribution in pools, reaches, and inside of major bends. Figures 7 and 8 illustrate the proposed surface water, sediment, and outfall/wash sampling locations.

Collocated sediment and surface water samples will be collected from the following locations in accordance with SOPs 007 and 021 (Appendix F):

- Waterways – Chaparral Gulch, Galena Gulch, Agua Fria River, and associated outfalls/washes;
- Iron King Mine – impoundments/retention ponds and associated outfalls/washes; and
- Humboldt Smelter – impoundments/retention ponds and associated outfalls/washes.

A sediment and surface water sample will be collected of the effluent from the downstream side of the Chaparral Gulch dam, which is located within the Humboldt Smelter AOI boundary, near the confluence of the Agua Fria River and the Chaparral Gulch. Additional sediments will be collected downstream of the confluence of Chaparral Gulch and Agua Fria River to determine the extent of potential impacts to the Aqua Fria River, if any.

Sediment and surface water samples will also be collected from upstream locations for each Waterway to evaluate whether concentrations of site-related metals and other inorganic compounds in the Waterways near the Site are significantly greater than background concentrations. A Background Workgroup has been setup to establish appropriate background locations.

The RI field program is currently scheduled for implementation during the monsoon season, which occurs during August. Therefore, EA does not anticipate encountering problems in collecting surface water samples from Waterways, outfalls, and washes. However, if surface water availability is limited or nonexistent, EA will proceed with sediment sampling for these locations with EPA concurrence.

In addition to the collection of sediment and surface water samples, transects will be conducted along the Chaparral Gulch to document the presence and potential volume of mine tailings; this effort may also be conducted in the Galena Gulch or outfalls leading from the Iron King Mine as necessary. A manual sampling device (e.g., slide hammer or hand auger) may be used to estimate the volume of mine tailings in a few select locations.

Finally, a storm water evaluation of the Iron King Mine drainage pathways (e.g., impoundments, outfalls, etc.) will be conducted to estimate the volumes of storm water that the Iron King Mine can manage and evaluate the potential for off-site migration of surface water during storm events.

2.3.3 Hydrogeological Investigation

EA will perform a limited hydrogeological assessment for the Site to include:

- Installation, development, and surface completion of one deep (bedrock) and up to five shallow (alluvial) monitoring wells;
- Following their installation and development, EA will collect ground water samples from the monitoring wells;
- EA will collect tap water samples from private and municipal wells; and
- A Background Workgroup has been setup to establish appropriate background locations.

Figure 9 illustrates the proposed monitoring well installation locations and proposed ground water sampling locations. Well construction details for the proposed ground water sampling locations are summarized in Table 8.

2.3.3.1 Monitoring Well Installation

EA will supervise subcontractor installation, development, and surface completion of shallow (alluvial) and deep (bedrock) monitoring wells within the Iron King Mine and Humboldt Smelter AOIs. Monitoring wells will be constructed in accordance with SOP 019 (Appendix F).

Before drilling each boring, the down-hole equipment, rig, and other equipment (as necessary) will be steam-cleaned or high-pressure washed using hot water, followed by a pressurized potable water rinse to minimize cross contamination. Special attention should be given to the threaded section of the casings and to the drill rods. Cleaned equipment should not be handled with soiled gloves. Drilling equipment should be steam-cleaned or high-pressure washed at the completion of the project to ensure that no contamination is transported from the site. Decontamination of the equipment will follow general practices listed in SOPs 005 and 019 (Appendix F). Water derived from decontamination will be collected and temporarily stored at the staging area for characterization.

The lithologic logs will prepared by examining soil cuttings, without the collection of soil samples. Once the boring is advanced to 10 feet above the anticipated top of the water table, the site geologist will direct the driller to slow down the rate of advancement. The water table will only be noted as a result of water being identified in the soil cuttings that are discharged. The soil borings will be advanced an additional 12 feet, with the drilling terminated so water levels can recover.

The monitoring wells will be developed following the correct completion of each well. The wells will be allowed to set 48 hours prior to well development. Down-hole equipment, including surge blocks and/or pumps, will be decontaminated before and after use. Water derived from decontamination will be collected and temporarily stored at the staging area for characterization.

<u>Shallow (Alluvial) Investigation</u>

EA proposes to install three shallow (alluvial) wells within the Iron King Mine property (see Figure 9):

- Two wells at the toe of the large tailings pile to assess whether the tailings pile is dewatering; and
- One well south of the impoundments and west of Highway 69 to assess whether infiltration from these impoundments is impacting shallow ground water.

EA proposes to install two shallow (alluvial) wells at the Humboldt Smelter property to assess whether infiltration water has impacted Waterways (Figure 9):

- One well along the bank between the Humboldt Smelter and the Aqua Fria River; and
- One well along the bank between the Humboldt Smelter and the Chaparral Gulch.

The shallow monitoring wells will be installed in accordance with SOP 019 (Appendix F) using air-rotary casing-hammer drilling methodology, which involves driving a steel casing into the boring at the same time that the rotary bit advances the boring. Use of this methodology would minimize the potential for borings in the loose alluvium to cave in, resulting in better well construction. As discussed with EPA, EA assumes that the cuttings will remain on-site. EA anticipates that shallow (alluvial) wells will be advanced to a depth of approximately 100 feet bgs.

<u>Deep (Bedrock) Investigation</u>

EA proposes to install a deep (bedrock) well at the Iron King Mine property adjacent to the Glory Hole to assess nature and extent for the RI. EA anticipates that deep (bedrock) well will be installed using an air-rotary drilling rig in accordance with SOP 019 (Appendix F). As discussed with EPA, EA assumes that the cuttings will remain on-site. For estimating purposes, EA anticipates that the deep (bedrock) well will be installed to a depth of approximately 400 feet bgs.

2.3.3.2 Ground Water Sampling

During the RI field program, EA anticipates performing the following ground water sampling activities and sample analysis:

- Following their installation and development, EA will collect ground water samples from the newly installed monitoring wells (see Section 2.3.3.1);

- EA will collect tap water samples from additional private and municipal supply wells as detailed in Table 8.

These data will be utilized to evaluate potential Site contributions to off-site ground water. In addition, private and municipal well sampling data will be important for the domestic use evaluation of ground water in the human health risk assessment.

Alluvial and bedrock background ground water samples will be collected from private and municipal taps to evaluate whether elevated inorganics in off-site shallow (alluvial) and deep (bedrock) ground water are regional or may be attributable to the Site (e.g., Iron King Mine). Proposed ground water sample quantities and analyses are provided on Table 7. Figure 9 illustrates the proposed ground water sampling locations.

Monitoring Well Sampling

Monitoring wells will be purged and sampled using low-flow (micro-purge) sampling protocol at a maximum flow rate of 0.5 liter per minute (SOP 048, Appendix F). Low-flow sampling requires that minimal drawdown is maintained throughout purging of the well to ensure that the water being purged is in fact entering the pump from the formation, and not as a result of lowering water levels within the well. Water level measurements should be collected periodically to confirm that drawdown is not occurring (SOP 010, Appendix F). The pump intake will be positioned near the middle of the screened water interval. Ground water sampling documentation will include records of the volume of water removed from the well, the depth of the pump intake, depth-to-water measurements prior to and at the completion of purging and sampling, and the identification and order of samples collected. Water quality parameters summarized in Table 11 will be collected throughout purging and logged for wells on ground water data sampling sheets which are provided in Appendix G.

TABLE 11 MONITORED WATER QUALITY PARAMETERS

Parameter	Field-based Method
Dissolved oxygen	Water quality meter
pH	Water quality meter
Specific conductance	Water quality meter
Water temperature	Water quality meter
Oxidation-reduction potential	Water quality meter
Turbidity	Water quality meter

Ground water will continue to be purged until measurements of temperature and conductivity have stabilized to within 10 percent, and pH has stabilized to within 0.1 units. Other parameters will be monitored during purging, including turbidity and oxidation-reduction potential, but will not be used as stabilizing criteria. Measurement of field parameters is further described in SOPs 008, 009, 012, 036, 037, 038, and 048 (Appendix F).

Tap Water Sampling

Table 8 lists the private and municipal supply wells proposed for tap water sampling. Figure 9 illustrates the proposed ground water sampling locations. Prior to the EA field team mobilizing, each resident will be notified by EPA and given an approximate date and time for their well to be sampled along with documentation of special requirements by the resident. EA will coordinate with EPA prior to Site mobilization to identify which wells are to be sampled and to ensure that the necessary access agreements are in place.

The residential wells will be purged and geochemical parameters monitored and logged using a calibrated water quality meter in accordance with SOP 014 (Appendix F). The parameters collected will include pH, temperature, and conductivity (SOPs 008, 009, and 012). These parameters will be measured for 15 minutes prior to sampling or until the readings have stabilized (conductivity within 10%, pH within plus or minus 0.5 pH units, and temperature within plus or minus 1 ^{o}C).

2.3.4 Air Sampling

EA will perform the following air sampling activities during the RI field program:

- Ambient air sampling to determine the sources and potential off-site migration of airborne contamination; and

- Personal air sampling to protect workers.

The type and quantities of ambient air to be collected during the RI field program are detailed in the Air Quality Monitoring Plan (Appendix D).

2.3.4.1 Ambient Air Sampling

EA will establish a meteorological station to determine the average wind velocity and prevailing wind direction for the Site. EA will collect approximately 90 ambient air samples (up to 6 stations/day x 5 days x 3 weeks) using BGI PQ100 samplers to determine the sources and potential off-site migration of airborne contamination. EA determined that 6 locations would be appropriate due to the short duration of the ambient air evaluation period. It is anticipated that samplers will be placed as follows: two samplers at Iron King Mine (upgradient and downgradient); two at Humboldt Smelter (upgradient and downgradient); and two in off-site downwind areas in the surrounding community. Samplers will be relocated during the field to evaluate potential off-site migration of airborne contamination as necessary.

2.3.4.2 Personal Air Sampling

As detailed in the site-specific HSP (EA 2008b), personal air monitoring and sampling for particulates (nuisance dust) and respirable lead dust will be performed during implementation of the RI field program to protect workers and the public. The current OSHA Permissible Exposure Limits (PELs) for total particulate matter (PM) and respirable lead dust for an 8-hour work period (integrated air monitoring) are 15 milligrams per cubic meter (mg/m^3) and 0.05 mg/m^3, respectively.

Personal air sampling for total airborne PM and lead will be conducted using pre-weighed filter cassettes and a Gilian GilAir-5™ Sampler, or an approved equivalent (per National Institute for Occupational Safety and Health [NIOSH] Method 0500) (NIOSH 1994). Representative field personnel performing field effort will be required to participate. A time-weighted average for an 8-hour period of sampling will determine the particulate level, and a subsequent analysis will be considered to determine lead content.

Total airborne PM and lead sample concentrations will be collected during an 8-hour work schedule using hand-held air sampling equipment on or near personnel. Ambient air will be analyzed in accordance with NIOSH Method 0500 (Particulates Not Otherwise Regulated, Total) and NIOSH Method 7300 (Elements by Inductively-coupled Plasma) (NIOSH 1994) to determine total dust and lead emissions, respectively. Pre-weighed filter cassettes will be submitted to the laboratory for a 3-day turnaround time basis.

Using pre-weighed filter cassettes, or an approved equivalent, air samples will be collected to determine total airborne PM and lead concentrations. The Gilian GilAir-5™ Samplers will be calibrated once a day to an approximate flow rate of 1,000 to 2,000 milliliters per minute using a Gilian Gilbrator™ Calibrator, or equivalent. The battery for each sampler will be recharged overnight to ensure no power failure during the 8-hours of air sampling. The sampling line, from the sampler to the pre-weighed filter cassettes, will be attached to personnel by tape or other means.

PM and lead will also be monitored continuously during the RI field program during intrusive activities, such as sampling, sample processing, and XRF analysis, unless rain occurs during the 8-hour sampling period. In the case of rain, air monitoring will continue after the rain has ceased, for the duration of the scheduled 8-hour sampling period or as advised by the SHSO. In addition, air monitoring will cease if fog or heavy mist is present.

Upon receipt of sample results for the first week of activity, the SHSO will evaluate the data against the applicable OSHA PEL. If the data indicates that airborne lead is less than ½ the PEL, the SHSO may discontinue personal air sampling activities, with concurrence from the Program Health and Safety Officer, or designee. Additional information concerning action levels and real-time air monitoring is provided in the site-specific HSP (EA 2008b).

2.3.5 Land Survey (Global Positioning System/Vertical Survey)

During the RI field program, EA will survey sample locations and source area dimensions (e.g., tailings piles) using portable GPS equipment. The determination of locations and top of casing (TOC) elevations for newly installed monitoring wells will be subcontracted to a local Registered Professional Licensed Surveyor in the State of Arizona. Elevations for each new monitoring well TOC will be measured and referenced to a relative benchmark. After field activities are complete, the surveyor will draft survey maps illustrating the information collected.

Private and municipal supply wells that have not previously surveyed may be surveyed using a GPS unit. GPS Data Attributes for each well position will be logged and include:

- Latitude and longitude;

- Collector name;
- Collection method;
- Datum;
- Maximum Positional Dilution of Precision;
- GPS date and time; and
- Total Positions collected at each well location.

2.3.6 Historic Property Survey

During the RI field program, EA will oversee subcontractor performance of a historical properties review in accordance with Section 106 of the National Historic Preservation Act (NHPA) of 1966.

2.3.7 Ecological Surveys

During the RI field program, EA will oversee subcontractor performance of an ecological habitat survey of the Iron King Mine, Humboldt Smelter, and Waterways by a local subcontracted firm that is familiar with the local ecology.

2.4 SAMPLE PROCESSING

Samples for fixed laboratory analysis will be processed and packaged in accordance with the *Contract Laboratory Program Guidance for Field Samplers* (EPA 2004c) and/or SOP 004 (Appendix F), as applicable.

The following soil samples will require special processing prior to submittal for analysis:

- Samples collected for field XRF analysis during the DMA Study; and
- Samples collected from the Off-site Soil AOI.

Special sample processing requirements are discussed in the following subsections.

2.4.1 XRF Sample Processing

As summarized in Section 2.3.1.1, the DMA Study will be completed using a field-portable Niton® XL3t XRF analyzer and various sample collection and preparation methods (*in situ, ex situ*, grinding, drying, and sieving).

The following general procedures (as recommended in EPA 2000a) will be followed during preparation of *ex situ* samples at the sample processing area:

- Unsieved soil samples will be ground and may be sieved with a No. 10 (2 millimeter [mm]) sieve to assist in removing large debris, such as sticks and stones.

- Sieved soil samples will be sieved using a No. 60 (250 micro-meter [µm]) sieve. If necessary, the sieved soil samples may be ground only after passing through a No. 60

sieve because the concentration of metals in the naturally-occurring fine material must be determined.

- Place approximately 5 grams of sample material into a Teflon™ sample cup (appropriate for XRF instrument).
- Tap the sample cup gently to settle the sample material.
- Add additional sample material, as necessary, to create a uniform surface level with the top of the sample cup.
- Cover the sample cup with a pre-sized sheet of Mylar™ film (x-ray window film).
- Lock the Mylar™ film onto the sample cup with the appropriate Teflon™ collar.
- Label each sample with the appropriate sample designation, either directly on the sample cup or on a resealable bag containing the sample cup.

Each sample will undergo analyses in the field laboratory (Support Zone) using a field-portable XRF analyzer to provide near-real time data as the DMA Study samples are being collected and processed. In order to evaluate the correlation between the field-laboratory XRF and fixed-laboratory data, DMA Study split samples will also be submitted to a fixed laboratory (CLP, EPA Region 9, or non-CLP subcontract laboratory) for TAL metals analyses using EPA CLP SOW ILM05.4 (2004b; 2006e) (Appendix H) or SW-846 Methods. Table 4 illustrates the distribution of the samples that will be submitted for fixed-laboratory analyses. The same material tested using the field XRF analyzer will be submitted to the fixed laboratory for these XRF-fixed laboratory correlation samples.

Fixed-laboratory analysis will be based on an estimated 7-day TAT, with preliminary data provided within a 72-hour TAT. EA will evaluate the correlation between XRF data and fixed laboratory data for site-related metals. The DMA Study will assist in determining the effectiveness of the XRF instrument as a screening tool or if the XRF instrument can be utilized for more definitive analysis.

Details about sample preparation, analysis, QC requirements, and potential interferences are discussed in EPA SW-846 Method 6200 (EPA 1998) (Appendix H).

2.5 DECONTAMINATION

Re-usable field equipment utilized during the RI/FS will be decontaminated prior to and after use in accordance with SOP 005 (Appendix F). Decontamination of field equipment will occur in buckets, plastic containers, or other similar containers with sealing lids, and the resulting fluid will be transferred to 55-gallon IDW drums staged designated staging area (Support Zone). The decontamination water will be properly sampled and disposed of following local, State, and Federal guidelines (see Section 2.6).

2.6 MANAGEMENT OF INVESTIGATION-DERIVED WASTE

Ea will incorporate best management practices of green remediation as it relates to the management of IDW. Drill cuttings and unused portions of soil samples from source areas (i.e., tailings, ash, and slag) will be returned to the applicable sampling location, boring, pile, etc. to minimize waste generation requiring off-site disposal. Unused portions of soil from the off-site areas will drummed, sealed, labeled, and stored at the designated staging area (Support Zone) until profiled for acceptance at an approved disposal facility (SOP 042, Appendix F). IDW soil samples will be submitted to an EA-subcontracted laboratory for disposal characterization. Landfill Disposal Restrictions will dictate sample quantities and analysis

Decontamination water generated during well installation, ground water sampling, and equipment decontamination will be drummed, sealed, labeled, and stored at the designated staging area (Support Zone) until profiled for acceptance at an approved disposal facility (SOP 042, Appendix F). IDW water samples will be submitted to an EA-subcontracted laboratory for disposal characterization.

The SMP provides additional detail regarding IDW management (EA 2008c).

2.7 SAMPLE DESIGNATION

Each sampling location will be designated with a unique alphanumeric designation according to the following sample classifications:

- **Soil Sample Designation.** Soil sample designation will include four fields that are separated by dashes; for example: IKV-120-0-2.
    - The first field, “IKV,” identifies the AOI and sample type. The first 2 alpha characters represents the AOI, where
        - IK = Iron King Mine
        - HS = Humboldt Smelter)
    - The 3rd alpha character represents the sample type, where
        - V = VSP output (virtual grid sample location)
        - J = Judgmental sample location
    - The second field, “120,” represents the sample identifier.
    - The third field, “0,” represents the top of the sample interval measured in feet bgs.
    - The fourth field, “2,” represents the bottom of the sample interval measured in feet bgs.

- **Off-site Soil Sample Designation.** Off-site Soil sample designation will include four fields that are separated by dashes; for example: OFS-101-0-0.5.
    - The first field, “OFS,” identifies the Off-site Soil AOI
    - The second field, “101,” represents the sample identifier (to be determined in the field).
    - The third field, “0,” represents the top of the sample interval measured in feet bgs.
    - The fourth field, “0.5,” represents the bottom of the sample interval measured in feet bgs.

- **Background Soil Sample Designation.** Background soil sample designation will include four fields that are separated by dashes; for example: BKG-101-0-2.
  - The first field, "BKG," identifies the sample as representing background.
  - The second field, "101," represents the sample identifier (to be determined in the field).
  - The third field, "0," represents the top of the sample interval measured in feet bgs.
  - The fourth field, "2," represents the bottom of the sample interval measured in feet bgs.

- **Sediment Sample Designation.** Sediment sample designation will include three fields that are separated by dashes; for example: SD-AF-12.
  - The first field, "SD," identifies the sample matrix as sediment.
  - The second field, "AF," represents the waterway, impoundment, or outfall, where
    - AF = Agua Fria River
    - CG = Chaparral Gulch
    - GG = Galena Gulch
    - IP = Impoundment or retention pond
    - OW = Outfall or wash
  - The third field, "12," represents the sample identifier.

- **Surface Water Sample Designation.** Surface water sample designation will include three fields that are separated by dashes; for example: SW-AF-12.
  - The first field, "SW," identifies the sample matrix as surface water.
  - The second field, "AF," represents the waterway, impoundment, or outfall, where
    - AF = Agua Fria River
    - CG = Chaparral Gulch
    - GG = Galena Gulch
    - IP = Impoundment or retention pond
    - OW = Outfall or wash
  - The third field, "12," represents the sample identifier.

- **Ground Water Sample Designation.** Ground water sample designation for private and municipal wells will utilize the well designations presented in Table 8. Two fields will be separated by dashes; for example: GW-509113.
  - The two alpha characters in the first field, "GW," identifies that the sample came from a permanent private or municipal ground water well.
  - The second field, "509113," represents the Arizona Well Registration ID.

- **New Monitoring Well Designation.** Newly constructed monitoring well sample designation will include three fields that are separated by dashes; for example: MW-01-S.
  - The two alpha characters in the first field, "MW," identifies that the sample came from a permanent monitoring well.
  - The second field, "01," represents the monitoring well number designation or identifier.
  - The third field, "S," represents the water-bearing zone or formation in which the well is screened, where

  - S = Shallow (alluvial) aquifer
  - D = Deep (bedrock) aquifer

- **Field Duplicate Sample Designation.** Field duplicate samples will be identified by adding a "D" to the end of the sample designations described above; for example, IKV-120-0-2D and SD-AF-12D.

- **Matrix Spike/Matrix Spike Duplicate (MS/MSD) Sample Designation** (for organic analysis). MS and MSD samples will be identified by adding an "MSD" to the end of the sample designations described above; for example, IKV-120-0-2MSD.

- **Matrix Spike/Matrix Duplicate (MS/MD) Sample Designation** (for inorganic analysis). MS and MD samples will be identified by adding an "MD" to the end of the sample designations described above; for example, IKV-120-0-2MD.

- **Field, Trip, and Equipment Rinsate Blank Sample Designation**. Trip and equipment blank samples will be identified sequentially beginning with TB-1, FB-1, and ER-1, respectively.

2.8 SAMPLE CONTAINER, VOLUME, PRESERVATION, AND HOLDING TIME REQUIREMENTS

Table 12 specifies the required sample volume, container type, preservation technique, and holding time for each analysis that is to be conducted during each phase of sampling. Required containers, preservation techniques, and holding times for field QC samples, such as field duplicates, will be the same as for investigative samples, but may require additional volumes as described in Section 2.11.

2.9 SAMPLE HANDLING AND CUSTODY

Each sample collected by the EA field team will be traceable from the point of collection through analysis and final disposition to ensure sample integrity. Sample integrity helps to ensure the legal defensibility of the analytical data and subsequent conclusions. Sample handling will follow CLP protocols as required in EPA's *Contract Laboratory Program Guidance for Field Samplers* (EPA 2004c).

The EA field team will use EPA's data management system known as "Forms II Lite" to generate chain-of-custody records in the field. Applicable copies of generated Forms II Lite files will be delivered to EPA data management personnel as required by CLP protocols.

2.10 ANALYTICAL METHODS REQUIREMENTS

The source of analytical services to be provided will be determined in part by DQOs and the intended use of the resulting data. EA will use EPA-approved methods for laboratory analyses of the samples.

EA will follow the analytical services request procedures that are outlined EA's Analytical Services Delivery Plan (EA 2005b). If an analytical system fails, the QA officer will be notified, and corrective action will be taken. In general, corrective actions will include stopping the analysis, examining instrument performance and sample preparation information, and determining the need to re-prepare and reanalyze the samples.

TABLE 12 REQUIRED VOLUME, CONTAINERS, PRESERVATIES, AND HOLDING TIMES

Parameter	Method	Volume and Container	Preservatives	Holding Time[a]
Investigative Soil or Sediment Samples				
TAL metals (including mercury and cyanide)	CLP ILM05.4 [b]	One 8-ounce glass jar with Teflon™-lined cap	Store at 4±2°C	180 days for analysis (28 days Hg)
Total metals (Field-portable XRF)	SW-846 6200 (draft) [c]	One 1-gallon resealable plastic bag One XRF sample cup	NA	6 months
VOCs	CLP SOM01.2 [d]	Three 5-gram EnCore samplers One 4-ounce glass jar with Teflon™-lined cap (moisture content)	Methanol; Store at 4±2°C	48 hours
SVOCs	CLP SOM01.2 [d]	One 8-ounce glass jar with Teflon™-lined cap[h]	Store at 4±2°C	7 days
Pesticides/PCBs	CLP SOM01.2 [d]	One 8-ounce glass jar with Teflon™-lined cap[h]	Store at 4±2°C	14 days
Dioxins and Furans	DLM01.2 [d]	One 8-ounce glass jar with Teflon™-lined cap	Store at 4±2°C	14 days
Nitrate/sulfate/ perchlorate	SW-846 300.0, 314.0	One 8-ounce glass jar with Teflon™-lined cap[k]	Store at 4±2°C	48 hrs - nitrate 28 days – sulfate and perchlorate
SPLP metals (including mercury and cyanide)	SW-846 1312 [e]	One 8-ounce glass jar with Teflon™-lined cap	Store at 4±2°C	14 days
Geotechnical	To be determined	One 1-gallon resealable plastic bag	NA	6 months
Lead/arsenic speciation	To be determined	One 8-ounce glass jar with Teflon™-lined cap	Store at 4±2°C	14 days
Investigative Ground Water/Surface Water Samples				
TAL metals (including mercury)	CLP ILM05.4 [b]	One 500-millilter polyethylene bottle	Nitric Acid to pH < 2; Store at 4±2°C	180 days for analysis 28 days for Hg
Cyanide	CLP ILM05.4 [b]	One 500-milliliter polyethylene bottle	Sodium Hydroxide to pH > 12; Store at 4±2°C	180 days for analysis
TCL VOCs	CLP SOM01.2 [d]	Three 40-milliliter glass vials with Teflon™-lined cap	Hydrochloric acid to pH < 2; Store at 4±2°C	14 days
TCL SVOCs	CLP SOM01.2 [d]	Two 1-liter amber glass bottles with Teflon™-lined cap	Store at 4±2°C	7 days

Parameter	Method	Volume and Container	Preservatives	Holding Time[a]
Nitrate/sulfate/ perchlorate	SW-846 300.0, 314.0[f]	One 250-500 milliliter polyethylene bottles[l]	Store at 4±2°C	48 hrs - nitrate 28 days – sulfate and perchlorate
Anions/cations	SW-846 300.0, 6020	One 250-500 milliliter polyethylene bottles[l,m]	Store at 4±2°C	7 days
Total Dissolved Solids	SW-846 160.1	One 500-milliliter polyethylene bottle[l]	Store at 4±2°C	7 days
Dioxins and Furans	SW-846 8290	Two 1-Liter amber glass bottles	Store at 4±2°C	1 year if stored in the dark
Pesticides and Aroclors	SW-846 8081, 8082	Two 1-Liter amber glass bottles	Store at 4±2°C	7 days
Asbestos-containing Material				
Asbestos	Region 9 Lab SOP 490 (ASTM D22.05)	One 8-ounce glass jar with Teflon™-lined cap	NA	NA
Personal Air Samples				
Total airborne PM	NIOSH 0500 [g]	Pre-weighed filter cassettes	NA	NA
Lead dust	NIOSH 7300 [g]			
IDW Soil and Water Samples				
Reactivity Corrosivity Ignitibility	SW-846 9045C, 1030, and Chapter 7 [e]	One 8-ounce glass jar with Teflon™-lined cap[k]	Store at 4 °C ± 2 °C	NA/72 hours
TCLP metals (including mercury and cyanide)	SW-846 1311 [e]	One 8-ounce glass jar with Teflon™-lined cap	Store at 4±2°C	14 days

Notes:
a Holding time is measured from the time of sample collection to the time of sample extraction and analysis.
b EPA 2004b; 2006e; Appendix H
c EPA 1998; Appendix H
d EPA 2005a; 2007
e EPA 1996
f EPA 1993
g NIOSH 1994
h SVOC, Pesticides, and Aroclors will be combined in one 8 oz jar.
k Nitrate, Sulfate, Perchlorate, and pH will be combined in one 8 oz jar.
l Nitrate, Nitrite, Sulfate, Perchlorate, TDS, and Anions will be combined in one 500 ml polyethylene bottle.
m Cations will be collected with one 500 ml polyethylene bottle preserved with HNO_3.
CLP = Contract Laboratory Program
PCB = Polychlorinated Biphenyls
SVOC = Semi-volatile Organic Compound
TAL = Target Analyte List
TCL = Target Compound List
VOC = Volatile Organic Compound
XRF = X-ray Fluorescence

Laboratories that are subcontracted by EA or EPA will conduct definitive laboratory analysis of samples. Table 12 lists the laboratory analytical methods for this project. In cases, appropriate methods of sample preparation, cleanup, and analyses are based on specific analytical parameters of interest, sample matrices, and required quantitation limits. The following sections briefly discuss each analytical method and required modifications for definitive investigative analyses. Analyses for the IDW profiling will be conducted according to the specifications in the selected analytical method listed in Table 12.

The source of analytical services to be provided will be determined in part by DQOs and the intended use of the resulting data. EA will use EPA-approved methods for laboratory analyses of the samples.

2.10.1 Field Analytical Methods

Total metals in soil samples will be analyzed during the DMA Study using a field-portable XRF analyzer. XRF occurs when an atom is struck by an X-ray or gamma-ray (also called a photon) from a radioactive source and subsequently emits a fluorescence X-ray at a unique frequency (or energy). The XRF instrument will use this frequency to identify the element. The XRF instrument will determine the concentration of specific metals in the samples by determining the total number of X-rays emitted at its characteristic frequency during a given amount of time.

Details about sample analysis, QC requirements, and potential interferences are discussed in EPA SW-846 Method 6200 (EPA 1998) (Appendix H). Sample preparation procedures (as recommended in EPA 2000a) are detailed in Section 2.4. For samples to be submitted to the fixed laboratory, the same material that was tested with the XRF will be submitted to the laboratory.

During the DMA Study, a qualified XRF analyst will conduct XRF analysis for metals in soil samples. Splits of the XRF samples will be sent to a fixed laboratory for confirmatory analysis of total metals using CLP SOW ILM05.4 (EPA 2004b; 2006e). Quantitation of metals by XRF will be conducted using factory-installed algorithms. Soil sample results will be reported in milligrams per kilogram.

Sections 2.3 and 2.4 summarize the collection and preparation of sieved and unsieved soil samples undergoing field XRF and TAL metals analyses.

In conjunction with collection of Off-site Soil samples, field personnel may also perform *in situ* analysis on the property using a field-portable XRF analyzer.

Water quality parameters that include pH, temperature, specific conductivity, oxidation-reduction potential, dissolved oxygen, and turbidity will be monitored using field-based methods during the collection of ground water samples. EA will follow manufacturer-recommended procedures for operating field equipment.

2.10.2 Fixed-Laboratory Analytical Methods

Fixed-laboratory analyses will be conducted by EPA Region 9, a designated CLP laboratory, or a subcontracted non-CLP laboratory. Samples submitted to the analytical laboratory will be analyzed in accordance with CLP SOWs SOM01.2 (EPA 2005a; 2007) and ILM05.4 (EPA 2004b; 2006e). Modifications to analytical methods that may be required to manage atypical matrices or to achieve low quantitation limits are not anticipated. Decisions regarding the use and type of method modifications will be made during the procurement of laboratories, as different laboratories have equipment and SOPs that generate varying quantitation limits.

The EPA quick reference fact sheets that list the CRDLs for CLP SOWs SOM01.2 and ILM05.4 are provided in Appendix H.

Approximately 21 lead/arsenic speciation samples will be collected to determine if the material at the Humboldt Smelter and Off-Site Soil areas are consistent with the material at the Iron King Mine; this information will primarily be utilized to evaluate an operational link between the Iron King Mine and Humboldt Smelter. As discussed in DQO Step 3 (Section 1.3.4), lead/arsenic speciation sample analysis techniques may include, but are not limited to: (1) Polarized Light Microscopy; (2) Scanning Electron Microscopy; (3) Energy Dispersive X-Ray Spectrometry; (4) X-Ray Diffraction spectrometry; and (5) X-Ray Fluorescence Spectrometry.

2.11 QUALITY CONTROL REQUIREMENTS

Various field and laboratory QC samples and measurements will be used to verify that analytical data meet the QA objectives. Field QC samples and measurements will be collected to assess the influence of sampling activities and measurements on data quality. Similarly, laboratory QC samples will be used to assess how the laboratory's analytical program influences data quality. This section describes the QC samples that are to be analyzed during the site sampling activities for: (1) each field and laboratory environmental measurement method; and (2) each sample matrix type. Table 3 shows the acceptance criteria for each type of QC sample, and Table 13 presents the frequency of QC samples to be collected at the site.

2.11.1 Field Quality Control Requirements

Field QC samples will be collected and analyzed to assess the quality of data that are generated by sampling activities. These samples will include laboratory QC samples collected in the field, field duplicates, equipment rinsates, MS/MDs, and temperature blanks. QC samples collected in the field for fixed-laboratory analysis are presented in Table 13.

Field duplicates are independent samples that are collected as close as possible, in space and time, to the original investigative sample. Field duplicates can measure the influence of sampling and field procedures on the precision of an environmental measurement. They can also provide information on the heterogeneity of a sampling location. Field duplicates will be collected at a frequency of one for every 10 investigative samples, as listed in Table 13.

Immediately following collection of the original sample, the field duplicates are collected using the same collection method.

Field blanks are collected to assess: (1) impact from ambient air conditions during sample collection; (2) cross-contamination during sample collection, preservation, and shipment, as well as in the laboratory; and (3) cleanliness of the sample containers and preservatives. Field blank samples consist of sample containers filled with analytically-certified, organic-free water. Field blank samples are typically collected during ground water sample collection for VOC analysis at a frequency of one field blank for each day of ground water sampling activities (specifically for VOC analysis). Field blanks may be collected for other media and analytes as dictated by site conditions during investigative sampling activities. If contaminant is present in the blank samples above the method detection limit, the result for associated field samples that contain the same contaminant will be qualified as potentially not detected if the concentration of the field sample is less than five times the concentration found in the blank.

TABLE 13 FREQUENCY OF FIELD QUALITY CONTROL SAMPLES

Field QC Sample	**Frequency [a]**
Trip blank	1 per cooler containing aqueous samples for VOC analysis
Field blank	1 per day, if site conditions render this sample necessary
Filter blank	1 per 20 primary air samples
Field duplicate	1 per 10 samples
Equipment rinsate blank	1 per non-dedicated equipment type per day or 1 per 20 samples
MS/MD [b] (inorganics)	1 per 20 samples
MS/MSD[b] (organics)	1 per 20 samples
Temperature blank	1 per cooler

Notes:
a The QC sample collection frequency applies to samples collected for fixed-laboratory analysis (EPA 1996; 2004c; 2005a; 2006e; 2007). Samples collected for field XRF analysis will only warrant field duplicate samples.
b MS, MSD, and MD analyses are technically not field QC samples; however, they generally require that the field personnel collect additional volumes of samples and are, therefore, included on this table for easy reference.

A filter blank consists of a clean filter that is transported with associated primary air samples, but is never taken out of its protective sleeve. Analyses of filter blanks are used to assess the contamination of samples during sample collection. A filter blank consists of a clean filter that is placed onto the air sampler and then taken off without running the sampler. Filter blanks will be collected at a frequency of one for every 20 investigative air samples, as listed in Table 13. Filter blank samples will be analyzed for the same parameters specified for the associated primary samples.

Equipment rinsate blanks are collected when nondedicated or nondisposable sampling equipment is used to collect samples and put the samples into containers. These blanks assess the cleanliness of the sampling equipment and the effectiveness of equipment decontamination. Equipment rinsate blanks are collected by pouring analyte-free water over the decontaminated surfaces of sampling equipment that contacts sampling media. Equipment rinsate blanks are collected after sampling equipment has been decontaminated, but before the equipment is reused for sampling. If nondedicated or nondisposable equipment is used, equipment rinsate blanks will be collected in accordance with the frequency listed in Table 13.

MS/MSD samples are laboratory QC samples that are collected for organic methods; MS/MD samples are collected for inorganic methods. For aqueous samples, MS/MSDs require double or triple the normal sample volume, depending on analytical laboratory specifications; MS/MDs require double the normal sample volume. In the laboratory, MS/MSD and MS/MD samples are split and spiked with known amounts of analytes. Analytical results for MS/MSD and MS/MD samples are used to measure the precision and accuracy of the laboratory's organic and inorganic analytical programs, respectively. Each of these QC samples will be collected and analyzed at a frequency of one for every 20 investigative samples for CLP laboratories or subcontract non-CLP laboratories, or in accordance with the requirements of the EPA Region 9 Laboratory.

Trip blanks are analyzed for VOCs only. VOC samples are susceptible to contamination by diffusion of organic contaminants through the Teflon-lined septum of the sample vial; therefore, a VOC trip blank will be analyzed to monitor for possible sample contamination. Also, the trip blank will screen for possible contamination of VOC samples during handling and shipment from the field to the laboratory. The trip blanks will be provided by the laboratory and placed in each cooler that contains VOC samples.

Temperature blanks are containers of deionized or distilled water that are placed in each cooler shipped to the laboratory. Their purpose is to provide a container to test the temperature of the samples in the respective cooler.

2.11.2 Laboratory Quality Control Requirements

Laboratories that perform analytical work under this project must adhere to a QA program that is used to monitor and control laboratory QC activities. Each laboratory must have a written QA manual that describes the QA program in detail. The laboratory QA manager is responsible for ensuring that laboratory internal QC checks are conducted in accordance with EPA methods and protocols, the laboratory's QA manual, and the requirements of this SAP.

Many of the laboratory QC procedures and requirements are described in EPA-approved analytical methods, laboratory method SOPs, and method guidance documents.

The EPA methods specify the preparation and analysis of QC samples, and may include, but are not limited to, the following types: (1) LCSs; (2) method blanks; (3) MS, MSD, and MD samples; (4) surrogate spikes; and (5) standard reference materials or independent check standards. The following subsections discuss the QC checks that will be required for this project. The EPA multimedia, multi-concentration analytical service fact sheets for CLP SOWs SOM01.2 and ILM05.4 are provided in Appendix H.

2.11.2.1 Laboratory Control Sample

LCSs are thoroughly characterized, laboratory-generated samples that are used to monitor the laboratory's day-to-day performance of analytical methods. The results of LCS analyses are compared to well-defined laboratory control limits to determine whether the laboratory system is in control for the particular method. If the system is not in control, corrective action will be implemented. Appropriate corrective actions will include: (1) stopping the analysis, (2) examining instrument performance or sample preparation and analysis information, and (3) determining whether samples should be re-prepared or reanalyzed.

2.11.2.2 Method Blanks

Method blanks, which are also known as preparation blanks, are analyzed to assess the level of background interference or contamination in the analytical system and the level that may lead to elevated concentration levels or false-positive data. Method blanks will be required for laboratory analyses and will be prepared and analyzed at a frequency of one method blank per every 20 samples or one method blank per batch, if the batches consist of fewer than 20 samples.

A method blank consists of reagents that are specific to the analytical method and are carried through every aspect of the analytical procedure, including sample preparation, cleanup, and analysis. The results of the method blank analysis will be evaluated in conjunction with other QC information to determine the acceptability of the data generated for that batch of samples. Ideally, the concentration of a target analyte in the method blank will be below the reporting limit for that analyte. For some common laboratory contaminants, a higher concentration may be allowed.

If the method blank for analysis is beyond control limits, the source of contamination must be investigated, and appropriate corrective action must be taken and documented. This investigation includes an evaluation of the data to determine the extent of the contamination and its effect on sampling results. If a method blank is within control limits but analysis indicates a concentration of analytes that is above the reporting limit, an investigation should be conducted to determine whether corrective action could eliminate an ongoing source of target analytes.

For organic and inorganic analyses, the concentration of target analytes in the method blank must be below the reporting limit for that analyte for the blank to be considered acceptable. An exception may be made for common laboratory contaminants (such as methylene chloride, acetone, 2-butanone, and phthalate esters) that may be present in the blank at up to five times the reporting limit. These compounds are frequently detected at low levels in method blanks from materials that are used to collect, prepare, and analyze samples for organic parameters.

2.11.2.3 Matrix Spikes

MSs and MSDs are aliquots of an environmental sample for organic analysis to which known concentrations of target analytes and compounds have been added. The MS is used to evaluate the effect of the sample matrix on the accuracy of the analysis. If there are many target analytes, they will be divided into two to three spike standard solutions. Each spike standard solution will be used alternately. The MS, in addition to an unspiked aliquot, will be taken through the entire analytical procedure, and the recovery of the analytes will be calculated. Results will be expressed in terms of percent recoveries and RPD. The percent recoveries of the target analytes and compounds are calculated and used to determine the effects of the matrix on the precision and accuracy of the method. The RPD between the MS and MSD results is used to evaluate method precision.

The MS/MSD is divided into three separate aliquots, two of which are spiked with known concentrations of target analytes. The two spiked aliquots, in addition to an unspiked sample aliquot, are analyzed separately, and the results are compared to determine the effects of the matrix on the precision and accuracy of the analysis. Results will be expressed as RPD and percent recovery and compared to control limits that have been established for each analyte. If results fall outside control limits, corrective action will be performed.

2.11.2.4 Laboratory (Matrix) Duplicates

MDs, which are also called laboratory duplicates, are prepared and analyzed for inorganic analyses to assess method precision. Two aliquots of sample material are taken from the sample and processed simultaneously without adding spiking compounds. The MD and the original sample aliquot are taken through the entire analytical procedure, and the RPD of the duplicate result is calculated. Results are expressed as RPD and are compared to control limits that have been established for each analyte.

2.11.2.5 Surrogate Spikes

Surrogates are organic compounds that are similar to the analytes of interest in chemical properties but are not normally found in environmental samples. Surrogates are added to field and QC samples, before the samples are extracted, to assess the efficacy of the extraction procedure and to assess the bias that is introduced by the sample matrix. Results are reported in terms of percent recovery. Individual analytical methods may require sample reanalysis based on surrogate criteria.

The laboratory will use surrogate recoveries mainly to assess matrix effects on sample analysis. Obvious problems with sample preparation and analysis (such as evaporation to dryness or a leaking septum) that can lead to poor surrogate spike recoveries must be eliminated before low surrogate recoveries can be attributed to matrix effects.

2.11.3 Common Data Quality Indicators

This section describes how QA objectives for precision, accuracy, completeness, and sensitivity are measured, calculated, and reported.

2.11.3.1 Precision

Precision of many analyses is assessed by comparing analytical results of MS and MSD sample pairs for organic analyses, field duplicate samples, laboratory duplicate samples (MDs), and field replicate measurements. If precision is calculated from two measurements, it is normally measured as RPD. If precision is calculated from three or more replicates, relative standard deviation is calculated.

2.11.3.2 Accuracy

The accuracy of many analytical methods is assessed by using the results of MS and MSD samples for organic analyses, MS samples for inorganic analyses, surrogate spike samples, LCSs, standard reference materials, independent check standards, and measurements of instrument responses against zero and span gases.

For measurements in which spikes are used, percent recovery will be calculated.

2.11.3.3 Completeness

Completeness is a measure of the percentage of project-specific data that are valid. Valid data are obtained when samples are collected and analyzed in accordance with QC procedures outlined in this SAP, and when none of the QC criteria that affect data usability are exceeded.

When data validation is completed, the percent completeness value will be calculated by dividing the number of useable results by the total number of sample results planned for this investigation.

Completeness will also be evaluated as part of the data quality assessment (DQA) process (EPA 2006c; 2006d). This evaluation will help determine whether limitations are associated with the decisions to be made based on the data collected.

2.11.3.4 Sensitivity

The achievement of MDLs depends on instrument sensitivity and matrix effects. Therefore, it is important to monitor the instrument sensitivity to ensure data quality and to ensure that analyses meet the QA objectives that have been established for sensitivity.

2.11.4 Instrument and Equipment Testing, Inspection, and Maintenance Requirements

This section outlines testing, inspection, and maintenance procedures for field equipment and instruments and for laboratory instruments.

2.11.4.1 General Requirements

Testing, inspection, and maintenance methods and frequency will be based on: (1) the type of instrument; (2) the instrument's stability characteristics; (3) the required accuracy, sensitivity, and precision of the instrument; (4) the instrument's intended use, considering project-specific DQOs; (5) manufacturer's recommendations; and (6) other conditions that affect measurement or operational control. For most instruments, preventive maintenance is performed in accordance with procedures and schedules recommended in (1) the instrument manufacturer's literature or operating manual, or (2) SOPs associated with particular applications of the instrument.

In some cases, testing, inspection, and maintenance procedures and schedules will differ from the manufacturer's specifications or SOPs. This can occur when a field instrument is used to make critical measurements or when the analytical methods that are associated with a laboratory instrument require more frequent testing, inspection, and maintenance.

2.11.4.2 Field Equipment and Instruments

Leased field equipment and instruments will be used to conduct soil sampling, soil sample preparation, ambient air monitoring and sampling (health and safety), and field XRF analysis. The vendor will be responsible for thoroughly checking and calibrating field equipment and instruments before they are shipped or transported to the field. Copies of testing, inspection, and maintenance procedures will be shipped to the field with the equipment and instruments.

After the field equipment and instruments arrive in the field, they will be inspected for damage. Damaged equipment and instruments will be replaced or repaired immediately. Battery-operated equipment will be checked to ensure full operating capacity; if needed, batteries will be recharged or replaced.

Following use, field equipment will be decontaminated properly before being returned to the source. When the equipment is returned, copies of field notes regarding equipment problems will be included so that problems are not overlooked and necessary equipment repairs are performed.

2.11.4.3 Laboratory Instruments

Laboratories that analyze samples collected under the EPA Region 6 RAC II program must have a preventive maintenance program that addresses: (1) testing, inspection, and maintenance procedures; and (2) the maintenance schedule for each measurement system and required support activity. This program is usually documented by a SOP for each analytical instrument that is to be used. Typically, the program will be laboratory-specific; however, it should follow requirements outlined in EPA-approved guidelines. Some of the basic requirements and components of such a program are as follows:

- As a part of its QA/QC program, each laboratory will conduct a routine preventive maintenance program to minimize instrument failure and other system malfunction.

- An internal group of qualified personnel will maintain and repair instruments, equipment, tools, and gauges. Alternatively, manufacturers' representatives may provide scheduled instrument maintenance and emergency repair under a repair and maintenance contract.

- The laboratory will perform instrument maintenance on a regularly scheduled basis. The scheduled service of critical items should minimize the downtime of the measurement system. The laboratory will prepare a list of critical spare parts for each instrument. The laboratory will request the spare parts from the manufacturer and will store the parts.

- Testing, inspection, and maintenance procedures described in laboratory SOPs will be performed in accordance with manufacturer's specifications and the requirements of the specific analytical methods that are used.

- Maintenance and service must be documented in service logbooks (or the site-specific logbook) to provide a history of maintenance records. A separate service logbook should be kept for each instrument; however, due to the limited scope of this project, the service records will be maintained in the site-specific field logbook. Maintenance records will be traceable to the specific instrument, equipment, tool, or gauge.

- The laboratory will maintain and file records that are produced as a result of tests, inspections, or maintenance of laboratory instruments. These records will be available for review by internal and external laboratory system audits that are conducted under the EPA Region 6 RAC II program.

2.12 INSTRUMENT CALIBRATION AND FREQUENCY

This section describes the procedures for maintaining the accuracy of field equipment and laboratory instruments that are used for field tests and laboratory analyses. The equipment and instruments should be calibrated before each use or, when not in use, on a scheduled periodic basis.

2.12.1 Field Equipment

EA will perform calibration of field equipment during the site field activities specified herein. Calibration of the field equipment (XRF, Ludlum, and multi-parameter water quality meter) will be conducted on a daily basis following manufacturer recommendations, and will be performed prior to sample analysis activities. Should XRF or water quality readings appear to be questionable during sample analysis, EA will recalibrate the equipment as deemed necessary. The equipment calibration procedures described below will be followed.

Equipment will be maintained and calibrated with sufficient frequency and in such a manner that the accuracy and reproducibility of results are consistent with the manufacturer's specifications and with project-specific DQOs. Upon arrival of the field equipment, EA field personnel will examine it to verify that it is in good working condition. The manufacturer's operating manual and instructions that accompany the equipment will be consulted to ensure that calibration procedures are followed. Measuring and testing equipment may be calibrated either internally—by using in-house reference standards—or externally—by agencies, manufacturers, or commercial laboratories. Calibration records will contain a reference identifying the source of the procedure and, where feasible, the actual procedure. Each piece of measuring and testing equipment will also be accompanied by an equipment use log. The equipment use log (which may be contained within the site-specific field logbook) will be kept current and may contain the following information: (1) date of use; (2) times of use; (3) operating and assisting technicians; (4) calibration status; and (5) comments.

The following procedures are intended to supplement the user's guide that will accompany the each field instrument and provide additional clarification for operation of the instrument.

The following procedures should be followed in numerical sequence to ensure that the XRF instrument is operating within expected QC parameters prior to, during, and after analysis of soil samples.

2.12.1.1 XRF Calibration/Initial Setup

The XRF analyst will implement the following procedures during calibration and setup:

1. Prior to operation each day, the XRF instrument will be turned on and allowed to run for 15 minutes to stabilize.

2. Prior to sample or standard analysis, the instrument is calibrated using the self-calibration mode in accordance with procedures outlined in the accompanying user's guide (to be provided with the XRF instrument).

3. Because the instrument requires an isotope source to generate X-rays for the required analysis (typically Cadmium 109 [Cd-109] for analysis of metals, particularly lead and arsenic), the analyst will record instrument specification information provided in the setup menu specific to the source each day prior to conducting sample analysis.

4. The analyst will also check the date and time stamp for sample analysis provided by the instrument to ensure accuracy of reported sample times and dates. Required changes should be noted in the field logbook and changes will be made in the setup menu.

2.12.1.2 XRF Instrument Operation/Quality Control Checks

Following instrument calibration, the analyst will perform several source checks using National Institute of Standards and Technology (NIST) standards and record the values provided, as follows:

1. Ensure that the instrument is operating using the Cd-109 source, and provide a source check of the low-level NIST standard using a 120-second count time. Record the metals concentrations. Expected concentrations for certified standards can be found in the accompanying user's guide (to be provided with XRF instrument).

2. Ensure that the instrument is operating using the Cd-109 source, and provide a source check of the mid-level NIST standard using a 120-second count time. Record the metals concentrations. Expected concentrations for certified standards can be found in the accompanying user's guide (to be provided with XRF instrument).

3. Ensure that the instrument is operating using the Cd-109 source, and provide a source check of the high-level NIST standard using a 120-second count time. Record the metals concentrations. Expected concentrations for certified standards can be found in the accompanying user's guide (to be provided with XRF instrument).

4. To ensure that the XRF instrument is operating within control limits, comparability values will be calculated for each of the standard checks. Values exceeding 20% difference (80% to 120%) will be noted and immediately discussed with the QA manager. Results outside the 20% QC window indicate the instrument is not performing correctly and will be re-calibrated. In addition, samples analyzed after the previous source checks that passed the 20% QC window will be re-analyzed using the new calibration. Comparability will be calculated using the following equation.

(Measured Concentration / Known Concentration of Standard) x 100

The instrument has now been calibrated and sufficient standard materials analyzed to ensure that it is operating within standard conditions.

5. The analyst will analyze samples in accordance with this SAP and other applicable documents. Field sample results for site-related metals are transferred manually to a Microsoft Excel spreadsheet and information will be downloaded from the instrument daily as an additional backup and QC check to ensure transcription errors do not occur.
6. The instrument analyst should conduct source checks outlined in Steps 1 through 4 of the Instrument Operation/QC Checks procedures prior to sample analysis each day, at the midpoint of the workday, and at the end of each day that analyses are performed. Results should be recorded and deviations noted and discussed with the project chemist.

2.12.2 Laboratory Instruments

Laboratory equipment that is used to analyze samples collected under the EPA Region 6 RAC II program will be calibrated on the basis of written SOPs that are maintained by the laboratory. Calibration records (including the dates and times of calibration and the names of the personnel performing the calibration) will be filed at the location at which the analytical work was performed and maintained by the laboratory personnel who performed QC activities. Subcontractor laboratories may conduct laboratory work under the EPA Region 6 RAC II program. The laboratory QA manager is responsible for ensuring that laboratory instruments are calibrated in accordance with the requirements of this SAP.

The laboratories will follow the method-specific calibration procedures and requirements for laboratory measurements. Calibration procedures and requirements will also be provided, as appropriate, for laboratory support equipment, such as balances, mercury thermometers, pH meters, and other equipment that is used to take chemical and physical measurements.

2.13 REQUIREMENTS FOR INSPECTION AND ACCEPTANCE OF SUPPLIES AND CONSUMABLES

The EA Project Manager is responsible for identifying the types and quantities of supplies and consumables that are needed for collecting the samples for this Task Order. The Project Manager is also responsible for determining acceptance criteria for these items. When supplies are received, the EA field personnel will check packing slips against purchase orders and inspect the condition of supplies before the supplies are accepted for use on a project. If the supplies do not meet the acceptance criteria, deficiencies will be noted on the packing slip and purchase order. Afterward, the item will be returned to the vendor for replacement or repair.

2.14 DATA ACQUISITION REQUIREMENTS (NON-DIRECT MEASUREMENTS)

For this project, EA anticipates acquiring data from non-direct measurements such as databases, spreadsheets, and literature files.

2.15 DATA MANAGEMENT

A comprehensive data management program has been designed to assure that: (1) multiple information sources will result in similar data sets; and (2) data management practices will be adequate for the types of data processing required by a task order. Site team members will follow these protocols to assure results will have uniform units of measure, analytical methods, and reporting forms. The DMP (Appendix C to the SMP [EA 2008c]) details the design, development, maintenance, and intended uses of the analytical and spatial databases for the Site RI/FS.

Data for this project will be obtained from a combination of sources, including field measurements, field laboratory (XRF), subcontracted fixed laboratories, EPA Region 9 Laboratory, and CLP laboratories. The data-gathering process requires a coordinated effort and will be conducted by project staff members in conjunction with potential data producers. The data will be obtained from the analytical service provider, when appropriate, in the form of an EDD, in addition to the required hard copy analytical data package. Formal verification (or validation) of data will be conducted before associated results are presented or are used in subsequent activities.

Data tracking is essential to ensure timely, cost-effective, and high-quality results. Data tracking begins with sample chain of custody. When the analytical service provider receives custody of the samples, the provider will send a sample acknowledgment to EA. The sample acknowledgment will confirm sample receipt, condition, and required analyses. The EPA tracking software (Forms II Lite) will contain pertinent information about each sample and can track the data at each phase of the process. The tracking software carries the data through completion of the data validation.

EA will validate 10% of the investigative analytical data received from subcontract laboratories (other than the EPA Region 9 Laboratory or CLP laboratories) to ensure that the confirmatory data are accurate and defensible. A partial review will be conducted on the remaining 90% of the data received from subcontract laboratories. Data will be evaluated for usability by EA in accordance with EPA CLP guidelines for data review (EPA 2002a; 2004c; 2005b).

As a part of the data validation process, EDDs will be reviewed against hard copy deliverables to ensure accurate transfer of data. In addition, the hard copy will be evaluated for errors in the calculation of results. After the data validation, qualifiers can be placed on the data to indicate the usability of the data. These qualifiers will be placed into an electronic data file. Upon approval of the data set with the appropriate data qualifiers, the electronic data will be released to the Project Manager for reporting.

3. ASSESSMENT AND OVERSIGHT

This section describes the field and laboratory assessments that may be conducted during this project, the individuals responsible for conducting assessments, corrective actions that may be implemented in response to assessment results, and how quality-related issues will be reported to EA and EPA.

3.1 ASSESSMENT AND RESPONSE ACTIONS

Under the EPA Region 6 RAC II program, performance and system audits of field and laboratory activities may be conducted to verify that sampling and analysis are performed in accordance with the following:

- Performance and system audits
  - Audit personnel,
  - Audit scope of work,
  - Audit frequencies, and
  - Audit reports;

- Corrective action
  - Sample collection and field measurements, and
  - Laboratory analyses.

Nonconforming items and activities are those that do not meet the project requirements, procurement document criteria, and approved work procedures. Nonconformance may be detected and identified by the following personnel:

- Project personnel—During field operations, supervision of subcontractors, and field inspections;

- Testing personnel—During preparation for and performance of tests, equipment calibration, and QC activities; and

- QA personnel—During the performance of audits, surveillance, and other QA activities.

Each nonconformance that affects quality will be documented by the person who identifies or originates the nonconformance. Documentation of nonconformance will include the following components:

- Description of nonconformance;

- Identification of personnel who are responsible for correcting the nonconformance and, if verification is required, for verifying satisfactory resolution;

- Method(s) for correcting the nonconformance (corrective action) or description of the variance granted; and

- Proposed schedule for completing corrective action and the corrective action taken.

Nonconformance documentation will be made available to the Project Manager, QA Manager, and subcontractor (e.g., non-CLP subcontract laboratories) management personnel, as appropriate.

The field personnel and QA personnel, as appropriate, are responsible for notifying the Project Manager and the QA manager of the nonconformance. In addition, the Project Manager and the project staff, as appropriate, will be notified of significant nonconformances that could affect the results of the work. The Project Manager is responsible for determining whether notification of EPA is required.

The completion of corrective actions for significant nonconformances will be documented by QA personnel during future auditing activities. Significant recurring nonconformance will be evaluated by project and QA personnel, as appropriate, to determine its cause. Appropriate changes will be instituted, under corporate or project procedures, to prevent recurrence. When such an evaluation is performed, the results will be documented.

3.2 REPORTS TO MANAGEMENT

Effective management of environmental data collection operations requires timely assessment and review of measurement activities. It is essential that open communication, interaction, and feedback be maintained among project participants, including: (1) the EA QA Manager, Program Manager, Project Manager, technical staff, and laboratory subcontractors; and (2) the EPA Region 9 TOM and QA Officer.

During the RI field program, EA will prepare weekly reports that summarize the following elements:

- Work progress since the last weekly report;
- Site observations, problems, and decisions;
- Problems that may impede planned progress;
- Safety-related observations, incidents, or potential safety problems and the corrective action(s) taken to mitigate the problem(s);
- Corrective measures and procedures to regain the planned schedule, if required;
- Quality assurance/quality control activities (e.g., number of quality control samples); and
- Work scheduled for the next work period.

Additional field reporting requirements are discussed in greater detail in the SMP (EA 2008c).

EA prepares monthly progress reports for each Task Order that is conducted under the EPA Region 6 RAC II program. These reports address QA issues that are specific to the Task Order and facilitate timely communication of such issues.

At the program level, the QA Manager prepares quarterly status reports of QA issues that are related to EA's work on the EPA Region 6 RAC II program. These reports are distributed to EA's President, Corporate QA Manager, RAC II Program Manager, and, upon request, the EPA Region 6 Project Officer. QA status reports address the following areas:

- Results of QA audits and other inspections, including quality improvement; opportunities that have been identified for further action;
- Instrument, equipment, or procedural problems that affect QA;
- Subcontractor performance issues;
- Corrective actions;
- Status of previously reported activities and quality improvement initiatives; and
- Work planned for the next reporting period.

The data manager for the field investigation also acts as the quality assurance officer. It is the data manager's responsibility, in consult with the Site Manager and Sample Team Leader, to direct sample collection efforts. Also, the data manager is responsible for assigning quality assurance/quality control samples to the appropriate media in the appropriate quantities.

There are two independent checks on the data manager to ensure that sample data management is adequate and to ensure that the appropriate quality control samples are collected. The Sample Team Leader provides an initial check of the sampling program to ensure that the appropriate number and type of quality control samples are collected. In addition, it is the Site Manger's responsibility to provide oversight and independent technical review of the sample collection efforts on a daily and weekly basis. To ensure that these two systematic checks are adequate for the field effort, a quality assurance/quality control audit will be conducted during the initial phase of the field effort.

4. DATA VALIDATION AND USABILITY

This section describes the procedures that are planned to review, verify, and validate field and laboratory data. Procedures for verifying that the data are sufficient to meet DQOs and measurement quality objectives for the project are also discussed. Section 4.1 focuses on data review and reduction requirements for work conducted under the EPA Region 6 RAC II program. Section 4.2 addresses data validation and verification requirements. Section 4.3 addresses reconciliation with DQOs.

4.1 DATA REVIEW AND REDUCTION REQUIREMENTS

Data reduction and review are essential functions for preparing data that can be used effectively to support project decisions and DQOs. These functions must be performed accurately and in accordance with EPA-approved procedures and techniques. Data reduction includes computations and data manipulations that produce the final results that are used during the investigation. Data review includes procedures that field or laboratory personnel conduct to ensure that measurement results are correct and acceptable in accordance with the QA objectives that are stated in this SAP. Field and laboratory measurement data reduction and review procedures and requirements are specified in previously discussed field and laboratory methods, SOPs, and guidance documents.

Field personnel will record, in a field logbook and/or on the appropriate field form, raw data from chemical and physical field measurements (SOP 016, Appendix F). The EA field staff has the primary responsibility for: (1) verifying that field measurements were made correctly; (2) confirming that sample collection and handling procedures specified in this project-specific SAP were followed; and (3) ensuring that field data reduction and review procedures requirements are followed. The EA field staff is also responsible for assessing preliminary data quality and for advising the data user of potential QA/QC problems with field data. If field data are used in a project report, data reduction methods will be fully documented in the report.

The EPA Region 9 Laboratory, CLP laboratory, and/or subcontracted non-CLP laboratory will complete data reduction for chemical and physical laboratory measurements and will complete an in-house review of laboratory analytical results. The laboratory QA manager will be responsible for ensuring that laboratory data reduction and review procedures follow the requirements that are stated in this SAP. The laboratory QA manager will also be responsible for assessing data quality and for advising the EA QA Manager of possible QA/QC problems with laboratory data.

4.2 VALIDATION AND VERIFICATION METHODS

Data that are used to support activities under the EPA Region 6 RAC II program must be valid for their intended purposes. This section outlines the basic data validation procedures that will be followed for field and laboratory measurements. The following sections identify personnel who are responsible for data validation and the general data validation process and EPA data validation guidance that will be followed.

4.2.1 Data Validation Responsibilities

When analytical services are provided by laboratories subcontracted by EA, EA is responsible for data validation. The QA Manager has primary responsibility for coordinating EA's data validation activities. EA will conduct full validation on 10% of subcontracted laboratory data for investigation samples. Partial validation will be conducted on the remaining 90% of subcontracted laboratory data. Data validated by EA will be detailed in a data validation report.

Data validation and review will be completed by one or more experienced data reviewers. When data are generated by the EPA Region 9 Laboratory, it will be used as received from the laboratory, with no further validation. Data from CLP laboratories are validated by EPA's Environmental Services Assistance Team. Data validated by EPA will be summarized in a data validation report.

4.2.2 Data Validation Procedures

The validity of a data set is determined by comparing the data with a predetermined set of QC limits. EA data reviewers will conduct a systematic review of the data for compliance with established QC limits (such as sensitivity, precision, and accuracy), on the basis of spike, duplicate, and blank sampling results that are provided by the laboratory. The data review will identify out-of-control data points or omissions. EA data reviewers will evaluate laboratory data for compliance with the following information:

- Method and project-specific analytical service requests;
- Holding times;
- Initial and continuing calibration acceptance criteria;
- Field, trip, and method blank acceptance criteria;
- Surrogate recovery;
- Field duplicates and MS and MSD acceptance criteria;
- MD precision;
- LCS accuracy;
- Other laboratory QC criteria specified by the method or on the project-specific analytical service request form;
- Compound identification and quantitation; and
- Overall assessment of data, in accordance with project-specific objectives.

EA will follow the most current EPA CLP guidelines (EPA 2002a; 2004c; 2005b) for completing data validation for applicable test methods. General procedures in the CLP guidelines will be modified, as necessary, to fit the specific analytical method that is used to produce the data. In cases, data validation requirements will depend on: (1) DQO levels that are defined in Section 1.3; (2) reporting requirements that are defined in Section 1.4; and (3) data deliverables that are requested from the laboratory, as discussed in Section 1.6. Nevertheless, the data will be evaluate in accordance with EPA's National Functional Guidelines.

4.3 RECONCILIATION WITH DATA QUALITY OBJECTIVES

The main purpose of a QA system is to define a process for collecting data that are of known quality, are scientifically valid, are legally defensible, and fully support decisions that will be based on the data. To achieve this purpose, the SAP requires that DQOs be fully defined (Section 1.3). Other parts of the QA system must then be planned and implemented in a manner that is consistent with the DQOs. QA system components that follow directly from the DQOs include: (1) documentation and reporting requirements (Section 1.6); (2) sample process design and sampling methods requirements (Sections 2.1 through 2.9); (3) analytical methods and analytical service requests (Section 2.10); (4) QC requirements (Section 2.11); and (5) data reduction and validation and reporting methods (Sections 4.1 and 4.2).

After environmental data have been collected, reviewed, and validated, the data will undergo a final evaluation to determine whether the DQOs specified in this SAP have been met. EA will follow EPA's DQA process to verify that the type, quality, and quantity of data that are collected are appropriate for their intended use (EPA 2006c; 2006d).

The DQA process involves: (1) verifying that the data have met the assumptions under which the data collection design and DQOs were developed; (2) taking appropriate corrective action if the assumptions have not been met; and (3) evaluating the extent to which the data support the decision that must be made so that scientifically valid and meaningful conclusions can be drawn from the data. To the extent possible, EA will follow DQA methods and procedures that have been outlined by EPA (EPA 2006c; 2006d).

Following the conclusion of the RI field program and receipt of fixed-laboratory data, the data evaluation will include:

- Data usability evaluation and field QA/QC – The usability of the laboratory analytical data in terms of the CLP data validation summaries and field QA/QC will be evaluated.

- Data Reduction and Tabulation – Soil borings, field sampling data, and analytical results will be reduced and tabulated.

- DESR – A DESR will be submitted that documents and summarizes the analytical data collected during this RI/FS, including the data quality and usability as related to the site-specific DQOs. The DESR shall also include previous data collected during previous Site investigations (if made available) for statistical comparisons to the data collected during the RI/FS. Field QA/QC results will be summarized in context with fixed-laboratory sample results. In addition, the results of the DMA study will be summarized, including a statistical comparison of the XRF data to the fixed-laboratory results to evaluate the correlation of results. Finally, the lead/arsenic speciation data will be evaluated as part of the DESR.

As outlined in the DMP (Appendix C to the SMP [EA 2008c]), EA will compile analytical and field data into a format that is compatible with EPA Region 9 or National Electronic Data Management Network. EA will use the data to prepare the Baseline HHRA Report, Screening-level ERA Report, RACA Report, RI Report, and FS Report, as well as to support the ROD. The specific requirements and elements of each of these reports are discussed in detail in the EPA-approved RI/FS Work Plan (EA 2008a).

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FIGURES

Appendix A

Conceptual Understanding of the Site Technical Memorandum

Conceptual Understanding of the Site
Technical Memorandum
Remedial Investigation/Feasibility Study
Iron King Mine – Humboldt Smelter Superfund Site
Dewey-Humboldt, Yavapai County, Arizona
EPA Identification No. AZ0000309013

Remedial Action Contract 2 Full Service
Contract: EP-W-06-004

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LIST OF ACRONYMS AND ABBREVIATIONS

µg/L	Micrograms per liter
ACM	Asbestos containing material
ADEQ	Arizona Department of Environmental Quality
ADWR	Arizona Department of Water Resources
AGRA	AGRA Earth & Environmental, Inc.
AGFD	Arizona Game and Fish Department
AOI	Area of Interest
APP	Aquifer Protection Permit
AST	Above ground storage tank
BgD	Balon gravelly sandy clay loam
bgs	Below ground surface
cfs	Cubic feet per second
COPC	Contaminant of potential concern
CSM	Conceptual Site Model
CUS	Conceptual Understanding of the Site
EA	EA Engineering, Science, and Technology, Inc.
EPA	U.S. Environmental Protection Agency
EPC	Exposure point concentration
ERA	Ecological Risk Assessment
ESA	Environmental Site Assessment
ESI	Expanded Site Inspection
FS	Feasibility Study
ft	Feet
HHRA	Human Health Risk Assessment
HH CSM	Human Health Conceptual Site Model
MCL	Maximum Contaminant Level
MDL	method detection limit
MkF	Moano very rocky loam
MgD	Moano gravelly loam
mg/kg	Milligram(s) per kilogram
NAI	North American Industries
NOV	Notice of violation
NPDES	National Pollutant Discharge Elimination System
NPL	National Priority List
NRCS	Natural Resource Conservation Service
OALS	Office of Arid Lands Study
OU	Operational Unit
PA	Preliminary Assessment
PCB	Polychlorinated biphenyl
PRP	Potentially Responsible Party
RAC	Remedial Action Contract
REC	Recognized environmental condition
RI	Remedial investigation
SAP	Sampling and Analysis Plan
SI	Site Inspection

LIST OF ACRONYMS AND ABBREVIATIONS (CONT.)

Site	Iron King Mine-Humboldt Smelter Site
SOW	Statement of Work
SRL	Soil Remediation Level
SSL	Soil Screening Level
START	Superfund Technical Assessment & Response Team
SVOCs	Semi-volatile organic compounds
SWQS	Surface Water Quality Standards
TDS	total dissolved solids
UST	Underground storage tank
USACHPPM	United States Army Center for Health Promotion and Preventive Medicine
USDA	United States Department of Agriculture
USGS	United States Geological Survey
VOCs	volatile organic compounds
VRP	Voluntary Remediation Program
WQD	ADEQ Water Quality Division

1. INTRODUCTION

EA Engineering, Science, and Technology, Inc. (EA) has been authorized by the U.S. Environmental Protection Agency (EPA), under Remedial Action Contract (RAC) No. EP-W-06-004, Task Order 0034-RICO-09MX, to conduct a Remedial Investigation/Feasibility Study (RI/FS) at the Iron King Mine – Humboldt Smelter Superfund Site (Site). EA has prepared this Conceptual Understanding of the Site (CUS) Technical Memorandum in accordance with: (1) specifications provided in the EPA Statement of Work (SOW), dated 3 March 2008 (EPA 2008a); and (2) the EPA-approved EA Work Plan (Revision 01), dated 22 May 2008 (EA 2008).

1.1 PURPOSE

This CUS provides a basis for the technical approach that is being implemented in the Sampling and Analysis Plan (SAP). The purpose of the CUS was to summarize existing data, assess its completeness, and identify additional data needs. The following questions were addressed:

- Has the nature and extent of contamination been delineated both horizontally and vertically?
- What are the likely pathways for contaminant migration?
- What are the likely human health and ecological exposure pathways?

1.2 SCOPE

The scope of the CUS included the following:

- Reviewing existing reports;
- Compiling the data sets into a single cogent presentation;
- Evaluating the site geology with attention to the hydrogeology and definition of the various water-bearing zones; and
- Detailing a conceptual site model (CSM) that describes the nature and extent of contamination and identifies the primary pathways.

2. BACKGROUND

This section contains information pertaining to the site description, operational history, regulatory involvement, site features, and key investigations for the Site. Information presented in this section was obtained from the 2006 Expanded Site Inspection (ESI) prepared by Arizona Department of Environmental Quality (ADEQ 2006) unless otherwise noted below.

2.1 SITE DESCRIPTION

The Site is located in Dewey-Humboldt, Yavapai County, Arizona (Figure 1). The Site is a combination of contaminant sources and releases from two separate facilities: the Iron King Mine property and the Humboldt Smelter property. A portion of the Town of Humboldt is situated between the mine and the smelter (Figure 2).

The EA team met with EPA at the Site 19 March 2008, and performed a site walk that included a cursory review of the most probable sources of contamination. At that time, it was decided that the Site would be considered as several Areas of Interest (AOI) within a single Operable Unit (OU). The AOIs are as follows:

During the site visit that was conducted on 19 March 2008, the following AOIs were identified:

- Iron King Mine – The Iron King Mine Proper Area, Iron King Mine Operations Area, Former Fertilizer Plant Area, and ancillary associated properties;
- Humboldt Smelter and ancillary associated properties;
- Off-site Soil in the vicinity of the Site;
- Waterways - Including the Chaparral Gulch, Galena Gulch, Aqua Fria River, and adjoining drainage channels and outfalls; and
- Ground Water - Shallow alluvial and deep bedrock ground water.

These five AOIs were combined into a single OU for the purpose of conducting the RI/FS because: (1) ore from the Iron King Mine may have been processed at Humboldt Smelter; (2) off-site migration of particulates from the Iron King Mine and Humboldt Smelter may have overlapping air-depositional areas; (3) mine tailings from the Iron King Mine may have migrated onto the Humboldt Smelter property via the Chaparral Gulch; (4) the Aqua Fria River and its contributing waterways (e.g., Chaparral Gulch and Galena Gulch) may have impacts from both the Iron King Mine and Humboldt Smelter; and (5) ground water may be impacted from both the Iron King Mine and Humboldt Smelter.

The Iron King Mine property, located west of Highway 69, occupies approximately 153 acres. The Iron King Mine property is bordered by Chaparral Gulch to the north, Galena Gulch to the south, Highway 69 to the east, and undeveloped land to the west. The Iron King Mine was a periodically active gold, silver, copper, lead, and zinc mine from 1906 (when the mine produced fluxing ore for the Humboldt Smelter) until 1969. Ore from the Iron King Mine may have been processed at the Humboldt Smelter, which operated from the late 1800s until 1969.

The Humboldt Smelter property, located at the east end of Main Street, occupies approximately 189 acres. The smelter is situated less than 1-mile east of the Iron King Mine property. The Humboldt Smelter property is bordered by the Town of Humboldt to the west and north, the Agua Fria River to the east, and the Chaparral Gulch to the south.

The Iron King Mine property includes the following three subordinate properties (Figure 3):

- The Iron King Mine Proper Area, which consists of a large tailings pile and a plant area. In addition, there are 5 retention ponds or impoundments: Main Retention Ponds, Pond 40-01A, Pond 40-02A, Pond 100-003F, and Pond 200-5S.

- The Iron King Mine Operations Area, which historically contained at least 11 buildings, including the assay laboratory office, main office, change rooms, and the mechanical room. This property also contains multiple mine shafts, and the former Glory Hole; the latter of which has more recently been used as a landfill.

- The Former Fertilizer Plant Area includes several abandoned buildings, concrete pads, sumps, tanks, and an ore bin.

The Humboldt Smelter property consists of several abandoned buildings, a smelter stack, a tailings pile (763,000 square feet), a smelter ash pile (1,041,200 square feet), and a slag pile (456,000 square feet). On-site ponds, pits, and lagoons were reportedly used for the leaching of minerals from mined ore (Figure 4).

Chaparral Gulch, a natural drainage channel, flows from northwest to southeast along the border of the Iron King Mine property. The gulch crosses under Highway 69, passes through a residential area, and then enters the northeast boundary of the Humboldt Smelter property, flowing through the southwest corner. A tailings dam located on the smelter property within the Chaparral Gulch has retained tailings from both the Iron King Mine and Humboldt Smelter properties. The Chaparral Gulch flows into the Agua Fria River approximately ¼ mile downstream of the Chaparral Gulch dam. The Aqua Fria River also flows from the north to the south along the eastern boundary of the Humboldt Smelter property.

2.2 OPERATIONAL HISTORY

The Iron King Mine was first discovered in 1880, and the original mining claim was filed in 1899. In 1904, a small cyanide plant was built to recover gold and silver. The Iron King Mining Company, which began operating the mine in the 1930s, installed a mine plant in 1938 and built a cyanide plant in 1940 to treat the mill tailings. In 1942, the Shattuck-Denn Mining Company purchased the mine and operated it, primarily for lead and zinc, until 1969. It is estimated that 5.7 million tons of ore were mined and approximately 4 million tons of tailings were generated during this time. In 1969, the Shattuck-Denn Mining Company removed the underground equipment and sold the mill and mining equipment.

2.2.1 Iron King Operations Property

After the mine closed, the Iron King Laboratory conducted analyses of core samples on the property through the mid-1990s. Ownership is unknown from 1969 until 1978. In 1978, the Brown Company sold the property to Gibbs Enterprises and a private owner. In 2000, the present owner, Kuhles Capital, LLC, (Kuhles), acquired the property and operated the Iron King Waste Reduction Facility. The Solid Waste Permit Application stated that this facility would sort wastes, send recyclable materials off-site for further processing, and ship unacceptable materials off-site. From June 2002 through September 2005, Kuhles operated a construction debris landfill, which utilized the glory hole for disposal. Kuhles also ground wood and drywall to produce a soil stabilizer. Kuhles also operated a recycling business on-site. It is unknown what businesses are currently operating on the property.

2.2.2 The Iron King Mine Proper Area

The present owner of this facility is North American Industries (NAI). Previous ownership included Ironite Products Company, who marketed Ironite fertilizer from tailings between 1989 and 2006. Fertilizer was processed by mixing tailings with sulfuric acid, urea, and water; the tailings were later dried, sized, and packaged for sale. Wastewater was sent to a settling tank and then pumped to wastewater tanks, where it was allowed to evaporate; the sludge was fed back into the process. Ironite recently shut down the operation.

2.2.3 Former Fertilizer Plant

The Shattuck-Denn Mining Company began operating the original fertilizer plant in 1963. The process was similar to Ironite's process described above. Ownership is unknown from 1968 until 1974, when Ironite acquired the property and operated it until 1988. Ironite sold the property to a private owner in 1998. Aqua Tec, LLC, operated a permitted septage treatment facility on this property from 2003 until 2005. Waste solids from the septage treatment facility were shipped off-site to the Wolf Creek solid waste landfill. Clarified liquids were piped off-site for non-potable uses. The plant burned down several years ago.

2.2.4 Humboldt Smelter

From the late 1800s until the early 1960s, a smelter operated in the area processing copper, gold, lead, silver, and zinc. After the original smelter burned down in 1904, a 1,000-ton per day smelter was rebuilt in 1906. This smelter operated until 1918, and then intermittently between 1922 and 1927. The smelter reopened in 1930, and operated until 1937. There is no reliable documentation regarding the smelter's operation between 1937 and 1960. According to a previous landowner, the smelter has not operated since 1950. From 1960 to 1990, the property was privately owned. In 1990, the property was placed into the Bagby Family Trust. In 2003, Greenfields Enterprises, LLC, purchased the property. Some recent tenants included an aluminum recycling facility, a wooden shed manufacturer, a sawmill operation, and Humboldt Precast. No businesses are currently operating on the property.

2.3 REGULATORY INVOLVEMENT

The following subsections detail the main regulatory actions that have been undertaken at the Site. To the degree possible, these actions are separated by regulatory agency, although in some instances both the Arizona Department of Environmental Quality (ADEQ) and EPA were involved.

2.3.1 Arizona Department of Environmental Quality

ADEQ’s involvement at the Site dates back to at least 1989, with the key activities as follows:

- ADEQ's Water Quality Division (WQD) conducted inspections at the Ironite property in 1989, 1995, 2003, and 2005, and inspected the Iron King Mine and Humboldt Smelter in 2003. The WQD has issued notice of violations (NOVs) for all three of these properties, which included releases from the Ironite property, storm water violations at the Iron King Mine Operations Area property, and citations for unpermitted releases of tailings to Chaparral Gulch and violation of Surface Water Quality Standards (SWQS) at the Humboldt Smelter area (ADEQ 2006). Documentation regarding resolution of these NOVs was not reviewed.

- The Ironite property had held an Air Quality Permit with the ADEQ Air Quality Division. During the site inspections conducted in 1992 and 1994, and again in 1997 and 1999, the Ironite property was in compliance with the permit. An NOV was issued for the property in 1995, but the problem was satisfactorily addressed (ADEQ 2006).

- Numerous complaints regarding blowing dust on windy days were received by the ADEQ in 1997 while construction was ongoing. During the 1997 ADEQ site inspection of the Ironite facility, State personnel observed that the entrance road was paved, which they suspected would reduce the amount of blowing dust. At that site inspection, Ironite also indicated that their personnel would spray water on the unpaved areas to reduce dust emissions on windy days (ADEQ 2006).

- During a 1998 ADEQ site inspections, State personnel observed two piles of drums that may have contained cyanide situated north of the glory hole. These drums were not noted during the ADEQ site inspection performed in 2001, although State personnel noted that the waste rock pile where the drums had been stored was stained. The present owner, Kuhles Capital, LLC, indicated to State personnel that all scrap metal had either been recycled or stockpiled on-site (ADEQ 2006).

- During a 1998 ADEQ site inspection at the Iron King Mine property, State personnel observed small containers that appeared to contain laboratory chemical waste on the ground near the Iron King Mine assay laboratory. A follow-up letter was sent to the property owner and EPA was provided notice of the discovery by ADEQ. The 2002 Phase I Environmental Site Assessment (ESA) prepared for the Ironite Products Facility specified that laboratory wastes were stockpiled, graded, and spread out over an area 250 feet wide by 100 feet long (Hoque 2002); during a 2001 ADEQ site inspection this stockpile was not observed (ADEQ 2006).

- During a 1998 ADEQ site inspection, State personnel observed stains around the Iron King Mine laboratory, the east side of the mechanical room, next to the new change room, and close by mineshaft number 6. In addition, a gray berm was observed along the boundary of the Iron King Mine Operations Area and Large Tailings Pile. State personnel also noted a wash flowing from north to south on the west side of the Iron King Mine Operations Area (ADEQ 2006).

- Air quality permit violations were noted at the Ironite property during its most recent inspection on 16 March 2006. An NOV was issued by ADEQ dated 25 April 2006, and was still open at the time that the last site document was prepared (ADEQ 2006).

- An aquifer protection permit (APP) application for a proposed construction debris landfill was submitted by Kuhles to the ADEQ Solid Waste Section in May 2001. The application proposed to open a waste processing facility to send recyclable materials to recyclers and place construction debris into the glory hole. Other types of wastes would not be accepted. The APP (Permit No. 50409700A) was approved by ADEQ in January 2002, but was appealed in May 2002 by the Dewey-Humboldt Community Organization. ADEQ completed inspections of the landfill in August 2002, October 2003, and August 2004, and determined it was in compliance. A modification was approved by the ADEQ in July 2003 to allow expansion of the landfill by approximately 10 percent. A proposed amendment to open a new 22-acre landfill east of the existing landfill was submitted by Kuhles in October 2004 (ADEQ 2006).

- As a result of the Preliminary Assessment/Site Inspection (PA/SI) performed by ADEQ (ADEQ 2002), Ironite received notification from EPA requesting additional site characterization. The Ironite Property was proposed for inclusion in the ADEQ's Voluntary Remediation Program (VRP), which was accepted on 15 September 2003 Ironite proposed to collect samples to: determine the impact of storm water runoff and dust from the Ironite property to adjacent properties; determine whether controls are necessary to protect ground water; to ensure planned and existing dust and storm water controls are adequate to protect adjacent properties; and, to obtain a finding of no further action from ADEQ. Brown and Caldwell are performing site characterization activities under a revised work plan (Brown and Caldwell 2007). Investigation results have not been received.

- An APP for the Aqua Tec Septage Treatment facility was signed by the ADEQ on 16 October 2003. A complaint regarding the facility was received by the ADEQ on 22 August 2005. Therefore an ADEQ site inspection of the facility was conducted on 23 August 2005. State personnel noted that a combination of sludge, raw sewage, and storm water were overflowing the tanks and entering the wash running along the west side of the facility. An NOV was issued by ADEQ to Aqua Tec who subsequently ceased operation of the facility, drained the tanks, and constructed a berm as corrective actions, and the NOV was closed. Additional ADEQ site inspections of the landfill were conducted from July through September 2005. ADEQ determined that the landfill was not in compliance with the APP and issued an NOV. In accordance with an ADEQ issued Compliance Order, Kuhles stopped accepting waste in September 2005 (ADEQ 2006).

2.3.2 U. S. Environmental Protection Agency

A notice of intent for a general storm water permit under the National Pollutant Discharge Elimination System (NPDES) was submitted by the Ironite facility in 1992. The EPA issued NPDES storm water permit No. AZROOA425 for the Ironite facility in 1995, that expired in 1997. Under this NPDES permit, the facility was authorized to discharge storm water only from the Ironite plant site. Specifically not authorized under the NPDES permit was any runoff from the tailings, which was considered non-storm water.

In a 1995 inspection of the Ironite facility, EPA personnel noted that runoff from the north side of the tailings would flow into retention pond 40-01 A, and that overflow from this pond would then enter retention pond 40-02A. This second pond would then discharge though a metal culvert to a drainage channel that enters Chaparral Gulch, which may not be a permitted discharge. Runoff from the west side of the Ironite plant site and from a portion of the tailings pile is also received by Pond 40-02. In addition, both ponds were found to be filled with tailings.

EPA personnel also documented that retention pond 200-5S collects runoff from the tailings pile near the plant entrance on Highway 69 (ADEQ 2006). During the 1995 EPA inspection, EPA noted that drainage from this pond was discharging to a culvert beneath the plant entrance road, although the pond was dry, liquid was flowing from the culvert toward Highway 69. ADEQ personnel then collected samples of this liquid, which they suspected was natural ground water flow or discharge from the tailings. The personnel observed this water flowing beneath Highway 69, in a culvert, and then into Chaparral Gulch. As a result of this discovery, Ironite notified the EPA that they would close the culverts to prevent these unauthorized discharges. Ironite personnel also indicated that they would pursue preparing an application for an individual NPDES permit for discharge of storm water in emergency situations, and expand the NPDES permit to include the tailings as well as the Ironite plant site (ADEQ 2006).

During 1998 and 2002 ADEQ inspections of the Ironite property, State personnel noted that the culverts have not yet been closed but that pond 40-02A was no longer filled with tailing materials. In addition, approximately 2 feet of sediment had been removed from the northern portion of pond 200-5S, to allow larger volumes of water to accumulate before discharge through the culverts was allowed to occur. Ironite claimed that the culvert was closed in 2005 (ADEQ 2006).

A Removal Assessment in the vicinity of the Iron King Mine was conducted by the EPA in August 2005. The EPA report recommended Removal Action for four residential properties. ADEQ submitted a Request for Federal Action to the EPA in a letter dated 3 April 2006, and the EPA ordered Ironite to remove the contaminated soil. The removal action was completed on the properties (ADEQ 2006).

EPA received a response from Arizona Governor Napolitano consenting to the placement of the Site on the National Priorities List (NPL) in September 2007,and on 19 March 2008, EPA formally proposed the Site to the NPL.

2.4 SITE FEATURES

The following provides a description of the Site's demographics as well as the Site's cultural, geological, natural resource, and ecological features.

2.4.1 Demographics

Data from the U.S. Census Bureau (2000) indicated that the total population of Dewey-Humboldt, AZ, was 6,295. There were 3,358 housing units in the city and the average household size was 2.25. Twenty-six percent of the population was on disability status. Per capita income in 1999 was $20,326, and the median household income in 1999 was $36,839. Nine percent of the population lives under the poverty level.

2.4.2 Cultural Features

Cultural features information was adopted from "Mining was the backbone of Val Verde (now Humboldt)" (Leavitt 2003). Dewey-Humboldt's recorded history begins with the petroglyphs or rock carvings that were left by the Indians who lived in the area. Pit houses, shafts, and other evidence that were found in the land surrounding present-day Humboldt in the 1860s indicate that American Indian communities mined and farmed in the region from 900 A.D. to 1300 A.D. After this period, the Indian community called the Yavapai Tribe migrated east from Colorado and settled in present-day Arizona, where they were later relocated to the Yavapai-Prescott Reservation in 1935.

Many rich veins of ore were discovered in the mountain ranges of Arizona during the late 1800s. Yavapai County in particular contained large amounts of minerals. In 1905, residents settled into the routine of the mining lifestyle and raising their families. Humboldt's economy boomed in 1917; the mines produced more than two million pounds of copper and lead each month. Yet by the time World War I was coming to a close in 1918, the population of Humboldt was beginning a decline. Between 1922 and 1927, there was only intermittent operation of the smelter. The town's survival depended almost entirely on the mining business and it suffered dramatically after the Humboldt smelter closed in 1937.

When another vein of ore was discovered in Humboldt and the Iron King Mine began operation there in 1934, the town was rejuvenated. Nevertheless, Humboldt experienced a depressed economy and shrinking population during the 1940s and 1950s. Though the Iron King Mine closed in the late 1960s, it did not affect most the population of Humboldt because few miners actually lived in town. The last of the original smelter smoke stack was demolished in 1955 and the railroad tracks were removed in 1971.

Humboldt remains active after the closing of its mines, partly a result of its location on the well-traveled highway between Prescott and Phoenix. Since the 1970s, the town has exhibited slow but steady growth. Today, Humboldt is primarily a quiet residential town that houses mainly families and retirees.

2.4.3 Natural Resource Features

Natural resources features information was adopted from City Data (2008). The following streams and creeks run through the Dewey-Humboldt region: Ash Creek, Ash Spring Creek, Eugenie Stream, Bear Creek, Big Bug Creek, Bishop Creek, Cold Water Creek, Grapevine Creek, and Racetrack Wash. Minerals found in the rocks near Dewey-Humboldt include gold, silver, copper, lead, zinc, and cadmium.

2.4.4 Ecological Features

Ecological features information was adopted from the University of Arizona, College of Agriculture and Life Sciences, Flora and Fauna Image Gallery (2008). The flora in the surrounding area consists mainly of riparian trees that prefer high altitudes, such as the Arizona

Alder, the Fremont Cottonwood, the Desert Willow, the Velvet Mesquite, the Salt Cedar, and the Ponderosa Pine. Local bushes and shrubs include the Shrubby Coldenia, the Creosote Bush, Range Ratany, Broom Snakeweed, and the Four-wing Saltbush. These shrubs typically thrive in the dry mesas, though some are ubiquitous, surviving from the riverside to Ponderosa Pine forests. Banana Yucca, a type of cacti, is commonly found in the region, as well as the cacti species Century Plant, Desert Christmas Cactus, and Soaptree Yucca.

The coyote, or prairie wolf, roams through the length and breadth of Arizona. The black-tailed deer is common in the northern and central portions of the state. Cougars also exist in the central portion of the state. The antelope is commonly found on the elevated mesas and grassy plains in the region, and the fox and the wildcat are extensively distributed, some of the latter reaching a very large size. The wood rat, the kangaroo rat, and the white mouse are found in all parts of the state. Gophers, rabbits, and squirrels are also numerous.

2.5 KEY INVESTIGATIONS

Site characterization activities at the Site date back to the late 1990s, with the first report completed in 2002 (ADEQ 2002). The key investigations that were reviewed in preparing this CUS are as follows:

- Phase 1 ESA for the Ironite Products Facility (AGRA Earth and Environmental [AGRA] in 1998);
- Phase 1 ESA for the Iron King Smelter/Mill Site (Hoque & Associates 2002);
- PA/SI of the Iron King Mine (ADEQ 2002);
- Phase 2 Sampling Report for the Iron King Smelter/Mill Site (Hoque & Associates 2003);
- PA/SI of the Humboldt Smelter (ADEQ 2004);
- Soil Removal Assessment (Ecology and Environment 2005); and
- ESI of the Iron King Mine/ Humboldt Smelter (ADEQ 2006).

Key findings and elements of each of these investigations are summarized below.

2.5.1 Phase 1 Environmental Site Assessment (1998)

AGRA prepared a Phase 1 ESA for the Ironite Products Facility in 1998 (AGRA 1998). The report was prepared based on a review of available records, visual observations of the area, and personal interviews. No samples were collected. The following recognized environmental conditions (RECs) were identified:

- Samples of storm water runoff or water in catchment basins have not been collected and analyzed for inorganic parameters to determine the potential for exceedances of water quality standards. There is no mention made regarding an NPDES permit for the Ironite Products Facility.

- A potential RCRA violation was identified by the numerous improperly labeled drums and other small containers of waste materials, some uncovered or severely rusted, that were not within a designated containment area.
- The laboratory sink and floor drain lead to an on-site septic system. Therefore, there is a potential for any chemicals disposed of at these locations to eventually be released to subsurface soils.
- Three unused wells on the property are a potential threat to ground water if the wells are not properly abandoned.

2.5.2 Phase 1 Environmental Site Assessment (2002)

Hoque & Associates prepared a Phase 1 ESA for the Iron King Smelter/Mill Site in 2002 (Hoque & Associates 2002). The report was prepared based on readily available information and field observations. The following RECs were identified:

- Large areas of exposed surfaces of apparent mine tailings, smelter ash, and smelter slag;
- Many small and large piles of apparent smelter ash;
- Piles of apparent assay laboratory materials strewn sporadically;
- White powdery solid material contained in rusty barrels;
- Protruding pipes (capped and uncapped) from the ground near the abandoned on-site metal building, indicative of underground storage tanks (UST);
- Oil stained soils beneath the cargo truck box used to store used oil; and
- Diesel fuel stained soil beneath a 1,000 gallon frame mounted above-ground storage tank (AST).

2.5.3 Preliminary Assessment/Site Inspection Report (2002)

The ADEQ prepared a PA/SI of the Iron King Mine and Tailings site in 2002 at the request of the EPA to gather information on soil, ground water, sediment, and surface water (ADEQ 2002). Sampling was conducted in April and May 2002 with the objective being to determine whether hazardous substances had been released to surface and subsurface soils, sediments, surface water, and ground water.

Surface and subsurface soils samples were collected from 21 locations including the large tailing pile, ponds, Ironite plant area, former assay laboratory, former mill site, former fertilizer plant, stained soil area at the former Iron King Mine, the water rock pile on the Nolan property, the nearby school yard, and background areas. Ten sediment samples were collected from upstream and downstream of the Site from the Agua Fria River, Chaparral Gulch, and the unnamed stream (west of the Site). Surface water samples were collected from the Agua Fria River above, below, and at its confluence with Chaparral Gulch. Ground water samples were collected from three wells located upgradient and downgradient of the Site. The well locations included a background well, the old Ironite production well, and the Humboldt schools well. A fourth well (Kuhles Well) was found to be dry.

Based on the samples collected ADEQ identified the following hazard substance sources:

- Large tailings pile
- Ponds and sediments adjacent to large tailings pile
- Waste rock pile #1
- Assay laboratory waste dump
- Stained soil in waste rock pile #1
- Sediments in unnamed stream adjacent to waste rock pile #1
- Gray berm (berm that separates the Ironite and Kuhles properties)
- Glory hole
- School yard
- Sediments in Chaparral Gulch

At each of these sources, heavy metals including antimony, arsenic, cadmium, lead and/or mercury exceed EPA and/or ADEQ benchmarks. ADEQ also documented a release of arsenic to the Ironite production well above EPA benchmarks. ADEQ was unable document a release of contaminants from the Site to surface water, but did note that arsenic, lead, mercury, and cadmium were released to sediments in Chaparral Gulch.

2.5.4 Phase 2 Sampling Report (2003)

Hoque & Associates prepared a Phase 2 Sampling Report for the Iron King Smelter/Mill Site in 2003 (Hoque & Associates 2003) to address the following RECs:

- Large areas of exposed surfaces of apparent mine tailings, smelter ash, and smelter slag;
- Many small and large piles of apparent smelter ash;
- Piles of apparent assay laboratory materials strewn sporadically; and
- White powdery solid material contained in rusty barrels.

In November 2002 on-site surface sampling was conducted. Samples were collected from the apparent mine tailings, smelter ash, smelter slag, assay laboratory wastes, and the white powdery material, as well as background samples of native soil. All samples were analyzed for cyanide and/or RCRA metals (arsenic, barium, cadmium, chromium, lead, selenium, silver, and mercury). In addition one sample of black material in the tailings deposit was analyzed for hydrocarbons.

Only one sample contained cyanide at or above the laboratory method detection limit (MDL); the reported concentration (1.2 milligrams per kilogram [mg/kg]) was well below the ADEQ non-residential SRL of 14,000 mg/kg. No hydrocarbons were detected in the black tailings material sample. All of the samples contained one or more of the RCRA metals exceeding the average on-site background levels and/or ADEQ non-residential SRLs. The sampling results indicate a number of metals are present at concentrations above background, arsenic and lead exceeded ADEQ non-residential SRLs, as detailed below:

TABLE 1 PHASE 2 SOIL SAMPLE EXCEEDANCE SUMMARY

Sample Location	Exceed 3 Times On-site Background Levels	Above ADEQ Non-Residential SRL
Mine tailings	arsenic, cadmium, lead, selenium, silver, mercury	arsenic
Smelter ash	cadmium, chromium, lead	---
Slag	arsenic, cadmium, lead, silver	arsenic
Mixed ash/debris	cadmium, chromium, lead, selenium, silver, mercury	lead
Gray-white ash	cyanide, arsenic, cadmium, lead, silver, mercury	arsenic, lead
Assay lab soil	chromium, lead	---

On-site background samples contained an average of 47.5 mg/kg of arsenic, above the ADEQ non-residential SRL of 10 mg/kg.

2.5.5 Preliminary Assessment/Site Inspection Report (2004)

The ADEQ performed a PA/SI of the Humboldt Smelter in 2004 at the request of the EPA (ADEQ 2004) to determine in there had been a release of hazardous material to the unsaturated zone from the Site. The January 2004 sampling effort included collection of subsurface soil samples and surface water samples.

Subsurface soil samples were collected from the ore pile number one, evaporation pond at the assay lab discharge pipe, large ash pile, gray ash, large tailings pile, retention basin, school yard, two private residences, and background locations. In addition, sediment samples were collected from Chaparral Gulch and Agua Fria River. The samples were analyzed for semi-volatile organic compounds (SVOCs), total metals and cyanide. The sample results indicate the presence of arsenic, barium, cadmium, chromium, copper, lead, mercury, and zinc above the background concentrations. No SVOCs were detected in the samples. Samples from the tailing and ore piles, and from Chaparral Gulch also exhibited elevated arsenic concentrations. Samples from the school yard indicate the screening level criteria have been met for observed contamination of lead and zinc.

Surface water samples were collected from two locations along the Agua Fria and one location in Chaparral Gulch and analyzed for SVOCs, total metals and cyanide, dissolved metals, and anions. No SVOCs were detected in the samples. Sulfate was present in noteworthy concentrations, but does not have numeric standard. The surface water sample collected in Chaparral Gulch downstream of the dam contained dissolved arsenic at 53.7 micrograms per liter (µg/L), above the surface water standard of 50 µg/L, and meets the criteria for an observed release.

2.5.6 Soil Removal Assessment (2005)

At the request of ADEQ, a removal assessment of surface soils at residential properties along Chaparral Gulch was prepared by the Superfund Technical Assessment and Response Team (START) in 2005 (Ecology & Environment 2005). The assessment objective was to determine the level of arsenic and lead contained in the soils of 16 privately owned residential properties and 1 horse pasture along Chaparral Gulch resulting from erosion and tailings upset events from the Iron King Mine.

Samples were collected in August 2005 from 153 surface locations and 17 subsurface locations along the Chaparral Gulch investigation area. This included 9 surface samples and 1 subsurface sample from each of the properties. The samples were analyzed for lead and arsenic. In addition, surface and subsurface background samples were collected from 2 separate locations, and 8 bias samples were collected. Additional surface residential samples were collected near the smelter. The bias smelter samples and 1 of the background sample locations were analyzed for total metals as well.

Samples results were compared to previously-established background arsenic and lead concentrations of 30.72 mg/kg and 20.05 mg/kg, respectively as well as the 2002 EPA Region 9 residential PRG for arsenic (22 mg/kg) and lead (400 mg/kg). Based on these results, 8 of the properties had an average arsenic concentration significantly greater than background (and thus above the lower PRG). One sample had a lead concentration above the action level, but the average lead concentration for the property was well below the residential PRG, suggesting that the high lead value was likely due to property specific activities and not from the Iron King Mine. Compared to background lead concentrations, there were no significant differences noted at any of the residential property sample locations. The bias smelter samples contained similar lead and arsenic concentrations as the residential properties along Chaparral Gulch.

Subsurface soil results indicated 1 property with elevated arsenic and lead concentrations. This property is located directly adjacent to Chaparral Gulch. All other subsurface sampling locations had arsenic and lead concentrations that were not significantly different from background, indicative of surface contamination being confined to the top 1.5 feet.

A Potentially Responsible Party (PRP)-lead removal action was completed in 2006 to remove contaminated soil from four residential properties. Staff from EPA’s Office of Emergency Response supervised the sampling and removal of the contaminated soil conducted by the PRP’s contractor, Brown and Caldwell.

2.5.7 Expanded Site Inspection (2006)

The ADEQ prepared an ESI of the Iron King Mine and Humboldt Smelter in 2006 at the request of the EPA (ADEQ 2006) to gather ground water data from the Site. The January and February 2006 sampling effort included collection of ground water samples to evaluate the presence of cyanide and metals. Samples were collected from 12 drinking water wells that included the main and backup wells of the Humboldt Water System and 10 private domestic wells. The ground water samples were analyzed for total metals and cyanide.

Arsenic concentrations were found to be above EPA Maximum Contaminant Levels (MCL) in 5 samples including a background sample, and lead concentrations were above EPA MCLs in 1 sample. Therefore, a second sampling effort was conducted in May 2006 to further evaluate the presence of metals and cyanide in ground water. Samples were collected from 4 wells (3 domestic wells and 1 irrigation well), and 2 background wells (both domestic wells). The water samples were again analyzed for total metals and cyanide. Arsenic concentrations were found to be above the MCL in all samples. Detectable concentrations of copper, lead, mercury, and selenium were present in some of the wells, but were below benchmarks. Observed release criteria were met for arsenic, boron, cobalt, copper, cyanide, lead, manganese, mercury, molybdenum, nickel, selenium, sodium, and/or vanadium in 2 non-potable wells and 5 drinking water wells.

The following hazard substance sources associated with the Site were identified by ADEQ:

- Large tailings pile on the Ironite property;
- Small tailings pile adjacent to the Ironite property;
- Waste rock pile at the Iron King Mine and Former Fertilizer Plant; and
- Mining waste in the Humboldt Smelter area.

3. HYDROGEOLOGY

This section contains geologic and hydrogeologic information that is germane to understanding potential contaminant migration and background contributions to media concentrations at the Site. Additional information is available electronically in Appendix H of the main document.

3.1 GEOLOGY

Very little information exists regarding the geology of the Site. A geologic map of the Bradshaw Mountain Quadrangle was published by the United States Geological Survey (USGS) in 1905 (Jagger and Panache 1905.). Lindgren briefly described the geology of the Site with his focus being on the ore deposits of the region (1926). Creasy (1952) prepared a more detailed summary of the regional geology as part of his doctorate thesis.

In general the Site is underlain by a suite of Precambrian metamorphic rocks, primarily andesitic breccias and tuffs (Creasy 1952). The breccias are thought to be on the order of 4000 feet (ft) (though almost vertical in the vicinity of the Site), while the tuffs may be closer to 6000 ft thick. Most of the mineralization at the Iron King mine is associated with hydrothermal veins in the form of a massive sulfide deposit that trend along the primary foliations in the rocks. Minerals mined at the Site have included copper, gold, lead, silver, and zinc. The rocks are highly foliated, with associated joints and fractures likely influencing ground water flow.

Thin bands of locally-derived Quaternary Alluvium are also found on-site. The alluvium, consisting of sands and gravels, was observed to be 50 feet thick at the “Glory hole” at the Iron King Mine. The thickness of the alluvium along the valley bottom and along the gulches and drainages is unknown, though it is thought to be on the order of 100 feet thick to the east of the mine.

3.2 HYDROGEOLOGY

Two groundwater flow systems operate at the Site. Groundwater is encountered within the alluvium at depths between 30 and 50 feet below ground surface (bgs) under unconfined conditions with flow thought to generally follow topography. As such, groundwater is thought to flow east from the mine and smelter towards the Aqua Fria River. It is unknown whether the Aqua Fria River serves as a line of discharge or recharge. This question should be addressed during the RI.

Groundwater also flows under presumably confined conditions within the fracture system of the metamorphic bedrock underlying at the Site. Bedrock wells at the Site have been constructed at depths ranging between 200 and 1000 ft bgs, with measured potentiometric head depth to water ranging between 30 and 140 ft bgs. At this point a regional flow direction has not been determined. Interaction between these two water-bearing zones is unknown at this time, though it is thought that deep ground water (for example emanating from the mine shafts) has a high potential for impacting the alluvial aquifer through anthropogenic influences.

3.3 SOILS

A site-specific soils resources report was also prepared for the Site by the Natural Resources Conservation Service (NRCS) of the United States Department of Agriculture (USDA) (USDA 2008). The Site and surrounding area was broken into a total of 11 map units, based on grain size and slope angle. Of these 11 units, three units the Balon gravelly sandy clay loam (BgD), the Moano gravelly loam (MgD), and the Moano very rocky loam (MkF), encompass approximately 70 percent of the surface area in the immediate vicinity of the Site. More importantly, the BgD map unit is interpreted as being the dominant soil type at both the smelter and the mine sites. Additionally, these soil types are the most prominent upwind (south) of the Site.

Wind-borne transport of heavy metals is controlled by both the percent fines in a sample, with a 200 sieve size serving as the break between sand and silt. Furthermore, metals will substitute more freely into the silts and clays. As such, the coarser MgD and MkF are likely less significant sources of particulates. Because of this the RI study of background conditions should focus on these finer grained soils, including the BgD.

4. NATURE AND EXTENT OF CONTAMINATION

This evaluation will focus on the following media: surface and subsurface soils, sediments, surface water, and ground water. Figures 5 through 8 present the locations of the samples that were collected during the previous investigations, with the focus being on those samples results presented in the ESI (ADEQ 2006). Analytical results from the ESI (ADEQ 2006) have been included as Attachment A to this CUS.

An evaluation of previous investigation data shaped the field investigation by narrowing or broadening the data needs. A preliminary data quality assessment was conducted (see Worksheet #13 in Appendix C). Generally, the historical data are suitable for either: (1)

qualitatively evaluating the nature and extent of contamination; or (2) definitively evaluating potential risk to human health and ecological receptors. Because the CUS focused on the nature and extent of contamination, data that wasn't considered 'Unusable' was considered in this evaluation. Once these data are available electronically, it will be subject to further evaluation.

Soils collected from the Site have heavy metals concentration above the EPA Regional Screening Levels for Chemical Contaminants at Superfund Sites (EPA 2008b); Arizona Soil Remediation Levels (SRLs); and Ecological Soil Screening Levels (SSL) from EPA Region 5 (EPA 2003). Ground water exceeds MCLs as well as Arizona Ground Water Protection Levels (Table 2).

TABLE 2 SCREENING LEVELS

MEDIA	CRITERIA	ARSENIC	LEAD
Surface Soil (mg/kg)			
	EPA Residential	0.39	400
	EPA Industrial	1.6	no standard
	EPA Region 5 Ecological	18	11
	AZ Residential	10	400
	AZ Non-Residential	10	2,000
Subsurface Soil (mg/kg)			
	EPA Residential	0.39	400
	EPA Industrial	1.6	no standard
	AZ Residential	10	400
	AZ Non-Residential	10	2,000
Sediment (mg/kg)			
	EPA Region 5 Ecological	9.8	36
	AZ Non-Residential	2,000	no standard
Surface Water (µg/L)			
	Region 5 Ecological	148	1.2
	AZ Water Quality	50	50
Ground Water (µg/L)			
	EPA Tap Water	0.045	no standard
	MCL	10	15
	AZ Aquifer Water Quality	50	50

4.1 SOILS

The following discussion of the nature and extent of contamination has been segregated into surface soils (0 to 2 ft bgs) and subsurface soils (2 to 10 ft bgs). Arsenic and lead concentrations in surface soils are presented in Figures 9 through 14 for the Iron King Mine, Humboldt Smelter, and off-site sampling locations.

4.1.1 Surface Soils (0 to 2 ft bgs)

Surface soil samples were collected from the Iron King Mine, Humboldt Smelter, and Off-site Soil AOIs, as well as several background locations. Arsenic concentration in surface soil samples (0 to 2 ft bgs) are provided in Figures 9 through 11 and discussed in Section 4.1.1.1. Lead concentration in surface soil samples (0 to 2 ft bgs) are provided in Figures 12 through 14 and discussed in Section 4.1.1.2.

4.1.1.1 Arsenic

In the Iron King Mine AOI, arsenic concentrations ranged between 14.6 mg/kg in the former operations area to 7,600 mg/kg in one of the retention ponds below the large tailings pile (Figure 9). All of the samples collected had arsenic at concentrations in excess of the Arizona SRL for non-residential soils as well as the EPA Regional Screening Levels (EPA 2008b), with the exception of the lowest sample that was below the Ecological SSL only. Note that four background samples (IK-S16, IK-S17, IK-S30 and IK-S31) had reported arsenic concentrations ranging between 17.5 and 27.9 mg/kg, all of which exceed both the State and Federal standards, with the exception of two of the locations being just below the Ecological SSL of 18 mg/kg.

At the Humboldt Smelter AOI arsenic concentrations ranged between 9.1 mg/kg at the large ash pile to 1,100 mg/kg just north of the tailings pile near the office building (Figure 10). In addition, there were three samples between the large ash pile and former retention pond where arsenic was not detected above the laboratory detection limit. All but six of the samples collected had arsenic at concentrations in excess of the Arizona SRL for non-residential soils. EPA Regional Screening Levels (EPA 2008b) were exceeded in all samples with the exception of 10 locations that didn’t exceed the Ecological SSL. The two background samples (HS-47SS, HS-48SS [not located on the figures]) collected upwind of the Site near Highway 69, had reported arsenic concentrations ranging between 53.7 and 63.0 mg/kg, both of which exceed the State and Federal standards; given that these two sample concentrations are much higher than other background arsenic concentrations, they may represent a different soil type than that found in the vicinity of the Site. Arsenic concentrations ranged between 24 mg/kg to 66 mg/kg northwest of the Humboldt Smelter near Highway 69 (Figure 11). All of the samples collected had arsenic at concentrations in excess of the Arizona SRL for residential soils and EPA Regional Screening Levels (EPA 2008b). Note that nine background samples (1-BG through 9-BG) had reported arsenic concentrations ranging between 9.4 and 120 mg/kg, all but one had arsenic at concentrations in excess of the Arizona SRLs for residential soils. EPA Regional Screening Levels (EPA 2008b) were met or exceeded in all background samples with the exception of 2 locations that didn’t exceed the higher Ecological SSL.

Delineation of the affected or background surface soils for arsenic does not appear to be adequate with the current amount of surface soil data. Specifically, although a background concentration for arsenic was set at 30.72 mg/kg, the majority of surface samples collected exceed this value. As such, additional consideration of what is the proper value for background must be undertaken.

4.1.1.2 Lead

In the Iron King Mine AOI, lead concentrations ranged between 11.2 mg/kg in the Former Fertilizer Plant Area to 14,200 mg/kg in the Iron King Mine Operations Area near building 8 (Figure 12). Eleven of the samples collected had lead at concentrations in excess of the Arizona SRL for non-residential soils and all locations exceed the Ecological SSL. The four background samples (IK-S16, IK-S17, IK-S30 and IK-S31) had reported lead concentrations ranging between 2.3 and 336 mg/kg, two of which exceed only the Ecological SSL of 11 mg/kg.

At the Humboldt Smelter, lead concentrations ranged between 4.8 mg/kg at slag pile to 5,500 mg/kg for a small gray-white ash pile (Figure 13). Three of the samples collected had lead at concentrations in excess of the Arizona SRL for non-residential soils and all but 4 locations exceeded the Ecological SSL. The two background samples (HS-47SS, IK-48SS) collected upwind of the Site near Highway 69, had reported lead concentrations ranging between 12.8 and 15.5 mg/kg, both of which exceeded only the Ecological SSL.

Lead concentrations ranged between 13 mg/kg northwest of the Humboldt Smelter AOI to 34,200 mg/kg in the school yard south of the Iron King Mine AOI (Figure 14). Three of the samples collected had lead at concentrations in excess of the Arizona SRLs for residential soils and EPA Regional Screening Levels (EPA 2008b). All locations exceed the Ecological SSL for lead. Note that nine background samples (1-BG through 9-BG) had reported lead concentrations ranging between 5.5 and 91 mg/kg, none of which exceed the Arizona SRL for residential soils and EPA Regional Screening Levels for lead. Six of the background samples exceed the lower Ecological SSL of 11 mg/kg.

Delineation of the affected surface soils for lead does not appear to be adequate with the current amount of surface soil data. Much like arsenic, it is unclear whether the appropriate background level for lead has been set.

4.1.2 Subsurface Soils (2 to 10 ft bgs)

Subsurface soil samples were only collected at the Iron King Mine AOI. Samples were collected from the Former Fertilizer Plant and the Iron King Mine Operations Area near buildings 6 through 8, as well two background locations southwest of the Iron King Mine AOI (Figure 5).

Arsenic concentrations in subsurface soil (2 to 10 ft bgs) are shown in Figure 15. Arsenic concentrations ranged from 10.1 to 34.8 mg/kg, and two background concentrations were 16.3 and 29.7 mg/kg. Results from all locations exceed the arsenic Arizona SRL for non-residential subsurface soils as well as the EPA Regional Screening Levels (EPA 2008b).

Lead concentrations in subsurface soil (2 to 10 ft bgs) are provided in Figure 16. Lead concentrations ranged from 5 to 21.7 mg/kg for most locations, but a concentration of 3,660 mg/kg was measured between buildings 6 and 8. This sampling location exceeds the Arizona SRL for non-residential soils. The two background locations had lead concentrations of 1.9 and 2.2 mg/kg. Results from all but the one location are below the lead Arizona SRL for non-residential subsurface soils.

Delineation of subsurface soils is not adequate with the current amount of data.

4.2 SEDIMENTS

Sediment samples have been collected along Chaparral Gulch, Galena Gulch, the unnamed gulch at the Iron King Mine, and from the Agua Fria River. Background sediment samples were collected from the upper reaches of Chaparral Gulch, unnamed tributary to Galena Gulch, and Agua Fria River.

Arsenic concentrations in sediments are shown in Figure 17. Arsenic concentrations ranged from 9 mg/kg in the Agua Fria River below the confluence with Chaparral Gulch to 2,320 mg/kg in Chaparral Gulch at the dam which exceeds the Arizona SRL for non-residential sediment. Results from all but one location exceed the arsenic Region 5 ecological sediment screening level. Note the background sample concentrations ranged from 12.8 to 25.5 mg/kg, all of which also exceed the Region 5 ecological sediment screening level for arsenic.

Lead concentrations in sediments are shown in Figure 18. Lead concentrations ranged from 6.3 mg/kg in the Agua Fria River below the confluence with Chaparral Gulch to 1,430 mg/kg in the Main Retention Pond. Results from all locations but one exceed the lead Region 5 ecological sediment screening level. The background sediment sample concentrations ranged from 8.9 to 11 mg/kg, all below the Region 5 ecological sediment screening level for lead.

4.3 SURFACE WATER

Surface water samples have been collected from lower Chaparral Gulch and the Agua Fria River, as well as two ponds near the base of the large tailings pile. Background surface water samples were collected from the Agua Fria River upstream of the Site.

Arsenic concentrations in surface water are shown in Figure 19. Arsenic concentrations ranged from below the laboratory detection limits in the Agua Fria River to 720 µg/L in Pond-A. Results from both ponds and Chaparral Gulch at the dam locations exceed the lowest Arizona surface water quality standards and the Region 5 ecological surface water screening level for arsenic. The arsenic concentration in the background sample was 2.4 µg/L, which is lower than the Arizona surface water quality standard and the Region 5 ecological surface water screening level for arsenic.

Lead concentrations in surface water are provided in Figure 20. Lead was only detected in Pond 200-5S (samples Pond-A [180 µg/L] and Pond B [200 µg/L]). Results from both ponds exceed the lowest Arizona surface water quality standard and the Region 5 ecological surface water screening level for lead. Lead was not detected in the background sample.

4.4 GROUND WATER

Ground water samples have been collected from wells located at the Site as well as nearby public and domestic drinking water wells. Arsenic and lead concentrations in ground water are presented on Figures 21 and 22, respectively. To date, a hydrogeologic analysis regarding with aquifer wells are completed in has yet to be performed. A review of existing data suggests that the alluvial aquifer extends to a depth range of 30 to 50 feet bgs. Based on this assumption, and allowing some adjustments to this depth considering site topography, the existing wells are thought to be completed in the following aquifers:

Alluvial Aquifer: SW-02, H-56, H-58, H-62, H-65, H-68, H-80, H-81, and H-82

Bedrock Aquifer: K-Well, SW-05, SW-06, SW-07, SW-08, SW-09, SW-10, H-51, H-52, H-54, H-55, H-59, H-63, H-67, H-70, IK-G1, IK-G3, IK-G4, and IK-G9

4.4.1 Alluvial Aquifer

Arsenic was detected in all alluvial aquifer wells sampled at concentrations in excess of the EPA Regional Tap Water screening level of 0.045 µg/L (EPA 2008b). Detected concentrations in the alluvial aquifer ranged between 1.2 and 150 µg/L. All but two of the wells sampled were above the MCL, while one well, H-65 had a reported arsenic concentration of 50 µg/L, equaling the Arizona Water Quality Standard.

Lead was only detected in two wells completed in the alluvial aquifer. One sample from well SW-03 had a reported lead concentration of 140 µg/L (MCL of 15 µg/L), although a duplicate sample from this well contained lead at a concentration of 0.20 µg/L

4.4.2 Bedrock Aquifer

With the exception of the K-Well, SW-08 and SW-11, arsenic was detected in all bedrock aquifer wells at concentrations in excess of the EPA Regional Tap Water screening level of 0.045 µg/L (EPA 2008b). Detected concentrations ranged between 4.4 and 306 µg/L.

Lead was detected in approximately half of the wells sampled, with reported concentrations ranging between 0.27 and 25 µg/L. Only wells SW-15 at 25 µg/L and H-54 at 18.5 µg/L had lead present at concentrations in excess of the MCL.

5. CONCEPTUAL MODEL

Fate and transport of contaminants at the Site are relatively straightforward within the confines of a mine and associated smelter. The following discussion describes the contaminant distribution based on the AOIs as defined.

5.1 IRON KING MINE

Figure 3 presents the primary features at the Iron King Mine AOI. The mine property has been broken into three subareas: 1) the Iron King Mine Proper Area, 2) the Iron King Mine Operations Area, and 3) the Fertilizer Plant. Chaparral Gulch runs along the northeast side of the mine, while Galena Gulch runs along the southwest side of the mine. An area identified as the small tailings pile is north of the Site and immediately to the south of Chaparral Gulch.

The large tailings piles encompass the majority of the Iron King Mine Proper Area. Three retention ponds are located to the east of the tailings main retention pond and an additional three ponds are located near the Iron King Mine Proper Area. Tailings materials were placed in the ponds hydraulically. The most likely contaminants entering ground water from these operations consist of metals (arsenic and lead) as well as sulfate and total dissolved solids (TDS).

Also of significance is a large breach in the tailings pile that resulted in the off-site migration and deposition of tailing materials across Arizona Highway 69 into Chaparral Gulch. These materials are described under the Waterways AOI. An inspection of the surface of the tailings ponds resulted in the observation of a significant amount of fine materials. Where coarser materials (e.g. gravels) are present, the tailings pile surface appears relatively resistant to wind-blown impacts. Where coarser materials are not present, the tailings pile surface particulates may become airborne and deposited in other areas, including off-site residential neighborhoods.

The Iron King Mine Operations Area includes the former drum storage area, a number of buildings including the old assay building, waste rock, and the glory hole. Work in the Iron King Mine Operations Area has the potential to impact ground water as a result of chemical usage and disposal. In addition to the acids used in ore processing and at the assay laboratory, there is also the possibility that organic compounds including solvents and degreasers were used during equipment maintenance. Disposal operations related to the glory hole are unclear. Although an APP permit was received for use of the glory hole as a landfill, there is no existing information to discount that organic compounds may have been disposed of in this area. Potential airborne impacts from this area are similar to the Iron King Mine Proper Area. Dust from many areas as well as unpaved access roads have the potential to impact off-site residential areas.

Potential releases from the fertilizer plant have the potential to impact ground water. This area should first be evaluated with respect to surface spills and staining prior to a ground water investigation.

5.2 HUMBOLDT SMELTER

Figure 4 identifies the primary features at the Humboldt Smelter AOI. The key features and primary sources of contamination consist of a slag pile, ash pile, and tailings materials. There is also a potential for asbestos containing material (ACM) to be present within the smelter stack.

Previous investigations indicate that the tailings, ash, and slag piles contain arsenic and lead at concentrations in excess of existing background values as well as residential and non-residential screening levels. Although the arsenic concentrations in the slag are higher than in the ash piles, the slag is thought to be more inert. Nevertheless, both the slag and ash should be evaluated for the presence of leachable metals. Finally, the ash and tailings piles may serve as a potential source for airborne particulates.

An inspection of the tailing deposits within Chaparral Gulch as it crosses the Humboldt Smelter AOI reveals two distinct material types: 1) fine-grained tailings with a very distinct yellow color that have migrated from the smelter site into the drainage, and 2) coarser grained tailings within the drainage. Based on a review of Sanborn maps, a number of railways and elevated pipelines were indicated. It is possible that these distinct fine-grained tailings deposits were the result of spillage during the processing operations. These tailings materials had high arsenic concentrations (greater than 170 mg/kg). The coarser grained tailings within the drainage have not been sampled. It is speculated that the metal concentrations in these coarse-grained materials will be lower, though this question remains unanswered.

5.3 WATERWAYS

The Waterways AOI consists of both surface water and sediments. The Waterways included in this AOI are Galena Gulch, Chaparral Gulch, and the Aqua Fria River. Galena Gulch has the potential to be impacted as a result of surface runoff from the Iron King Mine, specifically in the vicinity of the Former Fertilizer Plant and the Iron King Mine Operations Area. A review of existing aerial photographs does not indicate that any tailing materials have entered Galena Gulch.

The Aqua Fria River has the potential to show an impact as a result of surficial runoff from the Humboldt Smelter AOI, primarily in the form of slag or ash piles. The slag deposits are thought to be more inert than the ash; although the slag has higher concentrations of metals. Chaparral Gulch appears to be the most heavily impacted waterway within the AOI, as detailed below.

A review of aerial photographs as well as observations made during the site visit reveal that Chaparral Gulch has been highly impacted from tailing materials. Close inspection of the Chaparral Gulch may reveal that tailing materials are present within the main channel from the small concrete dam near the confluence with the Aqua Fria River upstream to at least where the small tailings pile is located near the Iron King Mine AOI. The small tailings pile located near the Iron King Mine AOI as well as the tailings material in the Humboldt Smelter AOI may serve as potential sources for tailings material migrations into and via the Chaparral Gulch.

The dam near the confluence of the Chaparral Gulch and Agua Fria River is completely full of sediment and does not serve to contain either surface water or sediment; it has been reported that surface water and sediment spill over the top of the dam during storm water events. In addition, there are reports of a pipe that emerges through the center of the dam that may emit acid leachate water into the lower Chaparral Gulch.

Most of the tailing materials appear to have entered Chaparral Gulch as a result of the breach of the large tailings pile at the Iron King Mine. These materials were transported across Highway 69 much like debris flow, essentially choking the entire channel. When the large tailings pile impoundment failed, it was reported that tailings materials covered the highway as well as nearby residential properties. The extent of tailings materials within Chaparral Gulch as well as the leach potential of the fine- and coarse-grained materials is unknown at this time.

5.4 OFF-SITE SOIL

Off-site soils have been impacted as a result of windblown distribution of particulates from both the Iron King Mine and Humboldt Smelter AOIs. Observations made during the site visit also reveal that the access road to the mine is a significant source of particulates. Assessing the nature and extent of mine-related impacts is complicated by high background values for arsenic and lead near the Site. Background concentrations will need to be refined in order to determine whether measured metal concentrations in soils are mine related or naturally-occurring.

5.5 GROUND WATER

The extent of impacts to ground water is unknown. Information collected to date reveals that both the alluvial and bedrock aquifers contain arsenic and lead at concentrations above the

MCLs. The alluvial aquifer may be impacted as a result of infiltration of ground water from mine operations including from the retention ponds and the tailings pile. Static water levels within the glory hole are thought to be within the alluvium and may provide an additional conduit for contaminant transport.

Additional information regarding the direction of ground water flow within the various aquifers as well as gradients between the aquifers is needed. This information will be beneficial to evaluate the potential hydraulic communication between the to two aquifers. Some of the highest concentrations of arsenic in ground water are noted in wells H-80, H-81, and H-82 on the east side of the Aqua Fria River (Figure 21). Hydrologically, these wells are thought to be located on the other side of a hydraulic divide (i.e. Agua Fria River), and are thus may not be associated with Site activities.

Although information regarding arsenic and lead concentrations in ground water has been collected, additional inorganic data would help to refine the conceptual model. A review of work completed at other mine sites has shown both sulfate and TDS to be significant contributors to the inorganic plumes at mines. This information is likely to be useful in order to differentiate between elevated arsenic and lead values that are naturally-occurring, or Site related.

5.6 DATA GAPS

The Site has not been fully characterized to the extent necessary to adequately evaluate risks to human health and the environment as well as perform a FS. It is recommended that the following data gaps are addressed through investigatory activities:

1. The Iron King Mine AOI requires additional characterization. No information exists regarding potential sources of organic contamination from many areas, including: Former Fertilizer Plant, the glory hole, the Iron King Mine Operations Area, and the drum storage area. There is a deficit of subsurface soil data for this AOI.

2. Additional information is needed regarding the potential impact of the tailings pile and retention ponds on the alluvial aquifer; as well as the interconnectivity between the bedrock aquifer and the alluvial aquifer.

3. Particulate migration from the tailings piles and unpaved access roads should also be investigated.

4. The distribution of impacted mine tailings, ash piles, and slag at the Humboldt Smelter AOI must be further assessed. Although the slag has higher arsenic concentrations than are noted in the ash, further work assessing the leaching potential of the different materials should also be performed. Subsurface soil has not been characterized at the Humboldt Smelter AOI.

5. Investigation of the Waterways must focus on determining the nature and extent of the contaminants of and emanating from the tailings materials. Chaparral Gulch has primary tailing materials from the processing at the Humboldt Smelter as well as a significant volume of tailings materials associated with the breach of the tailings pile at the Iron

King Mine. It is anticipated that these materials may have very different leaching potentials and metal concentrations. In addition, the sediments in the Chaparral Gulch downstream of the dam should be investigated to determine the extent of impacts to the Chaparral Gulch and Agua Fria River.

6. A better understanding of site background is crucial. Nearly every surface soil sample collected in off-site areas has an elevated concentration of arsenic, while many also have elevated lead concentrations. It is possible that many of these arsenic concentrations are natural-occurring.

7. Additional information is required to evaluate the extent of impacts to the Ground Water AOI. Based on available information, the interconnection between the bedrock and alluvial aquifers is undetermined at this time. This data gap may in part be addressed with a water level survey. A review of all well logs maintained by the ADWR would also be beneficial. Additional water quality information on inorganic parameters such as sulfate and TDS will help to differentiate between Site-impacted ground water and naturally-occurring conditions.

8. The impacts to off-site soil via particulate migration from on-site source material is not well understood. Also, storm water runoff from on-site sources may be impacting off-site properties. Therefore, off-site soil will be characterized to evaluate these key migration pathways.

6. HUMAN HEALTH CONCEPTUAL EXPOSURE PATHWAY ANALYSIS

This preliminary human health conceptual site model (Preliminary HH CSM) analyzed the conceptual human health exposure pathways in accordance with the EPA’s Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (EPA 1989).

Some information in this section is redundant with information in other sections of this document to facilitate review.

6.1 SITE SETTING

As described in previous sections, the following AOI were identified for the Site:

- Iron King Mine – The Iron King Mine Proper Area, Iron King Mine Operations Area, Former Fertilizer Plant Area, and ancillary associated properties;
- Humboldt Smelter and ancillary associated properties;
- Off-site Soil in the vicinity of the Site;
- Waterways - Including the Chaparral Gulch, Galena Gulch, Aqua Fria River, and adjoining drainage channels and outfalls; and
- Ground Water - Shallow alluvial and deep bedrock ground water.

6.1.1 Source Areas and Chemicals of Potential Concern

There are a number of potential sources of chemicals at the Site. Primary among these are potential sources of metals, which include tailings piles, tailings ponds, ore piles, ash piles, and slag piles associated with either mining or smelting operations. Materials in these piles and ponds are expected to contain elevated concentrations of metals. Sampling data from past investigations indicates elevated concentrations of a number of metals. Most notable among these are arsenic and lead, which have been detected at concentrations as high as 1100 mg/kg and 2880 mg/kg, respectively in ore or ash piles. While most concentrations in soil and sediment are lower, substantially elevated concentrations can be found throughout the Site and in the drainages leading from it. Elevated metal concentrations are also found in the industrial/ processing areas of the Site. Therefore, much of the Site and associated drainages are considered a potential source of metals; past sampling indicates that arsenic and lead are of primary concern.

Specific primary sources of metals in the Iron King Mine area include the large tailings pile, small tailings pile, glory hole, area of waste rock, area of the mine plant, main retention pond, and smaller retention ponds. Primary sources of metals in the area of the Humboldt Smelter include the large area of tailings which washes into Chaparral Gulch, the slag pile, the large ash pile and two associated smaller ash piles, and the main industrial area which may contain residual ore or ash mixed into soil. Secondary sources of metals at the Site may include soil in and around the primary sources, including: soil off-site which has received contamination through wind or waterborne erosion; sediment in Chaparral Gulch, Galena Gulch, and the Agua Fria River; and minor ditches, drainages, and impoundments that may have received runoff or deposits of sediment.

Portions of the Site may also be a source for other chemicals. There is little or no data available to characterize site concentrations of organic compounds. However, the past use of portions of the Site for mining, processing, fertilizer production, and general industrial practices (i.e. equipment maintenance) provides an indicator that organic compounds could be present. In specific, activities at the plant area, drum storage areas, fertilizer plant, and glory hole could have resulted in the release of semivolatile or volatile organic chemicals, including solvents. Activities involving equipment in these areas may also have resulted in the release of polychlorinated biphenyls (PCB) from transformers or hydraulic equipment. Dioxins may be produced during burning and combustion; therefore, dioxins are also a concern in the smelter area, associated drainages, and areas that may have received ash. Elevated concentrations of nitrates, sulfates, and perchlorate may be associated with general mining and/or fertilizer production and are therefore a concern throughout the Site. Since many buildings were constructed or utilized when asbestos was commonly used as an insulator for piping or binder for construction materials, it is likely that it will be encountered in older buildings, rubble piles, and/or the Glory Hole.

Based on this information, the remedial investigation includes sampling and analysis for metals throughout the Site and in surrounding areas. It also includes analyses for organic compounds (volatile and semivolatile organic compounds; pesticides and PCBs; and dioxins) in specific areas where their presence is suspected based on historic use. The remedial investigation also includes analyses for nitrate, sulfate, and perchlorate in a subset of samples throughout the Site.

Asbestos samples will be collected in potential source areas, including: the Humboldt Smelter, the Assay Lab, and the Glory Hole.

6.1.2 Fate, Transport, and Media of Concern

A number of fate and transport pathways may transfer elevated concentrations of chemicals between different environmental media and different portions of the Site. The most important fate and transport pathways expected at the Site are: soil particulate migration, waterborne erosion, and infiltration to groundwater. An important factor determining fate and transport rates is the chemical form and mobility/bioavailability of metals.

Chemicals originating in the tailings, ash, and slag pile may be eroded by wind. At the Site, this is expected to result in a direct but temporary transfer of metals and organic chemicals bound in soil or sediment to particulate matter suspended in air ultimately resulting in transfer to off-site soil or sediment. Chemicals in soil and in air will be evaluated during the remedial investigation and human health risk assessment (HHRA).

Chemicals originating in the tailings, ash, and slag pile may also be eroded by water. At the Site, this is expected to result in a direct transfer of metals and organic chemicals to water either in dissolved form or bound to suspended particulate matter. Chemicals may remain in the water column or may be transferred to sediment either through precipitation or deposition. The highest deposition rates for suspended particles are expected in areas where water velocity decreases. This includes the areas inside of bends; impoundments; immediately upstream of dams; immediately upstream of narrowing within the drainage/streambed; and immediately downstream of widening within the streambed or confluences. Precipitation is most likely to occur in areas where the chemical composition of the water column changes; in the case of the Site, this would likely be limited to confluences with other water bodies. Waterborne erosion is considered relevant for its potential contribution to the chemical composition of the water column during precipitation events. Both distribution of chemicals in sediment and water will be evaluated during the remedial investigation.

It should be noted that, given the semi-arid environment of the Site, sediment and soil are not always distinct media. During periods of the year where there is no precipitation, the sediment present in the gulches and drainages may effectively become soil as overlying water evaporates. As such, references in the discussions below regarding exposures to soil should be assumed to include exposures to sediment during periods when there is no overlying water.

Another potential transport pathway is potential leaching of chemicals from sources (i.e. tailings, ash, and slag piles) to groundwater. Data from previous investigations indicates that groundwater at the Site may be found at shallow depths and may contain elevated concentrations of metals (ADEQ 2006). Given the proximity of the ash and slag piles at the Humboldt Smelter to the Agua Fria River, it is possible that precipitation that infiltrates through these sources may enter shallow groundwater that then discharged to the river. This would provide a transport pathway from groundwater to surface water. As such, site groundwater and its possible connection to surface water in the Agua Fria River will receive further evaluation in the remedial investigation and HHRA.

6.2 EXPOSURE AREAS

The five AOIs described in the previous section were further divided based on potential: (1) historical use; (2) waste streams; (3) contaminants of concern; (4) regulatory differences; (5) remedial alternatives; (6) future reuse; and/or (7) other mitigating factors. These subdivided areas will likely become individual exposure areas in the HHRA. The sampling design in the main document has been tailored to ensure that data will be adequate for the evaluation of these individual exposure areas. The following potential human health exposure areas were identified for the Site:

The Iron King Mine AOI includes the following three subordinate properties with several potential exposure areas:

- The Iron King Mine Proper Area – Large tailings pile and plant area;
- The Iron King Mine Operations Area – Former drum area, glory hole, and operations area; and
- The Former Fertilizer Plant Area – Entire property.

The following AOIs were segregated into the following potential exposure areas:

- Humboldt Smelter – Slag area, ash area, tailings pile, and remaining property;
- Off-site Soil – Small tailings pile and individual private properties;
- Waterways - Chaparral Gulch, Galena Gulch, and Aqua Fria River (adjoining drainage channels and outfalls will be incorporated into these three areas); and
- Ground Water - Shallow alluvial and deep bedrock ground water.

6.3 POTENTIALLY EXPOSED RECEPTORS

Potentially exposed receptors that were considered in this Preliminary HH CSM include: commercial/industrial workers, construction workers, recreational/trespassers, and adult//child residents (see Figure 23). Both a current and future exposure scenario will be considered for all receptors.

6.3.1 Commercial/Industrial Workers

The Iron King Mine is currently being used for commercial/industrial use. However, Humboldt Smelter has restricted access and is not being utilized for commercial or industrial purposes. Therefore a current commercial/industrial worker will not be evaluated for the Humboldt Smelter, but will be evaluated for the Iron King Mine and for Off-site Soil AOIs as appropriate. Information gathered during the course of the field investigation will determine whether current commercial/industrial exposure to the Ground Water AOI should be evaluated. The future commercial/industrial worker exposure scenario will be evaluated for the Iron King Mine, Humboldt Smelter, Off-site Soil, and Ground Water AOIs.

6.3.2 Construction Workers

Because it is likely that future reuse of the Iron King Mine and Humboldt Smelter may include intrusive redevelopment (i.e., subsurface excavation) a future construction worker exposure scenario will be evaluated. Similarly, future construction worker activities may occur on the Off-site Soil AOI so this scenario will be evaluated. Finally, construction workers are occasionally exposed to ground water during intrusive activities so this scenario will be evaluated.

6.3.3 Recreational/Trespassers

Recreational and trespasser exposure parameters are likely to be similar, so these potential receptors have been combined. Both recreational and trespasser exposure are likely to occur at the Iron King Mine, Humboldt Smelter, Off-site Soil, and Waterways AOIs, although the exposure parameters (e.g., exposure duration) will likely be different. For example, the perimeter fence surrounding the Humboldt Smelter is supposed to restrict access to the property; however, reports from the community indicate that trespasser intrusion/exposure is an ongoing issue. This is much less likely to occur at the Iron King Mine because of its proximity (i.e., it is across Highway 69 from most of the town residents). Nevertheless, current and future trespasser exposure will be evaluated for the Iron King Mine, Humboldt Smelter, Waterways and Off-site Soil AOIs, but not the Ground Water AOI.

TABLE 3 POTENTIAL HUMAN HEALTH RECEPTORS

Exposure Area	Commercial/ Industrial Worker	Construction Worker	Recreational/ Trespasser	Adult/Child Resident
Iron King Mine	X	X	X	X
Humboldt Smelter	X	X	X	X
Off-site Soil	X	X	X	X
Waterways			X	X
Ground Water	X	X		X

Current recreational exposure may be occurring in the Waterways and Off-site Soil AOIs, so these scenarios will be evaluated. Future reuse of the Iron King Mine, Humboldt Smelter, Waterways, and Off-site Soil AOIs may include recreational exposure; these large tracks of land could easily serve as a park or recreational area for the community at large.

6.3.4 Adult/Child Residents

Current residential exposure will be evaluated for the Off-site Soil AOI only. An unrestricted reuse (i.e., residential) exposure scenario will be evaluated for source areas so that a ‘no action’ alternative may be evaluated in the Feasibility Study. Therefore, in addition to the Off-site Soil AOI, the future residential exposure scenario will be evaluated for the Iron King Mine and

Humboldt Smelter AOIs. The current/future residential exposure scenarios will include exposure to the Ground Water and Waterway AOIs as appropriate.

6.4 POTENTIALLY COMPLETE EXPOSURE PATHWAYS

According to EPA guidance (1989), a complete exposure pathway consists of four elements:

- A source and mechanism of chemical release;
- A retention or transport medium (or media in cases involving transfer of chemicals);
- A point of potential human contact with the contaminated medium (referred to as the "exposure point"); and
- An exposure route (such as ingestion) at the exposure point.

If any of these elements is missing (except when the source itself is the exposure point), then the exposure pathway is considered incomplete. For example, if receptor contact with the source or transport medium does not occur, then the exposure pathway is considered incomplete and is not quantitatively evaluated for risk.

The Preliminary HH CSM (Figure 23) summarizes information on sources of chemicals of potential concern (COPCs), affected environmental media, COPC release and transport mechanisms that may occur at the Site, potentially exposed receptors, and potential exposure pathways for each receptor. Potentially complete exposure pathways are designated by a "C" in the HH CSM. Potentially complete but insignificant or incomplete exposure pathways are designated by an "I." Quantitative risk evaluation (i.e., calculation of numerical cancer and noncancer risk estimates) will be conducted for exposure pathways identified in the HH CSM as potentially complete ("C" in the HH CSM).

Many exposure pathways are based on hypothetical future exposures, so they are considered potentially complete and are evaluated to provide a conservative estimate of risk. Not all of these pathways may actually be complete for all receptors in the future.

Exposure routes for each receptor associated with the potentially complete exposure pathways are described in the following sections for the following potential receptors:

- Current and Future Commercial/Industrial Workers;
- Future Construction Worker;
- Current and Future Recreation/Trespasser; and
- Current and Future Adult/Child Resident.

Because all future exposure scenarios are hypothetical, this designation will not be repeated throughout the document for brevity.

6.4.1 Commercial/Industrial Workers

The following surface soil exposure pathways are potentially complete for the current and future commercial/industrial worker exposure scenarios:

- Incidental ingestion of surface soil;
- Dermal contact with surface soil; and
- Inhalation of chemicals adsorbed to windblown surface soils.

The following subsurface soil exposure pathways are potentially complete for the current and future commercial/industrial worker exposure scenarios if intrusive activities occur that may bring subsurface soils to the surface:

- Incidental ingestion of subsurface soil;
- Dermal contact with subsurface soil; and
- Inhalation of chemicals adsorbed to windblown subsurface soils.

The following subsurface soil exposure pathway is potentially complete for the current and future commercial/industrial worker exposure scenarios if volatile organic compounds (VOC) are detected in subsurface soil:

- Inhalation of indoor air vapors from vadose zone soil vapor intrusion.

The following ground water exposure pathways are potentially complete for the current and future commercial/industrial worker exposure scenarios:

- Ingestion of ground water;
- Dermal contact with ground water;
- Inhalation of chemicals volatilized from ground water during industrial use; and
- Inhalation of indoor air vapors from ground water vapor intrusion (pathway may be considered potentially complete if VOCs are detected in shallow zone ground water).

The following exposure pathways are either considered potentially complete but insignificant or incomplete for the current and future commercial/industrial worker exposure scenarios:

- A commercial/industrial worker is not expected to have routine exposure to surface water or sediments. Therefore, these pathways are considered potentially complete but insignificant.
- A commercial/industrial worker is not expected to conduct intrusive activities (e.g., installing pipe within a trench). Therefore, inhalation of volatiles from subsurface soil or ground water in out-door air may be a potentially complete but insignificant pathway because volatiles will tend to dissipate if not in a confined space like a trench.

6.4.2 Construction Workers

The following surface soil exposure pathways are potentially complete for the current and future construction worker exposure scenarios:

- Incidental ingestion of surface soil;

- Dermal contact with surface soil; and
- Inhalation of chemicals adsorbed to windblown surface soils.

The following subsurface soil exposure pathways are potentially complete for the current and future construction worker exposure scenarios during intrusive activities:

- Incidental ingestion of subsurface soil;
- Dermal contact with subsurface soil;
- Inhalation of chemicals adsorbed to windblown subsurface soils; and
- Inhalation of volatiles from subsurface soil during intrusive activities (e.g., installing a pipe in a trench) if VOCs are detected in subsurface soil.

The following ground water exposure pathways are potentially complete for the current and future construction worker exposure scenarios:

- Inhalation of volatiles from ground water during intrusive activities (e.g., installing a pipe in a trench) if VOCs are detected in shallow zone ground water.

The following exposure pathways are either considered potentially complete but insignificant or incomplete for the current and future construction worker exposure scenarios:

- A construction worker is not expected to have routine exposure to surface water or sediments. Therefore, these pathways are considered potentially complete but insignificant.
- A construction worker is not expected to spend significant time indoors. Therefore, the inhalation of indoor air vapors from subsurface soil or ground water vapor intrusion is considered a potentially complete but insignificant pathway.
- A construction worker is not expected to be exposed to ground water during the workday so ingestion, dermal contact, and inhalation of volatiles from ground water via industrial use are considered potentially complete but insignificant pathways.

6.4.3 Recreational/Trespasser

The following surface soil exposure pathways are potentially complete for the current and future recreational/trespasser exposure scenarios:

- Incidental ingestion of surface soil;
- Dermal contact with surface soil; and
- Inhalation of chemicals adsorbed to windblown surface soils.

The following subsurface soil exposure pathways are potentially complete for the current and future recreational/trespasser exposure scenarios if intrusive activities occur that may bring subsurface soils to the surface:

- Incidental ingestion of subsurface soil;

- Dermal contact with subsurface soil; and
- Inhalation of chemicals adsorbed to windblown subsurface soils.

The following sediment and surface water exposure pathways are potentially complete for the current and future recreational/trespasser exposure scenarios:

- Incidental ingestion of sediment and surface water; and
- Dermal contact with sediment and surface water.

The following exposure pathways are either considered potentially complete but insignificant or incomplete for the current and future recreational/trespasser exposure scenarios:

- A recreational/trespasser is not expected to conduct intrusive activities (e.g., installing pipe within a trench). Therefore, inhalation of volatiles from subsurface soil or ground water in out-door air may be a potentially complete but insignificant pathway because volatiles will tend to dissipate if not in a confined space like a trench.
- A recreational/trespasser is not expected to spend significant time indoors. Therefore, the inhalation of indoor air vapors from subsurface soil or ground water vapor intrusion is considered a potentially complete but insignificant pathway.
- A recreational/trespasser is not expected to be exposed to ground water during the day so ingestion, dermal contact, and inhalation of volatiles from ground water are considered potentially complete but insignificant pathways.

6.4.4 Adult/Child Resident

The following surface soil exposure pathways are potentially complete for the current and future adult/child resident exposure scenarios:

- Incidental ingestion of surface soil;
- Dermal contact with surface soil; and
- Inhalation of chemicals adsorbed to windblown surface soils.

The following subsurface soil exposure pathways are potentially complete for the current and future adult/child resident exposure scenarios if intrusive activities occur that may bring subsurface soils to the surface:

- Incidental ingestion of subsurface soil;
- Dermal contact with subsurface soil; and
- Inhalation of chemicals adsorbed to windblown subsurface soils.

The following subsurface soil exposure pathway is potentially complete for the current and future adult/child resident exposure scenarios if VOCs are detected in subsurface soil:

- Inhalation of indoor air vapors from vadose zone soil vapor intrusion.

The following ground water exposure pathways are potentially complete for the current and future adult/child resident exposure scenarios:

- Ingestion of ground water;
- Dermal contact with ground water;
- Inhalation of chemicals volatilized from ground water during household use; and
- Inhalation of indoor air vapors from ground water vapor intrusion (pathway may be considered potentially complete if VOCs are detected in shallow zone ground water).

The following sediment and surface water exposure pathways are potentially complete for the current and future recreational/trespasser exposure scenarios:

- Incidental ingestion of sediment and surface water; and
- Dermal contact with sediment and surface water.

The following exposure pathways are either considered potentially complete but insignificant or incomplete for the current and future adult/child resident exposure scenarios:

- An adult/child resident is not expected to conduct intrusive activities (e.g., installing pipe within a trench). Therefore, inhalation of volatiles from subsurface soil or ground water in out-door air may be a potentially complete but insignificant pathway because volatiles will tend to dissipate if not in a confined space like a trench.

7. ECOLOGICAL CONCEPTUAL EXPOSURE PATHWAY ANALYSIS

The purpose of the ecological exposure pathway analysis is to identify the routes by which ecological receptors may potentially be exposed to chemicals at the Site. This exposure pathway analysis is intended to support an ecological risk assessment (ERA) for the Site conducted according to EPA guidance (EPA 1997, 1999). The specific objectives selected to achieve this purpose are:

- Describe site ecology based on available information and data;

- Identify and characterize potential sources of chemicals;

- Identify media of concern and discuss relevant fate and transport pathways by which chemicals may enter these media;

- Identify complete and significant exposure pathways for ecological receptors;

- Identify representative receptors of concern; and

- Identify potentially relevant data groupings based on-site sources and exposure pathways.

The objectives of this pathway analysis and the current understanding of the Site were discussed in a conference call between EPA and EA on June 30, 2004. The results of this discussion were used as the basis of this analysis.

7.1 SITE ECOLOGY

The Site is located in Yavapai County Arizona. Site elevations range from approximately 4600 to 4800 feet above sea level. Based on large scale habitat maps (AGFD 2006; Marshall et al. 2004), it is located in Apache Highlands North Ecoregion, and the predominant terrestrial habitats in the vicinity are developed areas surrounded by interior chaparral, with riparian habitat along drainages. Field observations and aerial photographs indicate that the developed/industrial areas of the Site provide potentially accessible but very poor quality habitat. The tailings pile, ash pile, ore pile, slag pile, glory hole, processing area, smelter area, and other industrialized areas consist primarily of bare or sparsely vegetated ground.

Interior chaparral is a fire-dependent habitat which consists primarily of thickets of manzanita and shrub live oak (AGFD 2006). Chaparral habitat is expected in the areas immediately outside the industrialized portions of the Site. Chaparral provides relatively high quality habitat for wildlife, although habitat quality may vary dependent upon fire frequency. Additional terrestrial habitat is provided by the riparian corridors associated with Chaparral and Galena Gulches and Agua Fria River. While relatively small in spatial extent, these areas provide densely vegetated, high quality habitat that provides a resource for wildlife.

The aquatic habitats at the Site include drainages and impoundments, the Chaparral Gulch, the Galena Gulch, and the Agua Fria River. The drainages and impoundments within the industrialized areas of the Site are expected to provide poor quality habitat. Based on field observations and climatic information, the drainage ditches within the industrialized areas are likely to remain dry for long periods of time. The tailings ponds (i.e. Main Retention Pond) and impoundments are man-made and relatively isolated and therefore expected to provide little habitat for aquatic or benthic organisms. However, they could provide a water source for consumption by wildlife.

Chaparral Gulch and Galena Gulch are intermittent drainages that are dry for portions of each year. They both drain to the Agua Fria River and are associated with riparian corridor vegetation visible on aerial photographs. Therefore, these gulches may provide ephemeral habitat for aquatic organisms. The quality and significance of this habitat is expected to be relatively poor dependent on the length of time these gulches are flooded.

The Agua Fria River experiences flow year round with a mean flow of 3.89 cubic feet per second (cfs) measured near the Site from 2001 to 2004 (NRCS 2007). The Agua Fria represents the highest quality aquatic habitat associated with the Site; it is also expected to provide the most consistent source of water for wildlife.

7.2 SPECIES POTENTIALLY PRESENT AT THE SITE

Wildlife present at the Site are expected to be supported primarily by chaparral habitat and the associated riparian corridors; in general, chaparral supports comparatively small wildlife populations (Office of Arid Lands Study [OALS] 2002). The AGFD has prepared a Comprehensive Wildlife Conservation Strategy (AGFD 2006) evaluating the conservation of species present in each ecoregion within Arizona. This report identifies the species likely to be present in interior chaparral, human-dominated, and aquatic habitats within the Apache Highlands Ecoregion, which are the predominant habitats at the Site (see Attachment B). Species associated with these habitats are listed in Attachment A; these species are not necessarily present at the Site, but could be present and are likely to include species typically found at the Site.

- **Vegetation** - Interior chaparral is a fire-dependent habitat which consists primarily of thickets of manzanita and shrub live oak; other vegetation typical of interior chaparral includes birch leaf mountain mahogany, skunk bush sumac, silk tassels, desert ceanothus, prickly-pear cactus, agaves, and yuccas (AGFD 2006). Riparian corridors at the Site are expected to support additional terrestrial plant species as well as limited riparian vegetation. Photographs of aquatic habitats at the Site show that, due to their ephemeral nature, rocky substrate, and high rates of flow when it occurs, there is little or no aquatic vegetation.

- **Terrestrial Invertebrates** – Chaparral habitat is expected to support a variety of flying and crawling insects. Due to its semi-arid nature and fire dependence, chaparral is expected to support relatively few or no earthworms.

- **Mammals –** Chaparral support a variety of mammals (OALS 2002; AGFD 2006). Examples of typical herbivores include mice, chipmunks, squirrels, deer and antelope. Typical lower trophic level carnivores or omnivores include rats, bats, skunks, peccary, and badgers. Higher trophic level carnivores include fox, coyote, bobcat, and bears.

- **Birds** – Common chaparral bird species include a wide variety of perching birds, including sparrows, towhees, orioles, cardinals, kingbirds, robins, jays, vireos, warblers, and wrens (OALS 2002; AGFD 2006). Chaparral also supports gallinaceous birds including dove, quails, pigeons, and turkey, and birds of prey such as hawks, owls, and vultures (OALS 2002; AGFD 2006). Rivers and aquatic habitats may also support heron, geese, ducks, and other waterfowl (AGFD 2006).

- **Reptiles and Amphibians** – Chaparral habitats support a number of reptiles including snakes, lizards, and tortoises (AGFD 2006). It is also expected to support amphibian species, including frogs, toads, and salamanders, in association with permanent and some ephemeral waterways (AGFD 2006).

- **Aquatic Organisms** – Streams, rivers, and wetlands within the Apache Highlands North Ecoregion support a range of snails, dace, minnows, suckers, and larger game fish (AGFD 2006). The quantity and diversity of these species is expected to vary with the persistence of the water body and quality of the habitat; thus the species present at the Site in ephemeral water bodies may be limited.

It should be noted that the species listed above are based on general, regional information and may not accurately represent the species found at the Site. Better characterization of species and habitats will be provided by habitat surveys conducted as part of the remedial investigation and ecological risk assessment, which will also provide more specific information regarding threatened and endangered species. However, the information above is useful for developing the conceptual model and selecting receptors of concern.

7.3 SOURCE AREAS AND CHEMICALS OF POTENTIAL CONCERN

There are a number of potential sources of chemicals at the Site (Figure 24). Primary among these are potential sources of metals, which include tailings piles, tailings ponds, ore piles, ash piles, and slag piles associated with either mining or smelting operations. Materials in these piles and ponds are expected to contain elevated concentrations of metals. Sampling data from past investigations indicates elevated concentrations of a number of metals. Most notable among these are arsenic and lead, which have been detected at concentrations as high as 1100 mg/kg and 2880 mg/kg, respectively in ore or ash piles. While most concentrations in soil and sediment are lower, substantially elevated concentrations can be found throughout the Site and in the drainages leading from it. Elevated metal concentrations are also found in the industrial/processing areas of the Site. Therefore, much of the Site and associated drainages are considered a potential source of metals; past sampling indicates that arsenic and lead are of primary concern.

Specific primary sources of metals in the Iron King Mine area include the large tailings pile, small tailings pile, glory hole, area of waste rock, area of the mine plant, main retention pond, and smaller retention ponds. Primary sources of metals in the area of the Humboldt Smelter include the large area of tailings which washes into Chaparral Gulch, the slag pile, the large ash pile and two associated smaller ash piles, and the main industrial area which may contain residual ore or ash mixed into soil. Secondary sources of metals at the Site may include soil in and around the primary sources; soil off-site which has received contamination through wind or waterborne erosion; sediment in Chaparral Gulch, Galena Gulch, and the Agua Fria River; and minor ditches, drainages, and impoundments that may have received runoff or deposits of sediment.

Portions of the Site may also be a source for other chemicals. There is little or no data available to characterize Site concentrations of organic compounds. However, the past use of portions of the Site for mining, processing, fertilizer production, and general industrial practices (i.e. equipment maintenance) provides an indicator that organic compounds could be present. In specific, activities at the plant area, drum storage areas, fertilizer plant, and glory hole could have resulted in the release of semivolatile or volatile organic chemicals, including solvents. Activities involving equipment in these areas may also have resulted in the release of PCBs from transformers or hydraulic equipment. Dioxins may be produced during burning and combustion; therefore, dioxins are also a concern in the smelter area, associated drainages, and areas that may have received ash. Finally, elevated concentrations of nitrates, sulfates, and perchlorate may be associated with general mining and/or fertilizer production and are therefore a concern throughout the Site.

Based on this information, the remedial investigation includes sampling and analysis for metals throughout the Site and in surrounding areas. It also includes analyses for organic compounds (volatile and semivolatile organic compounds, pesticides and PCBs, and dioxins) in specific areas where their presence is suspected based on historic use. The remedial investigation also includes analyses for nitrate, sulfate, and perchlorate in a subset of samples throughout the Site.

7.4 FATE, TRANSPORT AND MEDIA OF CONCERN

A number of fate and transport pathways may transfer elevated concentrations of chemicals between different environmental media and different portions of the Site (Figure 24). The most important fate and transport pathways expected at the Site are wind and waterborne erosion, infiltration to groundwater, and bioaccumulation. An important factor determining fate and transport rates is the chemical form and mobility/bioavailability of metals.

Chemicals originating in the tailings, ash, and slag pile may be eroded by wind. At the Site, this is expected to result in a direct but temporary transfer of metals and organic chemicals bound in soil or sediment to particulate matter suspended in air ultimately resulting in transfer to off-site soil or sediment (e.g., in surrounding chaparral habitat or nearby drainages). Wind eroded material may be deposited onto the soil surface throughout surrounding areas. However, deposition rates are expected to be highest in areas where wind speed decreases due to microtopographic variation. This would include low lying areas and areas of dense vegetation. This fate and transport pathway is considered most relevant to ecological receptors in terms of its effects on redistribution of chemicals from contaminated low quality habitats (i.e. tailings piles) to high quality surrounding habitats (i.e. chaparral). It is unclear whether metals or organic chemicals bound to airborne particulates would remain suspended for a sufficient amount of time to produce substantial ecological exposures, or whether sufficient concentrations of volatile chemicals would be present to warrant further evaluation. Both distribution of chemicals in soil and in air will be evaluated during the remedial investigation and ecological risk assessment.

Chemicals originating in the tailings, ash, and slag pile may also be eroded by water. At the Site, this is expected to result in a direct transfer of metals and organic chemicals to water either in dissolved form or bound to suspended particulate matter. Chemicals may remain in the water column or may be transferred to sediment either through precipitation or deposition. The highest deposition rates for suspended particles are expected in areas where water velocity decreases. This includes the areas inside of bends, impoundments, immediately upstream of dams, immediately upstream of narrowing within the drainage/streambed, and immediately downstream of widening within the streambed or confluences. Precipitation is most likely to occur in areas where the chemical composition of the water column changes; in the case of the Site, this would likely be limited to confluences with other water bodies. Waterborne erosion is considered relevant to ecological receptors in terms of its effects on redistribution of chemicals from contaminated low quality habitats (i.e. on-site drainages, impoundments, and the gulches) to high quality surrounding habitats (i.e. Agua Fria River). It is also considered significant for its potential contributions to the chemical composition of the water column during precipitation events. Both distribution of chemicals in sediment and water will be evaluated during the remedial investigation.

It should be noted that, given the semi-arid environment of the Site, sediment and soil are not always distinct media. During periods of the year where there is no precipitation, the sediment present in the gulches and drainages may effectively become soil as overlying water evaporates. As such, references in the discussions below regarding exposures to soil should be assumed to include exposures to sediment during periods when there is no overlying water. This is an important consideration because wildlife may heavily utilize the riparian corridors present at the Site.

Another potential transport pathway is leaching of chemicals from sources (i.e. tailings, ash, and slag piles) to groundwater. Ecological receptors are not expected to come into contact with groundwater. However, data from previous investigations indicates that groundwater at the Site may be found at shallow depths and may contain elevated concentrations of metals (ADEQ 2006). Given the proximity of the ash and slag piles at the Humboldt Smelter to the Agua Fria River, it is possible that precipitation that infiltrates through these sources may enter shallow groundwater that then discharges to the river. This would provide a transport pathway from groundwater to surface water. As such, Site groundwater and its possible connection to surface water in the Agua Fria River will receive further evaluation in the remedial investigation and ecological risk assessment.

Bioaccumulation is also a relevant transport pathway. Plants and animals that come in contact with contamination in soil, sediment, or water may uptake chemicals. Dependent upon the chemical and the organism, these chemicals may accumulate in tissue. This transfer from abiotic media to biotic media constitutes a transport pathway and may result in exposures for wildlife that consumes plants and animals that have bioaccumulated chemicals. Both arsenic and lead are considered potentially bioaccumulative and may accumulate in the tissue of plants and animals. Other metals and hydrophobic organic compounds (i.e. PCBs) may also bioaccumulate. Therefore, bioaccumulation represents a significant transport pathway at the Site. During the remedial investigation, data will be collected to characterize concentrations of chemicals in soil, sediment, and surface water at the Site. In conjunction with information from the scientific literature regarding bioaccumulation rates, this will allow estimation of the potential significance of bioaccumulation as a transport and exposure pathway in the ecological risk assessment.

It is important to note that all of the transport pathways discussed above are dependent upon factors that influence the forms of chemicals in environmental media. This is especially important for metals. Metals are present in nature in a wide range of chemical forms. Some forms are readily soluble. Soluble forms of metals such as arsenic and lead are highly mobile in soil, sediment, and water and thus facilitate higher transport rates. Soluble forms of these metals are also more bioavailable, which means that they are taken up more easily by plants and animals. Many of the mineral forms of metals found in naturally occurring rocks and soils are relatively insoluble. They do not dissolve easily, are relatively immobile in environmental media, and are not readily taken up by wildlife. Changes in the chemistry of soil, sediment, or water may make metals more or less soluble, and thus determine their ultimate mobility and bioavailability.

In the case of arsenic and lead, insoluble, naturally occurring mineral forms include arsenopyrite and galena respectively; these are often the minerals associated with mining related wastes. Changes in pH, such as that caused by acid mine drainage, may result in solubilization of these metals to more mobile and bioavailable forms. Therefore, it is important to characterize the acidity of media at the Site as well as concentrations of sulfate, which may indicate acid mine drainage. These characteristics, as well as available data concerning chemical form at the Site, will be further evaluated in the remedial investigation and the risk assessment.

Based on the above information, soil, sediment, surface water are all environmental media which may receive chemicals transported from site sources, and which therefore may serve as a medium of exposure. Plant and animal tissue that has bioaccumulated chemicals is also a potential medium of exposure. It is unclear whether the transport of chemicals into the air via suspended particulates constitutes a transport pathway significant enough to warrant evaluation of air as a media of concern; therefore, air will be evaluated in the exposure pathway analysis below, but will be re-evaluated using data collected in the remedial investigation.

7.5 EXPOSURE ROUTES

Exposure routes link chemicals in exposure media to ecological receptors. The following sections describe the major exposure routes. As discussed above, ecological receptors potentially present at the Site include plants, terrestrial invertebrates, wildlife (birds, mammals, and wildlife), and aquatic organisms. The following sections identify the major routes of exposure and their applicability to each of these receptor groups (Figure 24).

7.5.1 Direct Contact/Dermal Contact

Plants, invertebrates, aquatic organisms, and wildlife may all be exposed to environmental media through direct contact. Plants may absorb chemicals from surface and subsurface soil via their roots. They may also absorb chemicals from air or airborne particles through their leaves. Absorption through the roots is expected to be the most significant pathway. Absorption of chemicals from air or airborne particles is expected to be a relatively insignificant pathway, although this pathway may be re-evaluated if data from the remedial investigation indicate that significant airborne contamination is present. It is also possible that deep rooting shrubs common to chaparral environments may come into direct contact with groundwater; however, additional information is required from the remedial investigation regarding depth to groundwater before this pathway can be considered complete. Plants are known to uptake metals and some organics; however, uptake of hydrophobic and/or large molecular weight compounds by plants is limited (Figure 24). Based on this information, direct exposure to surface and subsurface soil is considered a complete and significant pathway for plants.

Aquatic organisms may be exposed to chemicals in sediment and surface water through direct contact. Chemicals may be absorbed from water or sediment through the skin and gills. This exposure pathway is considered to be complete and significant for both media (Figure 24).

Terrestrial invertebrates may be exposed to chemicals in soil and air through direct contact. Chemicals may be absorbed from soil through the skin. Most invertebrates typical of arid and semi-arid environments such as those at the Site have hard exo-skeletons which are likely to limit exposure. Therefore, this exposure pathway is considered to be complete and significant for soil, but of limited significance for exposures to air (Figure 24).

Wildlife may be exposed to chemicals in air, soil (both surface and subsurface), sediment, or water via direct contact during foraging or burrowing. Most wildlife are equipped with protective outer coverings such as fur, feathers, or scales that prevent or limit the dermal absorption of chemicals from environmental media (United States Army Center for Health Promotion and Preventive Medicine [USAHCPPM] 2004). EPA guidance identifies that, in most cases, dermal exposures are likely to be less significant than exposures through ingestion and their evaluation involves considerable uncertainty (EPA 2005). This guidance provides example calculations for an example species showing that less than 0.2% of the total chemical dose to wildlife is likely to come from dermal contact. Given that many metals demonstrate relatively low dermal absorption, this exposure route is considered complete but relatively insignificant for wildlife (Figure 24).

7.5.2 Inhalation

Inhalation is a potentially complete pathway for both terrestrial invertebrates and wildlife. These animals may inhale chemicals which have volatilized or which are adsorbed to airborne particulates. Currently, it is unclear whether volatile compounds are present at the Site in high enough concentrations to cause significant exposures. Similarly, it is unclear whether suspension of airborne particulates occurs with sufficient duration or frequency to result in significant inhalation exposures. EPA guidance indicates that, in general, inhalation pathways are likely to be insignificant compared to ingestion pathways (EPA 2005). This guidance states that most chemicals inhaled with dust are trapped in mucus membranes and ingested; therefore, their impact is captured through analysis of incidentally ingested soil. It also provides example calculations showing that less than 0.1% of the total risk to wildlife is likely to come from inhalation. Finally, a large number of assumptions are required for quantification of inhalation exposures, leading to significant uncertainties. Based on this information, inhalation exposures are considered to be a complete but insignificant exposure pathway for the Site (Figure 24).

7.5.3 Ingestion

The most significant exposure route for wildlife is ingestion of chemicals in contaminated media (EPA 2005). Wildlife may ingest chemicals in environmental media by drinking surface water or by incidentally ingesting soil and sediment while grooming or foraging. As discussed above, chemicals may bioaccumulate in the tissue of plants and animals. Therefore, wildlife may also ingest chemicals from plants and animals that they consume as food. Herbivores may be exposed to chemicals that have bioaccumulated in plant tissue. Carnivores may be exposed to chemicals that have accumulated in prey. Omnivores may be exposed to chemicals in both plant and animal food items. The Site is expected to support a range of wildlife that spans several trophic levels and feeding guilds. This includes both primary and secondary consumers, and species which consume plants, invertebrates, small birds and mammals, and fish or aquatic organisms. Ingestion of chemicals in soil, sediment, surface water, and/or food is considered a complete and potentially significant exposure pathway (Figure 24).

7.6 ASSESSMENT ENDPOINTS

Assessment endpoints are clear statements of the environmental value to be protected from impacts (EPA 1997). Assessment endpoints are usually defined in terms of an ecological entity and its attributes.

The selection of assessment endpoints is based on the fundamental knowledge of site ecology, and incorporates consideration of the COPCs, exposure pathways, toxic mechanisms, and potentially important exposure groups. Per EPA guidance (EPA 1997, 1999), the focus of the ERA is to protect the ecological values at the population or community level except where threatened or endangered species are concerned. For example, maintenance of sustainable populations of a specific species of songbird is an example of a population level assessment endpoint, while maintenance of native bird diversity is a community level endpoint. While population and community level endpoints such as these express important ecological values, they are often very difficult to assess. Therefore, initial steps of an ERA typically focuses on assessment endpoints defined in terms of effects on individual organisms; this makes quantitation of risks easier, since potential individual exposures and impacts can be more easily measured or estimated. It should be noted that where threatened or endangered species are specifically concerned, the focus of the ERA is at the level of individual organisms.

The following preliminary assessment endpoints were defined to reflect the potential impacts of complete and significant exposure pathways discussed above and to aid in selecting representative receptor species:

- Viability of plant communities in chaparral and associated riparian corridor habitats;
- Viability of terrestrial invertebrate communities as resources for terrestrial wildlife;
- Viability of aquatic organism communities; and
- Viability of terrestrial wildlife communities, including a variety of feeding guilds likely to use site habitats.

These assessment endpoints are general and should be refined and revised if necessary during part of the early stages of the ERA.

7.7 SELECTION OF REPRESENTATIVE RECEPTORS

Ecological receptors potentially present at the Site include plants, terrestrial invertebrates, wildlife (e.g., birds, mammals, etc.), and aquatic organisms. Selection of representative receptor species is based primarily on several factors: 1) the likelihood of a species to use the Site and the area immediately surrounding the Site, 2) the potential for exposure to site-related contaminants based on the feeding habits and life history of the organisms/guild represented by the receptor species, 3) the availability of life history and exposure information for the selected receptor species, and 4) the availability of toxicity information for the representative receptor species. The rationale for selection of representative receptor species is summarized below.

7.7.1 Plants

The primary exposure medium for plants is soil, and the primary exposure route is direct contact through the roots. Plant species at the Site are expected to consist primarily of herbaceous and shrubby species associated with chaparral and riparian corridor habitats and dominated by manzanita, live oak, birch leaf mountain mahogany, skunk bush sumac, silk tassels, desert ceanothus, prickly-pear cactus, agaves, and yuccas (AGFD 2006). Given the fact that it is a dominant chaparral species, shrub live oak (*Quercus turbinella*) is selected as a representative receptor species, although available exposure and toxicity data for plants are largely species non-specific and thus protective of a broad range of plants. It is important to note that available information concerning aquatic habitats at the Site indicate that there is little or no aquatic vegetation; species growing within the riparian corridors is most appropriately considered as terrestrial plants.

7.7.2 Soil Invertebrates

The primary exposure medium for soil invertebrates is soil, and the primary exposure routes are direct contact and ingestion. Invertebrate species at the Site are expected to consist primarily of insects common to interior chaparral and riparian corridor habitats. Given their likely presence at the Site, their close contact and long term exposure with soil, their likely importance as a food source for many species of birds and mammals, and their common role as seed dispersers, ants (family Formicidae) are selected as a representative receptor species. It should be noted, however, that available exposure and toxicity data for terrestrial invertebrates are largely species non-specific or based on more sensitive surrogate receptors and thus protective of a broad range of invertebrates.

7.7.3 Aquatic Organisms

The primary exposure pathway for aquatic organisms is direct exposure to chemicals in sediment and surface water, and the primary exposure routes are direct contact and ingestion. Aquatic organism species at the Site are expected to consist primarily of crustaceans (i.e. shrimp) and fish. Given their likely presence at the Site, the fact that they are likely to be an important food source for piscivorous wildlife, and the abundance of toxicological information available, the fathead minnow (*Pimephales promelas*) is selected as a representative receptor species. It should be noted, however, that available exposure and toxicity data for aquatic organisms are largely species non-specific, based on more sensitive surrogate receptors, and defined in terms of overall exposures to sediment and surface water that protective of a broad range of aquatic organisms.

7.7.4 Wildlife

The primary exposure pathways for wildlife are ingestion of abiotic and biotic media. The Site is expected to support a range of wildlife that spans several trophic levels and feeding guilds. Therefore, separate representative receptor species are selected for several important feeding guilds, each of which is described below.

Herbivores – The exposure pathway analysis identified complete exposure pathways for wildlife. Herbivorous birds and mammals are an important component of chaparral wildlife communities. They may be exposed to chemicals at the Site through ingestion of chemicals in soil, surface water, and plant material (Figure 24). The pocket gopher (*Peromyscus leucopus*) is identified as a representative receptor species for evaluation of the potential for adverse effects to herbivorous mammals. The pocket gopher is an appropriate receptor species because it is common to chaparral habitats, consumes a wide variety of plant material, and is a potential food source for other animals. Given their life history and feeding habits, gophers are expected to provide a precautionarily representative model of exposures for other chaparral partially or predominantly herbivorous mammals, including mice, rats, gophers, and prairie dogs. Also, sufficient data are available for this species to support quantitative evaluation of food web exposures.

The song sparrow (*Melospiza melodia*) is identified as a representative receptor species for evaluation of the potential for adverse effects to herbivorous birds. Song sparrows are an appropriate representative receptor because they are expected to be present at the Site, consume primarily seeds, and have similar life history and feeding habits to that of many other herbivorous birds such as finches, doves, and cardinals. They are expected to provide a precautionarily representative model of exposures for other chaparral partially or predominantly herbivorous birds. Also, sufficient data are available for this species to support quantitative evaluation of food web exposures.

There are very few species of primarily herbivorous reptiles (i.e. tortoises and turtles) that may be present at the Site. The available exposure and toxicity information for reptiles is very limited and unlikely to support a quantitative evaluation. Therefore, unless additional information is provided from habitat surveys indicating that herbivorous reptiles are a special concern, the risk assessment for herbivores focuses on birds and mammals.

Insectivores - An important component of chaparral wildlife communities are species which consume primarily terrestrial invertebrates and other small prey. These insectivores may be exposed to chemicals at the Site through ingestion of chemicals in soil, surface water, and prey (Figure 24). The desert shrew (*Nitiosroex crawfordii*) is identified as a representative receptor species for evaluation of the potential for adverse effects to insectivorous mammals and other lower trophic level carnivorous mammals. Desert shrews consume a diet composed almost entirely of insects, and are a potential food source for other animals. Given their life history, feeding habits, and high ingestion rates, shrews are expected to be precautionarily representative of other chaparral partially or predominantly carnivorous mammals, including skunks, mice, and bats. Also, sufficient data is available for this species to support quantitative evaluation of food web exposures.

The greater roadrunner (*Geococcyx californianus*) is identified as a representative receptor species for evaluation of the potential for adverse effects to insectivorous birds. Roadrunners are an appropriate representative receptor because they are expected to be present at the Site, consume a diet composed of terrestrial insects, and have a life history and/or feeding habits similar to that of other insectivorous birds. They are expected to provide a precautionarily representative model of exposures for other chaparral birds including wrens, larks, orioles, quail, jays, and swallows.

Also, sufficient data is available for this species to support quantitative evaluation of food web exposures.

It should be noted that reptiles and amphibians which may be present at the Site are also insectivorous or consume primarily small, lower trophic level prey. Amphibians are expected to make limited use of the terrestrial habitats at the Site and to be limited in distribution to the riparian corridors. Reptiles are expected to be found throughout the Site. The data available for assessment of reptile and amphibian exposures is very limited, and may be insufficient to evaluate the potential for risks from all but a few chemicals. Despite the fact that assessment may be limited to qualitative methods, the Western black-necked gartersnake (*Thamnophis cyrtopsis cyrtopsis*) is identified as a representative receptor species is identified for insectivorous reptiles and amphibians. Garter snakes consume a broad range of small prey items, including invertebrates, amphibians, and small mammals. They are expected to provide a representative model of reptile exposures.

Terrestrial Predators - Higher trophic level predators are another key component of chaparral wildlife communities. These species consume a broad range of prey items, including a variety of mammals, birds, and reptiles. Predators may be exposed to chemicals at the Site through ingestion of chemicals in soil, surface water, and prey (Figure 24). The coyote (*Canis latrans*) is identified as a representative receptor species for evaluation of the potential for adverse effects to predatory mammals. Coyotes consume a diet composed primarily of small mammals, birds, and carrion. Given their life history and broad range of prey consumed, coyotes are expected to be precautionarily representative of other chaparral predators such as fox. Also, sufficient data is available for this species to support quantitative evaluation of food web exposures.

The red tailed hawk (*Buteo jamaicensis*) is identified as a representative receptor species for evaluation of the potential for adverse effects to predatory birds. Hawks are an appropriate representative receptor because they are expected to be present at the Site, consume a diet composed of primarily of small mammals and birds, and have a life history and/or feeding habits similar to that of other predatory birds. They are expected to provide a precautionarily representative model of exposures for other chaparral birds of prey including other hawks, owls, and eagles. Also, sufficient data is available for this species to support quantitative evaluation of food web exposures.

A number of reptiles may be present at the Site that are also higher trophic level predators. The data available for assessment of these reptiles is very limited, and may be insufficient to evaluate the potential for risks from all but a few chemicals. Despite the fact that assessment may be limited to qualitative methods, the western diamond-backed rattlesnake (*Crotalus atrox*) is identified as a representative receptor species is identified for predatory reptiles.

Piscivores - Species that consume primarily fish, called piscivores, may potentially be present at the Site in association with riparian corridor habitats. These species consume fish and other aquatic organisms such as crustaceans or amphibians. Piscivores may be exposed to chemicals at the Site through ingestion of chemicals in sediment, surface water, and prey (Figure 24). Given the limited amount of persistent aquatic habitat present at the Site, the number of primarily piscivorous species present at the Site is expected to be extremely limited. The most likely exposure scenario linking piscivores to site exposures is occasional or period foraging by highly mobile receptors such as herons or other waterfowl. The great blue heron (*Ardea herodias*) is identified as a representative receptor species for evaluation of the potential for adverse effects to piscivorous wildlife. Herons are an appropriate representative receptor because they could periodically utilize the waterways at the Site, consume a diet composed of primarily of fish and aquatic organisms. They are expected to provide a precautionarily representative model of exposures for other chaparral wildlife that consume prey from aquatic habitats. Also, sufficient data is available for this species to support quantitative evaluation of food web exposures.

7.8 EXPOSURE GROUPINGS AND DATA CONSIDERATIONS

The results of the exposure pathway analysis identify representative receptors that may use a variety of habitats at the Site and that may be exposed to specific sources. In preparation for the remedial investigation, this analysis proposes spatially explicit exposure groupings that will be used to guide data groupings in initial stages of the ERA.

In developing spatially explicit exposure groupings, it is important to examine two major factors. These are 1) major spatially-linked differences in the nature and extent of source areas and 2) factors or features that would alter exposure scenarios between different portions of the Site.

Terrestrial sources at the Site are present into two spatially distinct areas with different historic land uses and potentially differing chemicals of concern. These areas are the Iron King Mine and the Humboldt Smelter. It is possible that some mobile wildlife species may travel between the two areas, or that wildlife populations between the two areas may interbreed. However, the presence of a roadway between the two areas may provide some division between populations. Because there are potential differences in the types of sources associated with the Iron King Mine and the Humboldt Smelter, the following two separate exposure groupings will be evaluated for terrestrial receptors:

- Exposures to media west of Route 69; and
- Exposures to media east of Route 69.

As noted above, sediment in the gulches, drainage ditches, and other water bodies will be considered in exposure modeling as both sediment and soil if there is evidence that there is no overlying water above the sediment for a portion of the year.

For aquatic organisms and the wildlife that consume them, the greatest determinant of exposure at the Site is expected to be the hydrology and habitat quality of the water body. Drainages, impoundments, and ponds within the Site are expected to provide aquatic habitat only for brief periods and are likely to be subjected to anthropogenic disturbances. Each of the gulches is expected to provide aquatic habitat for only part of the year, while the Agua Fria River may provide habitat for longer periods or year round. Given the physical features that separate these water bodies from each other, the following aquatic groupings are identified for use in initial stages of the ERA:

- Drainage ditches, impoundments, and tailings ponds;
- Galena Gulch;
- Chaparral Gulch; and

- Agua Fria River.

The proposed groupings are based on available information. Additional information obtained during habitat surveys may be used to refine groupings and assumptions.

7.9 EXPOSURE AND TOXICITY DATA SOURCES

The availability and reliability of exposure and toxicity data sources were considered as part of the exposure pathway analysis and selection of representative receptor species. These data sources provide information that will be useful in the screening level ERA for preliminary exposure and toxicity estimation. Attachment C presents the sources utilized in preparing the analysis, and identifies which are preferred as sources of exposure parameters and benchmarks for use in further evaluation during the ERA

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Figures

Attachment A

Expanded Site Inspection Tables

TABLE 1: SUMMARY OF PREVIOUS SURFACE WATER SAMPLING RESULTS FOR TOTAL AND DISSOLVED METALS
Reproduced from Expanded Site Investigation
Iron King Mine-Humboldt Smelter Superfund Site Remedial Investigation and Feasibility Study

Sample Location	Ironite Leachate	# 1	# 2	# 3	# 4	# 1
EPA Method	None	200 Series	200.7	200.7	200.7	200 Series (Total)
Laboratory	Hazen Research	ADHS State Lab	ADHS State Lab	ADHS State Lab	ADHS State Lab	ADHS State Lab
Sampler	Unknown	Yavapai County	Yavapai County	Yavapai County	Yavapai County	ADEQ
Date	12/08/1988	03/23/1993	03/23/1993	03/23/1993	03/23/1993	04/27/1995
PH	Not Reported	4.71	Not Reported	Not Reported	Not Reported	7.29
Parameter						
Aluminum	2,000	24,700	<1,000	<1,000	<1,000	<500
Antimony	<600	<1,000	<1,000	<1,000	<1,000	6
Arsenic	22	80	<1,000	<1,000	<1,000	26
Barium	<100	<100	<100	<100	<100	<100
Beryllium	<6	<100	<100	<100	<100	0.5
Boron	100	Not Reported	Not Reported	Not Reported	Not Reported	<100
Cadmium	<100	100	<100	<100	<100	<50
Calcium	300,000	442,000	121,000	64,900	190,000	519,000
Chromium	<60	<10	<100	<100	<100	<10
Copper	<30	890	<100	<100	<100	<100
Hardness	Not Reported	Not Reported	Not Reported	Not Reported	Not Reported	3,980
Iron	<3,000	22,100	<1,000	<1,000	2,100	1,060
Lanthanum	300	Not Reported	Not Reported	Not Reported	Not Reported	Not Reported
Lead	30	<10	<500	<500	<500	5
Lithium	<600	<10,000	<10,000	< 10,000	<10,000	Not Reported
Magnesium	200,000	>100,000	17,100	10,400	34,500	718,000
Manganese	**8,000**	**14,100**	560	<100	1,420	**29,200**
Mercury	O.I	0.5	Not Reported	Not Reported	Not Reported	0.5
Molybdenum	100	Not Reported	Not Reported	Not Reported	Not Reported	Not Reported
Nickel	<30	<100	<100	<100	<100	<100
Potassium	<1,000	Not Reported	Not Reported	Not Reported	Not Reported	6,360
Selenium	Not Reported	<250	<2,000	<2,000	<2,000	<5
Silver	<3	<1	<100	<100	<100	<1
Sodium	100,000	163,000	23,000	16,500	31,100	78,900
Strontium	1,000	570	200	120	150	Not Reported
Thallium	Not Reported	<10,000	< 10,000	< 10,000	<1 0,000	<5
Vanadium	<60	<500	<500	<500	<500	Not Reported
Yttrium	100	Not Reported	Not Reported	Not Reported	Not Reported	Not Reported
Zinc	<1,000	**29,700**	**2,600**	340	780	950

Notes:

Results are in ug/L unless otherwise noted

TABLE 1: SUMMARY OF PREVIOUS SURFACE WATER SAMPLING RESULTS FOR TOTAL AND DISSOLVED METALS

Reproduced from Expanded Site Investigation

Iron King Mine-Humboldt Smelter Superfund Site Remedial Investigation and Feasibility Study

Sample Location	# 1	Pond A (Pool)	Pond A (Pool)	Pond B (Pool)	Pond B (Pool)	Outlet Trib to Gulch
EPA Method	200 Series (Dissolved)	200 Series (Total)	200 Series (Dissolved)	200 Series (Total)	200 Series (Dissolved)	200 Series (Total)
Laboratory	ADHS State Lab	ADHS State Lab	ADHS State Lab	ADHS State Lab	ADHS State Lab	ADHS State Lab
Sampler	ADEQ	ADEQ	ADEQ	ADEQ	ADEQ	ADEQ
Date	04/27/1995	02/24/2003	02/24/2003	02/24/2003	02/24/2003	02/24/2003
PH	Not Reported	Not Reported	Not Reported	Not Reported	Not Reported	Not Reported
Parameter						
Aluminum	<500	--	--	--	--	--
Antimony	<10	<5	<5	<5	<5	<5
Arsenic	10	**720**	**470**	**320**	**540**	<10
Barium	100	--	--	--	--	--
Beryllium	O.5	**3**	2.9	3.4	3	0.5
Boron	120	--	--	--	--	--
Cadmium	13	**390**	**340**	**390**	**370**	**140**
Calcium	543,000	--	--	--	--	--
Chromium	<10	28	29	29	30	<10
Copper	11	**2,500**	**2,600**	**2,600**	**2,600**	17
Hardness	Not Reported	1,600,000	1,500,000	1,600,000	1,500,000	3,200,000
Iron	<100	--	--	--	--	--
Lanthanum	Not Reported	--	--	--	--	--
Lead	<5	**180**	62	200	68	<5
Lithium	Not Reported	--	--	--	--	--
Magnesium	738,000	--	--	--	--	--
Manganese	29,100	--	--	--	--	--
Mercury	O.5	**0.78**	0.5	0.78	<0.5	O.5
Molybdenum	Not Reported	--	--	--	--	--
Nickel	<100	100	<100	110	<100	<100
Potassium	6,140	--	--	--	--	--
Selenium	<5	**7.3**	<5	7.9	<5	<5
Silver	<1	<1	<1	<1	<1	<1
Sodium	76,000	--	--	--	--	--
Strontium	Not Reported	--	--	--	--	--
Thallium	<5	<2	<2	<50	<2	<2
Vanadium	Not Reported	--	--	--	--	--
Yttrium	Not Reported	--	--	--	--	--
Zinc	<50	**120,000**	**120,000**	**120,000**	**120,000**	**54,000**

Notes:

Results are in ug/L un

TABLE 1: SUMMARY OF PREVIOUS SURFACE WATER SAMPLING RESULTS FOR TOTAL AND DISSOLVED METALS
Reproduced from Expanded Site Investigation
Iron King Mine-Humboldt Smelter Superfund Site Remedial Investigation and Feasibility Study

Sample Location	Outlet Trib to Gulch	SW-US 200 Series (Total)	SW-US 200 Series (Dissolved)	SW-DS 200 Series (Total)	SW-DS 200 Series (Dissolved)
EPA Method	200 Series (Dissolved)	--	--	--	--
Laboratory	ADHS State Lab	Del Mar Analytical	Del Mar Analytical	Del Mar Analytical	Del Mar Analytical
Sampler	ADEQ	Hoque & Associates	Hoque & Associates	Hoque & Associates	Hoque & Associates
Date	02/24/2003	07/29/2004	07/29/2004	07/29/2004	07/29/2005
PH	Not Reported	--	--	--	--
Parameter					
Aluminum	--	--	--	--	--
Antimony	<5	<50	<50	<50	<50
Arsenic	<10	**450**	<50	**820**	<50
Barium	--	--	--	--	--
Beryllium	0.5	16	<4	15	<4
Boron	--	--	--	--	--
Cadmium	**130**	**22**	<5	**26**	<5
Calcium	--	180,000	Not Reported	250,000	Not Reported
Chromium	<10	--	--	--	--
Copper	<10	**810**	<20	**1,000**	<20
Hardness	2,8000,000	--	--	--	--
Iron	--	470,000	<200	630,000	<200
Lanthanum	--	--	--	--	--
Lead	<5	**1,000**	<50	**2,100**	<50
Lithium	--	--	--	--	--
Magnesium	--	110,000	Not Reported	130,000	Not Reported
Manganese	--	**15,000**	200	**18,000**	110
Mercury	O.5	**3.2**	<0.2	**4.1**	0.2
Molybdenum	--	--	--	--	--
Nickel	<100	**200**	<50	**250**	<50
Potassium	--	--	--	--	--
Selenium	<5	<100	<50	<100	<50
Silver	<1	6.7	<5	13	<^5
Sodium	--	--	--	--	--
Strontium	--	--	--	--	--
Thallium	<2	--	--	--	--
Vanadium	--	--	--	--	--
Yttrium	--	--	--	--	--
Zinc	**43,000**	**3,800**	<50	**6,200**	<50

Notes:

Results are in ug/L unl

TABLE 2: SURFACE WATER QUALITY STANDARDS IN MICROGRAMS PER LITER[1]
Reproduced from Expanded Site Investigation
Iron King Mine-Humboldt Smelter Superfund Site Remedial Investigation and Feasibility Study

Surface Water Quality Standard	Aquatic & Wildlife Warm Water Fishery		Full Body Contact	Domestic Water Source	Fish Consumption	Agricultural Irrigation	Agricultural Livestock Watering
Parameter	Acute	Chronic					
Antimony	88D	30D	56T	6.0T	140T	NNS4	NNS
Arsenic	360D	190D	SOT	50T	1,4501	2,000T	200T
Barium	NNS	NNS	9,800D	2,000T	NNS	NNS	NNS
Beryllium	65D	5.3D	4.0T	4.0T	0.21T	NNS	NNS
Boron	NNS	NNS	12,600	630	NNS	1,000T	NNS
Cadmium	See Table 3	70T	5.0T	41T	50T	50T	
Chromium	NNS	NNS	NNS	100T	NNS	1,000T	1,000T
Copper	See Table 3	5,200D	1,000D	NNS	5,000T	5,000T	
Lead	See Table 3	NNS	50T	NNS	10.000T	100T	
Manganese	NNS	NNS	19,600T	4,900T	NNS	10,000T	NNS
Mercury	2.4D	0.01D	42T	2.0T	0.6T	NNS	10T
Nickel	See Table 3	2,800T	100T	730T	NNS	NNS	
Selenium	20T	2.0T	700T	50T	9,000T	20T	50T
Silver	See Table 3	NNS	NNS	NNS	NNS	NNS	
Thallium	700D	150D	12T	2T	41T	NNS	NNS
Zinc	See Table 3	42,000T	2,100T	22,000T	10,000T	25,000T	
Cyanide	41T	9.7T	2.800T	200T	210,000T	NNS	200T

Notes:

1 - The following analytes are not listed in the Surface Water Quality Standards: aluminum, calcium, cobalt, iron, lanthanum, lithium, magnesium, molybedum, potassium, sodium, strontium, vanadium, or yttrium

D - Dissolved Metals

T - Total Metals

NNS - Surface Water Quality Standards specify "No Numeric Standard"

Results are in ug/L unless otherwise noted

TABLE 3: AQUATIC WILDLIFE WARM WATER FISHERY SURFACE WATER QUALITY STANDARDS[1]

Reproduced from Expanded Site Investigation

Iron King Mine-Humboldt Smelter Superfund Site Remedial Investigation and Feasibility Study

Hardness	Standard	Cadmium	Copper	Lead	Nickel	Silver	Zinc
300,000	Acute Standard	83D	50D	331D	3,592D	27D	297D
300,000	Chronic Standard	2.7D	30D	13D	14,017D	NNS	269D
1,500,000	Acute Standard	510D	227D	2,565D	399D	428D	1,160D
1,500,000	Chronic Standard	9.5D	120D	100D	1.558D	NNS	1.051D

Notes:

1 - Aquatic & Wildlife standards for cadmium, copper, lead, silver, and zinc were calculated using the equations found in the Surface Water Quality Standards

Results are in ug/L unless otherwise noted

TABLE 4: SUMMARY OF URS SURFICIAL SOIL SAMPLING RESULTS

Reproduced from Expanded Site Investigation

Iron King Mine-Humboldt Smelter Superfund Site Remedial Investigation and Feasiblity Study

Sample ID	BAK-1	BAK-2	IK-9-0.5	IK-31-0.5	K-34-0.5	IK-28-0.5	IK-1-0.5	IK-12-0.5	IK- 1-7-0.5	IK-4-0.5	IK-24-0.5	IK-23-0.5	IK-20-0.5	IK-51-0.5	IK-49-0.5	IK-43-0.5	K-38-0.5	PIT-1	PIT-2
Date	8/29/2001	8/29/2001	8/29/2001	8/29/2001	08/09/2001	08/09/2001	08/09/2001	08/09/2001	08/09/2001	08/09/2001	08/09/2001	08/09/2001	08/09/2001	08/09/2001	08/09/2001	08/09/2001	08/09/2001	08/09/2001	08/09/2001
Parameter	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Antimony	<5	46	11	**110**	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Arsenic	**16**	**1,200**	**1,500**	**2,600**	**480**	**970**	**25**	**650**	**890**	**490**	**970**	**870**	**550**	**150**	**54**	**110**	**23**	**34**	**190**
Barium	92	130	15	50	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Beryllium	1.7	1.4	0.4	<0.40	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cadmium	0.5	10	7.1	**110**	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Chromium	28	29	10	200	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Copper	110	280	300	990	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Lead	48	**2,200**	**1,100**	**12,000**	**640**	**2,900**	47	**2,600**	**2,200**	**1,200**	**1,800**	**1,900**	**1,700**	**540**	130	74	24	60	51
Mercury	0.094	7.4	3.1	**69**	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Nickel	19	19	5.6	140	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Selenium	<5	<5	<50	19	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Silver	<0.5	7.7	<5	71	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Thallium	<5	<25	<50	<5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Zinc	170	1,200	580	**31,000**	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Notes:

Results are in ug/L unless otherwise noted

TABLE 5: SOIL PATHWAY BENCHMARKS
Reproduced from Expanded Site Investigation
Iron King Mine-Humboldt Smelter Superfund Site Remedial Investigation and Feasiblity Study

Soil Pathway Benchmark	EPA Preliminary Remediation Goal		Arizona Soil Remediation Level		Arizona Groundwater Protection Level	EPA Cancer Risk	EPA Reference Dose
Parameter	Residential Soil	Industrial Soil	Residential	Non-Residential			
Aluminum	76,000	100,000	77,000	1,000,000	None	None	None
Antimony	31	410	31	680	35	None	31
Arsenic	0.39	1.6	10	10	290	0.43	23
Barium	5,400	67,000	5,300	110,000	12,000	None	5,500
Beryllium	150	1,900	1.4	11	23	None	160
Cadmium	37	450	38	850	29	None	39
Chromium	210	450	2,100	4,500	590	None	230
Cobalt	900	1,900	4,600	97,000	None	None	None
Copper	3,100	41,000	2,800	63,000	None	None	None
Iron	23,000	100,000	None	None	None	None	None
Lead	400	800	400	2,000	290	None	None
Manganese	1,800	19,000	3,200	43,000	None	None	11,000
Mercury	23	310	6.5	68	12	None	23
Nickel	1,600	20,000	1,500	34,000	590	None	1,600
Selenium	390	5,100	380	8,500	290	None	390
Silver	390	5,100	380	8,500	None	None	390
Thallium	5.2	67	5.4	120	12	None	None
Vanadium	78	1,000	540	12,000	None	None	550
Zinc	23,000	100,000	23,000	510,000	None	None	23,000
Cyanide	1,200	12,000	1,300	14,000	None	None	1,600
Nitrate	None	None	100,000	1,000,000	None	None	None
Sulfate	None	None	None	None	None	None	None
Trichlorofluoromethane	390	2,000	380	1,300	None	None	23,000

Notes:

Results are in ug/L unless otherwise noted

TABLE 6: SUMMARY OF HOQUE ASSOCIATES SURFICIAL SOIL SAMPLING RESULTS, TOTAL METALS AND CYANIDE
Reproduced from Expanded Site Investigation
Iron King Mine-Humboldt Smelter Superfund Site Remedial Investigation and Feasiblity Study

Sample ID Type Desciption	SS-la,b,c Composite Tailings	SS-2a,b,c Composite Tailings	SS-4a,b,c Composite Tailings	SS-5a,b Composite Tailings	SS-6 Grab Gray Smelter Ash	SS-7a,b,c Composite White Powder in Drums	SS-8a,b,c Composite Gray Smelter Ash	SS-9a,b,c Composite Gray Smelter Ash	SS-10a,b Composite Black Slag	SS-lla,b,c Composite Black Slag	SS-12a,b,c Composite Gray Smelter Ash & Debris	SS-13 Grab Gray Smelter Ash & Debris	SS-14 Grab Gray Smelter Ash and Debris	SS-15a,b Composite Gray Smelter Ash & Debris	SS-16 Grab Black Slag	SS-17 Grab Grayish White Ash	SS-18 Grab Soil Adjacent to Laboratory	SS-19 Grab Background	SS-20 Grab Backgrond
Parameter																			
Arsenic	**260**	**170**	**420**	**270**	**33**	<5	**25**	**13**	**210**	**56**	**9.1**	**21**	**28**	**19**	**450**	**250**	**41**	**52**	**43**
Barium	84	49	110	160	120	2,300	84	87	120	25	47	35	50	87	280	62	71	430	280
Cadmium	7.9	15	11	9.9	10	<2.5	13	13	7.4	2.9	110	11	28	13	12	40	10	3.9	4.0
Chromium	<5	<5	<5	14	380	<5	**300**	**450**	5.6	<5	780	<5	180	**350**	<5	23	290	33	48
Lead	**360**	250	**370**	**450**	**570**	6.0	**510**	**870**	**290**	**240**	**290**	**2,500**	**330**	**360**	**1,000**	**5,500**	**380**	100	77
Mercury	0.50	0.46	0.63	1.8	0.13	O.083	0.21	0.083	0.088	O.083	0.085	3.9	0.39	0.20	O.083	12	0.28	0.25	0.17
Selenium	7.9	5.0	<5	<5	<5	<5	<5	<5	<5	<5	29	<5	<5	<5	<5	<5	<5	<5	<5
Silver	27	20	35	18	<5	<5	8.5	9.2	14	<5	<5	12	15	5.9	30	20	5.1	<5	<5
Cyanide	<1	<1	<1	<1	NA	<1	NA	NA	NA	NA	<1	<1	NA	<1	NA	1.2	<1	<1	<1

Notes:
Results are in ug/L unless otherwise noted

TABLE 7: SUMMARY OF GROUNDWATER SAMPLING RESULTS FOR TOTAL METALS, INORGANICS, AND VOCs

Reproduced from Expanded Site Investigation

Iron King Mine-Humboldt Smelter Superfund Site Remedial Investigation and Feasiblity Study

Well Name	Kuhles Well	Mine Shaft No. 7									
Depth to Water (ft)	111.1	NM	NM	391.8	388.85	393.98	393.3	392.61	390.89	385.55	385
Sample Date	12/06/00	12/06/00	04/26/02	06/04/02	06/28/02	08/20/02	09/27/02	10/22/02	12/27/02	12/05/03	12/15/04
Arsenic	<50	**1,100**	NA	**1,100**	**1,100**	**1,200**	**900**	**1,200**	NA	NA	NA
Barium	NA	NA	<10	16	16	16	14	18	17	15	0.015
Calcium	210,000	550,000	540,000	600,000	560,000	530,000	440,000	550,000	580,000	580,000	540,000
Copper	36	<20	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	<50	**71**	<50	<50	<50	<50	<50	<50	<50	<50	<50
Magnesium	24,000	990,000	960,000	1,000,000	1,000,000	940,000	790,000	980,000	1,000,000	1,000,000	980,000
Mercury	**4.5**	<0.2	<0.2	0.2	O.2	O.2	0.2	O.2	0.2	O.2	0.2
Potassium	NA	NA	11,000	12,000	11,000	11,000	10,000	11,000	14,000	11,000	2,900
Sodium	NA	NA	170,000	200,000	190,000	220,000	190,000	270,000	220,000	210,000	32,000
Zinc	1,200	**16,000**	NA	NA	NA	NA	NA	NA	NA	NA	NA
Alkalinity	190,000	840,000	850,000	880,000	840,000	860,000	860,000	870,000	870,000	900,000	870,000
Chloride	110,000	65,000	65,000	67,000	63,000	63,000	72,000	68,000	66,000	67,000	67,000
Fluoride	260	750	1,300	1,300	790	680	750	900	950	1,200	1,000
Nitrate	5,600	<50	<100	<100	<200	310	<100	<IOO	<100	<100	<100
pH (pH Units)	7.61	6.58	6.14	5.70	6.29	6.74	5.65	4.24	5.92	5.00	5.5
Sulfate	300,000	3,900,000	4,400,000	4,900,000	4,500,000	4,700,000	4,700,000	4,800,000	4,600,000	4,800,000	4,600,000
Total Dissolved Solids	910,000	7,600,000	7,800,000	7,600,000	7,700,000	7,800,000	7,800,000	7,700,000	7,900,000	7,500,000	NA

Note:

Bold indicates that ground water benchmarks are exceeded

NA - Not Analyzed

ND - Not Dectected

NM - Not Measured

Antimony, beryllium, nickel, thallium, and total Kjeldahl nitrogen were not detected in the samples collected on 12/06/2000. The other samples were not analyzed for these analytes

Cadmium, chromium, selenium, and silver were not detected in any of the samples

Volatile organic compunds were not detected in the samples collected on 12/06/2000, 12/27/2002, 12/05/2003, or 12/15/2004. The other samples were not analyzed for VOCs

Results are in ug/L unless otherwise noted

TABLE 8: GROUNDWATER PATHWAY BENCHMARKS
Reproduced from Expanded Site Investigation
Iron King Mine-Humboldt Smelter Superfund Site Remedial Investigation and Feasiblity Study

Groundwater Pathway Benchmark Parameter	EPA Maximum Contaminant Level	EPA Preliminary Remedial Goal	EPA Cancer Risk	EPA Reference Dose	Arizona Aquifer Water Quality Standards
Aluminum	None	36,000	None	None	None
Antimony	6.0	15	None	15	6.0
Arsenic	10.0	0.045	0.057	11	50
Barium	2,000	2,600	None	2,600	2,000
Beryllium	4.0	73	None	73	4.0
Cadmium	5.0	18	None	18	5.0
Chromium	100	None	None	110	100
Copper	1,300	1,500	None	None	None
Iron	None	11,000	None	None	None
Lead	15	None	None	None	50
Manganese	None	880	None	5,100	None
Mercury	2.0	11	None	11	2.0
Selenium	50	180	None	180	50
Silver	None	180	None	180	None
Thallium	2.0	2.4	None	None	2.0
Zinc	None	11,000	None	None	None
Cyanide	200	730	None	200	200
Fluoride	4,000	2,200	None	4,000	4,000
Nitrate	10,000	10,000	None	10,000	10,000
Nitrite	1,000	1,000	None	1,000	1,000
Sulfate	None	None	None	None	None
Trichlorofluoromethane	None	1,300	None	None	None

Notes:

Results are in ug/L unless otherwise noted

TABLE 9: SUMMARY OF GROUNDWATER SAMPLING RESULTS, TOTAL METALS, CYANIDE, AND ANIONS
Reproduced from Expanded Site Investigation
Iron King Mine-Humboldt Smelter Superfund Site Remedial Investigation and Feasilibity Study

Brown and Caldwell ID	SW01	SW02	SW03	SW03	SW03 (Dissolved)	SW04	SW05
ADWR Registration No.	55-550566	55-633890	55-566350	55-566350	55-566350	55-502562	Not Reported
ADWR Water Use	Domestic	Domestic	Domestic	Domestic	Domestic	Domestic	Not Reported
ADWR Well Depth (ft)	340	40	100	100	100	220	Not Reported
ADWR Cadastral (A- 13-01)	15abd	15dbc	15dcc	15dcc	15dcc	14ccb	Not Reported
B&C Latitude	34°30'22"	34°30'11"	34°30'04"	34°30'04"	34°30'04"	34°30'06"	34°30'09"
B&C Longitude	112°14'47"	112°14'46"	112°14'34"	112°14'34"	112°14'34"	112°14'16"	112°15'30"
B&C Water Use	Potable	Potable	Potable	Potable	Potable	Non-Potable	Dust Control
B&C Depth to Water (ft)	Not Measured	23.2	22.3	22.3	22.3	120.0	382.0
B&C Sample Date	08/10/20004	08/10/20004	08/10/20004	09/16/2004	09/16/2004	08/1 1/20004	08/10/20004
Arsenic	**4.4**	**17**	<4	Not Analyzed	Not Analyzed	**5.3**	**870**
Antimony	<3	<3	<3	Not Analyzed	Not Analyzed	<3	<3
Aluminum	<100	<100	<100	Not Analyzed	Not Analyzed	<100	<100
Barium	46	39	51	Not Analyzed	Not Analyzed	53	25
Beryllium	<1	<1	<1	Not Analyzed	Not Analyzed	<1	<1
Cadmium	<3	<3	<3	Not Analyzed	Not Analyzed	<3	<3
Chloride	25,000	34,000	32,000	Not Analyzed	Not Analyzed	48,000	62,000
Chromium	<10	<10	<10	Not Analyzed	Not Analyzed	<10	<10
Copper	26	<10	230	Not Analyzed	Not Analyzed	<10	<10
Cyanide (Free)	<10	<10	<10	Not Analyzed	Not Analyzed	<10	<10
Fluoride	<500	720	<500	Not Analyzed	Not Analyzed	<500	2,000
Iron	150	<100	1,000	Not Analyzed	Not Analyzed	<100	**32,000**
Lead	<3	<3	**140**	<3	<3	<3	**25**
Magnesium	19,000	11,000	59,000	Not Analyzed	Not Analyzed	23,000	1,000,000
Mercury	<0.2	<0.2	<0.2	Not Analyzed	Not Analyzed	<0.2	<0.2
Nitrate	1,900	4,500	1,400	Not Analyzed	Not Analyzed	6,000	<500
Nitrite	<20	<20	<20	Not Analyzed	Not Analyzed	<20	<20
pH	7.5	7.5	7.2	Not Analyzed	7.5	7.4	6.3
Silver	<5	<5	<5	Not Analyzed	Not Analyzed	<5	<5
Selenium	<3	<3	<3	Not Analyzed	Not Analyzed	7.6	<30
Sulfate	87,000	36,000	970,000	Not Analyzed	Not Analyzed	160,000	4,300,000
Total Dissolved Solids	380,000	490,000	1,800,000	Not Analyzed	1,600,000	550,000	7,500,000
Thallium	<1	<1	<1	Not Analyzed	Not Analyzed	<1	<2
Zinc	70	<50	320	Not Analyzed	Not Analyzed	<50	8,100

Note:

Samples collected by Brown and Caldwell, August 2004. Results in Micrograms per Liter

Results are in ug/L unless otherwise noted

TABLE 9: SUMMARY OF GROUNDWATER SAMPLING RESULTS, TOTAL METALS, CYANIDE, AND ANIONS

Reproduced from Expanded Site Investigation

Iron King Mine-Humboldt Smelter Superfund Site Remedial Investigation and Feasilibity Study

Brown and Caldwell ID	SW06	SW07	SW08	SW09	SW09	SW10	SW11
ADWR Registration No.	55-639818	55-639385	55-801122	Not Reported	Not Reported	55-592720	55-900905
ADWR Water Use	Domestic	Stock	Domestic	Not Reported	Not Reported	Industrial	Domestic
ADWR Well Depth (ft)	200 '	238	140	Not Reported	Not Reported	1,000	225
ADWR Cadastral (A- 13-01)	15ddd	22bd	22abb	Not Reported	Not Reported	22bab	15cad
B&C Latitude	34°29'57"	34°29'31"	34°29'55	Not Measured	Not Measured	Not Measured	Not Measured
B&C Longitude	112°14'19	112°15'03"	112°14'46"	Not Measured	Not Measured	Not Measured	Not Measured
B&C Water Use	Non-Potable	Non-Potable	Non-Potable	Non-Potable	Non-Potable	Non-Potable	Domestic
B&C Depth to Water (ft)	113.3	49.7	23.8	112.4	112.4	Not Measured	77.0
B&C Sample Date	08/10/20004	08/10/20004	08/10/20004	08/11/20004	08/11/20004	08/11/20004	09/29/2004
Arsenic	**6.1**	**20**	<4	**7.2**	**7.0**	**5.7**	<4
Antimony	<3	<3	<3	<3	<3	<3	<3
Aluminum	<100	<100	<100	<100	<100	<100	170
Barium	56	<10	25	41	42	53	62
Beryllium	<1	<1	<1	<1	<1	<1	<1
Cadmium	<3	<3	<3	<3	<3	<3	<3
Chloride	29,000	45,000	47,000	43,000	44,000	25,000	18,000
Chromium	<10	<10	<10	<10	<10	<10	<10
Copper	12	<10	10	<10	<10	<10	<10
Cyanide (Free)	<10	<10	<10	<10	<10	<10	<10
Fluoride	1,400	<500	<500	<500	<500	<500	<500
Iron	<100	<100	<100	560	640 .	210	170
Lead	<3	<3	<3	4.8	5.1	5.7	4
Magnesium	16,000	25,000	42,000	36,000	36,000	40,000	19,000
Mercury	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Nitrate	3,100	2,900	1,400	**11,000**	**11,000**	**22,000**	2,200
Nitrite	<20	<20	<20	<20	<20	<20	<20
pH	7.7	7.0	7.2	7.5	7.5	7.5	7.5
Silver	<5	<5	<5	<5	<5	<5	<5
Selenium	11	<3	6.8	19	21	16	<3
Sulfate	170,000	110,000	960,000	490,000	490,000	510,000	210,000
Total Dissolved Solids	590,000	560,000	1,900,000	1,100,000	1,100,000	1,300,000	560,000
Thallium	<0.001	<1	<1	<1	<1	<1	<1
Zinc	64	54	170	2,200	2,200	2,500	52

Note:

Samples collected by Brown and C

Results are in ug/L unless otherwis

TABLE 10: SUMMARY OF SURFACE WATER SAMPLING RESULTS, IRON KING MINE AND TAILINGS SITE INSPECTION

Reproduced from Expanded Site Investigation

Iron King Mine-Humboldt Smelter Superfund Site Remedial Investigation and Feasibility Study

Sample Location	Travel Blank	Upstream Agua Fria	Confluence Chaparral Gulch & Agua Fria	Downstream Agua Fria	Duplicate of IK-W20	Travel Blank	Upstream Agua Fria	Confluence Chaparral Gulch & Agua Fria	Downstream Agua Fria	Duplicate of DC-W20
Location ID No.	IK-W16	IK-W3	IK-W30	IK-W20	IK-W21	IK-W16	IK-W3	IK-W30	IK-W20	IK-W21
CLPAS ID No.	MYOKC5	MYOKC6	MYOKC7	MYOKC8	MYOKC9	MYOND2	MYOND3	MYOND4	MYOND5	MYOND6
Date and Time	05/16/2002 1025	05/16/2002 0940	05/16/2002 0955	05/16/2002 1005	05/16/2002 1015	05/16/2002 1025	05/16/2002 0940	05/16/2002 0955	05/16/2002 1005	05/16/2002 1015
Parameter										
Iron	9.0U	12.6LJ	100	39.7LJ	49.2LJ	U	9.0U	9.0U	9.0U	9.0U
Manganese	l.OU	2.2LJ	29.5	30.4	24.7	l.OU	1.6LJ	18.1	20.9	22.5
Mercury	0.10U	0.10U	0.10U	0.10U	0.10U	U	0.10U	0.10U	**0.10LJ**	**0.10LJ**
Selenium	2.0U	**2.4LJ**	2.0U	2.0U	2.0U	U	2.0U	2.0U	2.0U	2.0U
Thallium	**5.8LJ**	**9.4LJ**	**7.7LJ**	**7.7LJ**	**5.9LJ**	J	**7.2LJ**	**5.5LJ**	**7.3LJ**	**6.2LJ**
Hardness	5,OOOU	290,000	300,000	300,000	300,000	--	--	--	--	--

Notes:

Bold indicates that the value exceeds Surface Water Quality Standards

Shading indicates that the value meets Observed Release Critera

The samples were analyzed for the following analytes, but they were not detected: antimony, cadmium, copper, and lead.

The samples were analyzed for the following analytes, but the results were below SWQS and observed release criteria were not met: aluminum, arsenic, barium, beryllium, calcium, chromium, cobalt, magnesium, silver, sodium, vanadium, zinc, and cyanide.

U - The analyte was analyzed for, but was not detected above the reported value. The reported value is either the sample quantitation limit or the sample detection limit for all analytes.

L - Indicates results which fall between the sample detection limit and the CRDL. Results are estimated and considered qualitatively acceptable but quantitatively unreliable due to uncertainties in the analytical precision near the limit of detection.

J - The associated value is an estimated quantity. The analyte was analyzed for and was positively identified, but the reported numerical value may not be consistent with the amount actually present in the environmental sample.

Results in ug/L

TABLE 11: SUMMARY OF SOIL SAMPLING RESULTS, IRON KING MINE AND TAILINGS SITE INSPECTION
Reproduced from Expanded Site Investigation
Iron King Mine-Humboldt Smelter Superfund Site Remedial Investigation and Feasibility Study

Sample Location	Ironte Pond 200-5S	Ironite Pond 40-02A	School Yard	Ironite Plant Site	Duplicate of IK-S27	Waste Rock Pile#l
Location ID No.	IK-S20	IK-S21	IK-S24	QC-S27	IK-S28	IK-S8
CLPAS ID No.	MYOAP8	MYOAN9	MYOAN7	MYOAPO	MYOAP1	MYOAM1
Date and Time	04/11/2002 1500	04/11/2002 0905	04/11/2002 0710	O4/1 1/2002 0920	04/11/2002 0925	04/09/2002 1135
Sample Depth	0-3 Inches	0-3 Inches	0-3 Inches	0-3 Inches	0-3 Inches	0-6 Inches
Parameter						
Antimony	5.9LJ	13.4J	0.81LJ	32.8J	15.8J	3.5LJ
Arsenic	1510	1,430	101	3,090	2,900	341J
Barium	205	75.1	128	41.6LJ	54.9	30.5LJ
Cadmium	5.1L,J	7.3J	0.96LJ	24.6J	22.6J	1.5J
Calcium	25700	14900	28,100	27,500	29,100	17,400
Chromium	14.5	12.1	15.4	13.5	15.9	9.7J
Copper	108J	181J	59.9	297	285	104J
Iron	53900	60400	34,200	94,300	95,500	60,000J
Lead	1070J	1430	86.6	2,110	*1,6693*	576
Mercury	6.6J	8.8J	0.17J	10.0J	8.1J	4.2
Selenium	11.7J	18.4J	1.1J	26.7J	24.7J	8.1J
Silver	6.9J	9.1J	0.56LJ	13.0J	12.1J	4.5J
Thallium	2.0LJ	0.79J	0.73U	2.0LJ	2.9J	2.3J
Zinc	1850	2450	321	7,580	7,180	674
Cyanide	0.090LJ	0.23LJ	0.0600	0.21LJ	R	0.040UJ
Nitrate	0.6LJ	18	2.0	970	960	2.0
Sulfate	17000	20000	100	17,000	19,000	17,000
Soil pH	4.5	2.5	8.3	7.2	7.4	3.6
VOC: Trichlorofluoromethane	Not Analyzed	Not Analyzed	Not Analyzed	Not Analyzed	Not Analyzed	Not Analyzed
SVOCTIC: HA	Not Analyzed	Not Analyzed	Not Analyzed	Not Analyzed	Not Analyzed	Not Analyzed

Notes:

mg/kg	Milligrams per Kilogram
Bold	indicates that the value exceeds PRO, SRL, or GPL
Shading	indicates that the value meets Observed Release Criteria.
HA	Hexandedioic Acid, Bis (2-ethy)
U	The analyte was
L	Indicates results
J	The associated value is an estimated quantity. The analyte was analyzed for and was positively identified, but the reported numerical value may not be consistent with the amount actually present in the environmental sample.
NJ	The analysis indicates the presence of an analyte that has been tentatively identified and the associated numerical value represents its approximate concentration.
R	The data are unusable. The analyte was analyzed for, but the presence or absence of the analyte cannot be verified.

The samples were analyzed for the following analytes, but the results were below soil benchmarks and observed release criteria were not met: aluminum, beryllium, cobalt, magnesium, manganese, nickel, potassium,vanadium, and cyanide.

TABLE 11: SUMMARY OF SOIL SAMPLING RESULTS, IRON KING MINE AND TAILINGS SITE INSPECTION
Reproduced from Expanded Site Investigation
Iron King Mine-Humboldt Smelter Superfund Site Remedial Investigation and Feasibility Study

Sample Location	Gray Berm	Glory Hole	Former Assay Waste Dump	Background : East	Background West	Large Tailings Pile West
Location ID No.	IK-SI 8	IK-S23	IK-S25	IK-S30	IK-S31	IK-SI
CLPAS ID No.	MYOAN2	MYOAN3	MYOANl	MYOAM4	MYOAM3	MYOAP4
Date and Time	04/10/2002 1030	04/10/2002 1100	04/10/2002 1005	04/09/2002 1400	04/09/2002 1350	04/11/2002 1040
Sample Depth	0-6 Inches	0-6 Inches	0-6 Inches	0-6 Inches	0-6 Inches	1-2 Feet
Parameter						
Antimony	3.5LJ	2.7LJ	37.5J	0.80UJ	0.8 1UJ	38.6J
Arsenic	186J	195	1,000J	27.9J	27.2J	6,460
Barium	43.1	18.9LJ	86.1	142	189	76.8
Cadmium	2.3	2.9J	12.4J	0.14LJ	0.12LJ	33.1J
Calcium	38,700	58,600	8,020	4,420	6,780	42,600
Chromium	9.4J	20.3	11. 8J	6.1J	5.3J	27.7
Copper	127J	94.0J	391J	66.8J	34.2J	393
Iron	24,200J	42,100	55,100J	33,300J	33.700J	131,000
Lead	367	437	14,200	336	15.8	5,910J
Mercury	0.95	0.42	34.4	0.070LJ	0.060LJ	13.7J
Selenium	2.1	5.5J	29.6J	0.46U	0.47U	44. 8 J
Silver	2.7	1.4LJ	33.2J	1.8LJ	0.48LJ	22.9J
Thallium	0.89LJ	0.71UJ	3.9J	1.6LJ	1.7LJ	4.4J
Zinc	728	899	3,890	85.6	99.6	10,900
Cyanide	0.16LJ	0.060LJ	0.14LJ	0.040UJ	0.040UJ	1.3J
Nitrate	2.0	59	3.0	2.0	0.8LJ	1.OU
Sulfate	1,800	3,200	20,000	10.0U	5.0LJ	1,400
Soil pH	7.5	8.3	3.7	7.0	6.5	7.4
VOC: Trichlorofluoromethane	Not Analyzed	Not Analyzed	Not Analyzed	Not Analyzed	Not Analyzed	Not Analyzed
SVOCTIC: HA	Not Analyzed	Not Analyzed	Not Analyzed	Not Analyzed	Not Analyzed	Not Analyzed

Notes:

mg/kg
Bold
Shading
HA
U
L

J

NJ

R

TABLE 11: SUMMARY OF SOIL SAMPLING RESULTS, IRON KING MINE AND TAILINGS SITE INSPECTION
Reproduced from Expanded Site Investigation
Iron King Mine-Humboldt Smelter Superfund Site Remedial Investigation and Feasibility Study

Sample Location	Large Tailings Pile Center	Dup of IK-S2	Ironite Boneyard	Ore Bin	Stains East of Shed	Assay Lab South
Location ID No.	IK-S2	IK-S3	IK-S4	K-S6	IK-S7	IK-S9
CLPAS ID No.	MYOAP5	MYOAP6	MYOAP7	MYOAS2/YOG22	MYOAL67YOG26	MYOAS7/YOG15
Date and Time	04/11/2002 1110	04/11/2002 1120	04/11/2002 1200	04/09/2002 805	04/09/2002 0920	04/08/2002 1155
Sample Depth	1-2 Feet	1 - 2 Feet	1-2 Feet	1-2 Feet	1-2 Feet	1-2 Feet
Parameter						
Antimony	5.8LJ	6.9LJ	71.6J	92.6J	46.8J	2.4LJ
Arsenic	2,690	2,480	7,600	2,250	471J	2,920
Barium	46.7LJ	28.5LJ	7.7LJ	17.6LJ	98.4	180
Cadmium	41.2	34.3J	30.0J	16.2J	9.1	3.3J
Calcium	41,000	59,300	46,800	4,650	7,400	11,900
Chromium	33.1	37.7	61.4	6.1	11.2J	40.0
Copper	197	259	1,180	660J	525J	99.6J
Iron	101,000	98,900	193,000	107,000	33,100J	32400
Lead	2,160J	1.910J	3,500J	4,210	10,400	10.8
Mercury	8.9J	5.6J	15.9J	29.0	11.6	0.060U
Selenium	20.7J	15.4J	46.3J	33. 7J	55.1	7.3J
Silver	8.2J	8.8J	24.8J	102J	42.7	0.28LJ
Thallium	4.3J	5.9J	8.1J	3.3J	1.2LJ	0.84UJ
Zinc	9,170	10,000	10,900	3,810	2,830	1,150
Cyanide	0.72J	0.090LJ	0.060LJ	0.060LJ	0.10LJ	0.050LJ
Nitrate	0.8U	0.9U	0.9U	2.0	1.0	1.0
Sulfate	15,000	8,800	12,000	16,000	3,300	11,000
Soil pH	6.8	6.6	6.7	4.0	3.2	2.8
VOC: Trichlorofluoromethane	Not Analyzed	Not Analyzed	Not Analyzed	0.038	0.011U	Not Analyzed
SVOCTIC: HA	Not Analyzed	Not Analyzed	Not Analyzed	2.6NJ	0.93NJ	4.8NJ

Notes:

mg/kg
Bold
Shading
HA
U
L

J

NJ

R

TABLE 11: SUMMARY OF SOIL SAMPLING RESULTS, IRON KING MINE AND TAILINGS SITE INSPECTION
Reproduced from Expanded Site Investigation
Iron King Mine-Humboldt Smelter Superfund Site Remedial Investigation and Feasibility Study

Sample Location	Dup of IK-S9	Assay Lab East	Mechanical Building	Background East	Background West	Former Mill Site
Location ID No.	IK-S10	DC-SI 1	IK-S14	IK-S16	IK-S17	IK-SI9
CLPAS ID No.	MYOAS3/YOG17	MYOAS5/YOG19	MYOAM7	MYOAM5	MYOAL8/YOG28	MYOAM9
Date and Time	04/08/2002 1240	04/08/2002 1445	04/09/2002 1500	04/09/2002 1408	04/09/2002 1310	04/09/2002 1535
Sample Depth	1-2Feet	1-2Feet	1-2Feet	1-2Feet	1-2Feet	1-2Feet
Parameter						
Antimony	0.93LJ	0.86UJ	1.2LH	0.83UJ	0.79UJ	0.84UJ
Arsenic	970	14.6	3,600J	17.5J	17.9J	79.5J
Barium	141	233	138	149	285	167
Cadmium	4.3	0.1 1U	1.4J	0.11U	0.10U	2.2
Calcium	12,200	9,900	9,390	10,600	12,100	10,100
Chromium	8.0	14.0	36.6J	8.3J	5.0J	12.5
Copper	90.2	50.8	70.2J	32.0J	12.8J	76.9J
Iron	34900	51900J	63800J	63800J	23400J	29900
Lead	100	24.4	3.3J	3.3J	2.3	299
Mercury	0.060U	0.23	0.14	0.050U	0.050U	0.58
Selenium	1.0LJ	0.86LJ	3.8J	0.48UJ	0.55LJ	1.7
Silver	0.42LJ	0.60LJ	0.73LJ	0.54LJ	0.63LJ	1.9LJ
Thallium	0.79U	0.79U	1.9LJ	1.2LJ	2.6	1.1LJ
Zinc	1,230	83.4	382	123	56.3	843
Cyanide	0.050LJ	0.090LJ	0.070LJ	0.040U	0.040UJ	0.070LJ
Nitrate	1.0U	12	0.9U	1.0U	1.0U	0.6LJ
Sulfate	9,000	900	9,100	10U	10	3,300
Soil pH	2.8	8.4	3.6	6.3	7.0	7.4
VOC: Trichlorofluoromethane	Not Analyzed	Not Analyzed	Not Analyzed	Not Analyzed	Not Analyzed	Not Analyzed
SVOCTIC: HA	4.1NJ	3.8NJ	Not Analyzed	Not Analyzed	Not Identified	Not Analyzed

Notes:

mg/kg
Bold
Shading
HA
U
L

J

NJ

R

TABLE 11: SUMMARY OF SOIL SAMPLING RESULTS, IRON KING MINE AND TAILINGS SITE INSPECTION

Reproduced from Expanded Site Investigation

Iron King Mine-Humboldt Smelter Superfund Site Remedial Investigation and Feasibility Study

Sample Location	Ironite Pond 100-003F	Stained Soil Near Tanks	Ore Bin	Stains East of Shed	Assay Lab South	Dup of IK-SB9
Location ID No.	IK-S22	IK-S26	IK-SB6	K-SB7	K-SB9	IK-SB 10
CLPAS ID No.	MYOAP9	MYOAL9/YOG24	MYOAL3/YOG23	MYOAL7/YOG27	MYOAS8/YOO16	MYOAS4
Date and Time	04/11/2002 1520	04/09/2002 1025	04/09/2002 0830	O4/09/2002 0945	O4/08/2002 1220	04/08/2002 1305
Sample Depth	1-2Feet	1 - 2 Feet	5-7 Feet	5-7 Feet	5-7 Feet	5 - 7 Feet
Parameter						
Antimony	0.82UJ	0.90UJ	0.90UJ	0.86UJ	0.84UJ	0.85UJ
Arsenic	28.5	31.8J	17.2J	13.1J	24.4	38.6
Barium	109	342	194	1,160	94.6	98.4
Cadmium	0.11U	12.2	10.6	0.11U	26.8	24.3
Calcium	31,500	2,510	9,200	6,870	6,550	7,470
Chromium	15.3	10.6J	14.5J	11. U	17.7	10.9
Copper	52.7	38.7J	220J	43. 8 J	68.8	69.9
Iron	36900	18,800J	31,100J	30,600J	40,400	30,300
Lead	16.2J	11.2	18.1	21.7	5.0	8.1
Mercury	0.050UJ	0.090LJ	0.090LJ	0.060LJ	0.17	0.10LJ
Selenium	0.48U	0.52U	0.52U	0.50U	0.78LJ	0.63LJ
Silver	0.24U	0.46LJ	0.53LJ	0.74LJ	0.38LJ	0.25U
Thallium	0.76U	0.82U	1.4LJ	3.1	0.78U	0.78U
Zinc	100	644	2,920	90.1	5,940	5,620
Cyanide	0.090LJ	0.040UJ	0.040UJ	0.050LJ	0.050LJ	0.1 1LJ
Nitrate	2. 0	6.0	Not Analyzed	Not Analyzed	Not Analyzed	Not Analyzed
Sulfate	180	1,000	Not Analyzed	Not Analyzed	Not Analyzed	Not Analyzed
Soil pH	8.3	6.5	3.6	6.0	4.9	4.3
VOC: Trichlorofluoromethane	Not Analyzed	Not Analyzed	Not Analyzed	0.015	0.027	Not Analyzed
SVOCTIC: HA	Not Analyzed	3.7NJ	Not Analyzed	3.3NJ	Not Analyzed	Not Analyzed

Notes:

mg/kg
Bold
Shading
HA
U
L

J

NJ

R

TABLE 11: SUMMARY OF SOIL SAMPLING RESULTS, IRON KING MINE AND TAILINGS SITE INSPECTION

Reproduced from Expanded Site Investigation

Iron King Mine-Humboldt Smelter Superfund Site Remedial Investigation and Feasibility Study

Sample Location	Assay Lab East	Mechanical Building	Background East	Background West	Stained Soil Near Tanks
Location ID No.	IK-SB 11	IK-SB14	IK-SB16	IK-SB17	IK-SB26
CLPAS ID No.	MYOASO/YOG20	MYOAM8	MYOAM6	MYOAM2/YOG18	MYOAM0/YOG25
Date and Time	04/08/2002 1455	04/09/2002 1515	04/09/2002 1415	04/09/2002 1325	04/09/2002 1035
Sample Depth	5-7 Feet	5 -7 Feet	5 -7 Feet	5 -7 Feet	5 -7 Feet
Parameter					
Antimony	0.83UJ	0.85UJ	0.97UJ	0.79UJ	0.85UJ
Arsenic	34.8J	21.SJ	29.7J	16.3J	10.1J
Barium	109	138	207	207	174
Cadmium	0.29LJ	26.5	0.13U	0.10U	0.11U
Calcium	9,520	7,270	11,100	9,690	2,510
Chromium	23.7J	12.0J	2.0LJ	9.1J	8.0J
Copper	55.3J	196J	23.7J	20.8J	23.3J
Iron	34,300J	30,100J	104,OOOJ	46,100	19,800J
Lead	3,660	20.7	1.9J	2.2J	13.8
Mercury	0.22	0.17	0.060U	0.050U	0.070LJ
Selenium	0.48U	0.49U	0.56UJ	0.46UJ	0.49U
Silver	1.6LJ	0.38LJ	2.1LJ	l.OLJ	0.27LJ
Thallium	1.1LJ	1.9LJ	6.7J	2.6J	1.5LJ
Zinc	227	4,820	237	83.0	53.5
Cyanide	0.040LJ	0.10LJ	0.060LJ	0.040UJ	0.040UJ
Nitrate	Not Analyzed	Not Analyzed	Not Analyzed	Not Analyzed	Not Analyzed
Sulfate	Not Analyzed	Not Analyzed	Not Analyzed	Not Analyzed	Not Analyzed
Soil pH	7.4	4.8	7.2	7.5	7.1
VOC: Trichlorofluoromethane	0.039	Not Analyzed	Not Analyzed	0.008LJ	0.020
SVOCTIC: HA	2.3NJ	Not Analyzed	Not Analyzed	5.3NJ	Not Identified

Notes:

mg/kg

Bold

Shading

HA

U

L

J

NJ

R

TABLE 12: SUMMARY OF SEDIMENT SAMPLING RESULTS, IRON KING MINE AND TAILINGS SITE INSPECTION

Reproduced from Expanded Site Investigation

Iron King Mine-Humboldt Smelter Superfund Site Remedial Investigation and Feasibility Study

Sample Location	Background Unnamed Wash	Background chaparral Gulch	River Upstream of Chaparral Gulch	Unnamed Wash South of Iron King Rd	Wash Downstream of Ironite Pond 200-5S	Dup of IK-D7	Chaparral Gulch on Smelter Property	Chaparral Gulch East of Hwy 69	Chaparral Gulch West of Hwy 69	Chaparral Gulch North of 3rd St.	Dup of IK-D14	River Downstream of Chaparral Gulch
Location ID No.	IK-D1	IK-D2	IK-D3	IK-D4	IK-D7	IK-D8	IK-D10	IK-D12	IK-D13	QC-D14	IK-D15	IK-D20
CLPAS ID No.	MYOAN5	MYOAN4	MYOAQ5	MYOAQ2	MYOAP2	MYOAP3	MYOAQ4	MYOAQ1	MYOAN6	MYOAL4	MYOAL5	MYOAQ6
Date and Time	04/10/2002 1230	04/10/2002 1140	04/12/2002 1025	04/12/2002 0820	04/11/2002 1010	04/11/2002 1015	04/12/2002 0935	04/12/2002 0840	04/10/2002 1505	04/09/2002 0930	04/09/2002 0930	04/12/2002 1045
Sample Depth	0-6 Inches	0-6 Inches	0-3 Inches	0-6 Inches	0-3 Inches	0-3 Inches	0-3 Inches	0-6 Inches	0-6 Inches	0-6 Inches	0-6 Inches	0-6 Inches
Parameter												
Antimony	0.83UJ	0.79UJ	1.3LJ	2.5LJ	3.1LJ	3.5LH	I.ILJ	3.3LJ	4.6LJ	2.8LJ	5.0LJ	0.90UJ
Arsenic	**25.5**	**22.8**	**13.7**	**276**	**888**	**851**	**149**	**509**	**285**	**371J**	**475J**	**9.0**
Barium	126	77.5	45.2	90.9	167	154	66.6	55.0	70.3	61.1	69.5	98.6
Cadmium	0.1 7LJ	0.1 5LJ	0.11U	6.7J	4.6J	4.3J	0.86LJ	0.29LJ	1.3	0.98LJ	1.6	0.12U
Chromium	20.6	12.8	11.9	17.0	17.3	17.3	9.6	11.9	12.3	10.2J	11. 2J	11.2
Copper	56.0	24.8	19.7	140	128	122	388	51.0	48.6	50.1J	68.3J	24.1
Iron	43,000	20,900	16,700	53,200	54,900	54,100	23,500	35,100	28,800	28,900J	34,100	13,800
Lead	11. OJ	8.9	38.3J	**454J**	**738J**	**777J**	84.7J	**339J**	**298**	**303**	**513**	6.3J
Manganese	1,080	434	253	1,160	914	890	243	277	421	272	273	662
Mercury	0.070LJ	0.050U	0.060U	0.74	4.8J	3.7J	0.22	1.2	0.79	1.9	2.9	0.060U
Selenium	1.2J	0.46UJ	0.49U	4.0J	9.1J	9.0J	2.6	5.4	4.2J	4.2	5.8	0.52U
Silver	0.24UJ	0.28LJ	27.1	3.0J	5.1J	4.7J	1.0LJ	1.9LJ	1.8LJ	2.0LJ	3.3	0.26U
Thallium	0.77UJ	0.73U	0.79U	2.0LJ	2.5J	2.2LJ	0.77U	0.74U	0.72U	0.75U	1.5LJ	0.83U
Zinc	91.4	57.5	42.4	1,750	1,660	1,630	502	185	463	413	606	79.2
Cyanide	0.060LJ	0.070LJ	0.1 1LJ	0.090LJ	0.13LJ	0.070LJ	R	0.060LJ	0.080LJ	0.040LJ	0.060LJ	0.050LJ
Nitrate	3.0	5.0	2.0	4.0	2.0	2.0	0.5LJ	2.0	3.0	1.0	1.0	1.0
Sulfate	10U	6.0LJ	10	2,700	13,000	12,000	8,800	890	160	3,800	4,200	11
Soil pH	6.9	8.3	8.5	7.2	6.1	5.5	7.2	3.6	6.6	2.9	3.0	8.4

Notes

Bold	indicates that the value exceeds PRO, SRL, or GPL

Shading indicates that the value meets Observed Release Criteria

U	The analyte was analyzed for, but was not detected above the reported value. The reported value is either the sample quantitation limit or the sample detection limit for all analytes
L	Indicates results which fall between the sample detection limit and the CRDL. Results are estimated and considered qualitatively acceptable but quantitatively unreliable due to uncertainties in the analytical precision near the limit of detection.
J	The associated value is an estimated quantity. The analyte was analyzed for and was positively identified, but the reported numerical value may not be consistent with the amount actually present in the environmental sample.
R	The data are unusable. The analyte was analyzed for, but the presence or absence of the analyte cannot be verified

TABLE 13: ARIZONA DEPARTMENT OF WATER RESOURCES WELL INFORMATION

Reproduced from Expanded Site Investigation

Iron King Mine-Humboldt Smelter Superfund Site Remedial Investigation and Feasibility Study

Well Name	Private Domestic Well	Ironite	Humboldt Schools	Kuhles
ADWR Registration No.	55-586482	55-551459	55-576555	55-500167
ADWR Water Use	Domestic	Domestic	Domestic	Domestic
ADWR Well Depth (ft)	600	400	260	460
ADWR Cadastral	(A-13-01)21cca	(A-13-01)22bab	(A-013-01)15dad	(A-13-01)15ccc

TABLE 14: SUMMARY OF GROUNDWATER SAMPLING RESULTS FOR TOTAL METALS, CYANIDE, ANIONS, AND VOCs

Reproduced from Expanded Site Investigation

Iron King Mine-Humboldt Smelter Superfund Site Remedial Investigation and Feasibility Study

Sample Location	Travel Blank	Private Domestic Well (Background)	Ironite Well	Duplicate of IK-G4	Humboldt School Well
Location ID No.	IK-G14	IK-G1	IK-G4	IK-G6	DC-G9
CLPAS ID No.	MYOKB9	MYOKCO	MYOKC1	MYOKC2	MYOKC4
Date and Time	05/14/2002 100	05/14/2002 1105	05/14/2002 1250	5/14/2002 130	05/14/2002 1400
ADWRID No	None	55-586482	55-551459	55-551459	55-576555
Water Use	None	None	Non-Potable	Non-Potable	Non-Potable
Parameter					
Antimony	2.0U	2.0U	2.0U	2.0U	2.0U
Arsenic	**4.0LJ**	**4.7LJ**	**20.9**	**22.5**	5.6LJ
Barium	1.0U	73.1LJ	3.1LJ	3.0LJ	63.9LJ
Cadmium	1.0U	1.0U	1.0U	1.0U	1.0U
Chromium	1.0LJ	1.2LJ	1.0U	1.0U	1.0U
Copper	1.0U	1.0U	1.0U	1.0U	1.0U
Iron	9.0U	1,950	53.2LJ	48.7LJ	270
Lead	1.0U	1.0U	1.0U	1.0U	1.0U
Manganese	1.0U	340	2.2LJ	2.2LJ	3.4LJ
Mercury	0.10U	0.10U	0.10U	0.10U	0.10U
Selenium	2.0U	2.0U	3.4LJ	2.8LJ	3.5LJ
Silver	1.0U	1.0U	1.0U	1.0U	1.0U
Thallium	**4.2LJ**	**6.3LJ**	**6.9LJ**	**6.2LJ**	**7.1LJ**
Zinc	2.0U	3.1LJ	43.9	45.4	2,370
Cyanide	2.0U	2.0U	3.9LJ	2.0U	2.2LJ
Nitrate	0.1UJ	0.1UJ	0.1UJ	0.1UJ	12J
Sulfate	1.0U	480	82	82	130
Trichlorofluoromethane	0.5U	0.5U	0.5U	0.5U	0.5U

Notes:

Bold indicates that the value exceeds PRGs, MCLs, Reference Dose, Cancer Risk, or Aquifer Water Quality Standards

Shading indicates that the value meets Observed Release Criteria

U	The analyte was analyzed for, but was not detected above the reported value. The reported value is either the sample quantitation limit or the sample detection limit for all analytes
L	Indicates results which fall between the sample detection limit and the CRDL. Results are estimated and considered qualitatively acceptable but quantitatively unreliable due to uncertainties in the analytical precision near the limit of detection.
J	The associated value is an estimated quantity. The analyte was analyzed for and was positively identified, but the reported numerical value may not be consistent with the amount actually present in the environmental sample.

Results in ug/L

TABLE 15: SUMMARY OF SURFACE WATER SAMPLING RESULTS, HUMBOLDT SMELTER SITE INSPECTION

Reproduced from Expanded Site Investigation

Iron King Mine-Humboldt Smelter Superfund Site Remedial Investigation and Feasibilty Study

Sample Location	Chaparral Gulch At Dam	Agua Fria River at Slag Pile	Dup of HS-39SW	Agua Fria River Background
Location ID No.	HS-38SW	HS-39SW	HS-40SW	HS-41SW
CLPASIDNo.	MY1843	MY1844	MY1845	MY1846
Date and Time	01/28/2004 0940	01/28/2004 1110	01/28/2004 1115	01/28/2004 1135
Parameter				
Aluminum	229	948	952	244
Arsenic	214	15.0U	5.9J	2.4LJ
Calcium	378,000	87,500	87,700	83,900
Iron	46,000	954	933	222
Magnesium	80,400	18,500	18,700	17,700
Manganese	**5,640**	55.9	54.6	23.2
Thallium	**11.4LJ**	25.0U	25.0U	25.0U
Zinc	496	4.4LJ	4.0LJ	1.4LJ
Sulfate	1,100,000	60,000	60,000	58,000

Notes:

Bold indicates that the value exceeds PRGs, MCLs, Reference Dose, Cancer Risk, or Aquifer Water Quality Standards

Shading indicates that the value meets Observed Release Criteria

U	The analyte was analyzed for, but was not detected above the reported value. The reported value is either the sample quantitation limit or the sample detection limit for all analytes
L	Indicates results which fall between the sample detection limit and the CRDL. Results are estimated and considered qualitatively acceptable but quantitatively unreliable due to uncertainties in the analytical precision near the limit of detection.
J	The associated value is an estimated quantity. The analyte was analyzed for and was positively identified, but the reported numerical value may not be consistent with the amount actually present in the environmental sample.

The samples were analyzed for the following analytes, but they were not detected: antimony, cadmium, lead, mercury, selenium, and silver.

The samples were analyzed for the following analytes, but the results were below SWQS and observed release criteria were not met: barium, beryllium, chromium, cobalt, copper, nickel, potassium, sodium, vanadium, cyanide, bromide, chloride, fluoride, nitrate, nitrite, and o-phosphate.

Results in ug/L

TABLE 16: SUMMARY OF SURFACE WATER SAMPLING RESULTS, HUMBOLDT SMELTER SITE INSPECTION

Reproduced from Expanded Site Investigation

Iron King Mine-Humboldt Smelter Superfund Site Remedial Investigation and Feasibility Study

Sample Location Location ID No. CLPAS ID No. Date and Time Parameter	Chaparral Gulch At Dam HS-38SW MY1983 01/28/2004 0940	Agua Fria River at Slag Pile HS-39SW MY1984 01/28/2004 1110	Dup of HS-39SW HS-40SW MY1985 01/28/2004 1115	Agua Fria River Background HS-41SW MY1986 01/28/2004 1135
Aluminum	92.4J	14.7J	12.9J	9.5J
Arsenic	53.7	15.0U	15.0U	3.6LJ
Calcium	375,000	85,600	82,200	82,700
Iron	28,200	100U	100U	100U
Magnesium	80,000	18,200	17,600	17,400
Manganese	5,580	11.7LJ	11.8LJ	16.1
Thallium	10.8LJ	25.0U	25.0U	25.0U
Zinc	**416**	2.4LJ	60.0U	4.1LJ

Notes:

Bold indicates that the value exceeds PRGs, MCLs, Reference Dose, Cancer Risk, or Aquifer Water Quality Standards

Shading indicates that the value meets Observed Release Criteria

U	The analyte was analyzed for, but was not detected above the reported value. The reported value is either the sample quantitation limit or the sample detection limit for all analytes
L	Indicates results which fall between the sample detection limit and the CRDL. Results are estimated and considered qualitatively acceptable but quantitatively unreliable due to uncertainties in the analytical precision near the limit of detection.
J	The associated value is an estimated quantity. The analyte was analyzed for and was positively identified, but the reported numerical value may not be consistent with the amount actually present in the environmental sample.

The samples were analyzed for the following analytes, but they were not detected: antimony, cadmium, lead, mercury, selenium, and silver.

The samples were analyzed for the following analytes, but the results were below SWQS and observed release criteria were not met: barium, beryllium, chromium, cobalt, copper, nickel, potassium, sodium, vanadium, cyanide, bromide, chloride, fluoride, nitrate, nitrite, and o-phosphate.

Results in ug/L

TABLE 17: SUMMARY OF SOIL AND SEDIMENT SAMPLING RESULTS, HUMBOLDT SMELTER SITE INSPECTION
Reproduced from Expanded Site Investigation
Iron King Mine-Humboldt Smelter Superfund Site Remedial Investigation and Feasibility Study

Sample Location	Background # 1	Backround # 2	Ore Pile # 1	Dup of HS-OISS	Evaporation Pond	Ash Pile West	Ash Pile East	Assay Lab Center	Assay Lab East
Location ID No.	HS-47SS	HS-48SS	HS-01SS	HS-02SS	HS-04SS	HS-05SS	HS-06SS	HS-07SS	HS-08-SS
CLPAS ID No.	MY1841	MY1842	MY1818	MY1819	MY1820	MY1821	MY1822	MY1823	MY1824
Date and Time	01/27/2004 0810	01/27/2004 0815	01/27/2004 0908	01/27/2004 0910	01/27/2004 0910	01/27/2004 0927	01/27/2004 1030	4 1010	01/27/2004 1012
Matrix	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
Sample Depth	0-12 Inches	0-12 Inches	0-12 Inches	0-12 Inches	0-12 Inches	0-12 Inches	0-12 Inches	0-12 Inches	0-12 Inches
Parameter									
Aluminum	23,700	23,500	14,300	16,300	86,200	**190,000**	**193,000**	**153,000**	**104,000**
Antimony	4.5J	3.6J	16.6J	14.8J	5.4J	29.7J	14.5J	10.7J	**118J**
Arsenic	**63.0J**	**53.7J**	**1,100J**	**936J**	**78.9J**	**37.4J**	**30.7J**	**63.2J**	**270J**
Barium	92.6	88.2	93.2	88.0	281	208	171	355	115
Beryllium	0.34J	0.354J	0.15J	0.1 5J	3.0J	**12.0J**	**12.5J**	9.5J	5.6J
Cadmium	1.1U	1.1U	1.1U	1.2U	5.1	1.1U	1.1U	1.1U	1.1U
Calcium	9,010	7,580	5,560	10,600	27,800	5,620	5,810	14,500	7,870
Chromium	45.4J	35.3J	77. U	86.0J	185J	**1,460J**	**833J**	**370J**	**256J**
Copper	62.1	60.4	261	233	2,420	8,750	7,220	**5,010**	**5,460**
Iron	41,900	38,300	22,000	**111,000**	32,300	36,300	27,000	24,900	27,200
Lead	15.5J	12.8J	**668J**	**625J**	**406J**	**2,880J**	**1,410J**	**756J**	**543J**
Mercury	0.1 1UJ	0.030J	1.0J	1.0J	0.45J	0.17J	0.43J	0.51J	0.48J
Nickel	19.7	19.4	9.8	13.9	162	**949**	574	252	175
Selenium	7.4U	7.5U	7.6U	8.1U	0.90J	3.5J	3.3J	3.8J	3.9J
Silver	2.1UJ	2.2UJ	2.9J	2.6J	2.9J	397J	12.3J	7.6J	5.1J
Sodium	136J	150J	617J	603J	906J	3,410	3,040	1,710	1,630
Zinc	71.8	71.8	517J	447J	1,660J	5,030J	3,930J	3.100J	2,720J
Chloride	11U	Not Analyzed	24	25	7.6J	88	130	9.1J	11
Nitrate	2.4	Not Analyzed	0.8J	0.8J	4.7	81	56	12	26
Sulfate	9.6J	Not Analyzed	28,000	34,000	120	30	52	150	340

Notes:

Results in mg/kg

Bold indicates that the value exceeds PRGs, MCLs, Reference Dose, Cancer Risk, or Aquifer Water Quality Standards

Shading indicates that the value meets Observed Release Criteria

U	The analyte was analyzed for, but was not detected above the reported value. The reported value is either the sample quantitation limit or the sample detection limit for all analytes
L	Indicates results which fall between the sample detection limit and the CRDL. Results are estimated and considered qualitatively acceptable but quantitatively unreliable due to uncertainties in the analytical precision near the limit of detection.
J	The associated value is an estimated quantity. The analyte was analyzed for and was positively identified, but the reported numerical value may not be consistent with the amount actually present in the environmental sample.
R	The data are unusable. The analyte was analyzed for, but the presence or absence of the analyte cannot be verified

The samples were analyzed for the following analytes, but the results were below soil benchmarks and observed release critera were not met: cobalt, magnesium, manganese, potassium, thallium, vanadium, and cyanide.

TABLE 17: SUMMARY OF SOIL AND SEDIMENT SAMPLING RESULTS, HUMBOLDT SMELTER SITE INSPECTION
Reproduced from Expanded Site Investigation
Iron King Mine-Humboldt Smelter Superfund Site Remedial Investigation and Feasibility Study

Sample Location	Assay Lab West	Tailings Pile North	Tailings Pile South	Tailings Pile Center	Dup of HS-14SS	Tailings near Dam	Retention Basin	School Center
Location ID No.	HS-09SS	HS-12SS	HS-13SS	HS-14SS	HS-15SS	HS-16SS	HS-23SS	HS-34SS
CLPAS ID No.	MY1825	MY1826	MY1827	MY1828	MY1829	MY1830	MY1831	MY1832
Date and Time	O1/27/2004 1015	O1/27/2004 0945	01/27/2004 0950	01/27/2004 0947	01/27/2004 0948	1/28/2004 1005	01/27/2004 1058	01/27/2004 0835
Matrix	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
Sample Depth	0-12 Inches	0-12 Inches	0-12 Inches	0-12 Inches	0- 12 Inches	0- 12 Inches	0- 12 Inches	0- 12 Inches
Parameter								
Aluminum	98,000	9,730	6,820	7,840	5,670J	17,900	**154,000**	24,000
Antimony	5.9J	5.8J	6.3J	6.7J	12.7U	10.4J	5.7J	3.8J
Arsenic	**45.1J**	**134J**	**179J**	**204J**	**263**	**516J**	**75.8J**	**34.5**
Barium	259	19.7J	27.9J	27.7J	29.3J	135	360	205
Beryllium	3.2J	0.13J	0.060J	0.090J	0.080J	0.60J	17.5J	0.72J
Cadmium	4.8	1.1U	1.0U	1.1U	0.63J	1.4U	1.5U	1.1U
Calcium	32,800	7,740	1,490	5,840	4,490	2,710	8,580	9,000
Chromium	**246J**	1.2J	2.7J	2.5J	1.3J	83. 3J	**349J**	26.2
Copper	2,220	2,590	840	1730	1,780	1,510	4,550	65.4
Iron	46,800	29,000	38,100	36,500	44,900	88,600	29,100	**27,100**
Lead	**315J**	265J	215J	**290J**	**300J**	**408J**	**789J**	67.9
Mercury	0.37J	0.50J	0.1 8J	0.91J	0.060J	0.31J	0.90J	0.15
Nickel	141	1.7J	1.5J	1.8J	1.5J	18.1	166	20.6
Selenium	1.5J	13.0	14.3	14.6	17.4	10.0U	3.0J	7.9U
Silver	2.4J	13.4J	11.4J	14.6J	15.9J	5.1J	5.2J	2.3U
Sodium	877J	161J	167J	214J	189J	979J	2,500	162J
Zinc	1,590J	129J	110J	147J	152	1,750J	3,450J	230
Chloride	12U	10U	10U	7.2J	12	10J	1,600	7.9J
Nitrate	12	2.5	1.0U	1.8	2.5	20	83	49
Sulfate	60	5,200	2,000	14,000	21,000	10,000	250	34

TABLE 17: SUMMARY OF SOIL AND SEDIMENT SAMPLING RESULTS, HUMBOLDT SMELTER SITE INSPECTION

Reproduced from Expanded Site Investigation

Iron King Mine-Humboldt Smelter Superfund Site Remedial Investigation and Feasibility Study

Sample Location	School North	School South	Residence East	Residence North	Chaparral Gulch at Dam	Agua Fria River at Slag Pile	Dup of HS-39SS	Agua Fria River Background
Location ID No.	HS-35SS	HS-36SS	HS-42SS	HS-43SS	HS-38SS	HS-39SS	HS-40SS	HS-41SS
CLPAS ID No.	MY1833	MY1834	MY1839	MY1840	MY1835	MY1836	MY1837	MY1838
Date and Time	01/27/2004 0846	01/27/2004 0841	01/27/2004 1115	01/27/2004 1130	01/28/2004 1025	01/28/2004 0830	01/28/2004 0945	01/28/2004 1220
Matrix	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
Sample Depth	0- 12 Inches	0- 12 Inches	0- 12 Inches	0- 12 Inches	0- 12 Inches	0- 12 Inches	0- 12 Inches	0- 12 Inches
Parameter								
Aluminum		12,400			2,190	5,840	4,830	8,090
Antimony	2.7J	12.7U	5.21	7.5J	R	14.9U	14.7U	17.1U
Arsenic	**25.4J**	**20.7**	**25.5J**	**119J**	**2,320J**	**12.0**	**7.3**	**12.8**
Barium	121	141	155	292	99.2J	46.3J	46.4J	90.6
Beryllium		0.51J			0.080J	0.23J	0.19J	0.31J
Cadmium	1.1U	0.12J	1.1U	2.1	5.0J	1.2UJ	1.2UJ	1.4UJ
Calcium		5,330			22,800	5,990	5,270	8,400
Chromium	21.7J	18.2	65.6J	25.5J	3.5J	14.7	8.7	15.5
Copper	44.4	33.5	115	80.3	106J	18.9	15.7	23.5
Iron	21,100	**23,400**	**33,600**	**39,200**	**456,000J**	17,500	14,200	22,100
Lead	53.6J	15.8J	35.3J	543J	89.1J	4.8J	4.3J	9.5J
Mercury	0.080J	0.060J	0.21J	0.030J	0.75J	R	R	R
Nickel		17.2			3.7J	10.2	7.8J	14.8
Selenium	8.0U	7.4U	7.6U	7.8U	R	8.7U	8.6U	10.0U
Silver	2.3UJ	2.1UJ	2.2UJ	1.8J	R	2.5UJ	2.4UJ	2.8UJ
Sodium		84.9J			365J	163J	144J	172J
Zinc	234J	74.6	85.5J	1110J	1,880J	30.9	25.8	45.4
Chloride	67	11U	11U	11U	180	9.2J	16	15
Nitrate	120	1.5	3.3	6.7	5.8U	1.1	1.7	1.8
Sulfate	260	5.3U	8.6J	13J	8,300	10J	17J	21J

TABLE 18: SUMMARY OF SUBSURFACE SOIL SAMPLES (1.5 ft), IRON KING MINE REMOVAL ASSESSMENT
Reproduced from Expanded Site Investigation
Iron King Mine-Humboldt Smelter Superfund Site Remedial Investigation and Feasibility Study

Sample ID	Arsenic	Lead	Sample ID	Arsenic	Lead
02-E-1.5	100	75	13-E-1.5	17	37
02-E-2 (Duplicate of 02-E-1.5)	110	79	14-E-1.5	24	110
03-E-1.5	54	18	15-E-1.5	19	70
04-E-1.5	28	18	16-E-1.5	37	96
06-E-1.5	30	61	17-E-1.5	24	20
07-E-1.5	21	8.9	19-E-1.5	13	9.0
08-E-1.5	240	280	20-E-1.5	18	11
09-E-1.5	26	16	Ol-BG-1.5	21	14
10-E-1.5	21	19	02-BG-1.5	14	5.3
ll-E-1.5	28	27	06-BG-1.5	12	7.5
12-E-1.5	27	20	08-BG-1.5	43	28
12-E-2 (Duplicate of 12-E-1.5)	30	370	**Average Background Concentration**	22.5	13.7

Results in milogram per kilogram (mg/kg)

TABLE 19: SUMMARY OF SURFACE SOIL SAMPLES (0-2 in), IRON KING MINE REMOVAL ASSESSMENT

Reproduced from Expanded Site Investigation

Iron King Mine-Humboldt Smelter Superfund Site Remedial Investigation and Feasibility Study

Sample ID	Arsenic	Lead
02-A-O	83	45
02-B-O	160	120
02-B-l (Dup of 02-B-O)	140	110
02-C-O	140	68
02-D-O	77	35
02-E-O	52	57
02-F-O	60	27
02-G-O	160	85
02-H-O	79	40
02-1-0	160	83
03-A-O	40	21
03-B-O	57	29
03-B-l(Dup of03-B-0)	41	34
03-C-O	36	24
03-D-O	130	79
03-E-O	38	26
03-F-O	160	34
03-G-O	93	50
03-H-O	75	41
03-1-0	120	52
04-A-O	180	120
04-B-O	110	66
04-B-l(Dup of04-B-0)	100	60
04-C-O	120	72
04-D-O	120	130
04-E-O	170	110
04-F-O	110	63
04-G-O	130	69
04-H-O	110	59
04-1-0	67	74
06-A-O	48	85
06-B-O	20	41
06-B-l (Dup of 06-B-O)	19	40
06-C-O	22	8.9
06-D-O	13	9.8
06-E-O	28	42
06-F-O	75	71
06-G-O	34	48
06-H-O	22	30
06-1-0	35	41
07-A-O	56	63
07-B-O	44	84
07-B-l(Dup of07-B-0)	44	86
08-A-O	23	8.4
08-B-O	21	10
08-B-l(Dup of08-B-0)	18	11
08-C-O	25	14
08-D-O	21	12
08-E-O	25	13
08-F-O	23	39
08-G-O	16	7.6
08-H-O	58	33
08-1-0	17	8.4
09-A-O	69	44
09-B-O	65	61
09-B-l(Dup of09-B-0)	57	55
09-C-O	27	22
09-D-O	25	16
09-E-O	22	20
09-F-O	24	16
09-G-O	9.7	13
09-H-O	11	13
09-1-0	26	21
10-A-O	33	50
10-B-O	46	91
10-B-l(Dup of 10-B-O)	54	100
10-C-O	39	40
10-D-O	21	13
10-E-O	53	62
10-F-O	45	41
10-G-O	42	44
10-H-O	57	60
10-1-0	46	47
11-A-O	41	99
11-B-O	27	27
ll-B-l(Dup of 11-B-O)	24	26
11-C-O	23	1,300
11-D-O	36	69
11-E-O	19	15
11-F-O	9.9	<3.1
11-G-O	7.8	<3.7
11-H-O	86	120
11-1-0	42	38
12-A-O	64	92
12-B-O	36	40
12-B-l (Dup of 11-B-O)	39	44

TABLE 19: SUMMARY OF SURFACE SOIL SAMPLES (0-2 in), IRON KING MINE REMOVAL ASSESSMENT

Reproduced from Expanded Site Investigation

Iron King Mine-Humboldt Smelter Superfund Site Remedial Investigation and Feasibility Study

07-C-O	37	60	12-C-O	56	67
07-D-O	33	31	12-D-O	54	13
07-E-O	38	52	12-E-O	58	61
07-F-O	46	100	12-F-O	46	47
07-G-O	570	36	12-G-O	55	120
07-H-O	42	55	12-H-O	49	75
07-1-0	25	48	12-1-0	48	78
13-A-O	43	90	17-A-O	45	43
13-B-O	36	81	17-B-O	25	25
13-B-l(Dup ofl3-B-0)	41	77	17-B-l(Dup of 17-B-O)	23	25
13-C-O	48	99	17-C-O	51	56
13-D-O	26	51	17-D-O	40	56
13-E-O	12	7.2	17-E-O	42	60
13-F-O	47	62	17-F-O	55	85
13-G-O	39	120	17-G-O	87	54
13-H-O	29	70	17-H-O	64	100
13-1-0	26	35	17-1-0	57	83
14-A-O	38	29	19-A-O	42	63
14-B-O	41	31	19-B-O	57J	87
14-B-l (Dup of 14-B-O)	53	38	19-B-l(Dup of09-B-0)	33J	75
14-C-O	37	29	19-C-O	27	53
14-D-O	43	110	19-D-O	32	48
14-E-O	17	15	19-E-O	32	61
14-F-O	36	43	19-F-O	31	50
14-G-O	19	13	19-G-O	21	18
14-H-O	19	2.9	19-H-O	19	26
14-1-0	20	15	19-1-0	19	20
15-A-O	29	77	20-A-O	70	93
15-B-O	39	91	20-B-O	29	13
15-B-l(Dup ofl5-B-0)	37	80	20-B-l (Dup oflO-B-0)	32	11
15-C-O	66	120	20-C-O	29	40
15-D-O	42	230	20-D-O	32	17
15-E-O	35	120	20-E-O	41	31
15-F-O	30	71	20-F-O	85	32
15-G-O	29	79	20-G-O	54	30
15-H-O	76	170	20-H-O	89	40
15-1-0	42	110	20-1-0	69	32
16-A-O	48	96	01-BG-O	15	6.2
16-B-O	49	92	02-BG-O	18	5.8
16-B-l(Dup of 16-B-O)	42	80	02-BG-l (Duplicate of 02-BG-O)	18	8.0
16-C-O	41	92	03-BG-O	26	12
16-D-O	31	57	04-BG-O	33	15
16-E-O	50	120	05-BG-O	57	48
16-F-O	21	19	06-BG-O	13	8.4
16-G-O	76	120	07-BG-O	18	14
16-H-O	38	90	08-BG-O	120	91
16-1-0	79	330	09-BG-O	9.4	5.5
			Average Background Concentration	34.38	23.00

Results in milogram per kilogram (mg/kg)

TABLE 20: RESIDENTIAL PROPERTY SOIL SAMPLING RESULTS, IRON KING MINE REMOVAL ASSESSMENT
Reproduced from Expanded Site Investigation
Iron King Mine-Humboldt Smelter Superfund Site Remedial Investigation and Feasibility Study

Sample Location	S-1-0	S-2-0	S-2-1	S-3-0	S-4-0	S-5-0	S-6-0	S-7-0	S-8-0	HAB-1-0	01-BQ-O	Ol-BG-1.5
Description	Residence	Residence	Dup of S-2-0	Residence	Residence	Residence	Residence	Business	Residence	Tailings Pond	Background	Background
Depth	0-2 Inches	0-2 Inches	0-2 Inches	0-2 Inches	0-2 Inches	0-2 Inches	0-2 Inches	0-2 Inches	0-2 Inches	0-2 Inches	0-2 Inches	1.5 Feet
Parameter												
Antimony	22UJ	21U	21U	21U	21U	20U	21U	22U	21U	23J	21UJ	22U
Arsenic	**24**	**36**	**45**	**29**	**35**	**44**	**66**	**33**	**31**	**1,900**	**15**	**21**
Barium	580J	150	160	140	150	190	110	160	1,000	110	260	240
Beryllium	1.1	0.56	0.59	0.60	0.78	0.63	0.94	0.56	1.7	0.27	0.72	0.68
Cadmium	1.1U	1.3	1.5	0.69J	1.1U	1.2	1.5	1.1U	0.88J	8.8	1.1U	1.1U
Calcium	99.000J	19,000	19,000	9,000	6,300	5,300	6,600	15,000	13,000	21,000	17,000	18,000
Chromium	49	21	24	21	25	24	16	20	140	13	25	24
Copper	43	130	150	120	56	170	110	63	120	170	39	28
Iron	**33,000**	**29,000**	**29,000**	**28,000**	**36,000**	**42,000**	**49,000**	47,000	**46,000**	**79,000**	**31,000**	**30,000**
Lead	13J	120	130	67	62	77	180	36	37	**2,200**	6.2	14
Nickel	69	16	17	18	18	21	13	17	150	6.7	20	19
Selenium	2.2U	2.1U	2.5	2.1U	2.1U	1.2J	1.2J	2.2U	2.6U	23	2.1U	2.2U
Silver	2.2U	2.1U	2.1U	2.1U	2.1U	2.0U	2.1U	2.2U	2.6U	12	2.1U	2.2U
Vanadium	67	54	57	49	61	54	50	**91**	**110**	65	58	53
Zinc	100	390	420	210	210	280	530	170	110	2,700	65	71

Notes:

Bold indicates that the value exceeds PRGs, MCLs, Reference Dose, Cancer Risk, or Aquifer Water Quality Standards

Shading indicates that the value meets Observed Release Criteria

U	The analyte was analyzed for, but was not detected above the reported value. The reported value is either the sample quantitation limit or the sample detection limit for all analytes
J	The associated value is an estimated quantity. The analyte was analyzed for and was positively identified, but the reported numerical value may not be consistent with the amount actually present in the environmental sample.

The samples were analyzed for the following analytes, but the results were below soil benchmarks and observed release critera were not met: aluminum, cobalt, magnesium, manganese, molybednum, potassium, sodium, and thallium.

Results in mg/kg

TABLE 21: INORGANIC TARGET ANALYTE LIST, METALS AND CYANIDE

Reproduced from Expanded Site Investigation

Iron King Mine-Humboldt Smelter Superfund Site Remedial Investigation and Feasibility Study

Analyte	Contract Required Quantitation Limits		
	ICP-AES Water (ug/L)	ICP-AEW Soil (mg/kg)	ICP-MS Water (ug/L)
Aluminum	200	20	—
Antimony	60	6	2
Arsenic	10	1	1
Barium	200	20	10
Beryllium	5	0.5	1
Cadmium	5	0.5	1
Calcium	5,000	500	—
Chromium	10	1	2
Cobalt	50	5	1
Copper	25	2.5	2
Iron	100	10	—
Lead	10	1	1
Magnesium	5,000	500	—
Manganese	15	1.5	1
Mercury	0.2	0.1	—
Nickel	40	4	1
Potassium	5,000	500	—
Selenium	35	3.5	5
Silver	10	1	1
Sodium	5,000	500	—
Thallium	25	2.5	1
Vanadium	50	5	1
Zinc	60	6	2
Cyanide	10	2.5	—

TABLE 22: ESI GROUNDWATER INFORMATION, JANUARY AND FEBRUARY 2006
Reproduced from Expanded Site Investigation
Iron King Mine-Humboldt Smelter Superfund Site Remedial Investigation and Feasibility Study

Sample ID	Owner Name	Well Name	Well ID No	Cadastral (A-13-01)	ADWR Code	Actual Water Use	Depth to Water (ft)	Depth of Well (ft)	Screened Interval (ft)	Diameter of Well (ft)	Drill Date
H51 H53	Humboldt Water System	Main Well	55-533639	14bdb	E	Potable	50	305	50-150 200-305	8	1992
H52	Humboldt Water System	Backup Well	55-623784	14bd	E	Potable	40	170	NA	6	NA
H54	Private	Private	55-567387	23cbc	D	Not Used	200	325	225 - 325	7	1992
H55	Private	Private	55-550566	ISabd	D	Potable		340	260-340	7	1995
H56 H57	Private	Private	NA	15ddd	NA	Potable	NA	90	NA	NA	NA
H58 OA/OC	Private	Private	55-566350	15dcc	D	House*	30	100	60-100	4	1998
H59	Private	Private	55-900905	15cad	D	Potable	86	225	125-225	5	2004
H61	Private	Private	55-575380	15dbb	D	Potable	142	261	161-261	4	1999
H62	Private	Private	55-805189	14dbc	D	Potable	20	77	NA	8	1969
H63	Private	Private	55-558708	23baa	D	Potable	112	220	120-220	7	1996
H66	Private	Private	55-502562	14ccb	D	Potable	60	220	139-220	7	1982
H80	Private	Private	55-507388	lldba	D	Potable	37	104	NA	7	1984

Notes:

D	Domestic
E	Public Supply
NA	Not Available

TABLE 23: SUMMARY OF ESI GROUNDWATER SAMPLING RESULTS AND BENCHMARKS
Reproduced from Expanded Site Investigation
Iron King Mine-Humboldt Smelter Superfund Site Remedial Investigation and Feasibility Study

Sample Location	HWS Main	HWS Backup	DupofH51	Private	Private	Private	DupofH56	Private - Lab QA/QC	Private	Private
Location ID No.	H51	H52	H53	H54	H55	H56	H57	H58	H59	H61
CLPASIDNo.	MY2DC9	MY2DDO	MY2DD1	MY2DD2	MY2DD3	MY2DD4	MY2DD5	MY2DD6	MY2DD7	MY2DD9
Date	01/31/2006	01/31/2006	01/31/2006	02/01/2006	01/31/2006	02/01/2006	02/01/2006	01/31/2006	01/31/2006	01/31/2006
Time	1350	1400	1355	1035	1034	1110	1115	1311	1101	1143
Parameter										
Antimony	2.0U	2.0U	2.0U	2.0U	2.0U	2.0U	2.0U	2.0U	2.0U	2.0U
Arsenic	**11.6**	**5.9**	**11.9**	**306**	**4.9**	**3.5**	**3.3**	**1.2**	**3.7**	**4.5**
Barium	45.8J	39.5J	45.3J	26.0J	40.3J	67.7J	67.J3	37.9J	44.18J	40.3J
Beryllium	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Cadmium	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Chromium	0.92LJ	0.76LJ	0.98LJ	5.2	0.20LJ	0.73LJ	0.73LJ	0.090LJ	0.1 1LJ	0.1 8LJ
Cobalt	0.1 7LJ	0.060LJ	0.1 9LJ	1.7	1.9	3.5	3.5	3.6	3.3	2.9
Copper	12.9	3.8	13.1	327	10.5	1.1LJ	0.94LJ	3.0	1.3LJ	1.3LJ
Lead	3.8	0.84LJ	1.3	**18.6**	0.83LJ	0.1 1LJ	0.1 1LJ	0.20LJ	0.21LJ	0.27LJ
Manganese	1.6	0.41LJ	1.2	55.2	0.33LJ	2.5	2.6	**50.9**	0.49LJ	0.1 6LJ
Mercury	0.20U	0.20U	0.20U	0.20U	0.20U	0.20U	0.20U	0.20U	0.20U	0.20U
Nickel	1.1J	1.2J	0.96LJ	5.6J	0.86LJ	1.2J	1.2J	4.3J	1.2J	0.83LJ
Selenium	3.4LJ	5.0U	2.5LJ	5.0U	1.9LJ	14.5	13.4	2.4LJ	2.7LJ	5.0U
Silver	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Thallium	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Vanadium	10.9	8.2	11.0	26.4	6.2	6.8	6.9	2.3	4.3	5.8
Zinc	197	44.1	85.2	109	26.8	17.8	23.1	14.6	45.0	31.9
Cyanide	10.0U	11.0	10.0U	11.7	10.0U	13.3	11.3	10.0U	10.0U	10.2

Bold indicates that the value exceeds PRGs, MCLs, Reference Dose, Cancer Risk, or Aquifer Water Quality Standards
Shading indicates that the value meets Observed Release Criteria
Results in ug/L

TABLE 23: SUMMARY OF ESI GROUNDWATER SAMPLING RESULTS AND BENCHMARKS

Reproduced from Expanded Site Investigation

Iron King Mine-Humboldt Smelter Superfund Site Remedial Investigation and Feasibility Study

Sample Location	Private	Private	Private	Private--Background	Benchmark	Benchmark	Benchmark	Benchmark	Benchmark
Location ID No	H62	H63	H66	H80	EPA	EPA	EPA	EPA	Arizona
CLPAS ID No	MY2DEO	MY2DE1	MY2DE3	MY2DE4	Maximum Contaminant Level	Preliminary Remediation Goal	Reference Dose	Cancer Risk	Aquifer Water Quality Standard
Date	02/01/2006 0905	01/31/2006 1711	02/01/2006 0930	02/01/2006					
Time	905	1711	930	830					
Parameter									
Aluminum	NA[1]	NA	NA	NA	NE[2]	36,000	NE	NE	NE
Antimony	2.0U	2.0U	2.0U	2.0U	6.0	15	15	NE	6
Arsenic	**47.5**	**5.7**	**3.3**	**17.2**	10.0	0.045	11	0.057	50
Barium	53.U	37.3J	52.9J	66.8J	2,000	2,600	2,600	NE	2,000
Beryllium	1.0U	1.0U	1.0U	1.0U	4.0	73	73	NE	4
Boron	NA	NA	NA	NA	NE	7,300	3,300	NE	NE
Cadmium	1.0U	1.0U	1.0U	1.0U	5.0	18	18	NE	5
Calcium	NA	NA	NA	NA	NE	NE	NE	NE	NE
Chromium	1.6JL	0.1 9LJ	1.6LJ	4.7	100	NE	110	NE	100
Cobalt	0.040LJ	0.30LJ	0.31LJ	1.0U	None	730	NE	NE	NE
Copper	3.6	1.9LJ	16.6	0.58LJ	1,300	1,500	NE	NE	NE
Iron	NA	NA	NA	NA	NE	11,000	NE	NE	NE
Lead	0.32LJ	0.1 4LJ	2.0	0.1 8LJ	15.0	NE	NE	NE	50
Magnesium	NA	NA	NA	NA	NE	NE	NE	NE	NE
Manganese	1.1	0.75LJ	0.33LJ	0.1 4LJ	50[2]	880	5,100	NE	NE
Mercury	0.20U	0.20U	0.20U	0.20U	2.0	11	11	NE	2
Molybendum	NA	NA	NA	NA	NE	180	NE	NE	NE
Nickel	0.77LJ	1.5J	2.3J	0.68LJ	None	730	730	NE	100
Potassium	NA	NA	NA	NA	NE	NE	NE	NE	NE
Selenium	1.9LJ	5.0U	14.1	2.1LJ	50	180	180	NE	50
Silver	1.0U	1.0U	1.0U	1.0U	100[2]	180	180	NE	NE
Thallium	1.0U	1.0U	1.0U	1.0U	2.0	2.4	NE	NE	2
Vanadium	6.1	5.5	5.4	5.5	None	36	260	NE	NE
Zinc	13.1	30.9	34.9	85.3	5000[2]	11,000	1,100	NE	NE
Cyanide	10.0U	10.8	11.0	10.0U	200	730	730	NE	200

Notes:

Bold indicates that the value exceeds PRGs, MCLs, Reference Dose, Cancer Risk, or Aquifer Water Quality Standards
Shading indicates that the value meets Observed Release Criteria

[1] Not Established

[2] National Secondary Drinking Water Standards

TABLE 24: SUMMARY OF ESI GROUNDWATER SAMPLING RESULTS

Reproduced from Expanded Site Investigation

Iron King Mine-Humboldt Smelter Superfund Site Remedial Investigation and Feasibility Study

Sample Location	Private	Private	Private Irrigation	Private Domestic	Dup of H68	Private	Private	EPA Region 9 Laboratory Quantitation Values
Location ID No	H65	H70	H67	H68	H69	H81	H82	
Date	05/24/2006	05/24/2007	05/24/2008	05/24/2009	05/24/2010	05/24/2011	05/24/2012	
Time	1008	1040	1140	1200	1210	1245	1449	
Parameter								
Aluminum	20U	20U	20U	20U	20U	20U	20U	20
Antimony	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0
Arsenic	**50**	**15**	**150**	**11**	**10**	**20**	**17**	1.0
Barium	27	31	20	3.6	3.5	93	87	1.0
Beryllium	0.50U	0.50U	0.50U	0.50U	0.50U	0.50U	0.50U	0.50
Boron	330	56LJ	**5,800**	200	190	100U	100U	100
Cadmium	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0
Calcium	63,000	50,000	6,100	140,000	140,000	80,000	45,000	100
Chromium	1.0U	5.5	1.0U	1.0U	1.0U	3.7	8.5	1.0
Cobalt	0.50U	0.50U	0.50U	0.86	0.87	0.50U	0.50U	0.50
Copper	4.5	44	1.4J	9.4	11	7.7	3.5	2.0
Iron	100U	100U	100U	100U	100U	100U	100U	100
Lead	2.0U	9.3	2.0U	2.0U	2.0U	2.0U	2.0U	2.0
Magnesium	11,000	12,000	9,300	35,000	35,000	10,000	12,000	500
Manganese	2.0U	2.0U	1.5LJ	2.0U	2.0U	2.0U	2.0U	2.0
Mercury	0.030U	0.030U	0.030U	0.034	0.032	0.030U	0.030U	0.030
Molybendum	1.7	2.4	22	1.2	1.1	1.2	1.3	0.50
Nickel	1.0U	1.0U	3.4	1.2	1.1	1.0U	0.64LJ	1.0
Potassium	5.000U	5.000U	4.600LJ	5.000U	5.000U	5.000U	5.000U	5,000
Selenium	2.4	2.1	1.3	6.4	6.3	3.1	2.2	1.0
Silver	0.50U	0.50U	0.50U	0.50U	0.50U	0.50U	0.50U	0.50
Sodium	46,000	24,000	520,000	60,000	59,000	20,000	18,000	500
Thallium	2.0U	2.0U	2.0U	2.0U	2.0U	2.0U	2.0U	2.0
Vanadium	7.4	13	4.0U	3.9LJ	3.9LJ	6.7	8.4	4.0
Zinc	150	44	79	81	56	17	54	5.0
Cyanide	10U	10U	10U	10U	10U	10U	10U	10

Bold indicates that the value exceeds PRGs, MCLs, Reference Dose, Cancer Risk, or Aquifer Water Quality Standards
Shading indicates that the value meets Observed Release Criteria
Results in ug/L

TABLE 25: ESI GROUNDWATER WELL INFORMATION, MAY 2006
Reproduced from Expanded Site Investigation
Iron King Mine-Humboldt Smelter Superfund Site Remedial Investigation and Feasibility Study

Sample ID	Owner Name	Well Name	Well ID No	Cadastral (A-13-01)	ADWR Code	Actual Water Use	Depth to Water (ft)	Depth of Well (ft)	Screened Interval (ft)	Diameter of Well (in)	Drill Date
H65	Private	Private	66-634755	14dca	D	Domestic	39	90	NA	8 5/8	08/14/1975
H67	Private	Private Irrigation	55-900344	23cad	D	Irrigation	31	800	700-800	4.5	5/8/2004
H68/H69	Private	Private Domestic	55-599489	23ddc	D	Domestic	8	60	40-60	8	07/28/2003
H70	Private	Private	55-586144	14cbd	D	Domestic	NA	NA	NA	NA	NA
H81	Private	Private	55-551874	11 dad	D	Domestic	55	125	65-125	NA	10/04/1995
H82	Private	Private	55-512734	llacb	D	Domestic	60	125	60-120	5	10/15/1985

Notes:

D	Domestic
NA	Not Available

TABLE 26: PUBLIC SUPPLY WELLS AND DOMESTIC WELLS WITHIN 4 MILES OF THE IK/HS SITE

Reproduced from Expanded Site Investigation

Iron King Mine-Humboldt Smelter Superfund Site Remedial Investigation and Feasibility Study

Distance	Water Company	System Description	# Wells in Distance Ring	Population per Well	Total Population
0-1/4 mi	Domestic Wells	n/a	72	2.33	168
1/4-1/2 mi	Humboldt Water System	2 wells, 100% GW	2	300	600
1/4-1/2 mi	Domestic Wells	n/a	83	2.33	193
1/2-1 mi	Domestic Wells	n/a	186	2.33	433
1-2 mi	Soft Winds MHP	1 well, 100% GW	1	50	50
1-2 mi	Domestic Wells	n/a	609	2.33	1419
2-3 mi	Wilhoit Water Co--Blue Hills	2 wells, 100% GW	2	62	125
2-3 mi	Domestic Wells	n/a	571	2.33	1330
3-4 mi	Mayer Domestic Water -- Poland System	5 wells, 100% GW	1	26	26
3-4 mi	Prescott Valley Water--Lower System	2 wells, 100% GW	1	1896	1896
3-4 mi	Domestic Wells	n/a	221	2.33	515
Total					6756

TABLE 27: RESIDENTS WITHIN 4 MILES OF THE IK/HS SITE
Reproduced from Expanded Site Investigation
Iron King Mine-Humboldt Smelter Superfund Site Remedial Investigation and Feasibility Study

Distance	Population
0-1/4	278
1/4-1/2	140
1/2-1	376
1-2	820
2-3	1313
3-4	2382
Total	5309

Attachment B

Potential Species For Habitat Types Similar to the Site

Attachment B
Potential Species For Habitat Types Similar to the Site

Scientific Name	Common Name	Nonnative	Habitat Type Interior Chaparral	Human Dominated Landscapes	Wetlands/ Springs	Streams/ Rivers
Accipiter cooperii	Cooper's Hawk		x	x	x	x
Accipiter gentilis atricapillus	Northern Goshawk		x		x	x
Accipiter striatus	Sharp-shinned Hawk		x	x	x	x
Actitis macularius	Spotted Sandpiper			x	x	x
Aechmophorus clarkii	Clark's Grebe			x	x	x
Aechmophorus occidentalis	Western Grebe			x	x	x
Aegolius acadicus	Northern Saw-whet Owl			x	x	x
Aeronautes saxatalis	White-throated Swift		x	x	x	x
Agelaius phoeniceus	Red-winged Blackbird			x	x	x
Agosia chrysogaster	Longfin Dace				x	
Aimophila ruficeps	Rufous-crowned Sparrow		x		x	
Aix sponsa	Wood Duck			x	x	x
Ambloplites rupestris	Rock Bass	x			x	
Ambystoma tigrinum nebulosum	Arizona Tiger Salamander				x	x
Ammodramus savannarum perpallidus	Western Grasshopper Sparrow			x		
Ammospermophilus harrisii	Harris' Antelope Squirrel		x			
Amphispiza bilineata	Black-throated Sparrow			x		
Anas acuta	Northern Pintail			x	x	x
Anas americana	American Wigeon			x	x	x
Anas clypeata	Northern Shoveler			x	x	x
Anas crecca	Green-winged Teal			x	x	x
Anas cyanoptera	Cinnamon Teal			x	x	x
Anas discors	Blue-winged Teal			x	x	x
Anas platyrhynchos	Mallard			x	x	x
Anas strepera	Gadwall			x	x	x
Anodonta californiensis	California Floater				x	x
Anthus rubescens	American Pipit			x	x	x
Antrozous pallidus	Pallid Bat		x	x	x	x
Apalone spinifera	Spiny Softshell	x			x	x
Aphelocoma californica	Western Scrub-Jay		x	x	x	x
Aphelocoma ultramarina	Mexican Jay		x	x	x	x
Aquila chrysaetos	Golden Eagle		x	x	x	x
Archilochus alexandri	Black-chinned Hummingbird		x	x	x	x
Ardea alba	Great Egret			x	x	x
Ardea herodias	Great Blue Heron			x	x	x
Arizona elegans noctivaga	Arizona Glossy Snake		x			
Artemia franciscana	San Francisco Brine Shrimp				x	x
Asio otus	Long-eared Owl		x		x	x
Aspidoscelis flagellicauda	Gila Spotted Whiptail		x		x	
Aspidoscelis pai	Pai Striped Whiptail		x			
Aspidoscelis tigris	Tiger Whiptail		x	x	x	
Aspidoscelis uniparens	Desert Grassland Whiptail				x	
Aspidoscelis velox	Plateau Striped Whiptail		x		x	
Athene cunicularia hypugaea	Western Burrowing Owl			x		
Auriparus flaviceps	Verdin		x	x	x	x
Aythya affinis	Lesser Scaup			x	x	x
Aythya americana	Redhead			x	x	x
Aythya collaris	Ring-necked Duck			x	x	x
Aythya valisineria	Canvasback			x	x	x
Baeolophus ridgwayi	Juniper Titmouse		x	x	x	
Baeolophus wollweberi	Bridled Titmouse		x	x	x	
Bassariscus astutus	Ringtail		x		x	x
Biomphalaria havanensis	Ghost Rams-horn	x				x
Botaurus lentiginosus	American Bittern			x	x	x
Branta canadensis	Canada Goose			x	x	x
Bubo virginianus	Great Horned Owl		x	x	x	x
Bubulcus ibis	Cattle Egret			x	x	x
Bufo cognatus	Great Plains Toad				x	
Bufo microscaphus	Arizona Toad		x		x	
Bufo punctatus	Red-spotted Toad				x	
Bufo woodhousii woodhousi	Rocky Mountain Toad		x		x	x
Buteo albonotatus	Zone-tailed Hawk		x		x	x

Attachment B
Potential Species For Habitat Types Similar to the Site

Scientific Name	Common Name	Nonnative	Habitat Type Interior Chaparral	Human Dominated Landscapes	Wetlands/ Springs	Streams/ Rivers
Buteo jamaicensis	Red-tailed Hawk		x	x	x	x
Buteo regalis	Ferruginous Hawk			x		
Buteo swainsoni	Swainson's Hawk			x		
Buteogallus anthracinus	Common Black-Hawk		x		x	x
Butorides virescens	Green Heron			x	x	x
Calamospiza melanocorys	Lark Bunting			x		
Calcarius mccownii	McCown's Longspur			x		
Calcarius ornatus	Chestnut-collared Longspur			x		
Calidris minutilla	Least Sandpiper			x	x	x
Callipepla gambelii	Gambel's Quail		x	x	x	x
Callipepla squamata	Scaled Quail			x		
Callisaurus draconoides	Zebra-tailed Lizard		x			
Calypte anna	Anna's Hummingbird		x	x	x	x
Calypte costae	Costa's Hummingbird		x	x	x	x
Camptostoma imberbe	Northern Beardless-Tyrannulet				x	
Campylorhynchus brunneicapillus	Cactus Wren		x	x	x	x
Canis latrans	Coyote		x	x	x	x
Caprimulgus vociferus	Whip-poor-will				x	
Carassius auratus	Goldfish	x			x	x
Cardellina rubrifrons	Red-faced Warbler				x	
Cardinalis cardinalis	Northern Cardinal		x	x	x	x
Carduelis pinus	Pine Siskin		x	x	x	x
Carduelis psaltria	Lesser Goldfinch		x	x	x	x
Carpodacus cassinii	Cassin's Finch			x	x	x
Carpodacus mexicanus	House Finch		x	x	x	x
Castor canadensis	American Beaver				x	x
Cathartes aura	Turkey Vulture		x	x	x	x
Catharus guttatus	Hermit Thrush		x	x	x	x
Catharus ustulatus	Swainson's Thrush		x	x	x	
Catherpes mexicanus	Canyon Wren		x		x	
Catostomus clarki	Desert Sucker				x	
Catostomus insignis	Sonora Sucker				x	
Catostomus latipinnis	Flannelmouth Sucker				x	
Certhia americana	Brown Creeper			x	x	x
Cervus elaphus nelsoni	Rocky Mountain Elk		x		x	x
Ceryle alcyon	Belted Kingfisher			x	x	x
Chaetodipus baileyi	Bailey's Pocket Mouse		x			
Charadrius alexandrinus nivosus	Western Snowy Plover			x		x
Charadrius vociferus	Killdeer			x	x	x
Charina trivirgata gracia	Desert Rosy Boa		x			
Chen caerulescens	Snow Goose			x	x	x
Chen rossii	Ross's Goose			x	x	x
Chondestes grammacus	Lark Sparrow		x	x		
Chordeiles acutipennis	Lesser Nighthawk		x	x	x	x
Chordeiles minor	Common Nighthawk		x	x	x	x
Cinclus mexicanus	American Dipper				x	x
Circus cyaneus	Northern Harrier		x	x	x	x
Cistothorus palustris	Marsh Wren			x	x	x
Coccothraustes vespertinus	Evening Grosbeak			x	x	x
Coccyzus americanus occidentalis	Western Yellow-billed Cuckoo			x	x	x
Colaptes auratus	Northern Flicker		x	x	x	x
Coleonyx variegatus bogerti	Tucson Banded Gecko		x			
Coleonyx variegatus variegatus	Desert Banded Gecko		x	x		
Columba livia	Rock Pigeon	x	x	x		
Columbina inca	Inca Dove			x	x	x
Conepatus leuconotus leuconotus	Hog-nosed Skunk		x			
Contopus cooperi	Olive-sided Flycatcher		x	x	x	x
Contopus pertinax	Greater Pewee		x		x	
Contopus sordidulus	Western Wood-Pewee		x	x	x	x
Cophosaurus texanus scitulus	Chihuahuan Greater Earless Lizard		x			
Corvus brachyrhynchos	American Crow			x	x	x
Corvus corax	Common Raven		x	x	x	x

Attachment B
Potential Species For Habitat Types Similar to the Site

Scientific Name	Common Name	Nonnative	Habitat Type			
			Interior Chaparral	Human Dominated Landscapes	Wetlands/ Springs	Streams/ Rivers
Corynorhinus townsendii pallescens	Pale Townsend's Big-eared Bat		x		x	x
Crotalus atrox	Western Diamond-backed Rattlesnake		x			
Crotalus mitchellii pyrrhus	Southwestern Speckled Rattlesnake		x			
Crotalus molossus molussus	Northern Black-tailed Rattlesnake		x			
Crotalus oreganus cerberus	Arizona Black Rattlesnake		x			
Crotalus scutulatus scutulatus	Northern Mohave Rattlesnake		x			
Crotalus tigris	Tiger Rattlesnake		x			
Crotaphytus collaris	Eastern Collared Lizard		x			
Ctenopharyngodon idella	Grass Carp	x		x		
Cyanocitta stelleri	Steller's Jay		x	x	x	x
Cynomys gunnisoni	Gunnison's Prairie Dog		x			
Cyprinodon macularius	Desert Pupfish				x	
Cyprinus carpio	Common Carp	x			x	x
Cyrtonyx montezumae	Montezuma Quail		x		x	
Cyzicus mexicanus	Mexican Clam Shrimp				x	x
Cyzicus setosa	Bristletail Clam Shrimp				x	x
Dendrocygna autumnalis	Black-bellied Whistling-Duck			x		x
Dendroica coronata	Yellow-rumped Warbler		x	x	x	x
Dendroica graciae	Grace's Warbler			x	x	x
Dendroica nigrescens	Black-throated Gray Warbler		x	x	x	x
Dendroica petechia	Yellow Warbler		x	x	x	x
Diadophis punctatus regalis	Regal Ring-necked Snake		x		x	
Dipodomys merriami	Merriam's Kangaroo Rat		x			
Dipodomys ordii	Ord's Kangaroo Rat		x			
Dorosoma petenense	Threadfin Shad	x			x	x
Dumetella carolinensis	Gray Catbird			x	x	x
Egretta thula	Snowy Egret			x	x	x
Eleutherodactylus augusti cactorum	Western Barking Frog		x			
Elgaria kingii nobilis	Arizona Alligator Lizard		x		x	
Empidonax oberholseri	Dusky Flycatcher		x	x	x	x
Empidonax occidentalis	Cordilleran Flycatcher		x	x	x	x
Empidonax traillii extimus	Southwestern Willow Flycatcher		x	x	x	x
Empidonax wrightii	Gray Flycatcher		x	x	x	x
Eocyzicus digueti	Straightbacked Clam Shrimp				x	x
Eptesicus fuscus	Big Brown Bat		x	x	x	x
Eremophila alpestris	Horned Lark			x		x
Erethizon dorsatum	North American Porcupine		x			
Eubranchipus bundyi	Knobbedlip Fairy Shrimp				x	x
Eubranchipus serratus	Ethologist Fairy Shrimp				x	x
Euderma maculatum	Spotted Bat		x		x	x
Eulimnadia antlei	Fuzzy Cyst Clam Shrimp				x	x
Eulimnadia cylindrova	Cylindrical Cyst Clam Shrimp				x	x
Eulimnadia texana	Texan Clam Shrimp				x	x
Eumeces gilberti rubricaudata	Western Red-tailed Skink		x		x	
Eumeces multivirgatus epipluerotus	Variable Skink		x		x	
Eumeces obsoletus	Great Plains Skink		x		x	
Eumops perotis californicus	Greater Western Mastiff Bat		x			
Euphagus cyanocephalus	Brewer's Blackbird			x	x	x
Eutamias dorsalis	Cliff Chipmunk		x			
Falco mexicanus	Prairie Falcon		x	x	x	x
Falco peregrinus	Peregrine Falcon		x	x	x	x
Falco peregrinus anatum	American Peregrine Falcon		x	x	x	x
Falco sparverius	American Kestrel		x	x	x	x
Ferrissia fragilis	Fragile Ancylid				x	x
Ferrissia rivularis	Creeping Ancylid				x	x
Fulica americana	American Coot			x	x	x
Gallinago delicata	Wilson's Snipe			x	x	x
Gallinula chloropus	Common Moorhen			x	x	x
Gambelia wislizenii	Long-nosed Leopard Lizard		x		x	x
Gambusia affinis	Mosquitofish	x		x	x	x
Geococcyx californianus	Greater Roadrunner		x	x	x	x
Geothlypis trichas	Common Yellowthroat			x	x	x

Attachment B
Potential Species For Habitat Types Similar to the Site

Scientific Name	Common Name	Nonnative	Habitat Type			
			Interior Chaparral	Human Dominated Landscapes	Wetlands/ Springs	Streams/ Rivers
Gila elegans	Bonytail				x	
Gila intermedia	Gila Chub				x	
Gila nigra	Headwater Chub				x	
Gila robusta	Roundtail Chub				x	
Glaucidium gnoma californicum	Northern Pygmy-0wl				x	x
Gopherus agassizii (Sonoran Population)	Sonoran Desert Tortoise		x			
Grus canadensis	Sandhill Crane			x	x	x
Gymnorhinus cyanocephalus	Pinyon Jay		x		x	
Haliaeetus leucocephalus	Bald Eagle			x	x	x
Helisoma anceps	Two-ridge Rams-horn				x	x
Helix aspersa	Brown Gardensnail	x	x			
Heloderma suspectum cinctum	Banded Gila Monster		x			
Heloderma suspectum suspectum	Reticulate Gila Monster		x			
Himantopus mexicanus	Black-necked Stilt			x	x	x
Hirundo rustica	Barn Swallow		x	x	x	x
Hyla arenicolor	Canyon Treefrog		x		x	
Hyla wrightorum	Mountain Treefrog				x	
Hypsiglena torquata chlorophaea	Sonoran Nightsnake		x			
Ictalurus melas	Black Bullhead	x			x	x
Ictalurus natalis	Yellow Bullhead	x			x	x
Ictalurus punctatus	Channel Catfish	x			x	x
Icteria virens	Yellow-breasted Chat			x	x	x
Icterus bullockii	Bullock's Oriole		x	x	x	x
Icterus cucullatus	Hooded Oriole		x	x	x	x
Icterus parisorum	Scott's Oriole		x	x	x	x
Ictinia mississippiensis	Mississippi Kite			x	x	
Idionycteris phyllotis	Allen's Big-eared Bat		x		x	x
Ixobrychus exilis hesperis	Western Least Bittern			x	x	x
Junco hyemalis	Dark-eyed Junco		x	x	x	x
Junco phaeonotus	Yellow-eyed Junco				x	
Kinosternon sonoriense sonoriense	Sonora Mud Turtle		x		x	
Lampropeltis getula californiae	California Kingsnake		x	x		
Lampropeltis pyromelana pyromelana	Arizona Mountain Kingsnake				x	
Lanius ludovicianus	Loggerhead Shrike		x	x	x	x
Lasionycteris noctivagans	Silver-haired Bat		x		x	x
Lasiurus blossevillii	Western Red Bat		x		x	x
Lasiurus cinereus	Hoary Bat		x		x	x
Lasiurus xanthinus	Western Yellow Bat		x		x	x
Lepomis cyanellus	Green Sunfish	x			x	x
Lepomis gulosus	Warmouth	x			x	
Lepomis macrochirus	Bluegill	x			x	x
Lepomis microlophus	Redear Sunfish	x				x
Leptestheria compleximanus	Spineynose Clam Shrimp				x	x
Limnodromus scolopaceus	Long-billed Dowitcher			x	x	x
Loxia curvirostra	Red Crossbill			x	x	
Lutra canadensis lataxina	Southeastern River Otter				x	x
Lynceus brachyurus	Holarctic Clam Shrimp				x	x
Lynceus brevifrons	Short Finger Clam Shrimp				x	x
Lynx rufus	Bobcat		x			
Macrotus californicus	California Leaf-nosed Bat		x		x	x
Masticophis bilineatus	Sonoran Whipsnake		x		x	x
Masticophis flagellum piceus	Red Racer		x			
Masticophis taeniatus taeniatus	Desert Striped Whipsnake		x		x	
Meda fulgida	Spikedace				x	
Megascops kennicottii	Western Screech-Owl		x	x	x	x
Melanerpes formicivorus	Acorn Woodpecker		x	x	x	x
Melanerpes lewis	Lewis's Woodpecker			x	x	
Melanerpes uropygialis	Gila Woodpecker			x	x	
Meleagris gallopavo merriami	Merriam's Turkey		x	x	x	x
Melospiza lincolnii	Lincoln's Sparrow		x	x	x	x
Melospiza melodia	Song Sparrow			x	x	x
Mephitis macroura	Hooded Skunk		x		x	x

Attachment B
Potential Species For Habitat Types Similar to the Site

			Habitat Type			
Scientific Name	**Common Name**	**Nonnative**	**Interior Chaparral**	**Human Dominated Landscapes**	**Wetlands/ Springs**	**Streams/ Rivers**
Mephitis mephitis	Striped Skunk		x		x	x
Mergus merganser	Common Merganser			x	x	x
Micrathene whitneyi	Elf Owl		x	x	x	
Micropterus dolomieu	Smallmouth Bass	x			x	x
Micropterus salmoides	Largemouth Bass	x			x	x
Microtus mexicanus hualpaiensis	Hualapai Mexican Vole		x			
Microtus mexicanus mogollonensis	Mogollon Vole		x			
Mimus polyglottos	Northern Mockingbird		x	x	x	x
Molothrus aeneus	Bronzed Cowbird		x	x	x	x
Molothrus ater	Brown-headed Cowbird		x	x	x	x
Myadestes townsendi	Townsend's Solitaire		x	x	x	x
Myiarchus cinerascens	Ash-throated Flycatcher		x	x	x	x
Myiarchus tuberculifer	Dusky-capped Flycatcher			x	x	
Myiarchus tyrannulus	Brown-crested Flycatcher		x	x	x	x
Myioborus pictus	Painted Redstart		x	x	x	x
Myiodynastes luteiventris	Sulphur-bellied Flycatcher				x	
Myotis auriculus	Southwestern Myotis		x		x	x
Myotis californicus	California Myotis		x		x	x
Myotis ciliolabrum	Western Small-footed Myotis		x		x	x
Myotis evotis	Long-eared Myotis				x	x
Myotis occultus	Arizona Myotis		x	x	x	
Myotis thysanodes	Fringed Myotis		x	x	x	
Myotis velifer	Cave Myotis		x	x	x	
Myotis volans	Long-legged Myotis		x	x	x	
Nasua nasua	White-nosed Coati		x	x	x	
Neotoma albigula	Western White-throated Woodrat		x			
Neotoma stephensi	Stephen's Woodrat		x			
Notiosorex crawfordi	Crawford's Desert Shrew		x			
Notropis lutrensis	Red Shiner	x			x	x
Nucifraga columbiana	Clark's Nutcracker				x	x
Numenius americanus	Long-billed Curlew			x	x	x
Nycticorax nycticorax	Black-crowned Night-Heron			x	x	x
Nyctinomops femorosaccus	Pocketed Free-tailed Bat		x	x	x	
Nyctinomops macrotis	Big Free-tailed Bat		x	x	x	
Odocoileus hemionus crooki	Desert Mule Deer		x			
Odocoileus virginianus couesi	Coues whitetail deer		x	x	x	
Oncorhynchus clarki	Cutthroat Trout	x			x	x
Oncorhynchus gilae apache	Apache (Arizona) Trout				x	x
Oncorhynchus gilae gilae	Gila Trout				x	
Oncorhynchus mykiss	Rainbow Trout	x			x	x
Ondatra zibethicus	Common Muskrat				x	
Onychomys torridus	Southern Grasshopper Mouse		x			
Oporornis tolmiei	MacGillivray's Warbler		x	x	x	x
Orconectes virilis	Virile Crayfish	x			x	x
Oreoscoptes montanus	Sage Thrasher		x	x		
Otala lactea	Milk Snail		x			
Otus flammeolus	Flammulated Owl			x	x	
Ovis canadensis canadensis	Rocky Mountain Bighorn Sheep			x	x	
Ovis canadensis mexicana	Desert Bighorn Sheep			x	x	
Oxyura jamaicensis	Ruddy Duck			x	x	x
Pandion haliaetus	Osprey			x	x	x
Panthera onca	Jaguar		x			
Parabuteo unicinctus	Harris's Hawk				x	
Passer domesticus	House Sparrow	x		x		
Passerculus sandwichensis	Savannah Sparrow			x	x	x
Passerina amoena	Lazuli Bunting		x	x	x	x
Passerina caerulea	Blue Grosbeak		x	x	x	x
Passerina cyanea	Indigo Bunting			x	x	x
Patagioenas fasciata	Band-tailed Pigeon			x	x	
Pelecanus erythrorhynchos	American White Pelican			x	x	x
Perognathus amplus	Arizona Pocket Mouse		x			
Perognathus flavus	Silky Pocket Mouse		x			

Attachment B
Potential Species For Habitat Types Similar to the Site

Scientific Name	Common Name	Nonnative	Habitat Type Interior Chaparral	Human Dominated Landscapes	Wetlands/ Springs	Streams/ Rivers
Peromyscus boylii	Brush Mouse		x			
Peromyscus eremicus	Cactus Mouse		x			
Peromyscus leucopus	White-footed Mouse		x			
Peromyscus maniculatus	Deer Mouse		x			
Petrochelidon pyrrhonota	Cliff Swallow			x	x	x
Peucedramus taeniatus	Olive Warbler				x	
Phainopepla nitens	Phainopepla		x	x	x	x
Phalacrocorax auritus albociliatus	Double-crested Cormorant			x	x	x
Phalacrocorax brasilianus	Neotropic Cormorant			x		x
Phalaenoptilus nuttallii	Common Poorwill		x			
Phasianus colchicus	Ring-necked Pheasant	x		x	x	
Pheucticus melanocephalus	Black-headed Grosbeak		x	x	x	x
Phrynosoma hernandesi hernandesi	Hernandez's (Greater) Short-horned		x			
Physella humerosa	Corkscrew Physa				x	x
Physella osculans	Cayuse Physa				x	x
Physella virgata	Protean Physa				x	
Picoides scalaris	Ladder-backed Woodpecker		x	x	x	x
Picoides villosus	Hairy Woodpecker				x	
Pimephales promelas	Fathead Minnow	x			x	x
Pipilo aberti	Abert's Towhee			x	x	x
Pipilo chlorurus	Green-tailed Towhee		x	x	x	x
Pipilo fuscus	Canyon Towhee		x	x	x	
Pipilo maculatus	Spotted Towhee		x	x	x	x
Pipistrellus hesperus	Western Pipistrelle		x		x	x
Piranga flava	Hepatic Tanager				x	
Piranga ludoviciana	Western Tanager		x	x	x	x
Piranga rubra	Summer Tanager			x	x	x
Pituophis catenifer affinis	Sonoran Gophersnake		x			
Plagopterus argentissimus	Woundfin				x	
Planorbella tenuis	Mexican Rams-horn				x	x
Plegadis chihi	White-faced Ibis			x	x	x
Podiceps nigricollis	Eared Grebe			x	x	x
Podilymbus podiceps	Pied-billed Grebe			x	x	x
Poecile gambeli	Mountain Chickadee			x	x	
Poeciliopsis occidentalis occidentalis	Gila Topminnow				x	
Polioptila caerulea	Blue-gray Gnatcatcher		x	x	x	x
Pomoxis nigromaculatus	Black Crappie	x			x	x
Pooecetes gramineus	Vesper Sparrow			x		
Porzana carolina	Sora			x	x	x
Procambarus clarkii	Red Swamp Crawfish	x			x	x
Procyon lotor	Raccoon		x	x	x	x
Progne subis arboricola	Western Purple Martin			x	x	x
Promenetus exacuous	Sharp Sprite (A Planorbid Snail)				x	x
Psaltriparus minimus	Bushtit		x	x	x	x
Pseudacris triseriata	Western Chorus Frog				x	x
Ptychocheilus lucius	Colorado Pikeminnow				x	
Puma concolor	Mountain Lion		x			x
Pylodictis olivaris	Flathead Catfish	x			x	x
Pyrocephalus rubinus	Vermilion Flycatcher			x	x	x
Quiscalus mexicanus	Great-tailed Grackle			x	x	x
Rallus limicola	Virginia Rail			x	x	x
Rana chiricahuensis	Chiricahua Leopard Frog		x		x	x
Rana pipiens	Northern Leopard Frog				x	x
Rana yavapaiensis	Lowland Leopard Frog		x		x	x
Recurvirostra americana	American Avocet			x	x	x
Regulus calendula	Ruby-crowned Kinglet		x	x	x	x
Regulus satrapa	Golden-crowned Kinglet				x	
Reithrodontomys megalotis	Western Harvest Mouse		x			
Reithrodontomys megalotis megalotis	Western Harvest Mouse		x			
Reithrodontomys montanus	Plains Harvest Mouse		x			
Rhinichthys osculus	Speckled Dace				x	
Rhinocheilus lecontei lecontei	Western Long-nosed Snake		x			

Attachment B
Potential Species For Habitat Types Similar to the Site

Scientific Name	Common Name	Nonnative	Habitat Type			
			Interior Chaparral	Human Dominated Landscapes	Wetlands/ Springs	Streams/ Rivers
Salmo trutta	Brown Trout	x			x	x
Salpinctes obsoletus	Rock Wren		x	x	x	x
Salvadora hexalepis hexalepis	Desert Patch-nosed Snake		x			
Salvelinus fontinalis	Brook Trout	x			x	x
Sayornis nigricans	Black Phoebe			x	x	x
Sayornis saya	Say's Phoebe		x	x	x	x
Sceloporus tristichus	Plateau Lizard		x			
Sciurus arizonensis	Arizona Gray Squirrel				x	x
Selasphorus platycercus	Broad-tailed Hummingbird		x	x	x	x
Sialia currucoides	Mountain Bluebird		x	x		x
Sialia mexicana	Western Bluebird		x	x	x	x
Sitta canadensis	Red-breasted Nuthatch			x	x	x
Sitta carolinensis	White-breasted Nuthatch		x	x	x	x
Sitta pygmaea	Pygmy Nuthatch			x		
Sonora semiannulata semiannulata	Variable Groundsnake		x			
Sorex arizonae	Arizona Shrew				x	x
Sorex monticolus	Dusky Shrew				x	x
Spea multiplicata	Mexican Spadefoot		x		x	
Spermophilus variegatus	Rock Squirrel		x			
Sphyrapicus nuchalis	Red-naped Sapsucker		x	x	x	x
Sphyrapicus thyroideus	Williamson's Sapsucker			x	x	x
Spilogale gracilis	Western Spotted Skunk		x			
Spizella atrogularis	Black-chinned Sparrow		x			
Spizella breweri	Brewer's Sparrow		x	x	x	x
Spizella passerina	Chipping Sparrow		x	x	x	x
Stelgidopteryx serripennis	Northern Rough-winged Swallow		x	x	x	x
Stizostedion vitreum	Walleye	x				x
Streptocephalus dorothae	New Mexico Fairy Shrimp				x	x
Streptocephalus mackini	Chihuahuan Desert Fairy Shrimp				x	x
Streptocephalus sealii	Spinytail Fairy Shrimp				x	x
Streptocephalus texanus	Greater Plains Fairy Shrimp				x	x
Streptopelia decaocto	Eurasian Collared-Dove	x		x		
Strix occidentalis lucida	Mexican Spotted Owl		x		x	
Sturnella magna	Eastern Meadowlark			x		
Sturnella neglecta	Western Meadowlark			x	x	x
Sturnus vulgaris	European Starling	x		x	x	x
Sylvilagus audubonii	Desert Cottontail		x			
Sylvilagus floridanus	Eastern Cottontail		x			
Tachycineta bicolor	Tree Swallow		x	x	x	x
Tachycineta thalassina	Violet-green Swallow		x	x	x	x
Tadarida brasiliensis	Mexican Free-tailed Bat		x		x	x
Tantilla hobartsmithi	Smith's Black-headed Snake		x			
Taxidea taxus	American Badger		x			
Tayassau tajacu	Collared Peccary		x			
Thamnocephalus mexicanus	Mexican Beavertail Fairy Shrimp				x	x
Thamnocephalus platyurus	Beavertail Fairy Shrimp				x	x
Thamnophis cyrtopsis cyrtopsis	Western Black-necked Gartersnake		x		x	x
Thamnophis elegans vagrans	Wandering Gartersnake		x		x	x
Thamnophis eques megalops	Northern Mexican Gartersnake				x	x
Thamnophis rufipunctatus	Narrow-headed Gartersnake				x	
Thomomys bottae	Botta's Pocket Gopher		x			
Thomomys bottae desertorum	Pocket Gohper		x			
Thryomanes bewickii	Bewick's Wren		x	x	x	x
Tiaroga cobitis	Loach Minnow				x	
Tilapia sp.	Tilapia	x				x
Toxostoma bendirei	Bendire's Thrasher			x		
Toxostoma crissale	Crissal Thrasher		x	x	x	x
Toxostoma curvirostre	Curve-billed Thrasher			x		
Trimorphodon biscutatus lambda	Western Lyresnake		x			
Tringa melanoleuca	Greater Yellowlegs			x	x	x
Triops longicaudatus	Longtail Tadpole Shrimp				x	x
Triops newberryi	Desert Tadpole Shrimp				x	x

Attachment B
Potential Species For Habitat Types Similar to the Site

Scientific Name	Common Name	Nonnative	Habitat Type: Interior Chaparral	Habitat Type: Human Dominated Landscapes	Habitat Type: Wetlands/ Springs	Habitat Type: Streams/ Rivers
Troglodytes aedon	House Wren		x	x	x	x
Troglodytes troglodytes	Winter Wren				x	
Turdus migratorius	American Robin		x	x	x	x
Tyrannus verticalis	Western Kingbird		x	x	x	x
Tyrannus vociferans	Cassin's Kingbird		x	x	x	x
Tyto alba	Barn Owl		x	x	x	x
Urocyon cinereoargenteus	Common Gray Fox		x			
Urosaurus ornatus	Ornate Tree Lizard		x		x	x
Ursus americanus	American Black Bear		x		x	x
Uta stansburiana	Common Side-blotched Lizard		x	x		
Vermivora celata	Orange-crowned Warbler		x	x	x	x
Vermivora luciae	Lucy's Warbler		x	x	x	x
Vermivora virginiae	Virginia's Warbler		x	x	x	x
Vertigo berryi	Rotund Vertigo				x	x
Vireo bellii arizonae	Arizona Bell's Vireo		x	x	x	x
Vireo gilvus	Warbling Vireo		x	x	x	x
Vireo huttoni	Hutton's Vireo		x	x	x	x
Vireo plumbeus	Plumbeous Vireo		x	x	x	x
Vireo vicinior	Gray Vireo		x			
Xanthocephalus xanthocephalus	Yellow-headed Blackbird			x	x	x
Xantusia arizonae	Arizona Night Lizard		x			
Xantusia bezyi	Bezy's Night Lizard		x			
Xyrauchen texanus	Razorback Sucker				x	
Zapus hudsonius luteus	New Mexican Jumping Mouse				x	x
Zenaida asiatica	White-winged Dove		x	x	x	x
Zenaida macroura	Mourning Dove		x	x	x	x
Zonotrichia leucophrys	White-crowned Sparrow		x	x	x	x

* Table adapted from species list for Apache Highlands North Ecoregion in AFGD, 2006, Appendix F.

Attachment C

Sources of Ecological Exposure and Toxicity Information

Attachment C
Sources of Ecological Exposure and Toxicity Information

Receptor and Data Type	**Data Source (Listed in descending order of preferred use.)**
Plants	
Toxicity	• U.S. Environmental Protection Agency (EPA). 2003 - 2008. *Ecological Soil Screening Levels.* EPA Office of Solid Waste and Emergency Response (OSWER). URL: http://www.epa.gov/ecotox/ecossl/ • Efroymson, R.A., M.E. Will, and G.W. Suter II. 1997. *Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Terrestrial Plants: 1997 Revision.* ES/ER/TM-85/R3. Oak Ridge National Laboratory, Oak Ridge, Tennessee. • [Additional sources from scientific literature or guidance.]
Invertebrates	
Toxicity	• U.S. Environmental Protection Agency (EPA). 2003 - 2008. *Ecological Soil Screening Levels.* EPA Office of Solid Waste and Emergency Response (OSWER). URL: http://www.epa.gov/ecotox/ecossl/ • Efroymson, R.A, M.E, Will, and G.W. Suter II. 1997. *Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Processes: 1997 Revision.* Oak Ridge National Laboratory, Oak Ridge TN. ES/ER/TM-126/R2. • [Additional sources from scientific literature or guidance.]
Wildlife	
Exposure	• U.S. Environmental Protection Agency (EPA). 1993b. Wildlife Exposure Factors Handbook. 2 Vols. EPA/630/R-93/187a. U.S. Environmental Protection Agency (USEPA), Office of Research and Development, Washington, D.C. • Sample, B.E. and G.W. Suter. 1994. Estimating Exposure of Terrestrial Wildlife to Contaminants. ES/ER/TM-125. Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee. • U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM). 2004. “Development of Terrestrial Exposure and Bioaccumulation Informaion for the Army Risk Assessment Modeling System (ARAMS),” U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) Contract Number DAAD050-00-P-8365, Aberdeen Proving Ground, Maryland, 2004. • Sample, B. E., J. J. Beauchamp, R. A. Efroymson, and G. W. Suter, II. 1998a. Development and Validation of Bioaccumulation Models for Small Mammals. Oak Ridge National Laboratory, Oak Ridge TN. 89 pp. ES/ER/TM-219. • Sample, B.E., J.J. Beauchamp, R.A. Efroymson, G.W. Suter, II, and T.L. Ashwood. 1998b. Development and Validation of Bioaccumulation Models for Earthworms. Oak Ridge National Laboratory, Oak Ridge TN. 93 pp. ES/ER/TM-220 [Report, Appendices A-D]. • U.S. Environmental Protection Agency (EPA). 2003 - 2008. *Ecological Soil Screening Levels.* EPA Office of Solid Waste and Emergency Response (OSWER). URL: http://www.epa.gov/ecotox/ecossl/ • Beyer, W.N. 1990. Evaluating soil contamination. U.S. Fish and Wildlife Service. Biological Report 90(2). Washington, D.C. • Beyer, W.N. and C. Stafford. 1993. Survey and evaluation of contaminants in earthworms and in soils derived from dredged material at confined disposal facilities in the Great Lakes region. Environ. Monitor. Assess. 24:151-165. • Beyer. W. N., Connor. E. E. and Gerould, S. 1994. “Estimates of soil ingestion by wildlife.” Journal of Wildlife Management. 58, 375-82. • CAL/ECOTOX. 2007. California Wildlife Biology, Exposure Factor, and Toxicity Database (Cal/Ecotox). Online Database (http://www.oehha.org/cal_ecotox/). Accessed March 13, 2008. • [Additional sources from scientific literature or guidance.]

Attachment C
Sources of Ecological Exposure and Toxicity Information
(Continued)

Toxicity	- U.S. Environmental Protection Agency (EPA). 2003 - 2008. *Ecological Soil Screening Levels.* EPA Office of Solid Waste and Emergency Response (OSWER). URL: http://www.epa.gov/ecotox/ecossl/ - Sample, B.E., D.M. Opresko, and G.W. Suter II. 1996. Toxicological Benchmarks for Wildlife: 1996 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. 227 pp. ES/ER/TM-86/R3. - [Additional sources from scientific literature or guidance.]
Aquatic organisms	
Sediment toxicity	- MacDonald, D.D., C.G. Ingersoll and T.A. Berger. 2000. Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. *Arch. Environ. Contam. Toxicol.* 39: 20-31. - Long, E.R. and L.G. Morgan. 1990. The Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program. National Oceanic and Atmospheric Administration, National Ocean Service, Seattle, Washington. - Di Toro, D.M. and J.A. McGrath. "Technical Basis for Narcotic Chemicals and Polycyclic Aromatic Hydrocarbon Criteria. II. Mixtures and Sediments." Environ Toxicol Chem 19 (2000): 1971-1982. - Jones, D.S., G.W. Suter II, and R.N. Hull. 1997. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Sediment-Associated Biota: 1997 Revision. ES/ER/TM-95/R4. Prepared for U.S. Department of Energy, Office of Environmental Management. Oak Ridge National Laboratory, Oak Ridge, Tennessee. - [Additional sources from scientific literature or guidance.]
Water toxicity	- U.S. Environmental Protection Agency (EPA). 2008. National Recommended Water Quality Criteria. URL: http://www.epa.gov/waterscience/criteria/wqctable/ - [Additional sources from scientific literature or guidance.]

Appendix B

Interim Measures
Technical Memorandum

Interim Measures Technical Memorandum

Remedial Investigation/Feasibility Study
Iron King Mine – Humboldt Smelter Superfund Site
Dewey-Humboldt, Yavapai County, Arizona
EPA Identification No. AZ0000309013

Remedial Action Contract 2 Full Service
Contract: EP-W-06-004

Prepared for

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4	AOI Source Areas Where Dust Suppression May Be Warranted

LIST OF ACRONYMS AND ABBREVIATIONS

As	Arsenic
AOI	Area of Interest
COPC	Contaminant of potential concern
EA	EA Engineering, Science, and Technology, Inc.
EPA	U.S. Environmental Protection Agency
FS	Feasibility Study
IM	Interim measures
NPL	National Priorities List
ppb	Part(s) per billion
POE	Point-of-entry
POU	Point-of-use
PRP	Potentially Responsible Party
RI	Remedial Investigation
Site	Iron King Mine – Humboldt Smelter Superfund Site

1. INTRODUCTION

EA Engineering, Science, and Technology, Inc. (EA) has been authorized by the U.S. Environmental Protection Agency (EPA), under Remedial Action Contract No. EP-W-06-004, Task Order 0034-RICO-09MX, to conduct a Remedial Investigation/Feasibility Study (RI/FS) at the Iron King Mine – Humboldt Smelter Superfund Site (Site). EA has prepared this Interim Measures (IM) Technical Memorandum in accordance with: (1) specifications provided in the EPA Statement of Work (SOW), dated 3 March 2008 (EPA 2008); and (2) the EPA-approved EA Work Plan (Revision 01), dated 22 May 2008 (EA 2008).

This IM Technical Memorandum evaluates opportunities for implementation of interim remedial measures at the Site. In general, an IM is defined as a set of short-term actions or activities taken to quickly prevent, mitigate or remedy unacceptable risk(s) posed to human health and the environment by an actual or potential release of a hazardous substance, pollutant or contaminant.

The ultimate goal of an IM is to control or abate threats to human health and/or the environment from releases of or exposures to hazardous substances, pollutants or contaminants, and to prevent or minimize the further spread of contamination while long-term remedies are evaluated. An IM is intended to provide a partial, albeit more immediate, solution while being consistent with the final Site remedy. This IM Technical Memorandum is not an exhaustive compilation of existing data nor is it a detailed engineering evaluation and cost analysis of interim response actions. Rather, it is a preliminary assessment of known or suspected site conditions in relation to their potential environmental impacts to the neighboring community and ecology with emphasis of practical and cost-effective short- and medium-term site management strategies that can be implemented while RI activities are ongoing.

1.1 SITE BACKGROUND

The Site is located in Dewey-Humboldt, Yavapai County, Arizona (Figure 1). The Site is a combination of sources and releases from two separate facilities: the Iron King Mine property and the Humboldt Smelter property. A portion of the Town of Humboldt is situated between the mine and the smelter (Figure 2).

During the site visit that was conducted on 19 March 2008, the following Areas of Interest (AOI) were identified:

- Iron King Mine – The Iron King Mine Proper Area, Iron King Operations Area, Former Fertilizer Plant Area, and ancillary associated properties;
- Humboldt Smelter and ancillary associated properties;
- Off-site Soil in the vicinity of the Site;
- Waterways - Including the Chaparral Gulch, Galena Gulch, Aqua Fria River, and adjoining drainage channels and outfalls; and
- Ground Water - Shallow alluvial and deep bedrock ground water.

These five AOIs were combined into a single Operational Unit for the purpose of conducting the RI/FS because: (1) ore from the Iron King Mine may have been processed at Humboldt Smelter; (2) off-site migration of particulates from the Iron King Mine and Humboldt Smelter may have overlapping air-depositional areas; (3) mine tailings from the Iron King Mine may have migrated onto the Humboldt Smelter property via the Chaparral Gulch; (4) the Aqua Fria River and its contributing waterways (e.g., Chaparral Gulch and Galena Gulch) may have impacts from both the Iron King Mine and Humboldt Smelter; and (5) ground water may be impacted from both the Iron King Mine and Humboldt Smelter.

The Iron King Mine property, located west of Highway 69, occupies approximately 153 acres. The Iron King Mine property is bordered by Chaparral Gulch, to the north, Galena Gulch to the south, Highway 69 to the east, and undeveloped land to the west. The Iron King Mine was a periodically active gold, silver, copper, lead, and zinc mine from 1906 (when the mine produced fluxing ore for the Humboldt Smelter) until 1969. Ore from the Iron King Mine may have been processed at the Humboldt Smelter, which operated from the late 1800s until 1969.

The Humboldt Smelter property, located at the east end of Main Street, occupies approximately 189 acres. The smelter is situated less than 1 mile east of the Iron King Mine property. The Humboldt Smelter property is bordered by the Town of Humboldt to the west and north, the Agua Fria River to the east, and the Chaparral Gulch to the south.

The Iron King Mine property includes the following three subordinate properties (Figure 3):

- The Iron King Mine Proper Area, which consists of a large tailings pile and a plant area. In addition, there are 5 retention ponds or impoundments: Main Retention Pond, Pond 40-01A, Pond 40-02A, Pond 100-003F, and Pond 200-5S.

- The Iron King Operations Area, which historically contained at least 11 buildings, including the assay laboratory office, main office, change rooms, and the mechanical room. This property also contains multiple mine shafts, and the former Glory Hole; the latter of which has more recently been used as a landfill.

- The Former Fertilizer Plant Area includes several abandoned buildings, concrete pads, sumps, tanks, and an ore bin.

The Humboldt Smelter property consists of several abandoned buildings, a smelter stack, a tailings pile (763,000 square feet), a smelter ash pile (1,041,200 square feet), and a slag pile (456,000 square feet) (Figure 4). On-site ponds, pits, and lagoons were reportedly used for the leaching of minerals from mined ore.

Chaparral Gulch, a natural drainage channel, flows from northwest to southeast along the border of the Iron King Mine property. The gulch crosses under Highway 69, passes through a residential area, and then enters the northeast boundary of the Humboldt Smelter property, flowing through the southwest corner. A tailings dam located on the smelter property within the Chaparral Gulch has retained tailings from both the Iron King Mine and Humboldt Smelter properties. The Chaparral Gulch flows into the Agua Fria River approximately ¼ mile downstream of the Chaparral Gulch dam. The Aqua Fria River also flows from the north to the south along the eastern boundary of the Humboldt Smelter property.

Presently, the full extent of off-site soil contamination and possible ground water contamination has not been assessed. Arsenic and other metals have impacted on-site soil, sediments, surface water, and ground water at concentrations significantly above background levels. The 2006 Expanded Site Inspection revealed arsenic concentrations in ground water ranging from 1.2 parts per billion (ppb) to 306 ppb. The Federal Maximum Contaminant Level for arsenic in public drinking water is 10 ppb. At this point, the data are inconclusive regarding the Site's contribution to the arsenic concentrations detected in ground water samples, due to elevated levels of naturally-occurring arsenic in this area. Additional investigation of the ground water is required to identify possible sources of arsenic contamination.

A Potentially Responsible Party (PRP) lead removal action was completed in 2006 to remove contaminated soil from four off-site residential properties. Staff from EPA's Office of Emergency Response supervised the sampling and removal of the contaminated soil conducted by the PRP's contractor.

Portions of this Site were regulated under the Arizona Department of Environmental Quality's Voluntary Remediation Program. In September 2007, EPA received a response from Arizona Governor Napolitano consenting to the placement of the Site on the National Priorities List (NPL). On 19 March 2008, EPA formally proposed the Site to the NPL.

2. OBJECTIVE

The objective of the IM Technical Memorandum is to identify and list known sources or points of exposure (hereafter referred to as "source areas") at each AOI, based on physical features, contaminants of potential concern (COPC), and COPC exposure and transport mechanisms and to assess where one or more of the following seven general interim remedial measures categories (i.e., Items):

1. Mitigate the migration of surface water into the Chaparral Gulch and Galena Gulch;
2. Address the source areas on the Humboldt Smelter property, which may be impacting the Agua Fria River;
3. Install (point-of-use) filtration systems on private wells to prevent exposure to arsenic in drinking water;
4. Address the tailings near the dam located in the Chaparral Gulch;
5. Restrict access to the Humboldt Smelter property;
6. Apply a soil sealant or biocover to prevent windblown dust from the Iron King Mine; and

7. Address other migration or exposure pathways impacting off-site properties/receptors.

3. TECHNICAL APPROACH

Table 1 lists the AOI-specific source areas along with relevant COPC, exposure/transport mechanisms, and site features information in relation to the seven general IM categories. Factors that were considered in assessing the need for IM implementation at a particular source area included the following:

- Actual or imminent threat of exposure to hazardous substances, pollutants or contaminants by nearby human populations, ecological receptors or ecosystem food web;

- Actual or imminent threat of contamination of drinking water supplies or sensitive ecosystems;

- Hazardous substances or wastes in piles or other bulk storage that may pose an imminent threat of release;

- High levels of hazardous substances, pollutants or contaminants in predominantly surface soils that may readily migrate;

- Weather conditions that may cause hazardous substances, pollutants or contaminants to migrate or be released; and

- Other situations or factors that may pose imminent threats to public health or welfare or the environment.

As illustrated by Table 1 more than one IM category may be warranted at a particular source area. Figures 3 and 4 show the location of the known source areas within the Iron King Mine and Humboldt Smelter AOIs. These source areas may directly affect the remaining three AOI; waterways (Chaparral and Galena Gulches), Off-site Soil and Ground Water AOI (e.g., private properties) and will either be addressed indirectly by implementation of IMs at the other AOI (e.g., Off-site Soil AOI will be addressed by mitigation of potential on-site sources such as the large tailings pile) or addressed directly by one of the IM categories (e.g., off-site ground water addressed by Item 3). The IM Technical Memorandum should be reviewed in tandem with the Conceptual Understanding of the Site, prepared under separate cover, that evaluates site conditions (e.g., geology, surface water, etc.) and potential routes of exposure in more detail than is presented in this document.

For each IM category, general response actions were developed for which remedial technologies were identified as shown on Table 2. A descriptive narrative is presented in Section 4 for each technology listed in Table 2. In practice, these technologies can be subsequently scaled, tailored, or combined, as deemed appropriate in the field to achieve the required level of protection or risk reduction for each of the source areas listed on Table 1. The selected IM remedial technologies were considered if they met the following criteria:

- An IM remedial technology that is generally a less complex type of remedial response, requiring minimal design effort, and somewhat presumptive in nature, thereby negating the need for rigorous treatability study or pilot testing;
- An IM remedial technology was based on a non-emergency situation to manage the source(s) of contamination, control the exposure pathway(s) and/or control the hazard(s) to human and environmental receptors; and
- An IM remedial technology that is consistent with the concept of best management practices wherein overall improvement in site conditions is achieved.

In all cases the IM remedial technologies that were identified are not intended to circumvent the more linear remedial investigation, remedial alternatives evaluation, remedial design and remedial action processes. However, if area-specific or Site characteristics suggest that an IM designed to control or abate imminent threats or prevent or minimize the further spread of contamination was potentially viable it was identified on Table 2. If gross measurable or visible contamination to the environment is evident this also served as a threshold criterion for IM consideration. A remedial technology screen was not conducted for this IM Technical Memorandum, since the subset of either presumptive or proven technologies was purposely selected for consideration as a component of the overall Site management strategy.

As evidenced by Tables 1 and 2, there is obvious overlap of the identified remedial technologies between IM categories. This may be an important consideration for deciding the type and sequence IMs that are implemented at the Site. Section 5 evaluates the efficacy of remedial technology implementation from both a hierarchical and overall risk reduction benefit with respect to IMs for the AOI source areas. This information may be useful for subsequent site management planning purposes.

4. REMEDIAL TECHNOLOGY DESCRIPTIONS

This section provides a brief technical overview on remedial technologies for each response action listed in Table 2. As part of the descriptive narrative, each technology is assessed in terms of its effectiveness as a discrete or potential component of an IM and its implementability. Although there is overlap of remedial technologies between response actions, each technology is described only once. Descriptive narratives are general for the more conventional technologies, whereas additional technical details are provided for remedial technologies that are not as common, but are nonetheless proven to be effective in similar situations as cited herein. The list of technologies has purposely been narrowed to a subset that “make sense” from both a technical and implementation perspective and has considered that the Site is in the early stages of investigations and further refinement to the list is possible. In addition, costs, safety, and potential environmental impacts should be considered in the decision point.

TABLE 1 Summary of Site Conditions That May Be Considered for Interim Measures

Area of Interest (AOI)	**Location(s), Source(s), Point of Release(s)**	**Contaminants of Concern**	**Area or Volume of Impacted Media or Area to be Mitigated/ surface conditions**	**Primary Exposure Route or Contaminated Media Transport Mode**	**Interim Remedial Measure Categories**[i]						
					ITEM 1 - Mitigate the migration of surface water into *the Chaparral Gulch and Galena Gulch*	**ITEM 2 -** Address the source areas on the Humboldt Smelter property, which may be impacting the Agua Fria River	**ITEM 3 -** Install (point-of-use) filtration systems on private wells to prevent exposure to arsenic in drinking water	**ITEM 4 -** Address the tailings near the dam located in the Chaparral Gulch	**ITEM 5 -** Restrict access to the Humboldt Smelter property	**ITEM 6 -** Apply a soil sealant or biocover to prevent windblown dust from the Iron King Mine	**ITEM 7 -** Address other migration or exposure pathways impacting off-site properties/ receptors
IK	Large Tailings pile	Arsenic, lead, and other metals	62 acres Vegetation/ground cover is sparse Some of the surface is armored, other areas are fine powder material	Surface water runoff and erosion captured by Main Retention Pond and Pond 200-5S The eastern half generates dust with prevailing northeast winds Prior breech of tailings released sediment downstream into Chaparral Gulch that rest behind concrete Dam on Humboldt Smelter Property	Tailings pile surface water runoff collected by ponds. Pipe from Pond 200-5S flows under Highway 69 and may be directed to Chaparral Gulch Based on available data not considered for Interim Measures	Tailings present in Chaparral Gulch behind Dam due to former breech of tailings pile on Iron King property. This may be a continuing source of sediment loading to Aqua Fria River. (See Item 4)	NA	Sediment from Iron King tailings pile breech behind dam on Humboldt causes storm water runoff in Gulch to bypass Dam and is redirected downstream towards Aqua Fria River (see Upstream of concrete Dam AOI source area below)	NA	Portions of this area are susceptible to windblown erosion and dust generation **Based on available data this is considered for Interim Measures**	Possible tailings erosion along steep side slopes of tailings or another slope failure resulting in a release to Galena Gulch Based on available data not considered for Interim Measures
	Small tailings pile	Arsenic, lead, and other metals	8 acres Surface is not fine powder Vegetation/ground cover is sparse	Immediately adjacent to Chaparral Gulch, washes directly into Gulch. Not likely susceptible to wind erosion	Tailings and surface runoff wash into Gulch contribute to migration of metals-contaminated sediment **Based on available data this is considered for Interim Measures**	NA	NA	NA	NA	Portions of this area are susceptible to windblown erosion and dust generation **Based on available data this is considered for Interim Measures**	NA
	Waste rock / fertilizer plant and Glory Hole	Arsenic, lead, and other metals	30 acre Surface is fine powder processed residue material in processing area No vegetation/ground cover is present	Area (surface) is contaminated. storm water drains unchecked into Galena Gulch along southwest corner of property	Surface water erosion channeled into Galena Gulch	NA	NA	NA	NA	Portions of this area are susceptible to windblown erosion and dust generation **Based on available data this is considered for Interim Measures**	No other pathways have not been quantified
	Ironite Plant Site	Arsenic, lead, and other metals	12 acres Surface is combination of buildings, paved or armored areas and fine powder	Most of SW runoff appears to be captured by ponds 40-01A, 40-02A and 100-003F before entering into Chaparral Gulch	Not a significant issue for this site Based on available data not considered for Interim Measures	NA	NA	Na	NA	Portions of this area are susceptible to windblown erosion and dust generation **Based on available data this is**	No other pathways have not been quantified

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			Vegetation/ground cover is sparse							**considered for Interim Measures**	
	Other surface soil impacted by migration of COC	Arsenic, lead, and other metals	Not quantified	Most of remaining site likely impacted by wind blown dust of surface material Surface water runoff sediment erosion may or may not be captured, but not likely major contaminant transport mechanism	This issue has not been quantified Based on available data not considered for Interim Measures	NA	NA	NA	NA	Portions of this area are susceptible to windblown erosion and dust generation **Based on available data this is considered for Interim Measures**	No other pathways have not been quantified
	Ponds 40-01A, 40-02A, 100-003F, and 200-5S	Arsenic, lead, and other metals		These ponds receive SW flow from most of site. Most ponds allow for evaporation or infiltration	This issue has not been quantified Based on available data not considered for Interim Measures	N	NA	NA	NA	NA	NA
HS	Mine tailings	Arsenic, lead, and other metals	17.5 acres Surface is mixture of fine powder and coarser material Vegetation/ground cover is sparse	Yellow/Orange mine tailings erode into Chaparral Gulch and have filled behind the dam and is major contributor to sediment load in Galena Gulch Likely susceptible to wind erosion	Address sediment that causes surface runoff to divert around concrete Dam **Based on available data will be considered for Interim Measures**	Continued migration of sediment (i.e., tailings) along Chaparral Gulch **See Item 1**	NA	**Based on available data will be considered for Interim Measures under Item 1 and Item 4 for the "Upstream of concrete Dam" AOI/Source Area**	NA	Portions of this area are susceptible to windblown erosion and dust generation **Based on available data this is considered for Interim Measures**	Potential for dust generation **Based on available data will be considered for Interim Measures**
	Ash/Debris Piles	Arsenic, lead, and other metals	24 acres Surface is mixture of fine powder and coarser	Miscl. scattered piles of varied size material. Most of these piles are not located close to washes or Gulches	This issue has not been quantified. Based on available data not considered for Interim	This issue has not been quantified. Likely not a significant issue for this site	NA	NA	NA	Portions of this area are susceptible to windblown erosion and dust generation	Potential for dust generation **Based on available data**

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			material Vegetation/ground cover varies from pile to pile	Some piles may be susceptible to wind erosion Piles not located directly adjacent to River, Surface water pathways have not been quantified	Measures	Based on available data not considered for Interim Measures				**Based on available data this is considered for Interim Measures**	**will be considered for Interim Measures**
	Other surface soil impacted by migration of COC	Arsenic, lead, and other metals	Not quantified	Most of remaining site likely impacted by wind blown dust of surface material, Surface water runoff may not likely major contaminant transport mechanism	This issue has not been quantified Based on available data not considered for Interim Measures	NA	NA	NA	NA	Portions of this area are susceptible to windblown erosion and dust generation **Based on available data this is considered for Interim Measures**	No other pathways have not been quantified
	Slag Pile	Elevated metals (*this pile contains marginally elevated metals, but at comparatively lower levels that tailings or ash piles)*	11 acres Surface is fine coarse or crusty Vegetation/ground cover is sparse	This pile located adjacent and very close to Aqua Fria River Likely not susceptible to wind erosion Erosion potential low Surface water may leach metals and transport to stream	Not a significant issue for this site Based on available data not considered for Interim Measures	Not a significant issue for this site Based on available data not considered for Interim Measures	NA	NA	NA	NA	
	Upstream of concrete dam	Arsenic, lead, and other metals	Volume of sediment (tailings) has not been quantified	Most of sediment likely derived from tailings at IK site	**See Item 4**	**See Item 4**	NA	Tailings behind Dam divert surface water flow and do not allow for adequate surface water retention during storm runoff Sediment behind Dam is also windblown dust and downstream sediment transport issue **Based on available data this is**	NA	NA	NA

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								considered for Interim Measures			
Ground water	Well/Site specific	Arsenic, lead, and other metals	There are 10 to 15 that exceed MCLs now – including municipal well –	Some of these might not be used for domestic use –	NA	NA	**Based on available data this is considered for Interim Measures**	NA	NA	NA	NA
HS	Entire property	Arsenic, lead, and other metals			Gates, lock, bolster	NA	NA	NA	**Based on available data this is considered for Interim Measures**	NA	No other pathways have not been quantified

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[i] Bolded Red Text in table indicates actionable Items

Table 2 Interim Measures, Response Actions, and Remedial Technologies

Interim Remedial Measure	Applicable AOI/Source Areas	Response Action	Remedial Technologies
ITEM 1 - Mitigate the migration of surface water into *the Chaparral Gulch and Galena Gulch*	• Iron King Mine/Small tailings Pile • Humboldt Smelter/Tailings Pile • Humboldt Smelter/Ash Piles	Surface Water/Sediment and Erosion Control	• Silt Fence • Storm water Retention Ponds • French Drain or Interceptor Trench • Dike or Berm for Runon/Runoff Control • Slope Stabilization
	• Humboldt Smelter/Ash Piles	Excavation/Relocation	• Mechanical Excavation and Removal/Re-location on Site
ITEM 2 - Address the source areas on the Humboldt Smelter property, which may be impacting the Agua Fria River	• Humboldt Smelter/Tailings Pile	See Item 1	• See Item 1 for this site
ITEM 3 - Install (point-of-use) filtration systems on private wells to prevent exposure to arsenic in drinking water	• Off-site Private Wells	Alternate Water Supply	• Point-of-use Treatment
ITEM 4 - Address the tailings near the dam located in the Chaparral Gulch	• Humboldt Smelter [1]/ Tailings Upstream of Concrete Dam	Excavation/Relocation	• Mechanical Excavation and Removal/Re-location on-site
ITEM 5 - Restrict access to the Humboldt Smelter property	• Humboldt Smelter AOI	Institutional Controls	• Access Restrictions (e.g. fencing and signage) • Site Security • Public Education
ITEM 6 - Apply a soil sealant or biocover to prevent windblown dust from the Iron King Mine	• Iron King Mine/Small Tailings Pile • Iron King Mine/Waste rock /Fertilizer Plant and Glory Hole	Dust suppression	• Soil Sealant • Biosolids • Vegetative Cover/ Phytostabilization
ITEM 7 - Address other migration or exposure pathways impacting off-site properties/receptors	• Humboldt Smelter/Ash Piles • Humboldt Smelter/Tailings Pile	Dust suppression	• Soil sealant • Biosolids • Vegetative Cover/ Phytostabilization

Note:
[1] Does not include any Dam reconstruction activities

4.1 INSTITUTIONAL CONTROLS

Institutional controls affect site management and/or activities occurring at the site. Institutional controls do not physically alter conditions at the Site and do not reduce the toxicity, mobility, or volume of COPCs at the Site. Rather, institutional controls are used to limit the potential for exposure to COPCs, primarily through restrictions to land use or site access.

4.1.1 Site Access Restrictions (Fencing, Signage, Etc.)

Site access restrictions include property access controls, restrictions, and limitations on future Site development using passive physical restraints such as fencing, barriers or posted signs. This interim remedial measure (Item 5 on Tables 1 and 2) specifically addresses the issue of Site access restrictions for the Humboldt Smelter property. However, it is equally important that Site access restrictions be implemented and maintained (if not already in place) at any AOI source area where other types of IMs involving physical modifications or alterations that would be subject to potential vandalism or tampering. These types of unauthorized actions, in addition to being a potential health threat, would potentially reduce or negate the beneficial effects of other IMs, including their effectiveness and longevity. An example of this situation would be restricted access to human activity, such as use off all-terrain vehicles in areas where surface soil was covered, sealed, or temporary berms and erosion controls were constructed.

Control of Site access can be accomplished through installation of fencing, upgrade of existing fencing (including gates), or in some cases, conscious and deliberate effort to ensure existing fencing and gates are physically intact, maintained, and locked, accordingly. Specific AOI or AOI source areas where access controls may be warranted is dependent upon whether or not other complimentary IMs are implemented or current access restrictions are already in place.

Site access restrictions would reduce the likelihood of unauthorized access or trespassing, but will not be 100% effective if breeched or not maintained. The primary purpose of access restrictions would be to reduce or eliminate human receptor direct exposure to surficial contamination and/or destruction or interference with other on-site IMs or RI activities. Site access restrictions would not reduce the toxicity, mobility, or volume of COCs. Site access restrictions are readily implementable and should be considered a prerequisite at areas where other IMs require protection from outside physical disturbances.

4.1.2 Site Security

In addition to passive physical Site access restraints, manned security could be provided either on a part or full-time basis. While this is not typical at most sites, it may be considered, if passive measures are not effective or Site security is required on an as-needed basis.

4.1.3 Public Outreach/Education

Another cost-effective measure is open public forums, meetings and other general public notification measures such as flyers or newspaper designed to educate the local community on ongoing Site activities and the importance of restricting public access to sensitive or contaminated areas during investigation and IMs. It can be stressed that IMs taken to protect the public or reduce risk will only be effective if sites can be secured from unauthorized public access.

4.2 EXCAVATION/RELOCATION

In the context of Site IMs, mechanical excavation is considered only for situations involving targeted removal of "hot spots" or isolated ash piles/tailings/debris (Items 1 and 2 on Tables 1 and 2) that may be impacting the Chaparral or Galena Gulches, support activities for other remedial measures (e.g., retention pond enlargement/construction or slope regrading) or removal of tailings from behind the concrete Dam (Item 4 on Tables 1 and 2). These situations involve removal and relocation of material using conventional excavation equipment.

Excavated material could be placed directly onto trucks transferred to a staging area or to designated on-site location(s). It is assumed that all areas will be dry, require minimal removal/treatment of ponded water, and can be addressed utilizing standard excavation practices and equipment. Table 3 presents a preliminary list of AOI source areas where excavation/relocation may be warranted, which is somewhat dependent on whether or not other complimentary IMs are implemented.

Table 3 AOI Source Areas Where Excavation/Relocation May Be Warranted

AOI or AOI/ Source Area	Type of Excavation	Rationale
Tailings Behind Concrete Dam	Partial or complete removal of tailings to allow for additional storm water retention capacity and/or minimize dust generation	Reservoir behind Dam is full. Storm water runoff is not retained
Humboldt Smelter/Ash Piles	Removal or consolidation of any piles that may impact surface water (i.e. Gulches) or contribute to airborne dust generation	Consolidate piles into manageable graded piles with appropriate storm water and erosion control measures or reduce dust generation
General Regrading Ancillary to Other Interim Actions	In general some IMs will cause generation of silt materials from the construction of diversion channels, drainage canals, limestone channels, berms, fences and others and slope stabilization activities.	Consolidate or relocate any residual material generated from construction activities involving land re-contouring

Excavation is a well-proven and highly effective method for removing impacted material from a site. Selective excavation is highly effective for the removal of well-defined, localized volumes of contaminant-impacted material. Confirmatory sampling would be conducted to verify the effectiveness of excavation. The required services and equipment for excavation are readily available.

4.3 SURFACE WATER AND SEDIMENT EROSION CONTROL

There are several source areas that could pose a threat to the Chaparral and Galena Gulches and ultimately to the Agua Fria River. These interim remedial measures (Items 1 and 2 on Tables 1 and 2) specifically address the issue of surface water and erosion control. Surface water migration, sediment erosion, and sediment transport are potential concerns, but these pathways have not been fully quantified. In lieu of more site-specific data relative to dissolved-phase COPC transport in surface water, the more immediate issue is the transport of contaminated soil, sediment, or tailings by erosion. From a broad perspective erosion of tailings and other stockpiled granular material typically occurs along steep-side slopes (e.g., large tailings pile), and to a lesser degree along natural accumulation points down-slope of tailings or ash piles. In most cases, existing storm water control systems capture the eroded material and storm water runoff on the Iron King property. However, in the past, large-scale slope failures, such as the breech of the large tailings pile, have contributed to the filling of the reservoir behind the concrete Dam. Elsewhere across the site, obvious areas of incidental erosion include the small tailings pile on the Iron King property that is immediately adjacent to Chaparral Gulch, portions of the waste rock area adjacent to Galena Gulch, yellow ore pile on the Humboldt Property immediately adjacent to Chaparral Gulch, and slag pile adjacent to the Agua Fria River. Erosion from ash piles on the Humboldt Property may also be a continuing issue. Since the erosion and accumulation points have not been fully quantified, it is difficult to identify locations where IMs can be implemented most effectively. Based on present site data, the immediacy of new or upgrades to storm water and sediment erosion controls may not be apparent under current or static conditions. However, it is worth noting that any other type of IM implemented across the Site that reduces the infiltration capacity (e.g., soil sealing or application of a cover), or any land re-contouring may require new or upgraded sediment and erosion controls during and pursuant to the IM construction activities. For example, a reduction of the infiltration capacity of the large tailings pile due to a particular type of soil sealant may increase surface water runoff and side-slope erosion that would commensurately require upgrades to the existing surface water and erosion control system. Whether storm water and sediment erosion controls are implemented as a standalone IM or as an ancillary component to another type of response action, the following conventional engineering controls should be considered:

- Sediment erosion control berms and silt curtains;
- Construction of diversion channels or rip-rapped channels;
- Construction of silt traps inside channels at regular intervals to minimize and avoid the silt materials from flowing into the Gulches or river;
- Slope stabilization of selected areas;
- Construction of new or expanding existing surface water retention ponds; and
- Construction of limestone channels, step pools, or basin to neutralize the acidic water.

4.4 ALTERNATE WATER SUPPLY (POINT-OF-USE SYSTEMS)

Arsenic has been identified as a COPC in off-site ground water. The nature and extent as well as the physical and geochemical mechanisms have not been fully defined. However, Arsenic is commonly found in water as arsenate (As [V]) or the reduced arsenite ion (As [III]). The presence of oxidizing or reducing conditions in water bodies determines the oxidation state of arsenic. At pH values common in ground water , arsenite is in its neutral form, making species in the +3 oxidation state more mobile and generally more toxic. Arsenate is negatively charged at most drinking water pH levels, and, as a result, it is often more easily removed by treatment systems.

In-home treatment devices come in two sizes. Point-of-use (POU) devices are small treatment units that are commonly located under one or more sinks within a home. These devices treat only the water used at the tap and typically produce only a few gallons of potable water per day. Water used for non-potable uses, such as washing and bathing, are not treated by POU systems. Point-of-entry (POE) devices are larger systems designed to treat all of the water used within the home.

Because the negative health effects of arsenic are caused by ingestion, a POU device will reduce the majority of the health risk associated with arsenic-contaminated water. These devices are also generally less expensive and easier to maintain than a POE devices.

There are two main types of POU systems commonly available today. Both adsorptive media and reverse osmosis systems are capable of removing arsenic from drinking water. However, the effectiveness of the treatment process depends primarily on raw water quality and water use. Education of the end users will also be an important part of the utilization of these systems to assure proper maintenance, so that they are effective for their intended use.

Adsorptive media are aluminum- or iron-based media. In activated alumina adsorptive media processes, arsenic is adsorbed onto the surface of an aluminum-based media as the water passes through the device. When all of the adsorption sites are filled, the media is spent and must be replaced. Factors that affect the efficiency of activated alumina processes include pH (optimal range is 5.5-6.0) and arsenic speciation (As [III]) is often not efficiently removed). Particulates and colloids can also cause media fouling.

Ferric hydroxide-based media are also used in adsorptive media systems. As with activated alumina, arsenic ions are adsorbs to the media and once all the adsorption sites are filled, the media must be replaced. Water quality parameters can affect the efficiency of a ferric hydroxide-adsorptive media system. Particulates or colloids in the water can also lead to fouling of the media.

Advanced adsorptive media processes are able to operate over a wide range of water qualities and they can remove both As (III) and As (V). In addition to removing arsenic, adsorptive media processes also reduce heavy metal concentrations.

In reverse-osmosis (RO) treatment, untreated water flows under pressure past a semi-permeable membrane. The membrane allows treated water to flow through, while arsenic and other contaminants are retained and disposed of as a concentrated solution. RO systems are capable of effectively removing As (V), but do not typically have the same efficiency with respect to As (III). Turbidity, iron, and manganese can adversely impact RO systems. Most POU RO units are equipped with pre- and post-filtration units. Pre-filtration serves to reduce solids loading and extend the life of the membrane while post-filtration is used as a final polishing step. The most common membranes used in RO processes are cellulose acetate, thin-film polyamide composites, and sulfonated polysulfone.

4.5 DUST SUPPRESSION

High wind events combined with a semi-arid environment contribute to occasional erosion of the mine tailings piles, creating potentially contaminated fugitive dust blowing off of the Site. Exposed surface layers containing fine grain particles of wastes discarded from mineral processors are subject to regular erosion by wind and water. Interim remedial measure Items 6 and 7 on Tables 1 and 2 specifically address the issue of dust suppression.

There are many techniques controlling fugitive dust emissions. This group of response action technologies by-in-large is a subset of containment technologies specifically tailored, among other objectives, to prevent surface materials from being eroded and subsequently suspended and carried by wind (or carried by storm water). The technologies identified for this response action range from ones that may be consistent with a permanent remedy, such as application of biosolids to establish plant growth for stabilization of tailings material, to more short-term temporary measures, such as application of a soil sealant. Table 4 summarizes AOI source areas where dust suppression may be warranted.

Table 4 AOI Source Areas Where Dust Suppression May Be Warranted

AOI/Source Area	Dust Suppression Activities	Rationale
Large Tailings Pile	Partial or complete sealing on top and sloped areas for tailings to minimize dust generation and to allow infiltration. Load-bearing sealed surface not necessary.	Major dust generating surface
Spot sealing of surfaces such as waste rock area, small isolated piles of stockpiled fines or other areas where dust with entrained high level metals	Surface tack coat only	Secondary dust generation surfaces

4.5.1 Biosolids Application to Support Stable Vegetative Covers

Biosolids are the dark, organic, and nutrient-rich materials produced as a byproduct of current wastewater treatment practices. Biosolids are also used to improve fertility and structure of disturbed lands and mine tailings. Biosolids can provide much needed nutrients and organic matter to these barren materials by increasing microbial activity and nutrient cycling for sustained plant growth. In Arizona, the major goal of mine tailings reclamation is to facilitate plant establishment to control off-site dust and sediment runoff. For example, during periods of high winds and dryness, dust with high concentrations of As, lead (Pb), and other metals can be transported into residential areas, exposing its population to these toxic chemicals.

Similarly, during high rainfall periods, exposed mine tailing sediments can wash off-site and contaminate surface waters and wildlife. The application of biosolids to disturbed land is best determined by local soil, plant, and climatic conditions. For example, the addition of biosolids to disturbed lands in arid and semi-arid climates produces rich soil nutrient conditions favorable to microbial growth and nutrient cycling.

Biosolids have proven effective in the reclamation and treatment of former mining sites. They are able to cost-effectively establish a vegetative cover on contaminated lands and limit the movement of metals through erosion, leaching, and wind. A cap is formed upon the application of biosolids because their permeability and water adsorption characteristics prevent water contact with contaminants in the underlying soil. Depending on the amendments added, biosolids can serve many purposes, including pH control, metal control, and fertilization. Their adaptability allows them to conform to the specific characteristics of any reclamation site.

With few exceptions, the application rates of biosolids range between 5-20 tons of dry biosolids per acre, although higher application rates have been evaluated to produce an “instant soil.” When reclaiming mine sites, biosolids are almost always applied with lime, either pre-mixed or in stages. Lime serves to increase the pH of the soil rapidly, which may be a temporary condition.

A biosolids application would typically be advantageous for longer-term remedial actions where there would be a low likelihood of short-term modifications to surface contours following biosolids application. Presumably a desire to establish a sustainable vegetation growth would be another important factor to selection of biosolids application, and would only be used on larger source areas. Biosolids may be a very good candidate for long-term or permanent remedy, but it may not be the most practical or cost-effective for a short-term IM. Ideally, a final remedy may employ a biosolids application to promote growth of a sustainable vegetative cover that was placed on a stable, properly graded material, and where every opportunity for consolidation of smaller waste streams was considered as part of the remedy.

4.5.2 Soil Sealants

Soil sealants are highly effective against the problems associated with dust pollution and soil erosion. A soil sealant is an excellent alternative to the costly options of excavating and replacing unsuitable soils or installing other types of expensive liner systems. Most sealants are easy to use and require no special equipment or handling procedures.

The types of sealants range from soluble water-based formulations, salts, petroleum-based, and copolymers, and can include sulfuric acid, calcium chloride, enzymes, lignosite, and polyacrylamides. The type of sealant is dependent on the desired longevity, which can range from days to years based on type and application rates. Consideration of the type of sealant is based on cost, toxicity, compatibility with long-term remedial objectives, and site conditions (weather, climate, soil conditions, and presence of other in-place engineering controls). Application is typically a sprayed dilute liquid (water and the sealant); however, some sealants can be spread dry and subsequently watered down to complete the effort.

Erosion is controlled by creating a three-dimensional cap or surface crust, depending on the application rates. Heavier application rates can generate qualities similar to cement, which are load-bearing, and useful for soil solidification and stabilization found in road building. By adjusting the application rates, soil sealants can remain effective from weeks to several years. Many of the commercially available formulations are biodegradable and environmentally safe to use. Depending on sealant type, permeability of the treated material can either be increased (by

coagulation of fine particles into larger ones *in situ)* or decreased by filling in porous space with sealant.
A typical application may involve mixed sealant reagent with water and applied over the surface of the area of coverage with one or more applications. In most cases, all that is needed is a water truck or other means of even distribution of the diluted sealant. Hydroseeding often contains a latex agent or other binder and seed can be presoaked to speed germination. Another advantage to some soil sealants is they can be simultaneously applied with seed. For example, native vegetation seed could be spread over a designated area and covered with a thin layer of composted material, soil, or biosolids. The sealant acts like a plastic wrap, coating the area trapping the moisture into the soil. It allows the seeds to germinate faster. Water could still be applied to the surface, which would penetrate into the soil. When some sealants are used in sufficient quantities, it can ultimately transform the surface of the stockpiled material into an impermeable moisture resistant liner.

4.5.3 Phytostabilization

Phytostabilization is a common practice used to revegetate spoiled mine lands to prevent soil erosion and deposition of contaminated soils in streams and nearby lands. Phytotechnologies use plants to contain, stabilize, reduce, detoxify, and degrade contaminants in soil, ground water, surface water, or sediments. The EPA defines it as:

1. Immobilization of a contaminant in soil through adsorption and accumulation by roots, adsorption onto roots, or precipitation within the root zone of plants; and

2. Use of plants and plant roots to prevent contaminant migration via wind and water erosion, leaching, and soil dispersion.

Ideal plants for this technique use metal-tolerant, drought-resistant, fast-growing crops that can also grow in nutrient-deficient soils. The advantages are that it is a relatively inexpensive technique, soils do not need to be removed, ecosystem restoration is enhanced, and disposal of hazardous materials or biomass is not required.

The application of biosolids fits well with this phytoremediation technique as it provides necessary fertilizing agents and aids in microorganism establishment. Although biosolids limit the phytoavailability and bioavailability of toxic metals, they do not remove metal contaminants from the soil. Their application serves to control the mobility of heavy metals and various other contaminants, such as sulfates, through the soil. When combined with phytotechnologies, however, biosolids could not only contain contaminants, but also provide higher degrees of extraction than that offered by typical vegetative covers.

For purposes of the IMs assessment, the primary objective is to stabilize the fine-grained material and reduce erosion. Any fortuitous removal of metals from the surface or reduction in infiltration or surface water runoff was not considered as a primary factor in determining whether or not to retain this remedial technology for the short-term consideration. The application of biosolids to remediate mining sites is considered an innovative technology; however, unlike many others, it can be used effectively and efficiently at the current state of the technology. Biosolids technology is already available.

5. PRELIMINARY EVALUATION OF RESPONSE ACTIONS

Remedial technologies for the resolution of the seven interim remedial measures are shown in Table 2. Many of the remedial technologies solve more than one of the interim remedial measures, and some are so important that the failure to implement the technology could easily prevent or undo any benefits from other technologies. Consequently this section is provided as an initial prioritization effort for consideration during the implementation of any of these remedial measures. The suggested priority for these technologies is as follows:

1. Institutional Controls—Without appropriate institutional controls such as restricted Site access, the benefits of many of the remedial efforts, such as dust suppression, could be rendered moot.

2. Dust Suppression—A targeted implementation of dust suppression technologies at both the Iron King Mine and Humboldt Smelter areas will assist in achieving several of the interim remedial measures, by limiting airborne dissemination of contaminated particles as well as ameliorating overland flow of contaminated soil into the adjacent ditches and gulches.

3. Erosion Control—Adequate erosion control, combined with dust suppression will assist in limiting further contamination of Chaparral and Galena Gulch, as well as the Agua Fria River.

A brief discussion of the prioritization of these remedial technologies follows.

5.1 INSTITUTIONAL CONTROLS

The initiation of institutional controls to restrict Site access are critical to the successful implementation of any remedial measure. An effective public education program will serve multiple purposes. It will educate the public of the physical and chemical dangers associated with traversing either the Iron King Mine or Humboldt Smelter areas. In addition, it will allow for the introduction of the public of proposed security measures, be they signage, security fencing or site security. As noted earlier, without effective site management, many of the physical remedial technologies (e.g. dust suppression and erosion control) can be seriously compromised.

5.2 DUST SUPPRESSION

Regardless of the dust suppression technique chosen (soil sealant, biosolids, or phytostabilization), once the site is secure, it is second most important priority. Without control of dust, any remedial effort can be negated by a single dust storm. Properties in Dewey-Humboldt that have been cleaned up could be re-contaminated, and overland flow can move contaminants from the tailings piles into adjacent ditches and gulches. More than one type of dust suppression technology may be used, as well as others not listed in the IM Technical Memorandum, such as wind barriers or tarps.

5.3 EROSION CONTROL

Upon the successful control of surface dust in tailings piles at Iron King Mine and Humboldt Smelter, appropriate erosion control for the infrequent yet significant storm events is important. The use of a combination of storm water collection, along with slope stabilization and silt fencing, should limit the overland flow of contaminants from the sites into the adjacent ditches, gulches, and rivers.

5.4 OTHER RESPONSE ACTIONS

The prioritization of the above response actions is not intended to minimize the importance of other actions, such as excavation or relocation of contaminated material or providing an alternate water supply. This prioritization serves only to indicate a preliminary assessment of the order to tackle the complex response actions necessary to respond to the interim remedial measures necessary at Iron King Mine and Humboldt Smelter areas.

REFERENCES

EA Engineering, Science, and Technology, Inc. 2008. "Remedial Investigation/ Feasibility Study Work Plan for Iron King Mine – Humboldt Smelter Superfund Site (Revision 01), Dewey-Humboldt, Yavapai County, Arizona, EPA Identification No. AZ0000309013." 22 May.

U.S. Environmental Protection Agency. 2008. "RAC II Statement of Work for Remedial Investigation/Feasibility Study (RI/FS), Iron King Mine – Humboldt Smelter Superfund Site, Dewey-Humboldt, Yavapai County, Arizona." 3 March.

FIGURES

Appendix C

Uniform Federal Policy for Quality Assurance Project Plans Worksheets

QAPP Worksheet #1
Title and Approval Page

Site Name/Project Name: Iron King Mine – Humboldt Smelter Superfund Site

Site Location: Dewey-Humboldt, Yavapai County, Arizona

Document Title: Quality Assurance Project Plan for Iron King Mine – Humboldt Smelter Superfund Site

Lead Organization: U. S. Environmental Protection Agency (EPA) Region 6

Preparer's Name and Organizational Affiliation: Amber Mason, EA Engineering, Science, and Technology, Inc.

Preparer's Address and Telephone Number:
405 South Highway 121
Building C, Suite 100
Lewisville, Texas 75067
(972) 315-3922

Preparation Date (Month/Year): July 2008

Investigative Organization's Project Manager/Date: Doug McReynolds
Signature

Printed Name/Organization: **Doug McReynolds / EA Engineering, Science, and Technology, Inc.**

Investigative Organization's Project QA Office: ______________________
Signature

Printed Name/Organization: **David S. Santoro, P.E., L.S / EA Engineering, Science, and Technology, Inc.**

Approval Signatures/Dates: ______________________
Signature

Printed Name/Title: **Leah Butler / EPA Region 9 Task Order Monitor**

Approval Authority: **EPA Region 9 via EPA Region 6 Remedial Action Contract 2**

Document Control Number: __Unavailable__

QAPP Worksheet #2
QAPP Identifying Information

Site Name/Project Name: Iron King Mine – Humboldt Smelter Superfund Site

Site Location: Dewey-Humboldt, Yavapai County, Arizona

Site Number/Code: N/A

Operable Unit: 00

Contractor Name: EA Engineering, Science, and Technology, Inc.

Contractor Number: N/A

Contract Title: EPA Region 6 Remedial Action Contract 2 Full Service / Contract: EP-W-06-004

Work Assignment Number: Task Order 0034

Guidance Used To Prepare QAPP: Uniform Federal Policy for Quality Assurance Project Plan Version 1, March 2005.

Regulatory Program: Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)

Approval Entity: EPA Region 9 via EPA Region 6 Remedial Action Contract 2

Data Users: EPA Region 9 and designees

The QAPP is (select one): Generic (or) X - Project Specific

Scoping Session Date(s): 10 March 2008

QAPP Worksheet # 2
QAPP Identifying Information (continued)

Required QAPP Element(s) and Corresponding QAPP Section(s)	Required Information	QAPP Worksheet Number
Project Management and Objectives		
2.1 Title and Approval Page	- Title and Approval Page	1
2.2 Document Format and Table of Contents 2.2.1 Document Control Format 2.2.2 Document Control Numbering System 2.2.3 Table of Contents 2.2.4 QAPP Identifying Information	- Table of Contents - QAPP Identifying Information	2
2.3 Distribution List and Project Personnel Sign-Off Sheet 2.3.1 Distribution List 2.3.2 Project Personnel Sign-Off Sheet	- Distribution List - Project Personnel Sign-Off Sheet	3-4
2.4 Project Organization 2.4.1 Project Organizational Chart 2.4.2 Communication Pathways 2.4.3 Personnel Responsibilities and Qualifications 2.4.4 Special Training Requirements and	- Project Organizational Chart - Communication Pathways - Personnel Responsibilities and Qualifications Table - Special Personnel Training Requirements Table	5-8
2.5 Project Planning/Problem Definition 2.5.1 Project Planning (Scoping) 2.5.2 Problem Definition, Site History, and Background	- Project Planning Session Documentation (Refer to Work Plan) - Project Scoping Session Participants Sheet - Problem Definition, Site History, and Background - Site Maps (historical and present) - Refer to Figures in SAP	9-10
2.6 Project Quality Objectives and Measurement Performance Criteria 2.6.1 Development of Project Quality Objectives Using the Systematic Planning Process 2.6.2 Measurement Performance Criteria	- Site-Specific PQOs - Measurement Performance Criteria Table	11 - 12
2.7 Secondary Data Evaluation	- Sources of Secondary Data and Information - Secondary Data Criteria and Limitations Table	13
2.8 Project Overview and Schedule 2.8.1 Project Overview 2.8.2 Project Schedule	- Summary of Project Tasks - Reference Limits and Evaluation Table - Project Schedule/Timeline Table	14 - 16
Measurement/Data Acquisition		
3.1 Sampling Tasks 3.1.1 Sampling Process Design and Rationale 3.1.2 Sampling Procedures and Requirements 3.1.2.1 Sampling Collection Procedures 3.1.2.2 Sample Containers, Volume, and Preservation 3.1.2.3 Equipment/Sample Containers Cleaning and Decontamination Procedures 3.1.2.4 Field Equipment Calibration, Maintenance, Testing, and Inspection Procedures 3.1.2.5 Supply Inspection and Acceptance Procedures 3.1.2.6 Field Documentation Procedures	- Sampling Design and Rationale - Sample Location Map -- Refer to Figures in SAP - Sampling Locations and Methods/ SOP Requirements Table - Analytical Methods/SOP Requirements Table - Field Quality Control Sample Summary Table - Sampling SOPs - Project Sampling SOP References Table - Field Equipment Calibration, Maintenance, Testing, and Inspection Table	17-22
3.2 Analytical Tasks 3.2.1 Analytical SOPs 3.2.2 Analytical Instrument Calibration Procedures 3.2.3 Analytical Instrument and Equipment Maintenance, Testing, and Inspection Procedures 3.2.4 Analytical Supply Inspection and Acceptance Procedures	- Analytical SOPs - Analytical SOP References Table - Analytical Instrument Calibration Table - Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table	23-25

QAPP Worksheet # 2
QAPP Identifying Information (continued)

Required QAPP Element(s) and Corresponding QAPP Section(s)	Required Information	QAPP Worksheet Number
3.3 Sample Collection Documentation, Handling, Tracking, and Custody Procedures 3.3.1 Sample Collection Documentation 3.3.2 Sample Handling and Tracking System 3.3.3 Sample Custody	- Sample Collection Documentation Handling, Tracking, and Custody SOPs - Sample Container Identification - Sample Handling Flow Diagram - Example Chain-of-Custody Form and Seal	26-27
3.4 Quality Control Samples 3.4.1 Sampling Quality Control Samples 3.4.2 Analytical Quality Control Samples	- QC Samples Table - Screening/Confirmatory Analysis Decision Tree	28
3.5 Data Management Tasks 3.5.1 Project Documentation and Records 3.5.2 Data Package Deliverables 3.5.3 Data Reporting Formats 3.5.4 Data Handling and Management 3.5.5 Data Tracking and Control	- Project Documents and Records Table - Analytical Services Table - Data Management SOPs	29-30
Assessment/Oversight		
4.1 Assessments and Response Actions 4.1.1 Planned Assessments 4.1.2 Assessment Findings and Corrective Action Responses	- Assessments and Response Actions - Planned Project Assessments Table - Audit Checklists - Assessment Findings and Corrective Action Responses Table	31-32
4.2 QA Management Reports	- QA Management Reports Table	33
4.3 Final Project Report		NA
Data Review		
5.1 Overview		NA
5.2 Data Review Steps 5.2.1 Step I: Verification 5.2.2 Step II: Validation 5.2.2.1 Step IIa Validation Activities 5.2.2.2 Step IIb Validation Activities 5.2.3 Step III: Usability Assessment 5.2.3.1 Data Limitations and Actions from Usability Assessment 5.2.3.2 Activities	- Verification (Step I) Process Table - Validation (Steps IIa and IIb) Process Table - Validation (Steps IIa and IIb) Summary Table - Usability Assessment	34-37
5.3 Streamlining Data Review 5.3.1 Data Review Steps To Be Streamlined 5.3.2 Criteria for Streamlining Data Review 5.3.3 Amounts and Types of Data Appropriate for Streamlining		NA

QAPP Worksheet #3
Distribution List

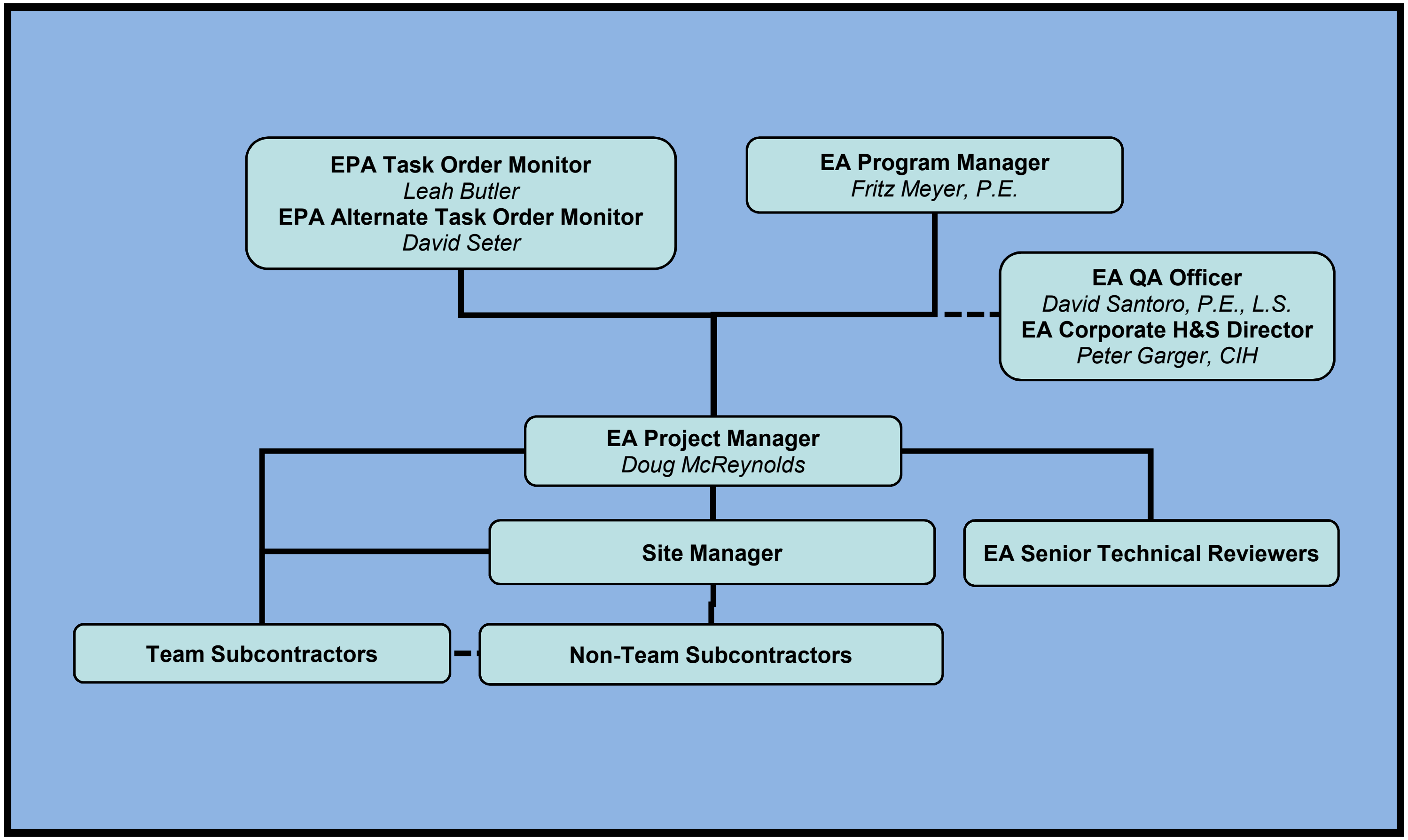
QAPP Recipients	Title	Organization	Telephone Number	Fax Number	E-mail Address	Document Control
Michael Pheeny	EPA Region 6 Contracting Officer	EPA Region 6	214-665-2798	214-665-8505	pheeny.michael@epamail.epa.gov	Letter Only
Rena McClurg	EPA Region 6 Project Officer	EPA Region 6	214-665-8314	214-665-6660	mcclurg.rena@epamail.epa.gov	Letter Only
Leah Butler	EPA Region 9 Task Order Monitor	EPA Region 9	415-972-3199	415-947-3528	butler.leah@epamail.epa.gov	1 Original + 3 Electronic Copies
Fritz Meyer	EA Engineering Program Manager	EA Engineering	410-527-2412	410-771-1625	fmeyer@eaest.com	Letter Only Via E-mail
Jeff Hills	EA Engineering Financial Manager	EA Engineering	410-527-2447	410-771-1625	jhills@eaest.com	Letter Only Via E-mail
Doug McReynolds	EA Engineering Project Manager	EA Engineering	972-459-5046	972-315-8930	dmcreynolds@eaest.com	Original and Electronic Copy
File	EA Document Control File	EA Engineering	Not Applicable	Not Applicable	Not Applicable	Original and Electronic Copy

QAPP Worksheet #4
Project Personnel Sign-Off Sheet

Oranization: EA Engineering

Project Personnel	Title	Telephone Number	Signature	QAPP Approval Date
Fritz Meyer	EA Program Manger	972-459-5046		18 July 2008
Dave Santoro	EA Quality Assurance Officer	410-584-7000	Dave Santoro	18 July 2008
Doug McReynolds	EA Project Manager	972-459-5046	Doug McReynolds	18 July 2008

QAPP Worksheet # 5
Project Organization Chart



QAPP Worksheet #6
Communication Pathways

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure (Timing, Pathways, etc.)
Any variances to EPA approved Work Plan	EPA Region 6 Contracting Officer	Michael Pheeny	214-665-2798	Communication relayed through Contractor Program or Financial Manager
Any variances to EPA approved Work Plan	EPA Region 6 Project Officer	Rena McClurg	214-665-8314	Communication relayed through Contractor Program or Financial Manager
EPA direction on implmentation of EPA approved Work Plan	EPA Region 9 Task Order Monitor (TOM)	Leah Butler	415-972-3199	Implementation of and/or deviations from the SAP/QAPP must be approved by EPA in advance
Program Management project oversight and communication	Contractor Program Manager	Fritz Meyer	410-527-2412	Communication with EPA regarding EPA approved Work Plan issues
Program Management financial oversight and communication	Contractor Financial Manager	Jeff Hills	410-527-2447	Communication with EPA regarding EPA approved Work Plan issues
Manage all project phases per EPA direction	Contractor Project Manager	Doug McReynolds	972-459-5046	Commication with EPA Region 9 TOM regarding EPA project direction
Provide guidance on issues related to quality assurance aspects of project	Contractor QA Officer	Dave Santoro	410-584-7000	Communication with Contrractor Project Manager and Program Manager regarding issues realated to quailty assurance

QAPP Worksheet #7
Personnel Responsibilities and Qualifications

Name	Title	Organizational Affiliation	Responsibilities	Education and Experience Qualifications
Fritz Meyer	Program Manager	EA Engineering	Oversees program management	B.S., Civil Engineering; 26 yrs exp.
Jeff Hills	Financial Manager	EA Engineering	Oversees financial management	M.B.A., Management; M.S., Civil Engineering; B.S., Civil Engineering; 23 yrs. exp.
Lou Barinka	Deputy Program Manager	EA Engineering	Senior technical reviewer of all deliverables	M.B.A.., Management; M.S., Environmental Engineering; B.S., Environmental Engineering; 27 yrs exp.
Doug McReynolds	Project Manager Senior Techical Reviewer - Human Health Risk Assessment	EA Engineering	Manages all phases of project Review/oversight of human health risk assessment	M. S., Environmental Toxicology; B.S., Chemistry; 10 yrs exp.
Dave Santoro	Project QA Officer	EA Engineering	Quality assurance oversight	B.S., Agricultural Engineering; 35 yrs exp.
Pete Garger	Corporate Health and Safety Director	EA Engineering	Coporate H&S Director	ScM., Environmental Health Science; B.A., Chemistry; 27 yrs exp.
Paul Caprio	Senior Technical Reviewer - Geology	EA Engineering	Review/oversight geology related aspects of project	B.S., Geology, 30 yrs exp.

QAPP Worksheet #7
Personnel Responsibilities and Qualifications

Name	Title	Organizational Affiliation	Responsibilities	Education and Experience Qualifications
Frank Barranco	Senior Technical Reviewer - Hydrogeology	EA Engineering	Review/oversight hydrogeology related aspects of project	Ph.D., Chemistry and Environmental Management; M.S., Geology; B.S., Geology; 21 yrs exp.
James Wathen	Senior Technical Reviewer - Engineering	EA Engineering	Review/oversight engineering related aspects of project	B.S., Civil Engineering; 31 yrs. exp.
Joe Neubauer	Senior Technical Reviewer - Ecological Risk Assessment	EA Engineering	Review/oversight engineering related aspects of project	M.S., Marine Biology; B.A., Biology; 16 yrs. exp.
Bob Newman	Senior Technical Reviewer - Air	EA Engineering	Review/oversight engineering related aspects of project	M. S., Environmental Engineering; B.S. Environmental Science; 25 yrs exp.
Dan Hinckley	Project Chemist	EA Engineering	Project Chemist	Ph.D., Marine Chemsitry; M.S., Environmental Chemistry; B.S., Chemistry; 25 yrs. exp.
Luis Vega	Demonstration of Methods Applicability Manager	EA Engineering	Oversight of Demonstration of Methods Applicability	B.S., Biology; 17 yrs exp.
Tim Startz	Air Sample Manager	EA Engineering	Oversight of Air Sampling and Air Monitoring	B.B.A., Management; M.S., Environmental Engineering; 16 yrs exp.
Amber Mason	Sample Manager and Data Manager	EA Engineering	EPA Region 9 or CLP Laboratory Coordinator and Data Manager	M. S., Environmental Science; B.S., Biology; 5 yrs exp.
Jose Flores	Field Team Leader	EA Engineering	Oversight of field sample collection	B. S., Enivronmental Science; 5 yrs exp.

*Resumes are on file at EA Engineering and are available upon request.

QAPP Worksheet #8
Special Personnel Training Requirements Table

Project Function	Specialized Training - Title or Description of Course	Training Provider	Training Date	Personnel/Groups Receiving Training	Personnel Titles/Organizational Affiliation	Location of Training Records/Certificates
40 Hour OSHA Training	40 Hour OSHA 8 Hour Refresher	EA Engineering	Single Event	All field staff	All field staff	Certificates will be available at the Command Post on request
8 Hour OSHA Supervisory Training	8 Hour OSHA Supervisory Training	EA Engineering	Yearly	Doug McReynolds Tim Startz Luis Vega Amber Mason Jose Flores	Project Manager Site Manager Field Sample Manager Field Team Leader	Certificates will be available at the Command Post on request
X-Ray Fluorescence	Radiation Safety/DOT Training for the Thermo Fisher Scientific NITON Analyzers	Anlytical Training Consultants, Inc.	17-Jan-2008	Luis Vega Amber Mason Jose Flores	Demonstration of Method Applicability Manager Field Sample Manager Field Team Leader	Certificate will be available at the Command Post on request
Asbestos Sampling	Arizona Certified Asbestos Inspector	--	--	To be determined	To be determined	Certificate will be available at the Command Post on request
Radiation Survey	Radiation Safety Training Course	Extension with Texas A&M University	June 2006	Doug McReynolds	Project Manager	Certificate will be available at the Command Post on request
FORMS II Lite	Region 6 Conract Laboratory Program Training	USEPA Environmental Services Branch	8-10 May 2008	Amber Mason Jose Flores	Field Sample Manager	EA Engineering: Certificates available on request

QAPP Worksheet #9
Project Scoping Session Participants Sheet

Project Name: Iron King Mine - Humboldt Smelter

Site Name: Iron King Mine - Humboldt Smelter Superfund Site

Site Location: Dewey-Humboldt, Yavapai County, Arizona

Projected Date(s) of Sampling: August - September 2008

Project Manager: Doug McReynolds

Date of Session: Scoping meeting held on 10 March 2008. Participants included individuals listed below.

Scoping Session Purpose: Plan Project

Name	Title	Affiliation	Phone #	E-mail Address
Michael Pheeny	EPA Region 6 Contracting Officer	EPA Region 6	214-665-2798	pheeny.michael@epa.gov
Rena McClurg	EPA Region 6 Project Officer	EPA Region 6	214-665-8314	mcclurg.rena@epa.gov
Angela Commisso	EPA Region 9 Project Officer	EPA Region 9	415-972-3198	commisso.angela@epa.gov
Leah Butler	EPA Region 9 Task Order Monitor	EPA Region 9	415-972-3199	butler.leah@epamail.epa.gov
Dave Seter	EPA Region 9 Alternate Task Order Manager	EPA Region 9	415-972-3250	seter.david@epa.gov
Fritz Meyer	Program Manager	EA Engineering	410-527-2412	fmeyer@eaest.com
Jeff Hills	Financial Manager	EA Engineering	410-527-2447	jhills@eaest.com
Lou Barinka	Deputy Program Manager	EA Engineering	972-459-5023	lbarinka@eaest.com
Doug McReynolds	Project Manager	EA Engineering	972-459-5046	dmcreynolds@eaest.com

Comments, decisions, and action items in the scoping meeting were incorporated in the EPA approved workplan.

QAPP Worksheet #10
Problem Definition

The problem definition and/or environmental questions for this site are provided in Section 1 of the Sampling and Analysis Plan.

QAPP Worksheet #11
Project Quality Objectives/Systematic Planning Process Statements

The project quality objectives/systematic planning process statements are provided in Section 1 of the Sampling and Analysis Plan.

QAPP Worksheet #12
Measurement Performance Criteria 12-1

Matrix:	Soil/Sediment
Analytical Group:	TAL Metals (including Mercury and Cyanide)
Concentration	Low-Medium-High

Sampling Procedure	Analytical Method/SOP	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
S-6 S-7	ILM05.4 SW-846 6010	Accuracy/ Contamination	< Reporting Limit	Method Blank	A
		Accuracy	% Recovery Consistent with ILM05.4	Laboratory Control Sample (Blank Spike)	A
		Precision and Accuracy	% Recovery RPD Consistent with ILM05.4	Matrix Spike/Matrix Spike Duplicate	A
		Matrix Interference	1:5 Dilution < 10 % RPD	Serial dilution	A

QAPP Worksheet #12
Measurement Performance Criteria 12-2

Matrix:	Aqueous
Analytical Group:	TAL Metals (including Mercury and Cyanide)
Concentration	Low-Medium-High

Sampling Procedure	Analytical Method/SOP	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
S-3 S-4 S-5	ILM05.4 SW-846 6010	Accuracy/ Contamination	< Reporting Limit	Method Blank	A
		Accuracy	% Recovery Consistent with ILM05.4	Laboratory Control Sample (Blank Spike)	A
		Precision and Accuracy	% Recovery RPD Consistent with ILM05.4	Matrix Spike/Matrix Spike Duplicate	A
		Matrix Interference	1:5 Dilution < 10 % RPD	Serial dilution	A

QAPP Worksheet #12
Measurement Performance Criteria 12-3

Matrix:	Soil/Sediment
Analytical Group:	VOC
Concentration	Low-Medium-High

Sampling Procedure	Analytical Method/SOP	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
S-6 S-7	SOM01.2 SW846 5035	Accuracy/ Contamination	< MDL	Method Blank	A
		Accuracy	% Recovery Consistent with SOM01.2	Laboratory Control Sample (Blank Spike)	A
		Precision and Accuracy	% Recovery RPD Consistent with SOM01.2	Matrix Spike/Matrix Spike Duplicate	A
		Precision and Accuracy	% Recovery Consistent with SOM01.2	Surrogate Spike all samples and QC	A
		Senitivity	Internal Standard Area Consistent with SOM01.2	Internal standard all samples and QC	A
		Instrument Performance	Tune Criteria	BFB	A

QAPP Worksheet #12
Measurement Performance Criteria 12-4

Matrix:	Aqueous
Analytical Group:	VOC
Concentration	Low-Medium-High

Sampling Procedure	Analytical Method/SOP	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
S-3 S-4 S-5	SOM01.2 SW846 8260	Accuracy/ Contamination	< MDL	Method Blank	A
		Accuracy	% Recovery Consistent with SOM01.2	Laboratory Control Sample (Blank Spike)	A
		Precision and Accuracy	% Recovery RPD Consistent with SOM01.2	Matrix Spike/Matrix Spike Duplicate	A
		Precision and Accuracy	% Recovery Consistent with SOM01.2	Surrogate Spike all samples and QC	A
		Senitivity	Internal Standard Area Consistent with SOM01.2	Internal standard all samples and QC	A
		Instrument Performance	Tune Criteria	BFB	A

QAPP Worksheet #12
Measurement Performance Criteria 12-5

Matrix:	Soil/Sediment
Analytical Group:	SVOC
Concentration	Low-Medium-High

Sampling Procedure	Analytical Method/SOP	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
S-6 S-7	SOM01.2 SW846 8270	Accuracy/ Contamination	< MDL	Method Blank	A
		Accuracy	% Recovery Consistent with SOM01.2	Laboratory Control Sample (Blank Spike)	A
		Precision and Accuracy	% Recovery RPD Consistent with SOM01.2	Matrix Spike/Matrix Spike Duplicate	A
		Precision and Accuracy	% Recovery Consistent with SOM01.2	Surrogate Spike all samples and QC	A
		Senitivity	Internal Standard Area Consistent with SOM01.2	Internal standard all samples and QC	A

QAPP Worksheet #12
Measurement Performance Criteria 12-6

Matrix:	Aqueous
Analytical Group:	SVOC
Concentration	Low-Medium-High

Sampling Procedure	Analytical Method/SOP	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
S-3 S-4 S-5	SOM01.2 SW846 8270	Accuracy/ Contamination	< MDL	Method Blank	A
		Accuracy	% Recovery Consistent with SOM01.2	Laboratory Control Sample (Blank Spike)	A
		Precision and Accuracy	% Recovery RPD Consistent with SOM01.2	Matrix Spike/Matrix Spike Duplicate	A
		Precision and Accuracy	% Recovery Consistent with SOM01.2	Surrogate Spike all samples and QC	A
		Senitivity	Internal Standard Area Consistent with SOM01.2	Internal standard all samples and QC	A
		Instrument Performance	Tune Criteria	DFTPP	A

QAPP Worksheet #12
Measurement Performance Criteria 12-7

Matrix:	Soil/Sediment
Analytical Group:	Pesticides
Concentration	Low-Medium-High

Sampling Procedure	Analytical Method/SOP	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
S-6 S-7	SOM01.2 SW846 8081	Accuracy/ Contamination	< MDL	Method Blank	A
		Accuracy	% Recovery Consistent with SOM01.2	Laboratory Control Sample (Blank Spike)	A
		Precision and Accuracy	% Recovery RPD Consistent with SOM01.2	Matrix Spike/Matrix Spike Duplicate	A
		Precision and Accuracy	% Recovery Consistent with SOM01.2	Surrogate Spike all samples and QC	A
		Instrument Performance	% Breakdown < 15%	Endrin/DDT	A

QAPP Worksheet #12
Measurement Performance Criteria 12-8

Matrix:	Aqueous
Analytical Group:	Pesticides
Concentration	Low-Medium-High

Sampling Procedure	Analytical Method/SOP	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
S-3 S-4 S-5	SOM01.2 SW846 8081	Accuracy/ Contamination	< MDL	Method Blank	A
		Accuracy	% Recovery Consistent with SOM01.2	Laboratory Control Sample (Blank Spike)	A
		Precision and Accuracy	% Recovery RPD Consistent with SOM01.2	Matrix Spike/Matrix Spike Duplicate	A
		Precision and Accuracy	% Recovery Consistent with SOM01.2	Surrogate Spike all samples and QC	A
		Instrument Performance	% Breakdown < 15%	Endrin/DDT	A

QAPP Worksheet #12
Measurement Performance Criteria 12-9

Matrix:	Soil/Sediment
Analytical Group:	Aroclors
Concentration	Low-Medium-High

Sampling Procedure	**Analytical Method/SOP**	**Data Quality Indicators (DQIs)**	**Measurement Performance Criteria**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)**
S-6 S-7	SOM01.2 SW846 8082	Accuracy/ Contamination	< MDL	Method Blank	A
		Accuracy	% Recovery Consistent with SOM01.2	Laboratory Control Sample (Blank Spike)	A
		Precision and Accuracy	% Recovery RPD Consistent with SOM01.2	Matrix Spike/Matrix Spike Duplicate	A
		Precision and Accuracy	% Recovery Consistent with SOM01.2	Surrogate Spike all samples and QC	A
		Instrument Performance	% Breakdown < 15%	Endrin/DDT	A

QAPP Worksheet #12
Measurement Performance Criteria 12-10

Matrix:	Aqueous
Analytical Group:	Aroclors
Concentration	Low-Medium-High

Sampling Procedure	Analytical Method/SOP	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
S-3 S-4 S-5	SOM01.2 SW846 8082	Accuracy/ Contamination	< MDL	Method Blank	A
		Accuracy	% Recovery Consistent with SOM01.2	Laboratory Control Sample (Blank Spike)	A
		Precision and Accuracy	% Recovery RPD Consistent with SOM01.2	Matrix Spike/Matrix Spike Duplicate	A
		Precision and Accuracy	% Recovery Consistent with SOM01.2	Surrogate Spike all samples and QC	A

QAPP Worksheet #12
Measurement Performance Criteria 12-11

Matrix:	Soil/Sediment
Analytical Group:	Dioxins and Furans
Concentration	Low-Medium-High

Sampling Procedure	Analytical Method/SOP	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
S-6 S-7	DLM01.2 SW846 8290	Accuracy/ Contamination	< MDL	Method Blank	A
		Accuracy	% Recovery Consistent with DLM01.2	Laboratory Control Sample (Blank Spike)	A
		Precision and Accuracy	% Recovery RPD Consistent with DLM01.2	Matrix Spike/Matrix Spike Duplicate	A
		Precision and Accuracy	% Recovery Consistent with DLM01.2	Surrogate Spike all samples and QC	A

QAPP Worksheet #12
Measurement Performance Criteria 12-12

Matrix:	Aqueous
Analytical Group:	Dioxins and Furans
Concentration	Low-Medium-High

Sampling Procedure	Analytical Method/SOP	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
S-3 S-4 S-5	DLM01.2 SW846 8290	Accuracy/ Contamination	< MDL	Method Blank	A
		Accuracy	% Recovery Consistent with DLM01.2	Laboratory Control Sample (Blank Spike)	A
		Precision and Accuracy	% Recovery RPD Consistent with DLM01.2	Matrix Spike/Matrix Spike Duplicate	A
		Precision and Accuracy	% Recovery Consistent with DLM01.2	Surrogate Spike all samples and QC	A

QAPP Worksheet #12
Measurement Performance Criteria 12-13

Matrix:	Soil/Sediment
Analytical Group:	Perchlorate
Concentration	Low-Medium-High

Sampling Procedure	Analytical Method/SOP	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
S-6 S-7	SW846 314.0	Accuracy/ Contamination	< MDL	Method Blank	A
		Accuracy	% Recovery In House Limits	Laboratory Control Sample (Blank Spike)	A
		Precision and Accuracy	% Recovery RPD In House Limits	Matrix Spike/Matrix Spike Duplicate	A
		Precision and Accuracy	% Recovery In House Limits	Surrogate Spike all samples and QC	A

QAPP Worksheet #12
Measurement Performance Criteria 12-14

Matrix:	Aqueous
Analytical Group:	Perchlorate
Concentration	Low-Medium-High

Sampling Procedure	Analytical Method/SOP	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
S-3 S-4 S-5	SW846 314.0	Accuracy/ Contamination	< MDL	Method Blank	A
		Accuracy	% Recovery In House Limits	Laboratory Control Sample (Blank Spike)	A
		Precision and Accuracy	% Recovery RPD In House Limits	Matrix Spike/Matrix Spike Duplicate	A
		Precision and Accuracy	% Recovery In House Limits	Surrogate Spike all samples and QC	A

QAPP Worksheet #12
Measurement Performance Criteria 12-15

Matrix:	Soil/Sediment
Analytical Group:	Nitrate and Sulfate
Concentration	Low-Medium-High

Sampling Procedure	Analytical Method/SOP	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
S-6 S-7	SW846 300.0	Accuracy/ Contamination	< MDL	Method Blank	A
		Accuracy	% Recovery In House Limits	Laboratory Control Sample (Blank Spike)	A
		Precision and Accuracy	% Recovery RPD In House Limits	Matrix Spike/Matrix Spike Duplicate	A
		Precision and Accuracy	% Recovery In House Limits	Surrogate Spike all samples and QC	A

QAPP Worksheet #12
Measurement Performance Criteria 12-16

Matrix:	Aqeous
Analytical Group:	Nitrate and Sulfate
Concentration	Low-Medium-High

Sampling Procedure	Analytical Method/SOP	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
S-3 S-4 S-5	SW846 300.0	Accuracy/ Contamination	< MDL	Method Blank	A
		Accuracy	% Recovery In House Limits	Laboratory Control Sample (Blank Spike)	A
		Precision and Accuracy	% Recovery RPD In House Limits	Matrix Spike/Matrix Spike Duplicate	A
		Precision and Accuracy	% Recovery In House Limits	Surrogate Spike all samples and QC	A

QAPP Worksheet #12
Measurement Performance Criteria 12-17

Matrix:	Soil/Sediment
Analytical Group:	Synthetic Precipitation Leaching Procedure
Concentration	Low-Medium-High

Sampling Procedure	**Analytical Method/SOP**	**Data Quality Indicators (DQIs)**	**Measurement Performance Criteria**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)**
S-6 S-7	SW846 1312	Accuracy/ Contamination	< MDL	Method Blank	A
		Accuracy	% Recovery In House Limits	Laboratory Control Sample (Blank Spike)	A
		Precision and Accuracy	% Recovery RPD In House Limits	Matrix Spike/Matrix Spike Duplicate	A
		Precision and Accuracy	% Recovery In House Limits	Surrogate Spike all samples and QC	A

QAPP Worksheet #12
Measurement Performance Criteria 12-18

Matrix:	Soil/Sediment
Analytical Group:	Lead/Arsenic Speciation
Concentration	Low-Medium-High

Sampling Procedure	Analytical Method/SOP	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
S-6 S-7	Scanning Electron Microscopy (SEM)	Accuracy/ Contamination	< MDL	Method Blank	A
		Accuracy	% Recovery In House Limits	Laboratory Control Sample (Blank Spike)	A
		Precision and Accuracy	% Recovery RPD In House Limits	Matrix Spike/Matrix Spike Duplicate	A
		Precision and Accuracy	% Recovery In House Limits	Surrogate Spike all samples and QC	A

QAPP Worksheet #12
Measurement Performance Criteria 12-19

Matrix:	Soil/Sediment
Analytical Group:	pH
Concentration	Low-Medium-High

Sampling Procedure	Analytical Method/SOP	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
S-6 S-7	SW846 9045	Accuracy/ Contamination	< MDL	Method Blank	A
		Accuracy	% Recovery In House Limits	Laboratory Control Sample (Blank Spike)	A
		Precision and Accuracy	% Recovery RPD In House Limits	Matrix Spike/Matrix Spike Duplicate	A
		Precision and Accuracy	% Recovery In House Limits	Surrogate Spike all samples and QC	A

QAPP Worksheet #12
Measurement Performance Criteria 12-20

Matrix:	Soil/Sediment
Analytical Group:	Asbestos
Concentration	Low-Medium-High

Sampling Procedure	Analytical Method/SOP	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
S-6 S-7	Region 9 Lab SOP 490 ASTM D22.05	Accuracy/ Contamination	< MDL	Method Blank	A
		Accuracy	% Recovery In House Limits	Laboratory Control Sample (Blank Spike)	A
		Precision and Accuracy	% Recovery RPD In House Limits	Matrix Spike/Matrix Spike Duplicate	A
		Precision and Accuracy	% Recovery In House Limits	Surrogate Spike all samples and QC	A

QAPP Worksheet #12
Measurement Performance Criteria 12-21

Matrix:	Aqueous
Analytical Group:	Anions/Cations
Concentration	Low-Medium-High

Sampling Procedure	Analytical Method/SOP	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
S-3 S-4 S-5	SW846 300.0 SW846 6020	Accuracy/ Contamination	< MDL	Method Blank	A
		Accuracy	% Recovery In House Limits	Laboratory Control Sample (Blank Spike)	A
		Precision and Accuracy	% Recovery RPD In House Limits	Matrix Spike/Matrix Spike Duplicate	A
		Precision and Accuracy	% Recovery In House Limits	Surrogate Spike all samples and QC	A

QAPP Worksheet #12
Measurement Performance Criteria 12-22

Matrix:	Aqueous
Analytical Group:	Total Dissolved Solids
Concentration	Low-Medium-High

Sampling Procedure	Analytical Method/SOP	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
S-3 S-4 S-5	SW846 160.1	Accuracy/ Contamination	< MDL	Method Blank	A
		Accuracy	% Recovery In House Limits	Laboratory Control Sample (Blank Spike)	A
		Precision and Accuracy	% Recovery RPD In House Limits	Matrix Spike/Matrix Spike Duplicate	A
		Precision and Accuracy	% Recovery In House Limits	Surrogate Spike all samples and QC	A

QAPP Worksheet #12
Measurement Performance Criteria 12-23

Matrix:	Air
Analytical Group:	Particulate Matter 10
Concentration	Low

Sampling Procedure	Analytical Method/SOP	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
S-12 S-13	NIOSH 0500 IO-3.1	Accuracy/ Contamination	< MDL	Method Blank	A
		Accuracy	% Recovery In House Limits	Laboratory Control Sample (Blank Spike)	A
		Precision and Accuracy	% Recovery RPD In House Limits	Matrix Spike/Matrix Spike Duplicate	A
		Precision and Accuracy	% Recovery In House Limits	Surrogate Spike all samples and QC	A

QAPP Worksheet #12
Measurement Performance Criteria 12-24

Matrix:	Air
Analytical Group:	Total Suspended Particulates
Concentration	Low

Sampling Procedure	Analytical Method/SOP	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
S-13	IO-3.1	Accuracy/ Contamination	< MDL	Method Blank	A
		Accuracy	% Recovery In House Limits	Laboratory Control Sample (Blank Spike)	A
		Precision and Accuracy	% Recovery RPD In House Limits	Matrix Spike/Matrix Spike Duplicate	A
		Precision and Accuracy	% Recovery In House Limits	Surrogate Spike all samples and QC	A

QAPP Worksheet #12
Measurement Performance Criteria 12-25

Matrix:	Air
Analytical Group:	Metals
Concentration	Low

Sampling Procedure	Analytical Method/SOP[3]	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
S-12 S-13	NIOSH 7300 ICP 6010 and Hg by CVAA 7471	Accuracy/ Contamination	< MDL	Method Blank	A
		Accuracy	% Recovery In House Limits	Laboratory Control Sample (Blank Spike)	A
		Precision and Accuracy	% Recovery RPD In House Limits	Matrix Spike/Matrix Spike Duplicate	A
		Precision and Accuracy	% Recovery In House Limits	Surrogate Spike all samples and QC	A

QAPP Worksheet #13
Secondary Data Criteria and Limitations Table

Secondary Data	Data Source (Originating Org., Report Title, and Date)	Data Generator(s) (Originating Org., Data Types, Data Generation/Collection Dates)	Data Quality Issues	How Data Will Be Used / Limitations on Data Use
Surface Water Data	3.1.1 Previous Surface Water Investigations	Ironite Products Company: Surface water leaching from tailings pond: December 1988	Ironite did not provide any addition sample collection information. Locations of samples unknown at this time so data usabillity is in question.	Data Not Currently Usable
Surface Water Data	3.1.1 Previous Surface Water Investigations	Yavapai County: Four surface water samples: Unnamed Tributary to Chaparral Gulch: March 1993	Unknown sample locations and no chain-of-custody	Data Not Currently Usable
Surface Water Data	3.1.1 Previous Surface Water Investigations	ADEQ Water Quality Division: One water sample: Unnamed Tributary to Chaparral Gulch downstream of pond 200-5S: May 1989	Unknown sample locations, and the data is questionable. A chain-of-custody is available.	Data Not Currently Usable
Surface Water Data	3.1.1 Previous Surface Water Investigations	ADEQ Water Quality Division: One surface water sample: Unnamed Tributary to Chaparral Gulch downstream of retention pond 100-5S: April 1995	Unknown sample location. Chain-of-custody is available.	Data Not Currently Usable
Surface Water Data	3.1.1 Previous Surface Water Investigations	ADEQ Water Quality Division: Two surface water samples from standing water in Pond 200-5S (approximate locations). One surface water sample from a culvert near Hwy 69 (unknown location): February 2003	Two sample locations are known and a chain-of-custody is available. Validation is uncertain	Qualitative Data for Nature and Extent Evaluation - Not suitable for Risk Assessment
Surface Water Data	3.1.1 Previous Surface Water Investigations	Hoque & Associates: Surface water samples: Collected from the wash that crosses the IK operations property: July 2004	Sample locations are unknown.	Data Not Currently Usable

QAPP Worksheet #13
Secondary Data Criteria and Limitations Table

Secondary Data	Data Source (Originating Org., Report Title, and Date)	Data Generator(s) (Originating Org., Data Types, Data Generation/Collection Dates)	Data Quality Issues	How Data Will Be Used / Limitations on Data Use
Soil Data	3.1.2 Previous Soil and Waste Investigations	Ironite Products Company	Ironite did not provide any addition sample collection information. Locations of samples unknown at this time so data usabillity is in question.	Data Not Currently Usable
Soil Data	3.1.2 Previous Soil and Waste Investigations	Semmens and Associates: Five soil samples	Semmens did not provide any information about sample dates, depths, or locations. Chain-of-custody information is not provided	Data Not Currently Usable
Soil Data	3.1.2 Previous Soil and Waste Investigations	Discount Dumpster Services: 17 superficial soil samples: Iron King Operations Area: August 2001	All sample locations are approximate. ADEQ does not consider one sample, BAK-2, to be representative of background conditions due to ore present in the vicinity of the sample. All samples have a chain-of-custody.	Qualitative Data for Nature and Extent Evaluation - Not suitable for Risk Assessment
Soil Data	3.1.2 Previous Soil and Waste Investigations	Hoque & Associates: 30 surficial soil samples composited into 11 composites and additional 9 grab samples: November 2002	Sample locations are approximate and chain-of-custody documentation is provided. Composite samples not suitable for risk assessment.	Qualitative Data for Nature and Extent Evaluation - Not suitable for Risk Assessment
Ground Water	3.1.3 Previous Ground Water Investigations	Ironite Products Company: Two samples from two wells: IRONITE-1 from the "farthest on site downgradient well" and Schumaker-1 from a "crossgradient well": September 1992	Sample location is unknown. In addition, chain-of-custody information was not provided. Validation is uncertain.	Data Not Currently Usable

QAPP Worksheet #13
Secondary Data Criteria and Limitations Table

Secondary Data	Data Source (Originating Org., Report Title, and Date)	Data Generator(s) (Originating Org., Data Types, Data Generation/Collection Dates)	Data Quality Issues	How Data Will Be Used / Limitations on Data Use
Ground Water	3.1.3 Previous Ground Water Investigations	Hoque & Associates: Two groundwater samples: Mine shaft No. 7: December 2000	Sample location is known, and a chain-of-custody is available. Validation is uncertain.	Data may be usable pending verification
Ground Water	3.1.3 Previous Ground Water Investigations	Brown and Caldwell: Eleven samples from ten wells: August 2004	Sample locations are known, and a chain-of-custody is available. Validation is uncertain.	Data may be usable pending verification
Ground Water	3.1.3 Previous Ground Water Investigations	Brown and Caldwell: One well sample: September 2004	The location is known, but it is unclear if a chain-of-custody is available. Validation is uncertain.	Data may be usable pending verification
Ground Water Data	3.1.3 Previous Ground Water Investigations	Brown and Caldwell: Groundwater sample: September 2004	The location is known, but it is unclear if a chain-of-custody is available. Validation is uncertain.	Data may be usable pending verification
Surface Water Data	3.2.1 Iron King Mine and Tailings Site Inspection	ADEQ Water Quality Division: Surface water samples: Agua Fria River upstream of the Chaparral Gulch confluence, at the confluence, and downstream of the confluence: May 2002	ADEQ Data (Locations are known, chain-of-custody is documented, and the data are validated).	Data suitable for nature and extent evaluation and risk assessment.
Soil and Sediment Data	3.2.1 Iron King Mine and Tailings Site Inspection	ADEQ Water Quality Division: 35 Soil and 12 sediment samples: Collected from the school yard adjacent to the IK area, nearby washes, and the Agua Fria river: April 2002	ADEQ Data (Locations are known, chain-of-custody is documented, and the data are validated).	Data suitable for nature and extent evaluation and risk assessment.

QAPP Worksheet #13
Secondary Data Criteria and Limitations Table

Secondary Data	Data Source (Originating Org., Report Title, and Date)	Data Generator(s) (Originating Org., Data Types, Data Generation/Collection Dates)	Data Quality Issues	How Data Will Be Used / Limitations on Data Use
Ground Water Data	3.2.1 Iron King Mine and Tailings Site Inspection	ADEQ Water Quality Division: Four groundwater samples: Three wells: one domestic well, the old production well on the Ironite property, and a well at the Humboldt Elementary School: May 2002	ADEQ Data (Locations are known, chain-of-custody is documented, and the data are validated).	Data suitable for nature and extent evaluation and risk assessment.
Surface Water Data	3.2.2 Humboldt Smelter Site Investigation	ADEQ Water Quality Division: Four surface water samples: Agua Fria River: January 2004	ADEQ Data (Locations are known, chain-of-custody is documented, and the data are validated).	Data suitable for nature and extent evaluation and risk assessment.
Soil and Sediment Data	3.2.2 Humboldt Smelter Site Investigation	ADEQ Water Quality Division: 21 soil and 4 sediment samples: Nearby residences and the Humboldt Elementary School: January 2004	ADEQ Data (Locations are known, chain-of-custody is documented, and the data are validated).	Data suitable for nature and extent evaluation and risk assessment.
Soil Data	3.2.3 Iron King Mine Removal Assessment	Ecology and Environment, Inc.: Soil samples: 16 residential properties and one horse pasture: August 2005	Locations are known, chain-of-custody is documented, and the data are validated.	Data suitable for nature and extent evaluation and risk assessment.
Ground Water Data	3.2.4 Iron King Mine/Humboldt Smelter Expanded Site Inspection	ADEQ Site Asessment Unit: Groundwater samples: 12 water wells: January 2006 and Febuary 2006	ADEQ Data (Locations are known, chain-of-custody is documented, and the data are validated).	Data suitable for nature and extent evaluation and risk assessment.
Ground Water Data	3.2.4 Iron King Mine/Humboldt Smelter Expanded Site Inspection	ADEQ Site Asessment Unit: Groundwater samples: 6 ground water samples: May 2006	ADEQ Data (Locations are known, chain-of-custody is documented, and the data are validated).	Data suitable for nature and extent evaluation and risk assessment.

Note:
The majority of the data were not available electronically so only a superficial data quality assessment could be conducted. These data will be subject to further evaluation, when available electronically, in the Remedial Investigation.

QAPP Worksheet #14
Summary of Project Tasks

Sampling Tasks:
Details are provided in the Sampling and Analysis Plan

Analysis Tasks:
Details are provided in the Sampling and Analysis Plan

Quality Control Tasks:
All matrices will have the following QC samples analyzed: duplicates, matrix spikes, matrix spike duplicates, VOA trip blanks, VOA field blank, equipment blanks, and rinse blanks.

Secondary Data:
Refer to Worksheet #13

Data Management Tasks:.
Analytical data will be placed in a database after validation. Field measurements will also be included in the database. Secondary data, deemed usable, will be added to the database.

Documentation and Records:
Records of each sample collected and all field measurements will be recorded in field notebooks. Traffic reports, airbills and sample logs will be collected for the samples and copies will be kept in the project file.

Assessment/Audit Tasks:
Field activities will be assessed by the EPA as appropriate. Sampling efforts will be conducted in accordance with the Sampling and Analysis Plan and appropriate Standard Operating Proceedures.

Data Review Tasks:
The analytical laboratory performing the analysis of samples will verify that all data are complete for samples received. Data will be validated using EPA Region 9 and/or EPA Contract Laboratory Program data validation guidelines (2006 versions or most recent). Subcontracted laboratory data will be validated by EA. Validated data will be reviewed by the project team and data usability will be assessed. Data limitations will be determined and data will be compared to project objectives. Data will be placed in database, tables, charts, and graphs will be generated.

QAPP Worksheet #15
Reference Limits and Evaluation Table #15-1

Comparison of Quantitation Limits to Comparison Values for Inorganic Analysis in Soil or Sediment

ANALYTES	CONTRACT REQUIRED QUANTITATION LIMITS[1]	ECOLOGICAL SOIL COMPARISON VALUES						ECOLOGICAL SEDIMENT COMPARISON VALUES		Regional Screening Levels for Chemical Contaminants at Superfund Sites, May 20, 2008.	
	ICP-AES	EPA Ecological Soil Screening Level (mg/kg)				ORNL PRGs		Sediment Benchmarks			
	Soil (mg/kg)	Plants	Soil Invertebrates	Birds	Mammals	Value (mg/kg)	Receptor Basis	Value (mg/kg)	Source	Residential Soil (mg/kg)	Industrial Soil (mg/kg)
Aluminum	20	Dependent on pH				--	--	--		77000	990000
Antimony	6	--	78	--	***0.27***	***5***	plant	**2**	Value is LEL from OMEE (1993).	31	410
Arsenic	1	18	--	43	46	9.9	shrew, plant	9.79	MacDonald et al. 2000	***0.39***	1.6
Barium	20	--	330	--	2000	283	woodcock	--	--	15000	190000
Beryllium	0.5	--	40	--	21	10	plant	--	--	160	2000
Cadmium	0.5	32	140	0.77	0.36	4	plant, woodcock	0.99	MacDonald et al. 2000	70	810
Calcium	500	--	--	--	--	--	--	--	--	--	--
Chromium (III/VI)	1	--	26/--	--	34/130	***0.4***	earthworm	43.4	MacDonald et al. 2000	120000	1500000
Cobalt	5	13	--	120	230	20	plant	--	--	--	--
Copper	2.5	--	--	--	--	60	earthworm	31.6	MacDonald et al. 2000	3100	41000
Iron	10	Dependent on pH & eH				--	--	20000	Value is TEL from MacDonald et al. (1996)	55000	720000
Lead	1	120	1700	11	56	40.5	woodcock	35.8	MacDonald et al. 2000	400	
Magnesium	500	--	--	--	--	--	--	--	--	--	--
Manganese	1.5	220	450	4300	4000	--	--	460	Value is TEL from MacDonald et al. (1996)	1800	23000
Mercury	0.1	--	--	--	--	***0.00051***	woodcock	0.18	MacDonald et al. 2000	6.7	28
Nickel	4	38	280	210	130	30	plant	22.7	MacDonald et al. 2000	14000	69000
Potassium	500	--	--	--	--	--	--	--	--	--	--
Selenium	3.5	***0.52***	4.1	***1.2***	6.3	***0.21***	mouse	--	--	390	5100
Silver	1	--	--	--	--	2	plant	1	Value is LEL from OMEE (1993)	390	5100
Sodium	500	--	--	--	--	--	--	--	--	--	--
Thallium	2.5	--	--	--	--	***1***	plant	--	--	5.1	66
Vanadium	5	--	--	--	--	***2***	plant	--	--	390	5200
Zinc	6	160	120	46	79	8.5	woodcock	121	MacDonald et al. 2000	23000	310000
Cyanide	2.5	--	--	--	--	--	--	--	--	1600	20000

objectives.

EPA analytical method detection limits are consistent with EPA CLP methods.

Bold-Itallics - Comparison values are less than the Contract Required Quantitation Limits.

QAPP Worksheet #15
Reference Limits and Evaluation Table #15-2
Comparison of Quantitation Limits to Comparison Values for Inorganic Analysis in Surface Water

ANALYTES	CONTRACT REQUIRED QUANTITATION LIMITS[1]	ECOLOGICAL SURFACE WATER COMPARISON VALUES			Regional Screening Levels for Chemical Contaminants at Superfund Sites, May 20, 2008. [2]	
	ICP-AES	ORNL PRGs				
	Water (ug/L)	Value (ug/L)	Receptor Basis	Plants	Tapwater (ug/L)	MCL (ug/L)
Aluminum	200	***87***	aquatic life	chronic NAWQC	37000	--
Antimony	60	30	aquatic life	secondary chronic value	***15***	***6.0***
Arsenic	10	190/3.1	piscivores	chronic NAWQC/SCV	***0.045***	10
Barium	200	***4***	aquatic life	secondary chronic value	7300	2000
Beryllium	5	***0.66***	aquatic life	secondary chronic value	73	***4.0***
Cadmium	5	1.1	aquatic life	chronic NAWQC	18	5.0
Calcium	5000	--	--	--	--	--
Chromium (III/VI)	10	210/11	aquatic life	chronic NAWQC	55000/110	--
Cobalt	50	23	aquatic life	secondary chronic value	--	--
Copper	25	12	aquatic life	chronic NAWQC	1500	1300
Iron	100	1000	aquatic life	chronic NAWQC	26000	
Lead	10	3.2	aquatic life	chronic NAWQC	--	15
Magnesium	5000	--	--	--	--	--
Manganese	15	120	aquatic life	secondary chronic value	880	--
Mercury (total vs. methyl)	0.2	1.3/***0.0026***	aquatic life/piscivores	secondary chronic value/from river otter LOAEL	0.63	***2.0***
Nickel	40	160	aquatic life	chronic NAWQC	730	--
Potassium	5000	--	--	--	--	--
Selenium	35	***0.39***	piscivores	from river otter LOAEL	180	50
Silver	10	***0.36***	aquatic life	secondary chronic value	180	--
Sodium	5000	--	--	--	--	--
Thallium	25	9	piscivores	from river otter LOAEL	***2.4***	2.0
Vanadium	50	20	aquatic life	secondary chronic value	180	--
Zinc	60	110	aquatic life	chronic NAWQC	11000	--
Cyanide	10	***5.2***	aquatic life	chronic NAWQC	730	200

1. Analytical method detection limits (MDLs) are determined by individual laboratories to meet data quality objectives.
   EPA analytical method detection limits are consistent with EPA CLP methods.
2. Tap water screening levels and Maximum Contaminant Levels are not applicable to surface water. Nevertheless, these criteria are presented for illustritive purposes.

Bold-Itallics - Comparison values are less than the Contract Required Quantitation Limits.

QAPP Worksheet #15
Reference Limits and Evaluation Table #15-3

Comparison of Quantitation Limits to Comparison Values for Organic Analysis in Soil and Sediment

ANALYTES	CONTRACT REQUIRED QUANTITATION LIMITS ^{1}	ECOLOGICAL SOIL COMPARISON VALUES						ECOLOGICAL SEDIMENT COMPARISON VALUES		Regional Screening Levels for Chemical Contaminants at Superfund Sites, May 20, 2008.	
		EPA Ecological Soil Screening Level (mg/kg)				ORNL PRGs		Sediment Benchmarks			
	Low Soil (mg/kg)	Plants	Soil Invertebrates	Birds	Mammals	Value (mg/kg)	Receptor Basis	Value (mg/kg)	Source	Residential Soil (mg/kg)	Industrial Soil (mg/kg)
2378-TCDD	0.000001	--	--	--	--	***3.15E-09***	shrew	--	--	0.0000045	0.000018
12378-PeCDD	0.000005	--	--	--	--	--	--	--	--	--	--
123678-HxCDD	0.000005	--	--	--	--	--	--	--	--	--	--
123478-HxCDD	0.000005	--	--	--	--	--	--	--	--	--	--
123789-HxCDD	0.000005	--	--	--	--	--	--	--	--	--	--
1234678-HpCDD	0.000005	--	--	--	--	--	--	--	--	--	--
OCDD	0.00001	--	--	--	--	--	--	--	--	0.013	0.053
2378-TCDF	0.000001	--	--	--	--	***0.00000084***	hawk	--	--	0.000032	0.00011
12378-PeCDF	0.000005	--	--	--	--	--	--	--	--	0.00011	0.00038
23478-PeCDF	0.000005	--	--	--	--	--	--	--	--	0.000011	0.000038
123678-HxCDF	0.000005	--	--	--	--	--	--	--	--	--	--
123789-HxCDF	0.000005	--	--	--	--	--	--	--	--	--	--
123478-HxCDF	0.000005	--	--	--	--	--	--	--	--	--	--
234678-HxCDF	0.000005	--	--	--	--	--	--	--	--	--	--
1234678-HpCDF	0.000005	--	--	--	--	--	--	--	--	--	--
1234789-HpCDF	0.000005	--	--	--	--	--	--	--	--	--	--
OCDF	0.00001	--	--	--	--	--	--	--	--	0.011	0.038
alpha-BHC	0.0017	--	--	--	--	--	--	0.006	Value is TEL from MacDonald et al. (1996).	--	--
beta-BHC	0.0017	--	--	--	--	--	--	0.005	Value is TEL from MacDonald et al. (1996).	--	--
delta-BHC	0.0017	--	--	--	--	--	--	0.003	Value is TEL from MacDonald et al. (1996); BHC.	--	--
gamma-BHC (Lindane)	0.0017	--	--	--	--	--	--	0.00237	MacDonald et al. 2000	--	--
Heptachlor	0.0017	--	--	--	--	--	--	***0.0003***	--	0.11	0.38
Aldrin	0.0017	--	--	--	--	--	--	0.002	Value is TEL from MacDonald et al. (1996).	0.029	0.10
Heptachlor epoxide	0.0017	--	--	--	--	--	--	0.00247	MacDonald et al. 2000	0.053	0.19
Endosulfan I	0.0017	--	--	--	--	--	--	0.0029	ET from OSWER (1996)	--	--
Dieldrin	0.0033	--	--	0.022	0.049	--	--	***0.0019***	MacDonald et al. 2000	0.030	0.11
4,4'-DDE	0.0033	--	--	93	0.021	--	--	***0.00316***	MacDonald et al. 2000	1.4	5.1
Endrin	0.0033	--	--	--	--	--	--	***0.00222***	MacDonald et al. 2000	18	180
Endosulfan II	0.0033	--	--	--	--	--	--	0.0055	SQB calculated from Tier II SCV (Jones et al., 1997)	--	--
4,4'-DDD	0.0033	--	--	0.093	0.021	--	--	0.00488	MacDonald et al. 2000	2	7.2
Endosulfan sulfate	0.0033	--	--	--	--	--	--	0.0054	ET from OSWER (1996); based on 1% OC for endosulfan.	--	--
4,4'-DDT	0.0033	--	--	0.093	0.021	--	--	0.00416	MacDonald et al. 2000	1.7	7.0
Methoxychlor	0.017	--	--	--	--	--	--	0.019	SQB calculated from Tier II SCV (Jones et al., 1997)	310	3100
Endrin ketone	0.0033	--	--	--	--	--	--	***0.00267***	Value is ER-L from Long et al. (1995); value for endrin.	--	--
Endrin aldehyde	0.0033	--	--	--	--	--	--	***0.00267***	Value is ER-L from Long et al. (1995); value for endrin.	--	--
alpha-Chlordane	0.0017	--	--	--	--	--	--	0.00324	MacDonald et al. 2000	--	--

QAPP Worksheet #15
Reference Limits and Evaluation Table #15-3

Comparison of Quantitation Limits to Comparison Values for Organic Analysis in Soil and Sediment

ANALYTES	CONTRACT REQUIRED QUANTITATION LIMITS [1]	ECOLOGICAL SOIL COMPARISON VALUES						ECOLOGICAL SEDIMENT COMPARISON VALUES		Regional Screening Levels for Chemical Contaminants at Superfund Sites, May 20, 2008.	
		EPA Ecological Soil Screening Level (mg/kg)				ORNL PRGs		Sediment Benchmarks			
	Low Soil (mg/kg)	Plants	Soil Invertebrates	Birds	Mammals	Value (mg/kg)	Receptor Basis	Value (mg/kg)	Source	Residential Soil (mg/kg)	Industrial Soil (mg/kg)
gamma-Chlordane	0.0017	--	--	--	--	--	--	0.00324	MacDonald et al. 2000	--	--
Toxaphene	0.17	--	--	--	--	--	--	***0.028***	ET from OSWER (1996)	0.44	1.6
Aroclor-1016	0.033	--	--	--	--	--	--	--	--	3.9	21
Aroclor-1221	0.033	--	--	--	--	--	--	--	--	0.17	0.62
Aroclor-1232	0.033	--	--	--	--	--	--	--	--	0.17	0.62
Aroclor-1242	0.033	--	--	--	--	--	--	--	--	0.22	0.74
Aroclor-1248	0.033	--	--	--	--	--	--	--	--	0.22	0.74
Aroclor-1254	0.033	--	--	--	--	--	--	--	--	0.22	0.74
Aroclor-1260	0.033	--	--	--	--	--	--	--	--	0.22	0.74
Aroclor-1262	0.033	--	--	--	--	--	--	--	--	--	--
Aroclor-1268	0.033	--	--	--	--	--	--	--	--	--	--
Acenaphthylene	0.17	--	1.8	--	1.1	--	--	240	DiToro et al. 2000	--	--
Fluorene	0.17	--	1.8	--	1.1	--	--	***0.0774***	MacDonald et al. 2000	2300	22000
Phenanthrene	0.17	--	1.8	--	1.1	--	--	0.204	MacDonald et al. 2000	--	--
Anthracene	0.17	--	1.8	--	1.1	--	--	***0.0572***	MacDonald et al. 2000	17000	170000
Carbazole	0.17	--	1.8	--	1.1	--	--	--	--	24	86
Fluoranthene	0.17	--	1.8	--	1.1	--	--	0.423	MacDonald et al. 2000	2300	22000
Pyrene	0.17	--	1.8	--	1.1	--	--	0.195	MacDonald et al. 2000	1700	17000
Benzo(a)anthracene	0.17	--	1.8	--	1.1	--	--	--	--	***0.15***	2.1
Chrysene	0.17	--	1.8	--	1.1	--	--	0.166	MacDonald et al. 2000	15	210
Benzo(b) fluoranthene	0.17	--	1.8	--	1.1	--	--	--	--	***0.15***	2.1
Benzo(k) fluoranthene	0.17	--	1.8	--	1.1	--	--	--	--	1.5	21
Benzo(a) pyrene	0.17	--	1.8	--	1.1	--	--	--	--	***0.015***	0.21
Indeno(1,2,3,-cd) pyrene	0.17	--	1.8	--	1.1	--	--	--	--	***0.15***	2.1
Dibenzo(a,h) anthracene	0.17	--	1.8	--	1.1	--	--	--	--	***0.015***	0.21
Benzo(g,h,i) perylene	0.17	--	1.8	--	1.1	--	--	--	--	--	--
Pentachlorophenol	0.33	5	31	2.1	2.8	***0.003***	plant	0.36	Washington State SQS.	3	9.0
Benzaldehyde	0.17	--	--	--	--	--	--	--	--	7800	100000
Phenol	0.17	--	--	--	--	***0.03***	earthworm	***0.031***	SQB calculated from Tier II SCV (Jones et al., 1997)	18000	180000
Bis(2-chloroethyl) ether	0.17	--	--	--	--	--	--	--	--	0.19	0.90
2-Chlorophenol	0.17	--	--	--	--	--	--	--	--	390	5100
2-Methylphenol	0.17	--	--	--	--	--	--	***0.012***	SQB calculated from Tier II SCV (Jones et al., 1997)	3100	31000
2,2'-Oxybis(1-choloropropane)	0.17	--	--	--	--	--	--	--	--	--	--
Acetophenone	0.17	--	--	--	--	--	--	--	--	7800	100000
4-Methylphenol	0.17	--	--	--	--	--	--	0.012	SQB calculated from Tier II SCV (Jones et al., 1997)	310	3100
N-Nitroso-di-n propylamine	0.17	--	--	--	--	--	--	--	--	***0.069***	0.25
Hexachloroethane	0.17	--	--	--	--	--	--	1	ET from OSWER (1996)	35	120

QAPP Worksheet #15
Reference Limits and Evaluation Table #15-3

Comparison of Quantitation Limits to Comparison Values for Organic Analysis in Soil and Sediment

ANALYTES	CONTRACT REQUIRED QUANTITATION LIMITS [1]	ECOLOGICAL SOIL COMPARISON VALUES						ECOLOGICAL SEDIMENT COMPARISON VALUES		Regional Screening Levels for Chemical Contaminants at Superfund Sites, May 20, 2008.	
		EPA Ecological Soil Screening Level (mg/kg)				ORNL PRGs		Sediment Benchmarks			
	Low Soil (mg/kg)	Plants	Soil Invertebrates	Birds	Mammals	Value (mg/kg)	Receptor Basis	Value (mg/kg)	Source	Residential Soil (mg/kg)	Industrial Soil (mg/kg)
Nitrobenzene	0.17	--	--	--	--	--	--	--	--	31	280
Isophorone	0.17	--	--	--	--	--	--	--	--	510	1800
2-Nitrophenol	0.17	--	--	--	--	--	--	--	--	--	--
2,4-Dimethylphenol	0.17	--	--	--	--	--	--	0.029	Washington State SQS.	1200	12000
Bis(2-chloroethoxy) methane	0.17	--	--	--	--	--	--	--	--	180	1800
2,4-Dichlorophenol	0.17	--	--	--	--	--	--	--	--	180	1800
Naphthalene	0.17	--	--	--	--	--	--	0.176	MacDonald et al. 2000	5300	23000
4-Chloroaniline	0.17	--	--	--	--	--	--	--	--	--	--
Hexachlorobutadiene	0.17	--	--	--	--	--	--	--	--	6.2	22
Caprolactam	0.17	--	--	--	--	--	--	--	--	31000	310000
4-Chloro-3-methylphenol	0.17	--	--	--	--	--	--	--	--	--	--
2-Methylnaphthalene	0.17	--	--	--	--	--	--	618	DiToro et al. 2000	310	4100
Hexachlorocyclopentadiene	0.17	--	--	--	--	***0.01***	plant	--	--	370	3700
2,4,6-Trichlorophenol	0.17	--	--	--	--	***0.004***	plant	--	--	44	160
2,4,5-Trichlorophenol	0.17	--	--	--	--	***0.009***	earthworm	--	--	6100	62000
1,1'-Biphenyl	0.17	--	--	--	--	--	--	--	--	3900	51000
2-Chloronaphthalene	0.17	--	--	--	--	--	--	--	--	6300	82000
2-Nitroaniline	0.33	--	--	--	--	--	--	--	--	--	--
Dimethylphthalate	0.17	--	--	--	--	--	--	--	--	--	--
2,6-Dinitrotoluene	0.17	--	--	--	--	--	--	--	--	61	620
3-Nitroaniline	0.33	--	--	--	--	--	--	--	--	--	--
Acenaphthene	0.17	--	--	--	--	***0.02***	plant	334	DiToro et al. 2000	3400	33000
2,4-Dinitrophenol	0.33	--	--	--	--	***0.02***	plant	--	--	120	1200
4-Nitrophenol	0.33	--	--	--	--	***0.007***	earthworm	--	--	--	--
Dibenzofuran	0.17	--	--	--	--	--	--	16.5	DiToro et al. 2000	--	--
2,4-Dinitrotoluene	0.17	--	--	--	--	--	--	--	--	120	1200
Diethylphthalate	0.17	--	--	--	--	--	--	0.6	SQB calculated from Tier II SCV (Jones et al., 1997)	49000	490000
4-Chlorophenyl-phenyl ether	0.17	--	--	--	--	--	--	--	--	--	--
4-Nitroaniline	0.33	--	--	--	--	--	--	--	--	--	--
4,6-Dinitro-2-methylphenol	0.33	--	--	--	--	--	--	--	--	--	--
N-Nitrosodiphenylamine	0.17	--	--	--	--	--	--	--	--	99	350
1,2,4,5-Tetrachlorobenzene	0.17	--	--	--	--	--	--	--	--	18	180
4-Bromophenyl-phenylether	0.17	--	--	--	--	--	--	--	--	--	--
Hexachlorobenzene	0.17	--	--	--	--	--	--	***0.02***	Value is TEL from MacDonald et al. (1996).	0.30	1.1
Atrazine	0.17	--	--	--	--	--	--	--	--	2.1	7.5
Di-n-butylphthalate	0.17	--	--	--	--	--	--	11	ET from OSWER (1996)	6100	62000
Butylbenzylphthalate	0.17	--	--	--	--	--	--	--	--	12000	120000

QAPP Worksheet #15
Reference Limits and Evaluation Table #15-3

Comparison of Quantitation Limits to Comparison Values for Organic Analysis in Soil and Sediment

ANALYTES	CONTRACT REQUIRED QUANTITATION LIMITS [1]	ECOLOGICAL SOIL COMPARISON VALUES						ECOLOGICAL SEDIMENT COMPARISON VALUES		Regional Screening Levels for Chemical Contaminants at Superfund Sites, May 20, 2008.	
		EPA Ecological Soil Screening Level (mg/kg)				ORNL PRGs		Sediment Benchmarks			
	Low Soil (mg/kg)	Plants	Soil Invertebrates	Birds	Mammals	Value (mg/kg)	Receptor Basis	Value (mg/kg)	Source	Residential Soil (mg/kg)	Industrial Soil (mg/kg)
3,3'-dicholorobenzidine	0.17	--	--	--	--	--	--	--	--	1.1	3.8
Bis(2-ethylhexyl) phthalate	0.17	--	--	--	--	--	--	--	--	35	120
Di-n-octylphthalate	0.17	--	--	--	--	--	--	--	--	--	--
2,3,4,6-Tetrachlorophenol	0.17	--	--	--	--	--	--	--	--	1800	18000
Dichlorodifluoromethane	0.005	--	--	--	--	--	--	--	--	190	780
Chloromethane	0.005	--	--	--	--	--	--	2.1	DiToro et al. 2000	1.7	8.4
Vinyl chloride	0.005	--	--	--	--	--	--	--	--	0.060	1.7
Bromomethane	0.005	--	--	--	--	--	--	--	--	7.9	35
Chloroethane	0.005	--	--	--	--	--	--	2.89	DiToro et al. 2000	--	--
Trichlorofluoromethane	0.005	--	--	--	--	--	--	--	--	800	3400
1,1-Dichloroethene	0.005	--	--	--	--	--	--	4.8	DiToro et al. 2000	250	1100
1,1,2-Trichloro-1,2,2-trifluoroethane	0.005	--	--	--	--	--	--	--	--	1.1	5.5
Acetone	0.01	--	--	--	--	--	--	2.3	DiToro et al. 2000	61000	610000
Carbon disulfide	0.005	--	--	--	--	--	--	0.00085	SQB calculated from Tier II SCV (Jones et al., 1997)	670	3000
Methyl acetate	0.005	--	--	--	--	--	--	--	--	78000	1000000
Methylene chloride	0.005	--	--	--	--	--	--	3.7	DiToro et al. 2000	11	54
trans-1,2-Dichloroethene	0.005	--	--	--	--	--	--	4.8	DiToro et al. 2000	110	500
Methyl tert-butyl ether	0.005	--	--	--	--	--	--	--	--	39	190
1,1-Dichloroethane	0.005	--	--	--	--	--	--	4.59	DiToro et al. 2000	3.4	17
cis-1,2-Dichloroethene	0.005	--	--	--	--	--	--	4.8	DiToro et al. 2000	780	10000
2-Butanone	0.01	--	--	--	--	--	--	2.93	DiToro et al. 2000	28000	190000
Bromochloromethane	0.005	--	--	--	--	--	--	--	--	--	--
Chloroform	0.005	--	--	--	--	--	--	5.59	DiToro et al. 2000	0.30	1.5
1,1,1-Trichloroethane	0.005	--	--	--	--	--	--	6.24	DiToro et al. 2000	9000	39000
Cyclohexane	0.005	--	--	--	--	--	--	--	--	--	--
Carbon tetrachloride	0.005	--	--	--	--	--	--	7.74	DiToro et al. 2000	0.25	1.3
Benzene	0.005	--	--	--	--	--	--	6.46	DiToro et al. 2000	1.1	5.6
1,2-Dichloroethane	0.005	--	--	--	--	--	--	4.43	DiToro et al. 2000	0.45	2.2
1,4-Dioxane	0.1	--	--	--	--	--	--	--	--	44	160
Trichloroethene	0.005	--	--	--	--	--	--	6.65	DiToro et al. 2000	2.8	14
Methylcyclohexane	0.005	--	--	--	--	--	--	--	--	3400	14000
1,2-Dichloropropane	0.005	--	--	--	--	--	--	--	--	0.93	4.7
Bromodichloromethane	0.005	--	--	--	--	--	--	7.7	DiToro et al. 2000	10	46
cis-1,3-Dichloropropene	0.005	--	--	--	--	--	--	--	--	1.7	8.4
4-Methyl-2-pentanone	0.01	--	--	--	--	--	--	4.39	DiToro et al. 2000	5300	52000
Toluene	0.005	--	--	--	--	0.2	plant	8.2	DiToro et al. 2000	5000	46000
trans-1,3-Dichloropropene	0.005	--	--	--	--	--	--	--	--	1.7	8.4

QAPP Worksheet #15
Reference Limits and Evaluation Table #15-3

Comparison of Quantitation Limits to Comparison Values for Organic Analysis in Soil and Sediment

ANALYTES	CONTRACT REQUIRED QUANTITATION LIMITS [1]	ECOLOGICAL SOIL COMPARISON VALUES						ECOLOGICAL SEDIMENT COMPARISON VALUES		Regional Screening Levels for Chemical Contaminants at Superfund Sites, May 20, 2008.	
		EPA Ecological Soil Screening Level (mg/kg)				ORNL PRGs		Sediment Benchmarks			
	Low Soil (mg/kg)	Plants	Soil Invertebrates	Birds	Mammals	Value (mg/kg)	Receptor Basis	Value (mg/kg)	Source	Residential Soil (mg/kg)	Industrial Soil (mg/kg)
1,1,2-Trichloroethane	0.005	--	--	--	--	--	--	6.24	DiToro et al. 2000	1.1	5.5
Tetrachloroethene	0.005	--	--	--	--	--	--	8.7	DiToro et al. 2000	0.57	2.7
2-Hexanone	0.01	--	--	--	--	--	--	4.43	DiToro et al. 2000	--	--
Dibromochloromethane	0.005	--	--	--	--	--	--	9.94	DiToro et al. 2000	5.8	21
1,2-Dibromoethane	0.005	--	--	--	--	--	--	--	--	0.034	0.17
Chlorobenzene	0.005	--	--	--	--	0.04	earthworm	5.58	DiToro et al. 2000	310	1500
Ethylbenzene	0.005	--	--	--	--	--	--	--	--	5.7	29
o-Xylene	0.005	--	--	--	--	--	--	--	--	5300	23000
m,p-Xylene	0.005	--	--	--	--	--	--	--	--	4500	19000
Styrene	0.005	--	--	--	--	0.3	plant	9.18	DiToro et al. 2000	6500	38000
Bromoform	0.005	--	--	--	--	--	--	12.2	DiToro et al. 2000	61	220
Isopropylbenzene	0.005	--	--	--	--	--	--	--	--	2200	11000
1,1,2,2-Tetrachloroethane	0.005	--	--	--	--	--	--	8.14	DiToro et al. 2000	0.59	2.9
1,3-Dichlorobenzene	0.005	--	--	--	--	--	--	7.78	DiToro et al. 2000	--	--
1,4-Dichlorobenzene	0.005	--	--	--	--	0.2	earthworm	7.73	DiToro et al. 2000	2.6	13
1,2-Dichlorobenzene	0.005	--	--	--	--	--	--	7.78	DiToro et al. 2000	2000	10000
1,2-Dibromo-3-chloropropane	0.005	--	--	--	--	--	--	--	--	0.0056	0.073
1,2,4-Trichlorobenzene	0.005	--	--	--	--	0.02	earthworm	10.2	DiToro et al. 2000	180	790
1,2,3-Trichlorobenzene	0.005	--	--	--	--	0.02	earthworm	--	--	--	--

1. Analytical method detection limits (MDLs) are determined by individual laboratories to meet data quality objectives.
EPA analytical method detection limits are consistent with EPA CLP methods.

Bold-Itallics - Comparison values are less than the Contract Required Quantitation Limits.

QAPP Worksheet #15
Reference Limits and Evaluation Tables #15-4

Comparison of Quantitation Limits to Comparison Values for Organic Analysis in Water

ANALYTES	CONTRACT REQUIRED QUANTITATION LIMITS [1]		Regional Screening Levels for Chemical Contaminants at Superfund Sites, May 20, 2008.
	Trace Water (ug/L)	Low Water (ug/L)	Tapwater (ug/L)
1,1,1-Trichloroethane	0.5	5	9100
1,1,2,2-Tetrachloroethane	0.5	5	0.067
1,1,2-Trichloro-1,2,2-trifluoroethane	0.5	5	59000
1,1,2-Trichloroethane	0.5	5	0.24
1,1'-Biphenyl	NA	5	1800
1,1-Dichloroethane	0.5	5	2.4
1,1-Dichloroethene	0.5	5	340
1,2,3-Trichlorobenzene	0.5	5	--
1,2,4,5-Tetrachlorobenzene	NA	5	11
1,2,4-Trichlorobenzene	0.5	5	19
1,2-Dibromo-3-chloropropane	0.5	5	0.00032
1,2-Dibromoethane	0.5	5	0.0065
1,2-Dichlorobenzene	0.5	5	370
1,2-Dichloroethane	0.5	5	0.15
1,2-Dichloropropane	0.5	5	0.39
1,3-Dichlorobenzene	0.5	5	--
1,4-Dichlorobenzene	0.5	5	0.43
1,4-Dioxane	--	100	6.1
1234678-HpCDD	0.00005	--	--
1234678-HpCDF	0.00005	--	--
1234789-HpCDF	0.00005	--	--
123478-HxCDD	0.00005	--	--
123478-HxCDF	0.00005	--	--
123678-HxCDD	0.00005	--	--
123678-HxCDF	0.00005	--	--
123789-HxCDD	0.00005	--	--
123789-HxCDF	0.00005	--	--
12378-PeCDD	0.00005	--	--
12378-PeCDF	0.00005	--	0.000015
2,2'-Oxybis(1-choloropropane)	NA	5	--
2,3,4,6-Tetrachlorophenol	NA	5	1100
2,4,5-Trichlorophenol	NA	5	3700
2,4,6-Trichlorophenol	NA	5	6.1
2,4-Dichlorophenol	NA	5	110
2,4-Dimethylphenol	NA	5	730
2,4-Dinitrophenol	NA	10	73
2,4-Dinitrotoluene	NA	5	73
2,6-Dinitrotoluene	NA	5	37
234678-HxCDF	0.00005	--	--
23478-PeCDF	0.00005	--	0.0000015
2378-TCDD	0.00001	--	0.00000052
2378-TCDF	0.00001	--	0.0000045
2-Butanone	5	10	7100

QAPP Worksheet #15
Reference Limits and Evaluation Tables #15-4

Comparison of Quantitation Limits to Comparison Values for Organic Analysis in Water

ANALYTES	CONTRACT REQUIRED QUANTITATION LIMITS [1]		Regional Screening Levels for Chemical Contaminants at Superfund Sites, May 20, 2008.
	Trace Water (ug/L)	Low Water (ug/L)	Tapwater (ug/L)
2-Chloronaphthalene	NA	5	2900
2-Chlorophenol	NA	5	180
2-Hexanone	5	10	--
2-Methylnaphthalene	NA	5	--
2-Methylphenol	NA	5	--
2-Nitroaniline	NA	10	--
2-Nitrophenol	NA	5	--
3,3'-dicholorobenzidine	NA	5	0.15
3-Nitroaniline	NA	10	--
4,4'-DDD	0.1	--	0.28
4,4'-DDE	0.1	--	0.20
4,4'-DDT	0.1	--	0.20
4,6-Dinitro-2-methylphenol	NA	10	1800
4,6-Dinitro-2-methylphenol	NA	10	1800
4-Bromophenyl-phenylether	NA	5	--
4-Chloro-3-methylphenol	NA	5	--
4-Chloroaniline	NA	5	150
4-Chlorophenyl-phenyl ether	NA	5	--
4-Methyl-2-pentanone	5	10	2000
4-Methylphenol	NA	5	180
4-Nitroaniline	NA	10	--
4-Nitrophenol	NA	10	--
Acenaphthene	NA	5	2200
Acenaphthylene	NA	5	--
Acetone	5	10	22000
Acetophenone	NA	5	3700
Aldrin	0.05	--	0.0040
alpha-BHC	0.05	--	--
alpha-Chlordane	0.05	--	--
Anthracene	NA	5	11000
Aroclor-1016	1	--	0.96
Aroclor-1221	1	--	0.0068
Aroclor-1232	1	--	0.0068
Aroclor-1242	1	--	0.034
Aroclor-1248	1	--	0.034
Aroclor-1254	1	--	0.034
Aroclor-1260	1	--	0.034
Aroclor-1262	1	--	--
Aroclor-1268	1	--	--
Atrazine	NA	5	0.29
Benzaldehyde	NA	5	3700
Benzene	0.5	5	0.41
Benzo(a) pyrene	NA	5	0.0029

QAPP Worksheet #15
Reference Limits and Evaluation Tables #15-4

Comparison of Quantitation Limits to Comparison Values for Organic Analysis in Water

ANALYTES	CONTRACT REQUIRED QUANTITATION LIMITS [1]		Regional Screening Levels for Chemical Contaminants at Superfund Sites, May 20, 2008.
	Trace Water (ug/L)	Low Water (ug/L)	Tapwater (ug/L)
Benzo(a)anthracene	NA	5	0.029
Benzo(b) fluoranthene	NA	5	0.029
Benzo(g,h,i) perylene	NA	5	--
Benzo(k) fluoranthene	NA	5	0.29
beta-BHC	0.05	--	0.037
Bis(2-chloroethoxy) methane	NA	5	110
Bis(2-chloroethyl) ether	NA	5	0.012
Bis(2-ethylhexyl) phthalate	NA	5	4.8
Bromochloromethane	0.5	5	--
Bromodichloromethane	0.5	5	1.1
Bromoform	0.5	5	8.5
Bromomethane	0.5	5	8.7
Butylbenzylphthalate	NA	5	7300
Caprolactam	NA	5	18000
Carbazole	NA	5	3.4
Carbon disulfide	0.5	5	1000
Carbon tetrachloride	0.5	5	0.20
Chlorobenzene	0.5	5	91
Chloroethane	0.5	5	21000
Chloroform	0.5	5	0.19
Chloromethane	0.5	5	1.8
Chrysene	NA	5	2.9
cis-1,2-Dichloroethene	0.5	5	370
cis-1,3-Dichloropropene	0.5	5	0.43
Cyclohexane	0.5	5	13000
delta-BHC	0.05		0.011
Dibenzo(a,h) anthracene	NA	5	0.0029
Dibenzofuran	NA	5	--
Dibromochloromethane	0.5	5	1
Dichlorodifluoromethane	0.5	5	--
Dieldrin	0.1	--	0
Diethylphthalate	NA	5	29000
Dimethylphthalate	NA	5	--
Di-n-butylphthalate	NA	5	3700
Di-n-octylphthalate	NA	5	--
Di-n-octylphthalate	NA	5	--
Endosulfan I	0.05	--	--
Endosulfan II	0.1	--	--
Endosulfan sulfate	0.1	--	--
Endrin	0.1	--	11
Endrin aldehyde	0.1	--	--
Endrin ketone	0.1	--	--
Ethylbenzene	0.5	5	1.5

QAPP Worksheet #15
Reference Limits and Evaluation Tables #15-4
Comparison of Quantitation Limits to Comparison Values for Organic Analysis in Water

ANALYTES	CONTRACT REQUIRED QUANTITATION LIMITS [1]		Regional Screening Levels for Chemical Contaminants at Superfund Sites, May 20, 2008.
	Trace Water (ug/L)	Low Water (ug/L)	Tapwater (ug/L)
Fluoranthene	NA	5	1500
Fluorene	NA	5	1500
gamma-BHC (Lindane)	0.05	--	0.061
gamma-Chlordane	0.05	--	--
Heptachlor	0.05	--	0.015
Heptachlor epoxide	0.05	--	0.0074
Hexachlorobenzene	NA	5	0.042
Hexachlorobutadiene	NA	5	0.86
Hexachlorocyclopentadiene	NA	5	220
Hexachloroethane	NA	5	11
Indeno(1,2,3,-cd) pyrene	NA	5	0.029
Isophorone	NA	5	71
Isopropylbenzene	0.5	5	680
m,p-Xylene	0.5	5	1400
Methoxychlor	0.5	--	180
Methyl acetate	0.5	5	37000
Methyl tert-butyl ether	0.5	5	12
Methylcyclohexane	0.5	5	6300
Methylene chloride	0.5	5	4.8
Naphthalene	NA	5	6.2
Nitrobenzene	NA	5	3.4
N-Nitroso-di-n propylamine	NA	5	0.010
N-Nitrosodiphenylamine	NA	5	14
OCDD	0.0001	--	0.0015
OCDF	0.0001	--	0.0015
o-Xylene	0.5	5	1400
Pentachlorophenol	NA	10	0.56
Phenanthrene	NA	5	--
Phenol	NA	5	11000
Pyrene	NA	5	1100
Styrene	0.5	5	1600
Tetrachloroethene	0.5	5	0.11
Toluene	0.5	5	2300
Toxaphene	5	--	0.061
trans-1,2-Dichloroethene	0.5	5	110
trans-1,3-Dichloropropene	0.5	5	0.43
Trichloroethene	0.5	5	1.7
Trichlorofluoromethane	0.5	5	1300
Vinyl chloride	0.5	5	0.016

1. Analytical method detection limits (MDLs) are determined by individual laboratories to meet data quality objectives. EPA analytical method detection limits are consistent with EPA CLP methods.

Bold-Itallics - Comparison values are less than the Contract Required Quantitation Limits

QAPP Worksheet #16
Project Schedule/Timeline

Activities	Organization	Deliverable	Deliverable Due Date
Site Management Plan (SMP)	EA Engineering	Site Management Plan (SMP)	14 days following EPA approval of RI/FS Work Plan
Health and Safety Plan (HSP)	EA Engineering	Health and Safety Plan (HSP)	14 days following EPA approval of RI/FS Work Plan
Draft Sampling and Analysis Plan (SAP) includes the following: Draft Quality Assurance Project Plan (QAPP); Draft Field Sampling Plan (FSP); Draft Conceptual Understanding of the Site Technical Memorandum; and Draft Interim Measures (IM) Technical Memorandum	EA Engineering	Draft Sampling and Analysis Plan (SAP) includes the following: Draft Quality Assurance Project Plan (QAPP); Draft Field Sampling Plan (FSP); Draft Conceptual Understanding of the Site Technical Memorandum; and Draft Interim Measures (IM) Technical Memorandum	30 days following EPA approval of RI/FS Work Plan
Final SAP includes the following: Final QAPP; Final FSP; Final Conceptual Understanding of the Site Technical Memorandum; and Final IM Technical Memorandum	EA Engineering	Final SAP includes the following: Final QAPP; Final FSP; Final Conceptual Understanding of the Site Technical Memorandum; and Final IM Technical Memorandum	14 days following receipt of EPA comments
Monthly Status Reports and Cost Invoices	EA Engineering	Monthly Status Reports and Cost Invoices	20th of the month
Public Meeting Support Materials	EA Engineering	Public Meeting Support Materials	1 week prior to scheduled meeting
Field Reports	EA Engineering	Field Reports	7 days following each week of field activities

QAPP Worksheet #16
Project Schedule/Timeline

Activities	Organization	Deliverable	Deliverable Due Date
Draft Data Validation Report (DVR)	EA Engineering	Draft Data Validation Report (DVR)	30 days following receipt of all analytical data from laboratory
Final DVR	EA Engineering	Final DVR	21 days following receipt of EPA comments
Draft Data Evaluation Summary Report (DESR)	EA Engineering	Draft Data Evaluation Summary Report (DESR)	30 days following submittal of Final DVR
Final DESR	EA Engineering	Final DESR	21 days following receipt of EPA comments
Draft Human Health Risk Assessment (HHRA) Report	EA Engineering	Draft Human Health Risk Assessment (HHRA) Report	45 days following submittal of Final DVR
Draft Ecological Risk Assessment (ERA) Report	EA Engineering	Draft Ecological Risk Assessment (ERA) Report	45 days following submittal of Final DVR
Final HHRA Report	EA Engineering	Final HHRA Report	30 days following receipt of EPA comments
Final ERA Report	EA Engineering	Final ERA Report	30 days following receipt of EPA comments
Draft Treatability Study (TS) Work Plan	EA Engineering	Draft Treatability Study (TS) Work Plan	30 days following completion of RI, if required as a result of the RI
Final TS Work Plan	EA Engineering	Final TS Work Plan	14 days following receipt of EPA comments
Draft TS Evaluation Report	EA Engineering	Draft TS Evaluation Report	30 days following completion of the TS

QAPP Worksheet #16
Project Schedule/Timeline

Activities	Organization	Deliverable	Deliverable Due Date
Final TS Evaluation Report	EA Engineering	Final TS Evaluation Report	14 days following receipt of EPA comments
Draft Remedial Investigation (RI) Report	EA Engineering	Draft Remedial Investigation (RI) Report	11 months following EPA approval of RI/FS Work Plan
Final RI Report	EA Engineering	Final RI Report	30 days following receipt of EPA comments
Draft Remedial Alternative Technical Memorandum (RATM)	EA Engineering	Draft Remedial Alternative Technical Memorandum (RATM)	18 months following EPA approval of RI/FS Work Plan
Final RATM	EA Engineering	Final RATM	30 days following receipt of EPA comments
Draft Feasibility Study (FS) Report	EA Engineering	Draft Feasibility Study (FS) Report	20 months following EPA approval of RI/FS Work Plan
Final FS Report	EA Engineering	Final FS Report	30 days following receipt of EPA comments
FS Addendum	EA Engineering	FS Addendum	To be determined
Administrative Record and Index	EA Engineering	Administrative Record and Index	To be determined
Task Order Closeout Report	EA Engineering	Task Order Closeout Report	14 days following receipt of Task Order Closeout Notification, or 60 days following submittal of Final FS Report, whichever is later
Final Costs	EA Engineering	Final Costs	90 days following Task Order Closeout

The project schedule is outlined in the EPA Statement of Work dated 3 March 2008 and the EPA approved Work Plan dated 22 May 2008. Activities and completion dates are tied to milestones, which are subject to project variability (e.g., field sampling timeline). Therefore, definative deliverable dates are not provided in Worksheet #16.

QAPP Worksheet #17
Sampling Design and Rationale

Describe and provide a rationale for choosing the sampling approach (e.g., grid system, biased statistical approach):

The sampling approach was designed to capture representative groundwater, surface water, soil, sediment, and air samples in order to characterize the existing conditions at each of the AOI locations in the RI/FS Work Plan. The sampling locations were arranged according to previous reports and any historical knowledge of each respective site.

Describe the sampling design and rationale in terms of what matrices will be sampled, what analytical groups will be analyzed and at what concentration levels, the sampling locations (including QC, critical, and background samples), the number of samples to be taken, and the sampling frequency (including seasonal considerations) [May refer to map or Worksheet #18 for details]:

Grab ground water samples will be collected in the Alluvial and Bedrock Aquifers over a wide area surrounding the Site as part of this investigation. Biased or judgemental surface water, soil, sediment, and air samples will be collected as part of this investigation to determine the nature and extent of contamination. In addition, Visual Sample Plan Version 5.0 was used to select random start grid sample locations for soil sampling. Additional details pertaining to sample design and rationale are provided in the Sampling and Analysis Plan.

QAPP Worksheet #18
Sampling Locations and Methods/SOP Requirements Table

Sampling Location/ID Number	Matrix	Depth (feet)	Analytical Group	Concentration Level	Number of Samples (identify field duplicates)	Sampling SOP Reference	Rationale for Sampling Location
To be determined	Soil	0 - 2	Total Metals, Cyanide, VOC, SVOC, Pesticides, Aroclors, Nitrate, Sulfate, Perchlorate, Dioxins and Furans, SPLP, Lead and Arsenic Speciation, pH, Asbestos	Low/Medium/High	Up to 565	S-6	To assess potential COC in soil
To be determined	Soil	> 2	Total Metals, Cyanide, VOC, SVOC, Pesticides, Aroclors, Nitrate, Sulfate, Perchlorate, Dioxins and Furans, SPLP, Lead and Arsenic Speciation, pH, Asbestos	Low/Medium/High	Up to 565	S-6	To assess potential COC in soil
To be determined	Sediment	Surface	Total Metals, Cyanide, VOC, SVOC, Pesticides, Aroclors, Nitrate, Sulfate, Perchlorate, Dioxins and Furans, SPLP, Lead and Arsenic Speciation, pH, Asbestos	Low/Medium/High	Up to 565	S-7	To assess potential COC in drainage area sediments
To be determined	Surface Water	Surface	Total Metals, Cyanide, VOC, SVOC, Nitrate, Sulfate, Perchlorate, Anionis/Cations, Total Dissolved Solids, Pesticides, Aroclors, Dioxins and Furans	Low/Medium/High	up to 256	S-3	To assess potential COC in surface water
To be determined	Ground Water	Water Table	Total Metals, Cyanide, VOC, SVOC, Nitrate, Sulfate, Perchlorate, Anionis/Cations, Total Dissolved Solids, Pesticides, Aroclors, Dioxins and Furans	Low/Medium/High	up to 256	S-4 and S-5	To assess potential COC in the water table
To be determined	Air	Ambient	PM 10.0, TSP, Metals	Low	up to 90	S-12 and S-13	To assess potential COC in the air

QAPP Worksheet #19
Analyitical SOP Requirements Table

Matrix	Analytical Group	Concentration Level	Analytical and Preparation Method	Sample Volume	Containers (number, size, and type)	Preservation Requirements (chemical, temperature, light protected)	Maximum Holding Time (preparation/analysis)
Soil/Sediment	Total Metals (including mercury and cyanide)	Low/Medium/High	CLP ILM05.4 SW846 6010	8 oz	1 - 8 oz. wide mouth glass jar	Cool 4°C	180 days 28 days for Hg
Soil/Sediment	VOC	Low/Medium/High	CLP ILM01.2 SW846 5035	40 mL	3 - 40 ml VOA Vials 1-4 oz. wide mouth glass jar (moisture content) (EnCore Sampler)	Methanol Preservative, Cool 4°C	48 hrs
Soil/Sediment	SVOC/Pesticides/ Aroclors	Low/Medium/High	CLP ILM01.2 SW846 8270, 8081,8082	8 oz	1 - 8 oz. wide mouth glass jar	Cool 4°C, protect from light	7 days - SVOC 14 days - pesticides/aroclors
Soil/Sediment	Nitrate/Sulfate/ Perchlorate	Low/Medium/High	SW846 300.0, 314.0	4 oz	1 - 4 oz. wide mouth glass jar	Cool 4°C	48 hrs - nitrate 28 days - sulfate perchlorate -
Soil/Sediment	Dioxins and Furans	Low/Medium/High	SW846 8290	8 oz	1 - 8 oz. wide mouth glass jar	Cool 4°C	14 days
Soil/Sediment	Synthetic Precipiation Leaching Procedure	Low/Medium/High	SW846 1312	4 oz	1 - 4 oz. wide mouth glass jar	Cool 4°C	14 days
Soil/Sediment	Lead/Arsenic Speciation	Low/Medium/High	SEM	4 oz	1 - 4 oz. wide mouth glass jar	Cool 4°C	14 days
Soil/Sediment	Asbestos	Low/Medium/High	Region 9 Lab SOP 490 (ASTM D22.05)	4 oz	1 - 4 oz. wide mouth glass jar	NA	NA
Soil/Sediment	pH	Low/Medium/High	SW846 9045	8 oz	1 - 8 oz. wide mouth glass jar	Cool 4°C	48 hrs
Water	Total Metals (including mercury)	Low/Medium/High	CLP ILM05.4 SW846 6010	250 ml	1 - 250 ml polythylene bottle	HNO3, pH <2, Cool 4°C	180 days (Hg = 28 days)
Water	Cyanide	Low/Medium/High	CLP ILM05.4 SW846 6010	250 ml	1 - 250 ml polythylene bottle	NaOH, pH > 12, Cool 4°C	180 days

QAPP Worksheet #19
Analyitical SOP Requirements Table

Matrix	Analytical Group	Concentration Level	Analytical and Preparation Method	Sample Volume	Containers (number, size, and type)	Preservation Requirements (chemical, temperature, light protected)	Maximum Holding Time (preparation/analysis)
Water	VOC	Low/Medium/High	CLP SOM01.2 SW846 8260	40 ml	3 - 40 ml VOA Vials	HCL, ph < 2, Cool 4°C	14 days
Water	SVOC	Low/Medium/High	CLP SOM01.2 SW846 8270	1 liter	2 - 1 liter glass amber	Cool 4°C, protect from light	7 days
Water	Nitrate/Sulfate/ Perchlorate	Low/Medium/High	SW846 300.0, 314.0	250 - 500 ml	1 - 250-500 ml polyethylene bottle	Cool 4°C	48 hrs - nitrates 28 days - sulfates perchlorate
Water	Anions/Cations	Low/Medium/High	SW846 300.0, 6020	250 - 500 ml	1 - 250-500 ml polyethylene bottle	Cool 4°C	7 days
Water	Total Dissolved Solids	Low/Medium/High	SW846 160.1	250 ml	1 - 250 ml polythylene bottle	Cool 4°C	7 days
Water	Pesticides/Aroclors	Low/Medium/High	SW846 8081, 8082	1 liter	2 - 1 liter glass amber	Cool 4°C	7 days
Water	Dioxins and Furans	Low/Medium/High	DLM01.2 SW846 8290	1 liter	2 - 1 liter glass amber	Cool 4°C	1 year if stored in the dark
Air	PM 10	Low	IO-3.1 NIOSH 0500	47 mm quartz filter	1 - Filter/sample	NA	180 days
Air	TSP	Low	IO-3.1	47 mm glass filter	1 - Filter/sample	NA	180 days
Air	Metals	Low	ICP-6010 Hg-CVAA 7471 NIOSH 7300	47 mm quartz filter	1 - Filter/sample	NA	180 days

QAPP Worksheet #20
Field Quality Control Sample Summary Table

Matrix	Analytical Group	Concentration Level	Analytical and Preparation SOP Reference	No. of Sampling Locations	No. of Field Duplicate Pairs	Inorganic No. of MS	No. of Field Blanks	No. of Equip. Blanks	No. of PT Samples	Total No. of Samples to Lab
Soil/Sediment	Total Metals (Hg), Cyanide, VOC, SVOC, Pesticides, Aroclors, Perchlorate, Nitrate, Sulfate, Dioxins and Furans, SPLP, Lead/Arsenic Speciation, pH, Asbestos	Low Medium High	S-6 and S-7; See Worksheet #23 for Analytical Preparation	up to 505	1/10	1/10 or 1/20	NA	1/Day	0	up to 565
Water	Total Metals (Hg), Cyanide, VOC, SVOC, Perchlorate, Nitrate, Sulfate, Anions, Cations, TDS, Pesticides, Aroclors, Dioxins and Furans	Low Medium High	S-3, S-4 and S-5; See Worksheet #23 for Analytical Preparation	up to 226	1/10	1/10 or 1/20	1/Day/VOCs	1/Day	0	up to 295
Air	PM 10, Total Suspended Particulates, Metals	Low	S-12 and S-13; See Worksheet #23 for Analytical Preparation	up to 90	1/10	NA	NA	NA	0	up to 90

QAPP Worksheet #21
Project Sampling SOP References Table

Reference Number	Title, Revision Date and/or Number	Originating Organization	Equipment Type	Comments
S-1	SOP No. 039 Sample Preservation	EA Engineering	Laboratory containers	NA
S-2	SOP No. 016 Surface Water, Ground Water, and Soil/Sediment Field Logbooks	EA Engineering	Field logbooks	NA
S-3	SOP No. 007 Surface Water Sampling Procedures	EA Engineering	Containers, dip sampler, disposable filters, PPE, etc.	NA
S-4	SOP No. 013 MW Sample Collection	EA Engineering	Tubing, pump, YSI, containers, PPE, plastic sheeting, water level meter, etc.	NA
S-5	SOP No. 051 Low Flow Sampling	EA Engineering	Tubing, pump, YSI, containers, PPE, plastic sheeting, water level meter, etc.	NA
S-6	SOP No. 025 Soil Sampling	EA Engineering	Drill rig, push probe, split spoon, auger, trowel, jars, ppe, etc.	NA
S-7	SOP No. 021 Sediment Sampling	EA Engineering	Sample collection, jars, PPE, etc.	NA
S-8	SOP No. 019 MW Installation	EA Engineering	Drilling equipment, PID, steel drums, plastic sheeting, absorbant pads, PPE, etc.	NA

QAPP Worksheet #21
Project Sampling SOP References Table

Reference Number	Title, Revision Date and/or Number	Originating Organization	Equipment Type	Comments
S-9	XRF Analysis	Thermo Fisher Niton XRF	XRF, standards, docking station, rechargeable battery, strap for XRF	NA
S-10	YSI Calibration	EA Engineering	YSI, flow thru cell, connections, electrode guard cage, batteries	NA
S-11	MIE Personal DataRam	Thermo Electon Corp.	MIE DataRam Monitor, pump unit, rechargeable battery	NA
S-12	Gilian GilAir 5	Sensidyne	Gilian GilAir 4 pump, cassettes with filters, tubing	NA
S-13	PQ 100 Air Sampler	BGI, Inc	PQ 100 Air Sampler, battery charger, communication adaptor cable	NA
S-14	Ludlum Survey Meter	Ludlum Meaurements, Inc.	Ludlum pocket survey meter, detector tubes, batteries	NA
S-15	UltraMeter Water Quality Instrument	Myron L. Company	Ultrameter, calibration standards	NA

Note:
Sampling SOPs are included in Appendix F of the Sampling and Analysis Plan.
Sampling SOP for Reference Number S-13 is included in Appendix D of the Air Quality Monitoring Plan.
NA = None Applicable

QAPP Worksheet #22
Field Equipment Calibration, Maintenance, Testing, and Inspection Table

Field Equipment	Calibration Activity	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
XRF	Calibrate with provided XRF standards	Decon and place in hard case at end of each day	NA	Inspect for external damage (i.e. LCD screen, dents, etc.)	Daily	Within calibration standard(s) range	Recalibration	Field personnel	S-9
YSI	Calibrate probe with pH, conductivity, ORP, DO, and turbidity standards	Decon and place in hard case at end of each day	NA	Inspect external damage (i.e. connections, LCD screen, etc.)	Daily before use and when unstable readings occur	Within calibration standard(s) range	Recalibration	Field personnel	S-10
MIE Rae Personal DataRam Air Monitor	Filter sample provided as a standard	Clean and place in case at end of each day	NA	Inspect for external damage (i.e. LCD screen, dents, etc.)	Daily	Within calibration standard(s) range	Recalibration	Field personnel	S-11
Gilian GilAir 5	Calibrate to target flow rate	Replace filters, tubing	NA	Inspect cassettes, tubing, pump flow rate	Frequently	Within calibrated flow rate	Recalibration	Field personnel	S-12
PQ 100 Air Sampler	Calibrate to target flow rate	Maintain sampler in an upright position, legs bolted to prevent wind damage	NA	Inspect main unit for damage and flow rate	Frequently	Within calibration standard(s) range	Recalibration	Field personnel	S-13
Ludlum Survey Meter	Manufacturer procedures upon request	Cleaning instrument, checking batteries, calibration, and slide switches	NA	Inspect instrument for dust specifically slide switches	After maintenance or adjustments have made	Within calibaration standard(s) range	Recalibration	Field personnel	S-14
Ultra Meter	Calibrate with provided water quality standard(s)	Decon and place in hard case at end of each day	NA	Inspect for external damage (i.e. LCD screen, dents, etc.)	Daily before use and when unstable readings occur	Within calibration standard(s) range	Recalibration	Field personnel	S-15

Note: Sampling SOPs are included in Appendix F of the Sampling and Analysis Plan.
NA = None Applicable

QAPP Worksheet #23
Analytical SOP References Table

Reference Number	Title, Revision Date, and/or Number	Definitive or Screening Data	Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work?
A-1	Multi Media, Multi Concentration Inorganic Analytical Services for Superfund ILM0.5.4 Inductively Coupled Plasma - Atomic Emission Spectrometry (SW846 6010)	Definitive	Total Metals (mercury and cyanide)	ICP-AES	EPA Region 9 Laboratory, CLP Laboratory, Private Laboratory	No
A-2	Multi Media, Multi Concentration Organic Analytical Services for Superfund SOM01.2 Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry (SW846 8260) Closed System Purge and Trap Extraction for Volatile Organics in Soil and Waste Samples (SW846 5035)	Definitive	VOC	GC/MS	EPA Region 9 Laboratory, CLP Laboratory, Private Laboratory	No
A-3	Multi Media, Multi Concentration Organic Analytical Services for Superfund SOM01.2 Semivolatile Organic Compounds by Gas Chromatography/Mass Spectrometry (SW846 8270)	Definitive	SVOC	GC/MS	EPA Region 9 Laboratory, CLP Laboratory, Private Laboratory	No
A-4	Multi Media, Multi Concentration Organic Analytical Services for Superfund SOM01.2 Organochlorine Pesticides by Gas Chromatography (SW846 8081)	Definitive	Pesticides	GC	EPA Region 9 Laboratory, CLP Laboratory, Private Laboratory	No
A-5	Multi Media, Multi Concentration Organic Analytical Services for Superfund SOM01.2 Polychlorinated Biphenyls (PCBs) by Gas Chromatography (SW846 8082)	Definitive	Aroclors	GC	EPA Region 9 Laboratory, CLP Laboratory, Private Laboratory	No
A-6	Multi Media, Multi Concentration Dioxins and Furans Analysis DLM01.2 (A Non-Routine Analytical Service) Polychlorinated Dibenzodioxins (PCDDs) and Polychlorinated Dibenzofurans (PCDFs) by High-Resolution Gas Chromatography/High-Resolution Mass Spectrometry (SW846 8290)	Definitive	Dioxins and Furans	HRGC/HRMS	EPA Region 9 Laboratory, CLP Laboratory, Private Laboratory	No
A-7	Dertermination of Perchlorate in Drinking Water by Ion Chromatography (SW846 314.0)	Definitive	Perchlorate	IC	EPA Region 9 Laboratory, CLP Laboratory, Private Laboratory	No

QAPP Worksheet #23
Analytical SOP References Table

Reference Number	Title, Revision Date, and/or Number	Definitive or Screening Data	Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work?
A-8	Determination of Inorganic Anions in Drinking Water by Ion Chromatography (SW846 300.0)	Definitive	Nitrate, Sulfate, Anions	IC	EPA Region 9 Laboratory, CLP Laboratory, Private Laboratory	No
A-9	Inductively Coupled Plasma -Mass Spectrometry (SW846 6020)	Definitive	Cations	ICP-MS	EPA Region 9 Laboratory, CLP Laboratory, Private Laboratory	No
A-10	Determination of Asbestos in Bulk Materials By Polarized Light Microscopy (EPA Region 9 Lab SOP 490)	Definitive	Asbestos	Polarized Light Microscopy	EPA Region 9 Laboratory, CLP Laboratory, Private Laboratory	No
A-11	Total Dissolved Solids (SW846 160.1)	Definitive	Total Dissolved Solids	Gravimetric	EPA Region 9 Laboratory, CLP Laboratory, Private Laboratory	No
A-12	Synthetic Precipiation Leaching Procedure (SW846 1312)	Definitive	SPLP	Filtration/ Extraction	EPA Region 9 Laboratory, CLP Laboratory, Private Laboratory	No
A-13	Solid and Waste pH (SW846 9045)	Definitive	pH	pH meter	EPA Region 9 Laboratory, CLP Laboratory, Private Laboratory	No
A-14	Scanning Electron Microscopy	Definitive	Lead and Arsenic Speciation	SEM	EPA Region 9 Laboratory, CLP Laboratory, Private Laboratory	No
A-15	Inorganic Compendium Method (IO) - 3.1 Gravimetric Analysis (EPA/625/R-96/010a) NIOSH 0500 (pre-weighed filter cassettes)	Definitive	PM_{10}	Gravimetric	EPA Region 9 Laboratory, CLP Laboratory, Private Laboratory	No
A-16	Inorganic Compendium Method (IO) - 3.1 Gravimetric Analysis (EPA/625/R-96/010a)	Definitive	TSP	Gravimetric	EPA Region 9 Laboratory, CLP Laboratory, Private Laboratory	No
A-17	ICP 6010 and Hg by CVAA 7471 NIOSH 7300 (pre-weighed filter cassettes)	Definitive	Metals (Air)	ICP	EPA Region 9 Laboratory, CLP Laboratory, Private Laboratory	No

QAPP Worksheet #24
Analytical Instrument Calibration Table

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference
ICP-AES	CLP ILM05.4 OR SW846 6010	EPA Laboratory Analytical Protocol	EPA Laboratory Analytical Protocol	Instrument Maintenance, standard inspection, recalibration	Laboratory Analyst	A-1
GS/MS	CLP SOM01.2 OR SW846 8260, 8270, and 5035	EPA Laboratory Analytical Protocol	EPA Laboratory Analytical Protocol	Instrument Maintenance, standard inspection, recalibration	Laboratory Analyst	A-2 A-3
GC	CLP SOM01.2 OR SW846 8081 and 8082	EPA Laboratory Analytical Protocol	EPA Laboratory Analytical Protocol	Instrument Maintenance, standard inspection, recalibration	Laboratory Analyst	A-4 A-5
HRGC/HRMS	CLP DLM01.2 OR SW846 8290	EPA Laboratory Analytical Protocol	EPA Laboratory Analytical Protocol	Instrument Maintenance, standard inspection, recalibration	Laboratory Analyst	A-6
IC	SW846 300.0 and 314.0	EPA Laboratory Analytical Protocol	EPA Laboratory Analytical Protocol	Instrument Maintenance, standard inspection, recalibration	Laboratory Analyst	A-7 A-8
ICP-MS	SW846 6020	EPA Laboratory Analytical Protocol	EPA Laboratory Analytical Protocol	Instrument Maintenance, standard inspection, recalibration	Laboratory Analyst	A-9
Polarized Light Microscopy	EPA Region 9 Lab SOP 490	EPA Laboratory Analytical Protocol	EPA Laboratory Analytical Protocol	Instrument Maintenance, standard inspection, recalibration	Laboratory Analyst	A-10

QAPP Worksheet #24
Analytical Instrument Calibration Table

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference
Gravimetric	SW846 160.1	EPA Laboratory Analytical Protocol	EPA Laboratory Analytical Protocol	Instrument Maintenance, standard inspection, recalibration	Laboratory Analyst	A-11
SPLP Filter/Extratction	SW846 1312	EPA Laboratory Analytical Protocol	EPA Laboratory Analytical Protocol	Instrument Maintenance, standard inspection, recalibration	Laboratory Analyst	A-12
pH meter	SW846 9045	EPA Laboratory Analytical Protocol	EPA Laboratory Analytical Protocol	Instrument Maintenance, standard inspection, recalibration	Laboratory Analyst	A-13
Scanning Electron Microscopy	SEM	EPA Laboratory Analytical Protocol	EPA Laboratory Analytical Protocol	Instrument Maintenance, standard inspection, recalibration	Laboratory Analyst	A-14
Gravimetric	Inorganic Compendium Method (IO) - 3.1 Gravimetric Analysis (EPA/625/R-96/010a) NIOSH 0500	EPA Laboratory Analytical Protocol	EPA Laboratory Analytical Protocol	Instrument Maintenance, standard inspection, recalibration	Laboratory Analyst	A-15 A-16
ICP-AES and Cold Vapor Atomic Absorption Specometry	ICP 6010 and Hg by CVAA 7471 NIOSH 7300	EPA Laboratory Analytical Protocol	EPA Laboratory Analytical Protocol	Instrument Maintenance, standard inspection, recalibration	Laboratory Analyst	A-17

QAPP Worksheet #25
Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
ICP-AES	EPA Analytical Laboratory Protocol	CLP ILM05.4 OR SW846 6010	EPA Analytical Laboratory Protocol	Daily or as needed	EPA Analytical Laboratory Protocol	Perform maintenance, check standards, recalibrate, reanalyze	Laboratory Analyst	A-1
GS/MS	EPA Analytical Laboratory Protocol	CLP SOM01.2 OR SW846 8260, 8270, and 5035	EPA Analytical Laboratory Protocol	Daily or as needed	EPA Analytical Laboratory Protocol	Perform maintenance, check standards, recalibrate, reanalyze	Laboratory Analyst	A-2 A-3
GC	EPA Analytical Laboratory Protocol	CLP SOM01.2 OR SW846 8081 and 8082	EPA Analytical Laboratory Protocol	Daily or as needed	EPA Analytical Laboratory Protocol	Perform maintenance, check standards, recalibrate, reanalyze	Laboratory Analyst	A-4 A-5
HRGC/HRMS	EPA Analytical Laboratory Protocol	CLP DLM01.2 OR SW846 8290	EPA Analytical Laboratory Protocol	Daily or as needed	EPA Analytical Laboratory Protocol	Perform maintenance, check standards, recalibrate, reanalyze	Laboratory Analyst	A-6
IC	EPA Analytical Laboratory Protocol	SW846 300.0 and 314.0	EPA Analytical Laboratory Protocol	Daily or as needed	EPA Analytical Laboratory Protocol	Perform maintenance, check standards, recalibrate, reanalyze	Laboratory Analyst	A-7 A-8
ICP-MS	EPA Analytical Laboratory Protocol	SW846 6020	EPA Analytical Laboratory Protocol	Daily or as needed	EPA Analytical Laboratory Protocol	Perform maintenance, check standards, recalibrate, reanalyze	Laboratory Analyst	A-9
Polarized Light Microscopy	EPA Analytical Laboratory Protocol	EPA Region 9 Lab SOP 490	EPA Analytical Laboratory Protocol	Daily or as needed	EPA Analytical Laboratory Protocol	Perform maintenance, check standards, recalibrate, reanalyze	Laboratory Analyst	A-10

QAPP Worksheet #25
Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
Gravimetric	EPA Analytical Laboratory Protocol	SW846 160.1	EPA Analytical Laboratory Protocol	Daily or as needed	EPA Analytical Laboratory Protocol	Perform maintenance, check standards, recalibrate, reanalyze	Laboratory Analyst	A-11
SPLP Filter/Extratction	EPA Analytical Laboratory Protocol	SW846 1312	EPA Analytical Laboratory Protocol	Daily or as needed	EPA Analytical Laboratory Protocol	Perform maintenance, check standards, recalibrate, reanalyze	Laboratory Analyst	A-12
pH meter	EPA Analytical Laboratory Protocol	SW846 9045	EPA Analytical Laboratory Protocol	Daily or as needed	EPA Analytical Laboratory Protocol	Perform maintenance, check standards, recalibrate, reanalyze	Laboratory Analyst	A-13
Scanning Electron Microscopy	EPA Analytical Laboratory Protocol	SEM	EPA Analytical Laboratory Protocol	Daily or as needed	EPA Analytical Laboratory Protocol	Perform maintenance, check standards, recalibrate, reanalyze	Laboratory Analyst	A-14
Gravimetric	EPA Analytical Laboratory Protocol	Inorganic Compendium Method (IO) - 3.1 Gravimetric Analysis (EPA/625/R-96/010a) NIOSH 0500	EPA Analytical Laboratory Protocol	Daily or as needed	EPA Analytical Laboratory Protocol	Perform maintenance, check standards, recalibrate, reanalyze	Laboratory Analyst	A-15 A-16
CVAA	EPA Analytical Laboratory Protocol	ICP 6010 and Hg by CVAA 7471 NIOSH 7300	EPA Analytical Laboratory Protocol	Daily or as needed	EPA Analytical Laboratory Protocol	Perform maintenance, check standards, recalibrate, reanalyze	Laboratory Analyst	A-17

QAPP Worksheet #26
Sample Handling System

SAMPLE COLLECTION, PACKAGING, AND SHIPMENT
Sample Collection (Personnel/Organization): Field personnel (EA Engineering, Science, and Technology)
Sample Packaging (Personnel/Organization): Amber Mason / Jose Flores (EA)
Coordination of Shipment (Personnel/Organization): Amber Mason / Jose Flores (EA)
Type of Shipment/Carrier: Federal Express
SAMPLE RECEIPT AND ANALYSIS
Sample Receipt (Personnel/Organization): EPA Region 9 Laboratory, EPA CLP Laboratory, Contracted Private Laboratory
Sample Custody and Storage (Personnel/Organization): EPA Region 9 Laboratory, EPA CLP Laboratory, Contracted Private Laboratory
Sample Preparation (Personnel/Organization): EPA Region 9 Laboratory, EPA CLP Laboratory, Contracted Private Laboratory
Sample Determinative Analysis (Personnel/Organization): EPA Region 9 Laboratory, EPA CLP Laboratory, Contracted Private Laboratory
SAMPLE ARCHIVING
Field Sample Storage (No. of days from sample collection): Samples will processed to provide for minimal storage prior to laboratory submittal for analysis. The laboratory holding times will be a significant factor in determining how long a sample will be stored prior to submittal. In general, samples will be sent to the laboratories on a daily basis to minimize field storage time.
Sample Extract/Digestate Storage (No. of days from extraction/digestion): Most sample analysis will be conducted by EPA Region 9 Laboratory or an EPA Contract Laboratory Program laboratory. Extraction digestate storage will comply with these laboratory protocols. Subcontracted laboratories will store digestates for approximately 60 days after sample analysis.
Biological Sample Storage (No. of days from sample collection): NA
SAMPLE DISPOSAL
Personnel/Organization: EPA Region 9 Laboratory, EPA CLP Laboratory, Contracted Private Laboratory
Number of Days from Analysis: Most sample analysis will be conducted by EPA Region 9 Laboratory or an EPA Contract Laboratory Program laboratory. Sample disposal will comply with these laboratory protocols. Subcontracted laboratories will store samples for approximately 60 days after sample analysis.

QAPP Worksheet #27
Sample Custody Requirements

Field Sample Custody Procedures (sample collection, packaging, shipment, and delivery to laboratory):

Soil/sediment and water samples will be containerized, labeled, and immediately placed in a cooler containing ice. Sample collection information (i.e., sample indentification, time of collection, sampler's initials, type of container, analytes to be tested, etc. will be processed using the EPA FORMS II Lite Database. Prior to shipment to the analytical laboratory, sample containers will be bubble-wrapped and the traffic reports will be inserted into a plastic bag and taped on the inside lid of the cooler. Each cooler will have one traffic report which will contain sampling information for samples that are in that specific cooler. Each cooler will then be taped closed and custody seals will be initialed and dated by the field personnel, and affixed on the lid of the cooler in manner such that if the cooler is opened, the custody seal will break. The coolers will then be shipped via Federal Express to the analytical laboratory.

Laboratory Sample Custody Procedures (receipt of samples, archiving, disposal):

Samples collected from this site may be shipped to different laboratories for analysis. The laboratory sample custody protocol will be dependent on the laboratories used for the analysis.

Sample Identification Procedures: Sample identification procedures are provided in Section 1 of the Sampling Analysis Plan.

Chain-of-custody Procedures:

Samples will be accompanied by a properly completed traffic report form with sample ID, date/time collected, sampler, matrix, analysis, preservative, and turn around time for analysis. When transferring possession of samples, the individuals relinquishing and receiving the samples, will sign, date and note the time on the traffic report form. This record will document transfer of custody of samples from the sampler to another person or to the laboratory. The original traffic report form will accompany the sample shipment, and copies will be retained by the EA Project Manager for the project file.

QAPP Worksheet #28
QC Samples Table 28-1

Matrix	Soil/Sediment
Analytical Group	TAL Metals (including Mercury and Cyanide)
Concentration Level	Low - Medium - High
Sampling SOP	S-6, S-7
Analytical Method/ SOP Reference	CLP ILM05.4 OR SW846 6010 A-1
Sampler’s Name	To be determined
Field Sampling Organization	EA Engineering
Analytical Organization	EPA Region 9 Laboratory, CLP Laboratory, Private Contract Laboratory
No. of Sample Locations	up to 505

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Field Duplicate	1/10 or 60	Consistent with ILM05.4	Possible Resampling	Field Crew	Precision	RPD
MS/MSD	1/10 or 57 1/20 or 29	Consistent with ILM05.4	Instrument maintenance, standard inspection, recalibration	Lab Analyst	Bias/Precisoin	% Recovery RPD
Equipment Rinsate	1/day see worksheet # 28-2	Consistent with ILM05.4	Possible Resampling	Field Crew	Accuracy/Bias	<CRQL

QAPP Worksheet #28
QC Samples Table 28-2

Matrix	Aqueous
Analytical Group	TAL Metals (including Mercury and Cyanide)
Concentration Level	Low - Medium - High
Sampling SOP	S-3, S-4, S-5
Analytical Method/ SOP Reference	CLP ILM05.4 OR SW846 6010 A-1
Sampler's Name	To be determined
Field Sampling Organization	EA Engineering
Analytical Organization	EPA Region 9 Laboratory, CLP Laboratory, Private Contract Laboratory
No. of Sample Locations	up to 226

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Field Duplicate	1/10 or 30	Consistent with ILM05.4	Possible Resampling	Field Crew	Precision	RPD
MS/MSD	1/10 or 30 1/20 or 15	Consistent with ILM05.4	Instrument maintenance, standard inspection, recalibration	Lab Analyst	Bias/Precisoin	% Recovery RPD
Equipment Rinsate	1/day or 39 (includes soil rinsates)	Consistent with ILM05.4	Possible Resampling	Field Crew	Accuracy/Bias	<CRQL

QAPP Worksheet #28
QC Samples Table 28-3

Matrix	Soil/Sediment
Analytical Group	VOC
Concentration Level	Low - Medium - High
Sampling SOP	S-6, S-7
Analytical Method/ SOP Reference	CLP SOM01.2 OR SW846 5035 A-2
Sampler's Name	To be determined
Field Sampling Organization	EA Engineering
Analytical Organization	EPA Region 9 Laboratory, CLP Laboratory, Private Contract Laboratory
No. of Sample Locations	up to 49

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Field Duplicate	1/10 or 6	Consistent with SOM01.2	Possible Resampling	Field crew	Precision	RPD
MS/MSD	1/10 or 6 1/20 or 3	Consistent with SOM01.2	Instrument maintenance, standard inspection, recalibration	Lab Analyst	Bias/Precisoin	% Recovery RPD
Equipment Rinsate	1/day (see worksheet # 28-4)	Consistent with SOM01.2	Possible Resampling	Field crew	Precision	<CRDL
Field Blank	1/day (see worksheet #28-4)	Consistent with SOM01.2	Possible Resampling	Field crew	Contamination (Accuracy/Bias)	<CRDL
Trip Blank	1/cooler (see worksheet #28-4)	Consistent with SOM01.2	Possible Resampling	Field crew	Contamination (Accuracy/Bias)	<CRDL

QAPP Worksheet #28
QC Samples Table 28-4

Matrix	Aqueous
Analytical Group	VOC
Concentration Level	Low - Medium - High
Sampling SOP	S-3, S-4, S-5
Analytical Method/ SOP Reference	CLP SOM01.2 OR SW846 8260 A-2
Sampler’s Name	To be determined
Field Sampling Organization	EA Engineering
Analytical Organization	EPA Region 9 Laboratory, CLP Laboratory, Private Contract Laboratory
No. of Sample Locations	up to 8

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Field Duplicate	1/10 or 2	Consistent with SOM01.2	Possible Resampling	Field crew	Precision	RPD
MS/MSD	1/10 or 7 1/20 or 4	Consistent with SOM01.2	Instrument maintenance, standard inspection, recalibration	Lab Analyst	Bias/Precisoin	% Recovery RPD
Equipment Rinsate	1/day or 19 (includes soil rinsates)	Consistent with SOM01.2	Possible Resampling	Field crew	Precision	<CRDL
Field Blank	1/day or 19 (includes soil rinsates)	Consistent with SOM01.2	Possible Resampling	Field crew	Contamination (Accuracy/Bias)	<CRDL
Trip Blank	1/cooler or 19 (includes soil rinsates)	Consistent with SOM01.2	Possible Resampling	Field crew	Contamination (Accuracy/Bias)	<CRDL

QAPP Worksheet #28
QC Samples Table 28-5

Matrix	Soil/Sediment
Analytical Group	SVOC
Concentration Level	Low - Medium - High
Sampling SOP	S-6, S-7
Analytical Method/ SOP Reference	CLP SOM01.2 OR SW846 8270 A-3
Sampler's Name	To be determined
Field Sampling Organization	EA Engineering
Analytical Organization	EPA Region 9 Laboratory, CLP Laboratory, Private Contract Laboratory
No. of Sample Locations	up to 49

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Field Duplicate	1/10 or 6	Consistent with SOM01.2	Possible resampling	Field crew	Precision	RPD
MS/MSD	1/10 or 6 1/20 or 3	Consistent with SOM01.2	Instrument maintenance, standard inspection, recalibration	Lab Analyst	Bias/Precisoin	% Recovery RPD
Equipment Rinsate	1/day (see worksheet # 28-6)	Consistent with SOM01.2	Possible resampling	Field crew	Contamination Accuracy/Bias	<CRDL

QAPP Worksheet #28
QC Samples Table 28-6

Matrix	Aqueous
Analytical Group	SVOC
Concentration Level	Low - Medium - High
Sampling SOP	S-3, S-4, S-5
Analytical Method/ SOP Reference	CLP SOM 01.2 OR SW846 8270 A-3
Sampler's Name	To be determined
Field Sampling Organization	EA Engineering
Analytical Organization	EPA Region 9 Laboratory, CLP Laboratory, Private Contract Laboratory
No. of Sample Locations	up to 8

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Field Duplicate	1/10 or 2	Consistent with SOM01.2	Possible resampling	Field crew	Precision	RPD
MS/MSD	1/10 or 3 1/20 or 2	Consistent with SOM01.2	Instrument maintenance, standard inspection, recalibration	Lab Analyst	Bias/Precisoin	% Recovery RPD
Equipment Rinsate	1/day or 19 (includes soil rinsates)	Consistent with SOM01.2	Possible resampling	Field crew	Contamination Accuracy/Bias	<CRDL

QAPP Worksheet #28
QC Samples Table 28-7

Matrix	Soil/Sediment
Analytical Group	Pesticides
Concentration Level	Low - Medium - High
Sampling SOP	S-6, S-7
Analytical Method/ SOP Reference	CLP SOM 01.2 OR SW846 8081 A-4
Sampler's Name	To be determined
Field Sampling Organization	EA Engineering
Analytical Organization	EPA Region 9 Laboratory, CLP Laboratory, Private Contract Laboratory
No. of Sample Locations	up to 49

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Field Duplicate	1/10 or 6	Consistent with SOM01.2	Possible resampling	Field crew	Precision	RPD
MS/MSD	1/10 or 5 1/20 or 3	Consistent with SOM01.2	Instrument maintenance, standard inspection, recalibration	Lab Analyst	Bias/Precisoin	% Recovery RPD
Equipment Rinsate	1/day (see worksheet # 28-8)	Consistent with SOM01.2	Possible resampling	Field crew	Contamination Accuracy/Bias	<CRDL

QAPP Worksheet #28
QC Samples Table 28-8

Matrix	Aqueous
Analytical Group	Pesticides
Concentration Level	Low - Medium - High
Sampling SOP	S-3, S-4, S-5
Analytical Method/ SOP Reference	CLP SOM01.2 OR SW846 8081 A-4
Sampler's Name	To be determined
Field Sampling Organization	EA Engineering
Analytical Organization	EPA Region 9 Laboratory, CLP Laboratory, Private Contract Laboratory
No. of Sample Locations	NA

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
MS/MSD	1/10 or 2 1/20 or 1	Consistent with SOM01.2	Instrument maintenance, standard inspection, recalibration	Lab Analyst	Bias/Precisoin	% Recovery RPD
Equipment Rinsate	1/day or 15 (soil rinsates)	Consistent with SOM01.2	Possible resampling	Field crew	Contamination Accuracy/Bias	<CRDL

QAPP Worksheet #28
QC Samples Table 28-9

Matrix	Soil/Sediment
Analytical Group	Aroclors
Concentration Level	Low - Medium - High
Sampling SOP	S-6, S-7
Analytical Method/ SOP Reference	CLP SOM01.2 OR SW846 8082 A-5
Sampler's Name	To be determined
Field Sampling Organization	EA Engineering
Analytical Organization	EPA Region 9 Laboratory, CLP Laboratory, Private Contract Laboratory
No. of Sample Locations	up to 49

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Field Duplicate	1/10 or 6	Consistent with SOM01.2	Possible resampling	Field crew	Precision	RPD
MS/MSD	1/10 or 5 1/20 or 3	Consistent with SOM01.2	Instrument maintenance, standard inspection, recalibration	Lab Analyst	Bias/Precisoin	% Recovery RPD
Equipment Rinsate	1/day (see worksheet # 28-10)	Consistent with SOM01.2	Possible resampling	Field crew	Contamination Accuracy/Bias	<CRDL

QAPP Worksheet #28
QC Samples Table 28-10

Matrix	Aqueous
Analytical Group	Aroclors
Concentration Level	Low - Medium - High
Sampling SOP	S-3, S-4, S-5
Analytical Method/ SOP Reference	CLP SOM01.2 OR SW846 8082 A-5
Sampler's Name	To be determined
Field Sampling Organization	EA Engineering
Analytical Organization	EPA Region 9 Laboratory, CLP Laboratory, Private Contract Laboratory
No. of Sample Locations	NA

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
MS/MSD	1/10 or 2 1/20 or 1	Consistent with SOM01.2	Instrument maintenance, standard inspection, recalibration	Lab Analyst	Bias/Precisoin	% Recovery RPD
Equipment Rinsate	1/day or 15 (soil rinsates)	Consistent with SOM01.2	Possible resampling	Field crew	Contamination Accuracy/Bias	<CRDL

QAPP Worksheet #28
QC Samples Table 28-11

Matrix	Soil/Sediment
Analytical Group	Dioxins and Furans
Concentration Level	Low - Medium - High
Sampling SOP	S-6, S-7
Analytical Method/ SOP Reference	CLP DLM01.2 OR SW846 8290 A-6
Sampler's Name	To be determined
Field Sampling Organization	EA Engineering
Analytical Organization	EPA Region 9 Laboratory, CLP Laboratory, Private Contract Laboratory
No. of Sample Locations	up to 49

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Field Duplicate	1/10 or 6	Consistent with DLM01.2	Possible resampling	Field crew	Precision	RPD
MS/MSD	1/10 or 5 1/20 or 3	Consistent with DLM01.2	Instrument maintenance, standard inspection, recalibration	Lab Analyst	Bias/Precisoin	% Recovery RPD
Equipment Rinsate	1/day (see worksheet # 28-12)	Consistent with DLM01.2	Possible resampling	Field crew	Contamination Accuracy/Bias	RPD

QAPP Worksheet #28
QC Samples Table 28-12

Matrix	Aqeuous
Analytical Group	Dioxins and Furans
Concentration Level	Low - Medium - High
Sampling SOP	S-3, S-4, S-5
Analytical Method/ SOP Reference	CLP DLM01.2 OR SW846 8290 A-6
Sampler's Name	To be determined
Field Sampling Organization	EA Engineering
Analytical Organization	EPA Region 9 Laboratory, CLP Laboratory, Private Contract Laboratory
No. of Sample Locations	NA

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
MS/MSD	1/10 or 2 1/20 or 1	Consistent with DLM01.2	Instrument maintenance, standard inspection, recalibration	Lab Analyst	Bias/Precisoin	% Recovery RPD
Equipment Rinsate	1/day or 10 (soil rinsates)	Consistent with DLM01.2	Possible resampling	Lab Analyst	Contamination Accuracy/Bias	<CRDL

QAPP Worksheet #28
QC Samples Table 28-13

Matrix	Soil/Sediment
Analytical Group	Perchlorate
Concentration Level	Low - Medium - High
Sampling SOP	S-6, S-7
Analytical Method/ SOP Reference	SW846 314.0 A-7
Sampler's Name	To be determined
Field Sampling Organization	EA Engineering
Analytical Organization	EPA Region 9 Laboratory, CLP Laboratory, Private Contract Laboratory
No. of Sample Locations	up to 82

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Field Duplicate	1/10 or 10	<50 RPD	Possible resampling	Field crew	Precision	RPD
MS/MSD	1/10 or 10 1/20 or 5	50-150	Instrument maintenance, standard inspection, recalibration	Lab Analyst	Bias/Precisoin	% Recovery RPD In House Limits
Equipment Rinsate	1/day (see worksheet # 28-14)	<RL	Possible resampling	Field crew	Contamination Accuracy/Bias	<RL

QAPP Worksheet #28
QC Samples Table 28-14

Matrix	Aqueous
Analytical Group	Perchlorate
Concentration Level	Low - Medium - High
Sampling SOP	S-3, S-4, S-5
Analytical Method/ SOP Reference	SW846 314.0 A-7
Sampler's Name	To be determined
Field Sampling Organization	EA Engineering
Analytical Organization	EPA Region 9 Laboratory, CLP Laboratory, Private Contract Laboratory
No. of Sample Locations	up to 37

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Field Duplicate	1/10 or 5	<50 RPD	Possible resampling	Field crew	Precision	RPD
MS/MSD	1/10 or 8 1/20 or 4	50-150	Instrument maintenance, standard inspection, recalibration	Lab Analyst	Bias/Precisoin	% Recovery RPD In House Limits
Equipment Rinsate	1/day or 35 (includes soil rinsates)	<RL	Possible resampling	Field crew	Contamination Accuracy/Bias	< RL

QAPP Worksheet #28
QC Samples Table 28-15

Matrix	Soil/Sediment
Analytical Group	Nitrate and Sulfate
Concentration Level	Low - Medium - High
Sampling SOP	S-6, S-7
Analytical Method/ SOP Reference	SW846 300.0 A-8
Sampler's Name	To be determined
Field Sampling Organization	EA Engineering
Analytical Organization	EPA Region 9 Laboratory, CLP Laboratory, Private Contract Laboratory
No. of Sample Locations	up to 82

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Field Duplicate	1/10 or 10	<50 RPD	Possible resampling	Field crew	Precision	RPD
MS/MSD	1/10 or 10 1/20 or 5	50-150	Instrument maintenance, standard inspection, recalibration	Lab Analyst	Bias/Precisoin	% Recovery RPD In House Limits
Equipment Rinsate	1/day (see worksheet # 28-16)	<RL	Possible resampling	Field crew	Contamination Accuracy/Bias	<RL

QAPP Worksheet #28
QC Samples Table 28-16

Matrix	Aqueous
Analytical Group	Nitrate and Sulfate
Concentration Level	Low - Medium - High
Sampling SOP	S-3, S-4, S-5
Analytical Method/ SOP Reference	SW846 300.0 A-8
Sampler's Name	To be determined
Field Sampling Organization	EA Engineering
Analytical Organization	EPA Region 9 Laboratory, CLP Laboratory, Private Contract Laboratory
No. of Sample Locations	up to 37

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Field Duplicate	1/10 or 5	<50 RPD	Possible resampling	Field crew	Precision	RPD
MS/MSD	1/10 or 8 1/20 or 4	50-150	Instrument maintenance, standard inspection, recalibration	Lab Analyst	Bias/Precisoin	% Recovery RPD In House Limits
Equipment Rinsate	1/day or 35 (includes soil rinsates)	<RL	Possible resampling	Field crew	Contamination Accuracy/Bias	RPD

QAPP Worksheet #28
QC Samples Table 28-17

Matrix	Soil/Sediment
Analytical Group	SPLP
Concentration Level	Low - Medium - High
Sampling SOP	S-6, S-7
Analytical Method/ SOP Reference	SW846 1312 A-12
Sampler's Name	To be determined
Field Sampling Organization	EA Engineering
Analytical Organization	EPA Region 9 Laboratory, CLP Laboratory, Private Contract Laboratory
No. of Sample Locations	up to 24

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Field Duplicate	1/10 or 4	<50 RPD	Possible resampling	Field crew	Precision	RPD
MS/MSD	1/10 or 3 1/20 or 2	50-150	Instrument maintenance, standard inspection, recalibration	Lab Analyst	Bias/Precisoin	% Recovery RPD In House Limits

QAPP Worksheet #28
QC Samples Table 28-18

Matrix	Soil/Sediment
Analytical Group	Lead Arsenic Speciation
Concentration Level	Low - Medium - High
Sampling SOP	S-6, S-7
Analytical Method/ SOP Reference	SEM A-14
Sampler's Name	To be determined
Field Sampling Organization	EA Engineering
Analytical Organization	EPA Region 9 Laboratory, CLP Laboratory, Private Contract Laboratory
No. of Sample Locations	up to 21

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Field Duplicate	1/10 or 4	Qualitative Comparison	Possible Resampling	Field crew	Precision	Qualitative
MS/MSD	1/10 or 3 1/20 or 2	50-150	Instrument maintenance, standard inspection, recalibration	Lab Analyst	Bias/Precisoin	% Recovery RPD In House Limits

QAPP Worksheet #28
QC Samples Table 28-19

Matrix	Soil/Sediment
Analytical Group	pH
Concentration Level	Low - Medium - High
Sampling SOP	S-6, S-7
Analytical Method/ SOP Reference	SW846 9045 A-13
Sampler's Name	To be determined
Field Sampling Organization	EA Engineering
Analytical Organization	EPA Region 9 Laboratory, CLP Laboratory, Private Contract Laboratory
No. of Sample Locations	up to 50

QC Sample:	**Frequency/Number**	**Method/SOP QC Acceptance Limits**	**Corrective Action**	**Person(s) Responsible for Corrective Action**	**Data Quality Indicator (DQI)**	**Measurement Performance Criteria**
Field Duplicate	1/10 or 5	<50 RPD	Instrument maintenance, standard inspection, recalibration	Lab Analyst	Precision	RPD
MS/MSD	1/10 or 6 1/20 or 3	50-150	Instrument maintenance, standard inspection, recalibration	Lab Analyst	Bias/Precisoin	% Recovery RPD In House Limits

QAPP Worksheet #28
QC Samples Table 28-20

Matrix	Soil/Sediment
Analytical Group	Asbestos
Concentration Level	Low - Medium - High
Sampling SOP	S-6, S-7
Analytical Method/ SOP Reference	EPA Region 9 Lab SOP 490 (ASTM D22.08) A-10
Sampler’s Name	To be determined
Field Sampling Organization	EA Engineering
Analytical Organization	EPA Region 9 Laboratory, CLP Laboratory, Private Contract Laboratory
No. of Sample Locations	up to 5

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Field Duplicate	1/10 or 1	<50 RPD	Instrument maintenance, standard inspection, recalibration	Lab Analyst	Precision	RPD
MS/MSD	1/10 or 1 1/20 or 1	50-150	Instrument maintenance, standard inspection, recalibration	Lab Analyst	Bias/Precisoin	% Recovery RPD In House Limits

QAPP Worksheet #28
QC Samples Table 28-21

Matrix	Aqueous
Analytical Group	Anions/Cations
Concentration Level	Low - Medium - High
Sampling SOP	S-3, S-4, S-5
Analytical Method/ SOP Reference	SW846 300 SW846 6020 A-8, A-9
Sampler's Name	To be determined
Field Sampling Organization	EA Engineering
Analytical Organization	EPA Region 9 Laboratory, CLP Laboratory, Private Contract Laboratory
No. of Sample Locations	up to 30

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Field Duplicate	1/10 or 4	<50 RPD	Possible resampling	Field crew	Precision	RPD
MS/MSD	1/10 or 4 1/20 or 2	50-150	Instrument maintenance, standard inspection, recalibration	Lab Analyst	Bias/Precisoin	% Recovery RPD In House Limits
Equipment Rinsate	1/day or 5	<RL	Possible resampling	Field crew	Contamination Accuracy/Bias	<RL

QAPP Worksheet #28
QC Samples Table 28-22

Matrix	Aqueous
Analytical Group	Total Dissolved Solids
Concentration Level	Low - Medium - High
Sampling SOP	S-3, S-4, S-5
Analytical Method/ SOP Reference	SW846 160.1 A-11
Sampler's Name	To be determined
Field Sampling Organization	EA Engineering
Analytical Organization	EPA Region 9 Laboratory, CLP Laboratory, Private Contract Laboratory
No. of Sample Locations	up to 30

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Field Duplicate	1/10 or 4	<50 RPD	Possible resampling	Field crew	Precision	RPD
MS/MSD	1/10 or 4 1/20 or 2	50-150	Instrument maintenance, standard inspection, recalibration	Lab Analyst	Bias/Precisoin	% Recovery RPD In House Limits
Equipment Rinsate	1/day or 5	<RL	Possible resampling	Field crew	Contamination Accuracy/Bias	<RL

QAPP Worksheet #28
QC Samples Table 28-23

Matrix	Air
Analytical Group	Particulate Matter 10
Concentration Level	Low
Sampling SOP	S-12, S-13
Analytical Method/ SOP Reference	IO-3.1 and NIOSH 0500 A-15
Sampler's Name	To be determined
Field Sampling Organization	EA Engineering
Analytical Organization	EPA Region 9 Laboratory, CLP Laboratory, Private Contract Laboratory
No. of Sample Locations	up to 90

QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Field Duplicate	To be determined	<50 RPD	Possible resamping	Field crew	Precision	RPD
MS/MSD	1/10 or 9 1/20 or 4	50-150	Instrument maintenance, standard inspection, recalibration	Lab Analyst	Bias/Precisoin	% Recovery RPD In House Limits

QAPP Worksheet #28
QC Samples Table 28-24

Matrix	Air
Analytical Group	Total Suspended Particulates
Concentration Level	Low
Sampling SOP	S-12, S-13
Analytical Method/ SOP Reference	IO-3.1 A-16
Sampler’s Name	To be determined
Field Sampling Organization	EA Engineering
Analytical Organization	EPA Region 9 Laboratory, CLP Laboratory, Private Contract Laboratory
No. of Sample Locations	up to 90

QC Sample	**Frequency/Number**	**Method/SOP QC Acceptance Limits**	**Corrective Action**	**Person(s) Responsible for Corrective Action**	**Data Quality Indicator (DQI)**	**Measurement Performance Criteria**
Field Duplicate	To be determined	<50 RPD	Possible resampling	Field crew	Precision	RPD
MS/MSD	1/10 or 9 1/20 or 4	50-150	Instrument maintenance, standard inspection, recalibration	Lab Analyst	Bias/Precisoin	% Recovery RPD In House Limits

QAPP Worksheet #28
QC Samples Table 28-25

Matrix	Air
Analytical Group	Metals
Concentration Level	Low
Sampling SOP	S-12, S-13
Analytical Method/ SOP Reference	ICP 6010, Hg by CVAA 7471, NIOSH 7300 A-17
Sampler's Name	To be determined
Field Sampling Organization	EA Engineering
Analytical Organization	EPA Region 9 Laboratory, CLP Laboratory, Private Contract Laboratory
No. of Sample Locations	up to 90

QC Sample	**Frequency/Number**	**Method/SOP QC Acceptance Limits**	**Corrective Action**	**Person(s) Responsible for Corrective Action**	**Data Quality Indicator (DQI)**	**Measurement Performance Criteria**
Field Duplicate	To be determined	<50 RPD	Possible resampling	Field crew	Precision	RPD
MS/MSD	1/10 or 9 1/20 or 4	50-150	Instrument maintenance, standard inspection, recalibration	Lab Analyst	Bias/Precisoin	% Recovery RPD In House Limits

QAPP Worksheet #29
Project Documents and Records Table

Sample Collection Documents and Records	On-site Analysis Documents and Records	Off-site Analysis Documents and Records	Data Assessment Documents and Records	Other
Health and Safety Plan	Airbills	Case narrative	Data Validation Report	None
Sampling and Analysis Plan	Chain-of-custody records	Definitions of laboratory qualifiers	Data Evaluation Summary Report	--
Site Management Plan	Communication regarding corrective action or deviation from methods	Documentation of corrective action results	--	--
--	Field data collection sheets	Documentation of laboratory method deviations	--	--
--	Field sampling audit checklists	Electronic data deliverables	--	--
--	Identification of QC samples	Identification of QC samples	--	--
--	Meteorological data from field (e.g., wind, temperature)	Laboratory name	--	--
--	Preparation and analysis forms and/or logbooks	Laboratory sample identification numbers	--	--
--	Sample receipt forms and sample tracking forms	MDL study information	--	--
--	Sampling instrument calibration logs	NELAP accreditation	--	--
--	Sampling notes and drilling logs	Reporting forms, completed with actual results	--	--
--	--	Sample chronology (time of receipt, extraction, and analysis)	--	--
--	--	Tabulated data summary forms and raw data for field samples, standards, QC checks, and QC samples	--	--

QAPP Workwheet #30
Analytical Services Table

Matrix	Analytical Group	Concentration Level	Sample Locations/ID Numbers	Analytical SOP	Data Package Turnaround Time	Laboratory/ Organization	Backup Laboratory/Organization
						(Name and Address, Contact Person and Telephone Number)	(Name and Address, Contact Person and Telephone Number)
Soil/ Sediment	See Worksheets 12-1 to 12-20	Low/Medium/High	See Sampling and Analysis Plan Tables	See Worksheets 12-1 to 12-20	35 days	EPA Region 9 Laboratory Richard Bauer 510-412-2312	To be determined
Water	See Worksheets 12-2 to 12-22	Low/Medium/High	See Sampling and Analysis Plan Tables	See Worksheets 12-2 to 12-22	35 days	EPA Region 9 Laboratory Richard Bauer 510-412-2312	To be determined
Air	See Worksheets 12-23 to 12-25	Low	See Sampling and Analysis Plan Tables	See Worksheets 12-23 to 12-25	35 days	EPA Region 9 Laboratory Richard Bauer 510-412-2312	To be determined

Note: Sampling details are provided in Section 2 of the Sampling and Analysis Plan.

QAPP Worksheet #31
Planned Projects Assessment Table

Assessment Type	Frequency	Internal or External	Organization Performing Assessment	Person(s) Responsible for Performing Assessment (Title and Organizational Affiliation)	Person(s) Responsible for Responding to Assessment Findings (Title and Organizational Affiliation)	Person(s) Responsible for Identifying and Implementing Corrective Actions (CA) (Title and Organizational Affiliation)	Person(s) Responsible for Monitoring Effectiveness of CA (Title and Organizational Affiliation)
Field sampling TSA	Single Occurance During Sampling Event	Internal	EA Engineering	To Be Determined	Site Manager, EA Engineering	Doug McReynolds, Project Manager, EA Engineering	Fritz Meyer, Program Manager, EA Engineering
Health and Safety TSA	Single Occurance During Sampling Event	Internal	Team Subcontractor	To Be Determined	Site Health and Safety Officer, EA Engineering	Doug McReynolds, Project Manager, EA Engineering	Pete Garger, Corporate Health and Safety Director, EA Engineering
Data Review TSA	Single Occurance in Accordance with EPA approved Work Plan	Internal	EA Engineering	Dave Santoro, Quality Assurance Officer, EA Engineering	Data Manager, EA Engineering	Doug McReynolds, Project Manager, EA Engineering	Fritz Meyer, Program Manager, EA Engineering
Mangement Systems Review	Quarterly Review	Internal	EA Engineering	Dave Santoro, Quality Assurance Officer, EA Engineering	Doug McReynolds, Project Manager, EA Engineering	Doug McReynolds, Project Manager, EA Engineering	Fritz Meyer, Program Manager, EA Engineering

QAPP Worksheet #32
Assessment Findings and Corrective Action Responses

Assessment Type	Nature of Deficiencies Documentation	Individual(s) Notified of Findings (Name, Title, Organization)	Timeframe of Notification	Nature of Corrective Action Response Documentation	Individual(s) Receiving Corrective Action Response (Name, Title, Org.)	Timeframe for Response
Field sampling TSA	Audit Memo	Site Manager, EA Engineering	Immediate correction - written documentation due within 1 week	E-mail to File	Fritz Meyer, Program Manager, EA Engineering	Immediate correction - written
Health and Safety TSA	Audit Checklist/Memo	Site Health and Safety Officer, EA Engineering	Immediate correction - written documentation due within 1 week	E-mail to File	Pete Garger, Corporate Health and Safety Director, EA	Immediate correction - written
Data Review TSA	Data Evaluation Summary Report	Data Manager, EA Engineering	30 days after review	Reissuance of report	Fritz Meyer, Program Manager, EA Engineering	21 days for reissuance
Mangement Systems Review	Quartery Project Review Summary	Doug McReynolds, Project Manager, EA Engineering	7 days after audit	E-mail or Memo	Fritz Meyer, Program Manager, EA Engineering	

QAPP Worksheet #33
QA Management Reports Table

Type of Report	Frequency (daily, weekly monthly, quarterly, annually, etc.)	Projected Delivery Date(s)	Person(s) Responsible for Report Preparation (Title and Organizational Affiliation)	Report Recipient(s) (Title and Organizational Affiliation)
Field Reports	7 days following each week of field activities	7 days following each week of field activities	Site Manager	Leah Butler, EPA Region 9 Task Order Manager; Doug McReynolds, EA Project Manger; File Copy
Draft Data Validation Report	Draft and Final report	30 days following receipt of all analytical data from laboratory	To Be Determined, EA Engineering	Leah Butler, EPA Region 9 Task Order Manager; Doug McReynolds, EA Project Manger; File Copy
Draft Data Evaluation Summary Report	Draft and Final report	30 days following submittal of Final Data Validation Report	To Be Determined, EA Engineering	Leah Butler, EPA Region 9 Task Order Manager; Doug McReynolds, EA Project Manger; File Copy
Task Order Closeout Report	Report	14 days following receipt of Task Order Closeout Notification, or 60 days following submittal of Final FS Report, whichever is later	To Be Determined, EA Engineering	Leah Butler, EPA Region 9 Task Order Manager; Doug McReynolds, EA Project Manger; File Copy

QAPP Worksheet #34
Verification (Step I) Process Table

Verification Input	Description	Internal/ External	Responsible for Verification (Name, Organization)
Field Data Measurements (e.g., pH)	Daily field calibration logs and measurement results from the portable multi-meters will be reviewed daily internally for completeness. Any corrective actions will be addressed with the field samples prior to further measurements.	Internal	Site Manager
Daily Field Notes/Summary	Field notes will be reviewed daily internally for completeness, accuracy, and comparability between sample locations and field samplers. Any required corrective actions will be addressed with the field samplers prior to further site work. The Field Team Leader will summarize the results of field notes in a brief daily field summary statement and transmit this brief summary to the EA Project Manager.	Internal	Site Manager
Traffic Reports and Shipping Forms	Traffic Reports and shipping documentation will be reviewed internally upon their completion and verified against the packed sample coolers that they represent. Upon verification of completeness and accuracy, the reviewer will initial the shipper's signature on the chain-of-custody. A copy of the traffic report will be retained in the site file and the original and remaining copies will be taped inside the cooler for shipment.	Internal	Site Manager
Weekly Progress Reports	The EA Project Manager will create a weekly summary of the field progress for distribution to project team members. The weekly field reports will be proofed internally by an EA employee for grammar and content prior to distribution.	Internal	EA - Doug McReynolds
Laboratory Data Packages	All laboratory data packages will be verified internally by the laboratory performing the work for completeness prior to submittal to EA. All received data packages will be verified internally according to the data validation screening procedures.	External Internal	EPA Region 9 Laboratory or Contract Laboratory Program laboratory EA - To be determined
Field Audit Reports	These reports indicate that the samples were collected, field measurements performed, and field equipment calibrated according to the Quality Assurance Project Plan.	Internal	Site Manager

APP Verification #35
Verification (Steps II a and II b) Process Table

Step IIa/IIb	Validation Input	Description	Responsible for Validation (Name, Organization)
IIa	Holding time and sample preservation	Ensures that samples were analyzed within required holding times and preserved specific to analysis requirements and were within required temperature range.	EPA Region 9 or Contract Laboratory Program laboratory for most data, EA Engineering will perform validation on subcontracted laboratory data
IIa	Gas chromatography/ Mass Spectrometry (GC/MS) tunes	The frequency and abundance of decafluorotriphenylphoshpine (DFTPP) tunes are within the QC acceptance criteria associated with the method.	EPA Region 9 or Contract Laboratory Program laboratory for most data, EA Engineering will perform validation on subcontracted laboratory data
IIa	Initial and continuing calibrations	Percent relative standard deviations and response factors of all target analytes are within the QC acceptance criteria in the initial calibration. All initial and continuing calibration meet acceptance criteria.	EPA Region 9 or Contract Laboratory Program laboratory for most data, EA Engineering will perform validation on subcontracted laboratory data
IIa	Blanks	Determine if target analytes are detected in trip and rinse blanks.	EPA Region 9 or Contract Laboratory Program laboratory for most data, EA Engineering will perform validation on subcontracted laboratory data
IIa	Surrogate recoveries	Ensure that the surrogate recoveries are within the laboratory QC acceptance limits in all samples analyzed.	EPA Region 9 or Contract Laboratory Program laboratory for most data, EA Engineering will perform validation on subcontracted laboratory data
IIa	Matrix spike/ matrix spike duplicates (MS/MSD)	Ensure recoveries and relative percent difference for the MS/MSD are within laboratory control limits.	EPA Region 9 or Contract Laboratory Program laboratory for most data, EA Engineering will perform validation on subcontracted laboratory data
IIa	Laboratory control spikes	Ensure internal standard performance meets the QC acceptance criteria in all sample QC analysis.	EPA Region 9 or Contract Laboratory Program laboratory for most data, EA Engineering will perform validation on subcontracted laboratory data
IIa	Field duplicates	Ensure laboratory’s precision by comparison of field duplicates with parent samples through acceptable ranges of analyte concentrations.	EPA Region 9 or Contract Laboratory Program laboratory for most data, EA Engineering will perform validation on subcontracted laboratory data
IIa	Quantitation limits and sample results	Spot check calculations of dilutions.	EPA Region 9 or Contract Laboratory Program laboratory for most data, EA Engineering will perform validation on subcontracted laboratory data
IIa	ICP serial dilution results	Ensure results of ICP serial dilution are within acceptable method control limits.	EPA Region 9 or Contract Laboratory Program laboratory for most data, EA Engineering will perform validation on subcontracted laboratory data

QAPP Worksheet #36
Validation (Steps IIa and IIb) Summary Table

Step IIa/IIb	Matrix	Analytical Group	Concentration Level	Validation Criteria	Data Validator (title and organizational affiliation)
IIa	Soil/Sediment/Aqueous	TAL Metals (including Mercury and Cyanide)	Low/ Medium/High	SW846 6010	EPA Region 9 or CLP Laboratory
IIa	Soil/Sediment/Aqueous	VOC	Low/ Medium/High	SW846 5035 SW846 8260	EPA Region 9 or CLP Laboratory
IIa	Soil/Sediment/Aqueous	SVOC	Low/ Medium/High	SW846 8270	EPA Region 9 or CLP Laboratory
IIa	Soil/Sediment/Aqueous	Pesticides	Low/ Medium/High	SW846 8081	EPA Region 9 or CLP Laboratory
IIa	Soil/Sediment/Aqueous	Aroclors	Low/ Medium/High	SW846 8082	EPA Region 9 or CLP Laboratory
IIa	Soil/Sediment/Aqueous	Perchlorate	Low/ Medium/High	SW846 314.0	EPA Region 9 or CLP Laboratory
IIa	Soil/Sediment/Aqueous	Nitrate/Sulfate	Low/ Medium/High	SW846 300.0	EPA Region 9 or CLP Laboratory
IIa	Soil/Sediment/Aqueous	Dioxins and Furans	Low/ Medium/High	SW846 8290	EA Subcontracted Laboratory
IIa	Soil/Sediment	SPLP	Low/ Medium/High	SW846 1312	EPA Region 9 or CLP Laboratory
IIa	Soil/Sediment	Lead and Arsenic Speciation	Low/ Medium/High	SEM	EA Subcontracted Laboratory
IIa	Soil/Sediment	pH	Low/ Medium/High	SW846 9045	EPA Region 9 or CLP Laboratory
IIa	Soil/Sediment	Asbestos	Low/ Medium/High	EPA Region 9 Laboratory SOP 490	EPA Region 9 or CLP Laboratory
IIa	Aqueous	Anions/Cations	Low/ Medium/High	SW846 300.0 SW846 6020	EPA Region 9 or CLP Laboratory
IIa	Aqueous	Total Dissolved Solids	Low/ Medium/High	SW846 160.1	EA Subcontracted Laboratory
IIa	Air	Particulate Matter 10	Low	IO-3.1 NIOSH 0500	EA Subcontracted Laboratory
IIa	Air	Total Suspended Particulates	Low	IO-3.1	EA Subcontracted Laboratory
IIa	Air	Metals	Low	ICP 6010 and Hg by CVAA 7471 NIOSH 7300	EA Subcontracted Laboratory

QAPP Worksheet #37
Usability Assessment

Summarize the usability assessment process and all procedures, including interim steps and any statistics, equations, and computer algorithms that will be used:

A data usability assessment will be performed upon completion of data validation. Several parameters (precision, accuracy, and completeness) will be calculated according to the given equations.

Precision is determined through the reproducibility of measurements (i.e., the variability among duplicate samples). Accuracy measures 'correctness' and the amount of error associated with the measurement. Matrix spikes (MS) provide a measure of accuracy. Completeness is calculated by dividing the number of valid results by the number of possible individual analyte results.

Describe the evaluative procedures used to assess overall measurement error associated with the project:

The appropriate formulas will be applied to the data to calculate values for precision, accuracy, and completeness. These computed values will be used to assess overall measurement error.

Identify the personnel responsible for performing the usability assessment:

Precision, accuracy, and completeness values are computed by the laboratory and submitted with the analytical data package.

Describe the documentation that will be generated during usability assessment and how usability assessment results will be presented so that they identify trends, relationships (correlations), and anomalies:

The results achieved for precision, accuracy, and completeness will be thoroughly discussed in the Data Evaluation Summary Report. Trends, relationships, and anomalies will be evaluated in the Remedial Investigation Report.

Appendix D

Air Quality Monitoring Plan

Air Quality Monitoring Plan

Remedial Investigation/Feasibility Study
Iron King Mine – Humboldt Smelter Superfund Site
Dewey-Humboldt, Yavapai County, Arizona
EPA Identification No. AZ0000309013

Remedial Action Contract 2 Full Service
Contract: EP-W-06-004

Prepared for

U.S. Environmental Protection Agency
Region 6
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Prepared by

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3	Proposed Air Monitoring Locations

LIST OF TABLES

Number	Title
1	Analytical Methods

LIST OF ACRONYMS AND ABBREVIATIONS

ADEQ	Arizona Department of Environmental Quality
AOI	Area of Interest
AQM	Air quality monitoring
CVAA	Cold Vapor Atomic Absorption
COPC	Chemical of primary concern
DL	Detection limit
DQO	Data quality objective
EA	EA Engineering, Science, and Technology, Inc.
ERA	Ecological Risk Assessment
EPA	U.S. Environmental Protection Agency
FS	Feasibility Study
H_o	Null hypothesis
H_a	Alternative hypothesis
HHRA	Human Health Risk Assessment
ICP	Inductively Coupled Plasma
Ironite	Ironite Products Company
LCS	Laboratory control sample
LD	Laboratory duplicate
lpm	Liters per minute
MDD	Minimum detectable difference
mm	Millimeter
NPL	National Priorities List
PM_{10}	Particulate matter less than 10 microns
ppb	Parts per billion
PRP	Potentially responsible party
QAPP	Quality Assurance Project Plan
QC	Quality control
RI	Remedial Investigation
SOP	Standard operating procedure
TSP	Total Suspended Particulates
Site	Iron King Mine – Humboldt Smelter Superfund Site
WRS	Wilcoxon rank sum
µm	Micron

1. INTRODUCTION

EA Engineering, Science, and Technology, Inc. (EA) has been authorized by the U.S. Environmental Protection Agency (EPA), under Remedial Action Contract No. EP-W-06-004, Task Order 0034-RICO-09MX, to conduct a Remedial Investigation/Feasibility Study (RI/FS) at the Iron King Mine – Humboldt Smelter Superfund Site (Site). EA has prepared this Air Quality Monitoring Plan (AQMP) in accordance with: (1) specifications provided in the U.S. Environmental Protection Agency (EPA) Statement of Work (SOW), dated 3 March 2008 (EPA 2008); and (2) the EPA-approved EA Work Plan, dated 22 May 2008 (EA 2008).

The Site is located in Dewey-Humboldt, Yavapai County, Arizona (Figure 1). The Site is a combination of sources and releases from two separate facilities: the Iron King Mine property and the Humboldt Smelter property. A portion of the Town of Humboldt is situated between the mine and the smelter (Figure 2).

During the site visit that was conducted on 19 March 2008, the following Areas of Interest (AOI) were identified:

- Iron King Mine – The Iron King Mine Proper Area, Iron King Operations Area, Former Fertilizer Plant Area, and ancillary associated properties;
- Humboldt Smelter and ancillary associated properties;
- Off-site Soil in the vicinity of the Site;
- Waterways - Including the Chaparral Gulch, Galena Gulch, Aqua Fria River, and adjoining drainage channels and outfalls; and
- Ground Water - Shallow alluvial and deep bedrock ground water.

These five AOIs were combined into a single Operational Unit for the purpose of conducting the RI/FS because: (1) ore from the Iron King Mine may have been processed at Humboldt Smelter; (2) off-site migration of particulates from the Iron King Mine and Humboldt Smelter may have overlapping air-depositional areas; (3) mine tailings from the Iron King Mine may have migrated onto the Humboldt Smelter property via the Chaparral Gulch; (4) the Aqua Fria River and its contributing waterways (e.g., Chaparral Gulch and Galena Gulch) may have impacts from both the Iron King Mine and Humboldt Smelter; and (5) ground water may be impacted from both the Iron King Mine and Humboldt Smelter.

The Iron King Mine property, located west of Highway 69, occupies approximately 153 acres. The Iron King Mine property is bordered by Chaparral Gulch, to the north, Galena Gulch to the south, Highway 69 to the east, and undeveloped land to the west. The Iron King Mine was a periodically active gold, silver, copper, lead, and zinc mine from 1906 (when the mine produced fluxing ore for the Humboldt Smelter) until 1969. Ore from the Iron King Mine may have been processed at the Humboldt Smelter, which operated from the late 1800s until 1969.

The Humboldt Smelter property, located at the east end of Main Street, occupies approximately 189 acres. The smelter is situated less than 1-mile east of the Iron King Mine property. The Humboldt Smelter property is bordered by the Town of Humboldt to the west and north, the Agua Fria River to the east, and the Chaparral Gulch to the south.

The Iron King Mine property includes the following three subordinate properties:

- The Iron King Mine Proper Area, which consists of a large tailings pile and a plant area. In addition, there are 5 retention ponds or impoundments: Main Retention Pond, Pond 40-01A, Pond 40-02A, Pond 100-003F, and Pond 200-5S.

- The Iron King Operations Area, which historically contained at least 11 buildings, including the assay laboratory office, main office, change rooms, and the mechanical room. This property also contains multiple mine shafts, and the former Glory Hole; the latter of which has more recently been used as a landfill.

- The Former Fertilizer Plant Area includes several abandoned buildings, concrete pads, sumps, tanks, and an ore bin.

The Humboldt Smelter property consists of several abandoned buildings, a smelter stack, a tailings pile (763,000 square feet), a smelter ash pile (1,041,200 square feet), and a slag pile (456,000 square feet). On-site ponds, pits, and lagoons were reportedly used for the leaching of minerals from mined ore.

Chaparral Gulch, a natural drainage channel, flows from northwest to southeast along the border of the Iron King Mine property. The gulch crosses under Highway 69, passes through a residential area, and then enters the northeast boundary of the Humboldt Smelter property, flowing through the southwest corner. A tailings dam located on the smelter property within the Chaparral Gulch has retained tailings from both the Iron King Mine and Humboldt Smelter properties. The Chaparral Gulch flows into the Agua Fria River approximately ¼ mile downstream of the Chaparral Gulch dam. The Aqua Fria River also flows from the north to the south along the eastern boundary of the Humboldt Smelter property.

Presently, the full extent of off-site soil contamination and possible ground water contamination has not been assessed. Arsenic and other metals have impacted off-site soil, sediments, surface water, and ground water at concentrations significantly above background levels.

Portions of this Site were regulated under the Arizona Department of Environmental Quality (ADEQ)'s Voluntary Remediation Program. In September 2007, EPA received a response from Arizona Governor Napolitano consenting to the placement of the Site on the National Priorities List (NPL). On 19 March 2008, EPA formally proposed the Site to the NPL.

1.1 Air Quality Monitoring Plan Objectives

The primary objectives of the RI/FS are to determine the nature and extent of contamination and to gather sufficient information so that the EPA can select a remedy that eliminates, reduces, or controls risks to human health and the environment. The off-site migration of particulates from site soils is a primary migration pathway for the Iron King Mine and Humboldt Smelter AOIs. Therefore, the RI/FS field program has included ambient air sampling to evaluate this pathway from these potential sources.

1.2 Air Quality Monitoring Plan Goals

The goal of the Air Quality Monitoring program is determine potential source areas where airborne particulate material originates and quantify the off-site migration of air particulates. Data collected during the field investigation will include:

- Meteorological data to support the ambient air sampling program;
- Total suspended particulates (TSP) data, which may be useful for evaluating the off-site migration of airborne particulates, but may not be useful for the human health risk assessment because the coarse particle size of TSP is not respirable;
- Particulate matter less than 10 microns (PM_{10}) data, which is considered respirable and is directly applicable to human health exposure; and
- Inorganics data to evaluate analyte-specific human health exposure.

EPA guidance documents that were used to develop this plan include, but are not limited to:

- Air/Superfund National Technical Guidance Study Series: Volume I – Overview of Air Pathway Assessments for Superfund Sites (EPA, 1992a);
- Air/Superfund National Technical Guidance Study Series: Volume IV – Guidance for Ambient Air Monitoring at Superfund Sites (EPA, 1993);
- Design Considerations for Ambient Air Monitoring at Superfund Sites (EPA, 1992b); and
- Superfund Program Representative Sampling Guidance: Volume II – Air Short-term Monitoring (EPA, 1995).

1.3 Air Monitoring Program Design Considerations

EPA's *Air/Superfund National Technical Guidance Study Series: Volume IV – Guidance for Ambient Air Monitoring at Superfund Sites* (EPA, 1993) describes a general design for an air monitoring network used to assess off-site migration. The approach includes the measurement of target analytes concentrations at various locations around the Site.

Data will be collected at six locations upwind and downwind of the Site (Figure 3). The data will be compared to Residential and Industrial Air Regional Screening Levels for Chemical Contaminants at Superfund Sites (Oak Ridge National Laboratory [ORNL] 2008) to evaluate human health exposure at downwind locations. The difference in concentrations measured upwind and downwind of the Site will represent the Site-related contribution to local air quality.

The factors that often dictate the air monitoring methodology include the list of target analytes, detection limits, temporal resolution, spatial resolution, and cost. Sampling duration and frequency depend upon the monitoring program goals and the relevant action levels. Because the air monitoring program will occur over a short-duration, six samplers will be deployed over a three-week period. Understanding wind patterns and other meteorological measurements is important for evaluating off-site migration of particulates and potentially exposed populations.

1.4 Air Monitoring Locations

Six TSP and six PM_{10} samplers will be utilized over a three week period. Therefore, approximately 90 ambient air samples (of each type) will be available for evaluation (6 sample locations x 5 day per week x 3 weeks). EA will deploy one upwind and one downwind sampler of each type at the Iron King Mine property and the Humboldt Smelter property (Figure 3). Additionally, two samplers of each type will be placed in the town of Humboldt to evaluate human health exposure to air particulates from the Site.

The predominant wind direction is from the south-southwest (see Attachment A). The initial sample locations were selected to account for this variable. Nevertheless, sample locations may be adjusted as necessary based on the data collected from the meteorological station. To minimize disturbance to the community and also to minimize the risk of theft or vandalism, the air samplers will be deployed during daylight hours. It is anticipated that the samplers will be deployed for approximately 8 hours per day.

1.5 Summary of Air Monitoring Methods

There are three main monitoring methods that will be used in the AQM program: TSP samplers, PM_{10} samplers, and meteorological monitoring equipment. The objectives for each of these monitoring methods are described below.

1.5.1 BGI PQ100

BGI PQ100 samplers will be used for the collection of PM_{10} and TSP samples (followed by chemical analyses for metals). The air sampling equipment is further discussed in section 3.1.

1.5.2 Meteorological Monitoring Equipment

Meteorological data will be collected to evaluate the wind patterns. The primary parameters are wind speed, wind direction, and precipitation.

1.6 Air Sampling Frequencies and Duration

EPA's *Air/Superfund National Technical Guidance Study Series: Volume IV – Guidance for Ambient Air Monitoring at Superfund Sites* (EPA, 1993) provides recommendations on the frequency, duration, and type of air monitoring. The recommended frequency and duration of data collection are dictated by the averaging period of the action level (e.g., acute, chronic, etc.). Generally, annual averages will result in average concentrations that reflect seasonal variations due to climate changes. This recommendation is also supported by the following EPA guidance:

- *A Preliminary Risk-based Screening Approach for Air Toxics Monitoring Data Sets* (EPA, 2006a);
- *Ambient Monitoring Guidelines for Prevention of Significant Deterioration* (EPA, 1987);
- *Guidelines on Air Quality Modeling* (EPA, 2006b); and
- *Meteorological Monitoring Guidance for Regulatory Modeling Applications* (EPA, 2000a).

The Site is located in a mountainous region of Arizona and has an average high temperature of approximately 50-degrees Fahrenheit (F) in the winter and 90-degrees F in the summer. The wind direction tends to come from the south-southwest and is slightly calmer during the summer months (see Attachment A). Precipitation tends to fall during the monsoon season (i.e., July and August) and again during the winter (e.g., December). Because of this variation, there is a temporal aspect to exposure and migration of site contaminants. Exposure to site-related contaminants will tend to be greater during the summer when receptors are more active. Off-site migration of air-borne particulates may tend to be lower in the summer months, when average wind speeds are decreased. However, off-site migration of contaminated soil and water would likely be higher during the summer monsoon season. These temporal variances are considered minor and are not considered a significant source of uncertainty.

Given the nature and purpose of this Task Order, an abbreviated air monitoring program is considered appropriate. The results of this first air sampling event will assist EPA in evaluating the impact of the Iron King Mine and Humboldt Smelter on downwind receptors. After evaluation of the data, EPA may elect to conduct additional air monitoring studies at the Site as necessary.

2. DATA QUALITY OBJECTIVES

The following sections present the DQOs for this project. Much of the information used to develop DQOs was obtained from the SOW issued by the EPA (2008) and the EPA approved Work Plan (EA 2008). The CUS technical memorandum, which is presented in Appendix A, also forms the basis for the DQO assessment as it functions as the preliminary Conceptual Site Model (CSM). This DQO assessment follows EPA's 7-step DQO process (Table 2), which is outlined in *Guidance on Systematic Planning Using the Data Quality Objectives Process (QA/G-4)* (EPA 2006c) and *Systematic Planning: A Case Study for Hazardous Waste Site Investigations (QA/CS-1)* (EPA 2006d)

Additional information is referenced, as appropriate, in the following sections:

- Section 2.1.1 Purpose and Goal;
- Section 2.1.2 Step 1 – State the Problem;
- Section 2.1.3 Step 2 – Identify the Goal of the Study;
- Section 2.1.4 Step 3 – Identify Information Inputs;
- Section 2.1.5 Step 4 – Define the Boundaries of the Study;
- Section 2.1.6 Step 5 – Develop the Analytical Approach;
- Section 2.1.7 Step 6 – Specify the Performance or Acceptance Criteria; and
- Section 2.1.8 Step 7 – Develop the Plan for Obtaining Data.

2.1.1 Step 1 – State the Problem

The first step in any systematic planning process, and therefore the DQO process, is to define the problem that has initiated the study. As environmental problems are often complex combinations of technical, economic, social, and political issues, it is critical to the success of the process to separate each problem, define it completely, and express it in an uncomplicated format.

The most important activities in DQO Step 1 are as follows:

- Give a concise description of the problem;
- Identify leader and members of the planning team;
- Develop a CSM of the environmental hazard to be investigated; and
- Determine resources (i.e., budget, personnel, and schedule).

2.1.1.1 Problem Description

The soil at Iron King Mine and Humboldt Smelter has high concentrations of COPCs (primarily lead and arsenic) that may be being transported off-site via air particulate migration to the Off-site Soil AOI.

2.1.1.2 Planning Team Members and Stakeholders

A proven effective approach to formulating a problem and establishing a plan for obtaining information that is necessary to resolve the problem is to involve a team of experts and stakeholders that represent a diverse, multidisciplinary background. Such a team provides the ability to develop a concise description of complex problems, and multifaceted experience and awareness of potential data uses. Planning team members (including the leader) and stakeholders are presented below.

Planning Team Members

- Leah Butler, EPA TOM
- David Seter, EPA Alternate TOM
- Sophia Serda, EPA Human Health Risk Assessor

- Ned Black, EPA Ecological Risk Assessor
- Brian Stonebrink, ADEQ Project Manager

Stakeholders

- EPA Region 9 Superfund Division Management
- EPA Headquarters
- EPA's Lead Sites and Technical Review Workgroups
- United States Bureau of Land Management
- ADEQ Remediation Division
- Arizona Game and Fish Department
- Local residents.

If additional planning team members and/or stakeholders are identified as the RI progresses, they will be incorporated into the decision-making process as appropriate.

2.1.1.3 Conceptual Site Model

It is critical to carefully develop an accurate conceptual site model (CSM) of the environmental problem, as this model will serve as the basis for all subsequent inputs and decisions.

The soil at Iron King Mine and Humboldt Smelter has high concentrations of COPCs (primarily lead and arsenic) that may be being transported off-site via air particulate migration to the Off-site Soil AOI.

Historically, the Iron King Mine and Humboldt Smelter were used for mining related or other industrial activities. It is likely, that future reuse will remain commercial or industrial at these two AOIs. However, future reuse that would include construction worker, recreational, trespasser, or residential exposure is possible. The Off-site Soil AOI includes residential or commercial/industrial exposure as appropriate for the designated land use.

Ecological receptor exposure at the Iron King Mine and Humboldt Smelter is expected to be limited due to the lack of natural resources, habitat, and vegetation. The Galena and Chaparral Gulches provide a more suitable environment for ecological receptors, especially during periods when the gulches retain water. However, the most sensitive and valuable habitat is the Agua Fria River, which contains water throughout the year.

Additional details pertaining to the CSM are provided in the CUS Technical Memorandum presented in Appendix A, and are not repeated here for brevity.

2.1.1.4 Determine Resources

Resources should be identified by the planning team so that constraints (e.g., budget, time, etc.) associated with collecting/evaluating data can be anticipated during the Project Life Cycle. To assist in this evaluation, the DQO process (e.g., developing performance or acceptance criteria) and the SAP (i.e., for collecting and analyzing samples, and interpreting and assessing the collected data) should be completed.

The EPA will perform a review of each required deliverable and provide comments as necessary. EPA will also solicit comments from other planning team members or stakeholders as appropriate. EPA anticipates that a RI/FS Report will be submitted to the EPA prior to 18 May 2009, which is 11 months after the Task Order approval date of 18 June 2008. Additional details pertaining to the schedule of events and deliverables necessary to meet this milestone are provided in the RI/FS Work Plan (EA 2008).

2.1.2 Step 2 – Identify the Goal of the Study

Step 2 of the DQO process involves identifying the key questions that the study attempts to address, along with alternative actions or outcomes that may result based on the answers to these key questions. These two items are combined to develop a decision statement, which is critical for defining decision performance criteria later in Step 6 of the DQO process.

The most important activities in DQO Step 2 are as follows:

- Identify principal study question(s).
- Consider alternative actions that can occur upon answering the question(s).
- Develop decision statement(s) and organize multiple decisions.

2.1.2.1 Principal Study Question

The principal study question(s) (PSQ) define the question(s) to be answered by the Human Health Risk Assessment (HHRA), Screening Level Ecological Risk Assessment (ERA); and RI. The PSQs are as follows:

What are the nature and extent of air contamination at the AOIs?

What are the migration pathways for these contaminants to be transported to other AOIs?

Are concentrations of AOI COPCs significantly greater than background?

What is the potential risk to human health and ecological receptors from exposure to Site related COPCs at the AOIs?

2.1.2.2 Alternative Actions

The alternative actions provide PSQ alternatives in the FS, as follows. Potential alternative actions, which will be evaluated in the FS, include, but are not limited to, the following:

- Remediate the source areas at Iron King Mine and Humboldt Smelter;

- Restrict access to the Iron King Mine or Humboldt Smelter properties to limit exposure;

- Mitigate the air and surface water migration pathways from the Iron King Mine and Humboldt Smelter;

- Remediate off-site soil areas impacted by other AOIs; and

- Address other migration/exposure pathways impacting receptors by employ engineering or institutional controls.

An Interim Measures Technical Memorandum, which addresses some potential alternative actions, is provided in Appendix B; details of that evaluation are not repeated here for brevity.

2.1.2.3 Decision Statement

For decision-making problems, the PSQs and alternative actions are combined to develop decision statements, which are critical for defining decision performance criteria later in DQO Step 6.

The decision statements are as follows:

> ***Determine the nature and extent of air contamination at the AOIs.***
>
> ***Determine the migration pathways for these contaminants to be transported to other AOIs.***
>
> ***Determine whether the concentrations of AOI COPCs are significantly greater than background.***
>
> ***Determine if exposure to Site related COPCs at the AOIs pose a potential unacceptable risk to human health and ecological receptors.***

2.1.3 Step 3 – Identify Information Inputs

Step 3 of the DQO process determines the types and sources of information needed to resolve: (1) the decision statement or produce the desired estimates; (2) whether new data collection is necessary; (3) the information basis the planning team will need for establishing appropriate analysis approaches and performance or acceptance criteria; and (4) whether appropriate sampling and analysis methodology exists to properly measure environmental characteristics for addressing the problem.

The most important activities in DQO Step 3 are as follows:

- Identify types and sources of information needed to resolve decisions or produce estimates;

- Identify the basis of information that will guide or support choices to be made in later steps of the DQO process; and

- Select appropriate sampling and analysis methods for generating the information.

The EPA RI/FS SOW (EPA 2008) and EPA approved Work Plan (EA 2008) sets forth the framework and requirements for this effort.

2.1.3.1 Necessary Information and Sources

A variety of sources and types of information form the basis for resolving the decision statements. The following information and sources are necessary to resolve this step of the DQO process.

The decision statements are supported by the following:

Determine the nature and extent of air contamination at the AOIs.

- Air data will be collected as noted in Section 1.

Determine the migration pathways for these contaminants to be transported to other AOIs.

- A weather station will be constructed at the Site to collect meteorological data for the evaluation of off-site migration of airborne particulates from the Iron King Mine and Humboldt Smelter to off-site soil.

Determine whether the concentrations of AOI COPCs are significantly greater than background.

- Air data will be collected to evaluate the potential anthropogenic and ambient contributions of contaminants above background.

Determine if exposure to Site related COPCs at the AOIs pose a potential unacceptable risk to human health and ecological receptors.

- A HHRA and Screening Level ERA will be conducted to evaluate potential unacceptable risk from off-site migration of air particulates.

2.1.3.2 Basis of Information

The basis of information, which will guide or support choices to be made in later steps of the DQO process.

The basis of information is supported by the following:

Determine the nature and extent of air contamination at the AOIs.

- During the RI field program, air data will be collected at six locations upwind and downwind of the Site (Figure 3).

Determine the migration pathways for these contaminants to be transported to other AOIs.

- The Interim Final Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (EPA 1988) describes the process for evaluating migration pathways.

Determine whether the concentrations of AOI COPCs are significantly greater than background.

- Statistical approaches, including the background evaluation, will be consistent with EPA guidance, including, but not limited to: ProUCL 4.0 User Guide (Singh, Singh, and Maichle 2007); EPA Guidance for Comparing Background and Chemical Concentrations in soil for CERCLA Sites (EPA 2002a); and Role of Background in CERCLA Cleanup Program (EPA 2002b).

Determine if exposure to Site related COPCs at the AOIs pose a potential unacceptable risk to human health and ecological receptors.

- A HHRA will be conducted in accordance with the EPA's guidance which includes, but is not limited to: Risk Assessment Guidance for Superfund (RAGS), Volume I: Human Health Evaluation Manual (EPA 1989); and Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites (EPA 2002c).

- A Screening Level ERA will be conducted in accordance with the EPA's guidance which includes, but is not limited to: Risk Assessment Guidance for Superfund, Volume II: Environmental Evaluation Manual (EPA 1997a); Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (EPA 1997b, 1999); and other relevant EPA guidance.

To determine the nature and extent of contamination at the Site, a field investigation has been proposed to collect air data. Details pertaining to this effort are contained in Section 1.0 and will not be repeated here for brevity.

2.1.3.3 Sampling and Analysis Methods

A field investigation has been proposed to collect air data. Details pertaining to this effort are contained in Section 1.0 and will not be repeated here for brevity.

2.1.4 Step 4 – Define the Boundaries of the Study

In Step 4 of the DQO process, the target population of interest and spatial/temporal features pertinent for decision making should be identified. The most important activities in DQO Step 4 are as follows:

- Define the target population of interest.

- Specify temporal or spatial boundaries and other practical constraints associated with sample/data collection.

2.1.4.1 Target Population

The target population of interest are human health and ecological receptors near or in the vicinity of the Site that may be impacted by site-related impacts. These receptors are evaluated in a conceptual exposure pathway analysis in Appendix A. Details of this evaluation are not repeated here for brevity.

2.1.4.2 Temporal or Spatial Boundaries

The horizontal study boundary for the Site RI/FS includes five AOIs discussed in Section 1.1.2 (Figure 3):

- Iron King Mine – The Iron King Mine Proper Area, Iron King Operations Area, Former Fertilizer Plant Area, and ancillary associated properties;

- Humboldt Smelter and ancillary associated properties; and

- Off-site Soil in the vicinity of the Site.

This investigation will evaluate the three AOIs and any additional areas identified during this investigation, as appropriate. The Site is located in a mountainous region of Arizona and has an average high temperature of approximately 50-degrees Fahrenheit (F) in the winter and 90-degrees F in the summer. The wind direction tends to come from the south-southwest and is slightly calmer during the summer months. Precipitation tends to fall during the monsoon season (i.e., July and August) and again during the winter (e.g., December). Because of this variation, there is a temporal aspect to exposure and migration of site contaminants. Exposure to site-related contaminants will tend to be greater during the summer when receptors are more active. Off-site migration of air-borne particulates may tend to be lower in the summer months, when average wind speeds are decreased. However, off-site migration of contaminated soil and water would likely be higher during the summer monsoon season. These temporal variances are considered minor and are not considered a significant source of uncertainty.

2.1.5 Step 5 – Develop the Analytical Approach

Step 5 of the DQO process involves developing an analytic approach that will guide how to analyze the study results and draw conclusions from the data. It is the intention of this step to integrate the outputs from the previous four steps with the parameters developed in this step.

The most important activities in DQO Step 5 are as follows:

- Specify the appropriate population parameters for making decisions.

- Choose a workable action level and generate an "If … then … else" decision rule which involves it.

2.1.5.1 Population Parameters

The population parameter is defined as the value used in the decision statement to evaluate a decision point. The population parameter will be used as an exposure point concentration in the HHRA and Screening Level ERA. A population parameter will be determined for each chemical (e.g., arsenic); in each exposure area (e.g., Iron King Mine); for each sample group (e.g., air particulates). In this example, the population is arsenic in air samples from near the Iron King Mine. The population parameter for site comparisons will be the 95% Upper Confidence Limit of the Mean (95UCLM), which will be calculated using ProUCL version 4.0 (Singh, Singh, and Maichle 2007), or the maximum detected concentration if lower.

Background statistical evaluations will also be conducted. Two-population tests may be used to determine if an exposure area is significantly greater than background. Also, background level threshold values (BTV) may be used to evaluate some datasets (e.g., property specific off-site soils).

2.1.5.2 Action Level Decision Rule

The action levels for the Site will likely be either: (1) risk-based screening criteria developed during the HHRA or Screening Level ERA; or (2) site-specific background concentrations (i.e., BTVs). Site-specific background concentrations will be developed during the course of the investigation.

Residential and Industrial Air Regional Screening Levels for Chemical Contaminants at Superfund Sites (ORNL 2008) will be used to evaluate whether analytical data are of sufficient quality for risk assessment

The decision rule for the Site is as follows:

- If Site concentrations are not significantly greater than background and are less than risk based criteria, then the remedial actions are generally not recommended;

- Else, if Site concentrations are significantly greater than background or greater than risk based criteria, then a risk evaluation is generally recommended.

2.1.6 Step 6 – Specify the Performance or Acceptance Criteria

Step 6 of the DQO process specifies the tolerable limits on decision errors. Data are subject to various types of errors due (e.g., how samples were collected, how measurements were made, etc.). As a result, estimates or conclusions that are made from the collected data may deviate from what is actually true within the population. Therefore, there is a chance that an erroneous conclusion could be made or that the uncertainty in the estimates will exceed what is acceptable.

The performance or acceptance criteria for collected data will be derived to minimize the possibility of either making erroneous conclusions or failing to keep uncertainty in estimates to within acceptable levels. Performance criteria and QA practices will guide the design of new data collection efforts. Acceptance criteria will guide the design of procedures to acquire and evaluate existing data.

The most important activities in DQO Step 6 are as follows:

- Recognizing the total study error and devising mitigation techniques to limit error.
- Specify the decision rule as a statistical hypothesis test, examine consequences of making incorrect decisions from the test, and place acceptable limits on the likelihood of making decision errors.

2.1.6.1 Total Study Error

Even though unbiased data collection methods may be used, the resulting data will still be subject to random and systematic errors at different stages of the collection process (e.g., from field sample collection to sample analysis). The combination of all these errors is called the “total study error” (or “total variability”) associated with the collected data. There can be many contributors to total study error, but there are typically two main components, sampling error and measurement error.

Sampling Error

Sampling error, sometimes called statistical sampling error, is influenced by the inherent variability of the population over space and time, the sample collection design, and the number of samples collected. It is usually impractical to measure the entire population space, and limited sampling may miss some features of the natural variation of the measurement of interest. Sampling design error occurs when the data collection design does not capture the complete variability within the population space, to the extent appropriate for making conclusions. Sampling error can lead to random error (i.e., random variability or imprecision) and systematic error (bias) in estimates of population parameters. In general, sampling error is much larger than measurement error and consequently needs a larger proportion of resources to control.

Measurement Error

Sometimes called physical sampling error, measurement error is influenced by imperfections in the measurement and analysis protocols. Random and systematic measurement errors are introduced in the measurement process during physical sample collection, sample handling, sample preparation, sample analysis, data reduction, transmission, and storage.

The potential for measurement error will be mitigated by using accurate measurement techniques. Sampling techniques were selected to limit the measurement error, including the following:

- Sample collection procedures, sample processing, and field sample analysis protocols are fairly standard. This will ensure that the methodology remains consistent and limits the potential for measurement error.

- Field teams will be trained and will perform specific tasks (e.g., sample collection or processing) throughout the field sampling effort to limit the potential for measurement error.

- Potential for measurement error in the sample analysis will be limited by the analysis of QC samples (e.g., duplicates).

- Data management procedures, which are outlined in the DMP (Appendix C of the SMP [EA 2008b]), will limit the potential for data reduction, transmission, and storage errors.

2.1.6.2 Statistical Hypothesis Testing and Decision Errors

Decision-making problems are often transformed into one or more statistical hypothesis tests that are applied to the collected data. Data analysts make assumptions on the underlying distribution of the parameters addressed by these hypothesis tests, in order to identify appropriate statistical procedures for performing the chosen statistical tests.

Due to the inherent uncertainty associated with the collected data, the results of statistical hypothesis tests cannot establish with certainty whether a given situation is true. There will be some likelihood that the outcome of the test will lead to an erroneous conclusion (i.e., a decision error).

When a decision needs to be made, there are typically two possible outcomes: either a given situation is true, or it is not. Although it is impossible to know whether an outcome is really true, data are collected and statistical hypothesis testing is performed to make an informed decision. In formulating the statistical hypothesis test, one of the two outcomes is labeled the "baseline condition" and is assumed to represent the *de facto*, true condition going into the test, and the other situation is labeled the "alternative condition." The baseline condition is retained until the information (data) from the sample indicates that it is highly unlikely to be true.

The statistical theory behind hypothesis testing allows for defining the probability of making decision errors. However, by specifying the hypothesis testing procedures during the design phase of the project, the performance or acceptance criteria can be specified.

There are four possible outcomes of a statistical hypothesis test. Two of the four outcomes may lead to no decision error; there is no decision error when the results of the test lead to correctly adopting the true condition, whether it is the baseline or the alternative condition. The remaining two outcomes represent the two possible decision errors. The first is a false rejection decision error, which occurs when the data leads to decision that the baseline condition is false when, in reality, it is true. The second is a false acceptance decision error, which occurs when the data are insufficient to change the belief that the baseline condition is true when, in reality, it is false.

In the statistical language of hypothesis testing, the baseline condition is called the "null hypothesis" (H_o) and the alternative condition is called the "alternative hypothesis" (H_a). A false rejection decision error, or a Type I error, occurs when you reject the null hypothesis when it is actually true. The probability of this error occurring is called alpha (α) and is called the hypothesis test's level of significance. A false acceptance decision error, or a Type II error, occurs when you fail to reject the null hypothesis when it is actually false. The probability that this error will occur is called beta (β). Frequently, a false rejection decision error is the more severe decision error, and therefore, criteria placed on an acceptable value of alpha (α) are typically more stringent than for beta (β). Statisticians call the probability of rejecting the null hypothesis when it is actually false the statistical power of the hypothesis test. Statistical power is a measure of how likely the collected data will allow you to make the correct conclusion that the alternative condition is true rather than the default baseline condition and is a key concept in determining DQOs for decision-making problems. Note that statistical power represents the probability of "true rejection" (i.e., the opposite of false acceptance) and, therefore, is equal to $1-\beta$.

Decision errors can never be totally eliminated when performing a statistical hypothesis test. However, the primary aim of this step is to arrive at the upper limits on the probabilities of each of these two types of decision errors that the planning team finds acceptable.

Background Evaluation

Inorganics in air will be subject to a background evaluation to determine whether Site concentrations are significantly greater than background. Two-population tests will be used to determine if the concentrations downwind are significantly greater than background. Because the Site is heavily impacted by inorganics (i.e., lead and arsenic), the null hypothesis is the mean concentration of a contaminant does exceed (i.e., is greater than or equal to) the mean background concentration and the alternative hypothesis is the mean concentration does not exceed the mean background concentration as follows:

H_o = Mean Air Analyte Concentration $\geq$ Mean Air Analyte Background

H_a = Mean Air Analyte Concentration < Mean Air Analyte Background

Also, BTVs may be used to evaluate the datasets if appropriate. The null hypothesis is the mean concentration of a contaminant does exceed (i.e., is greater than or equal to) the action level or background dataset and the alternative hypothesis is the mean concentration does not exceed the action level as follows:

H_o = Mean Air Analyte Concentration $\geq$ Action Level

H_a = Mean Air Analyte Concentration < Action Level

For the statistical evaluations conducted for the Site, the probability of a Type I error occurring will be established at 5 percent and a Type II error will be established at 10 percent.

The Type I error rate was set more conservatively because this type of error would result in finding the site uncontaminated when it actually was contaminated. Type I error is considered more serious than Type II error because it would leave contamination in place for continuing exposure to receptors. By comparison, a higher Type II error rate of 10 percent was tolerable because this type of error would result in considering the site contaminated when it is actually not contaminated.

2.1.7 Step 7 – Develop the Plan for Obtaining Data

In the Steps 1 through 6 of the DQO process, performance or acceptance criteria were developed. The goal of Step 7 is to develop a resource-effective sampling design for collecting and measuring environmental samples, or for generating other types of information needed to address the PSQ. In addition, this sampling design will lead to data that will achieve the performance and acceptance criteria.

The most important activity in DQO Step 7 is as follows:

- Use the information from Steps 1 through 6 of the DQO process to identify a sampling and analysis design that will answer the PSQ and achieve the performance or acceptance criteria.

Normally, this step would require compiling a few different sampling and analysis designs, which could be evaluated to determine the best approach to answer the PSQ and achieve the performance or acceptance criteria. However, the sampling and analysis design was largely dictated by the SOW issued by EPA on 3 March 2008 (EPA 2008); the scoping meeting that was conducted on 10 March 2008; the site visit that was conducted on 19 March 2008; the negotiation meetings conducted on 12 and 14 May 2008; the comments received from EPA via e-mail dated 14 May 2008; the EPA-approved EA Work Plan dated 22 May 2008 (EA 2008a); and subsequent conference calls and E-mail correspondence. The sampling and analysis design is detailed throughout this document and will not be repeated here for brevity.

3. MONITORING EQUIPMENT

The following sections describe the AQM equipment for high volume air sampling, continuous particulate monitoring, and meteorological monitoring.

3.1 Air Sampling Equipment

The PQ100 is a battery operated mass flow controlled air sampler manufactured by BGI, Inc. for TSP and PM_{10} measurements. This instrument is approved by the EPA under Federal Reference Method Number RFPS-1298-124, and is designated as a reference method for PM_{10} air monitoring (CEPA 2003)

All system components are housed in an anodized aluminum case that supports a size selective vertically symmetric particulate inlet. During operation air is drawn by the pump through a filter (glass fiber for TSP and quartz fiber for metals and PM_{10}) and a flow mass sensor. This sensor allows the device to determine if the flow rate is correct. If the sensor determines that the flow rate is not correct, it will automatically adjust the pump speed to maintain the correct flow rate, pressure, and temperature. All parameter information is stored by the device, and can be displayed on the screen or downloaded to a computer using manufacturer-supplied software (BGI 2008)

The PQ100 can be programmed to begin its sampling job at a specific user-defined date and time and run for a pre-determined time period. If a fault occurs that prevents normal operation, the device enters a shutdown mode until the problem is corrected, consuming no battery power. The PQ100 was designed to operate from 1.0 standard liter per minute (lpm) to 25.0 lpm and is not affected by changes in ambient temperature and barometric pressure. The flow rate precision is guaranteed to 2 percent of the calibration set point (BGI 2008).

Default values in this instrument have been selected to reflect EPA air sampling procedures (BGI 2008). When configured in accordance with the EPA manual reference method, RFPS-1298-124, the PQ100 is designated as a reference method for PM_{10} monitoring. The PQ100 air sampler can be configured with different inlets to accommodate PM_{10} or TSP sampling (CEPA 2003). For additional details on the PQ100 sampler, please see Attachment B for the PQ100 Air Sampler Instruction Manual.

3.2 Meteorological Monitoring Equipment

The exact meteorological station that will be used for this project has not yet been determined. However, at a minimum, the station will be capable of recording data for the following parameters: (1) time; (2) wind speed; (3) wind direction; and (4) precipitation.

4. SAMPLING SPECIFICATIONS

This section describes the EPA-approved specifications for air sampling and meteorological monitoring performed at the Site.

PM_{10} sampling will be conducted in accordance with 40 CFR, Chapter I, Appendix J to Part 50, *Reference Method for the Determination of Particulate Matter as PM-10 in the Atmosphere* (EPA, 1998a). TSP sampling will be conducted in accordance with 40 CFR, Chapter I, Appendix B to Part 50, *Reference Method for the Determination of Suspended Particulate Matter in the Atmosphere (High-Volume Method)* (EPA, 1998b).

- **Air Sample Designation.** Air sample designation will include two fields that are separated by dashes; for example: AHS-01.
    - The first field, “AHS,” identifies the sample matrix as air near the Humboldt Smelter. Similarly, “AIK” is near the Iron King Mine.
    - The second field, “01,” represents the sample location identifier

5. ANALYTICAL PARAMETERS AND METHODS

This section describes analytical parameters and methods and sample holding times for high volume air sampling. The AQM program consists of gravimetric analysis of PM_{10} and TSP filters and chemical analysis of 17 metals present on PM_{10} filters shown below. EA will require analysis of air monitoring filters for PM_{10}, total particulates, and metals. The following is a list of the metals that are included: aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, calcium, copper, iron, mercury, nickel, lead, silver, selenium, sodium, and zinc.

Table 1 summarizes the analytical methods, sample matrix, estimated number of samples, turnaround times, and sample holding times for ambient air sampling.

TABLE 1 ANALYTICAL METHODS

Parameter	Method	Sample Matrix	Estimated Number of Samples	TAT (days)	Holding Time [a]
Ambient Air Samples					
TAL metals (including Hg)	ICP 6010 and Hg by CVAA 7471	47 mm quartz fiber	Up to 90	14 days	180 days
PM_{10}	Gravimetric Analysis, Inorganic Compendium Method IO-3.1, Section 5, (EPA/625/R-96/010a)	47 mm quartz fiber	Up to 90	14 days	180 days
TSP	Gravimetric Analysis, Inorganic Compendium Method IO-3.1, Section 5, (EPA/625/R-96/010a)	47 mm glass fiber	Up to 90	14 days	180 days

Notes:

a Holding time is measured from the time of sample collection to the time of sample extraction and analysis.

CVAA	Cold vapor atomic absorption
Hg	Mercury
ICP	Inductively coupled plasma
mm	millimeter
PM_{10}	Particulate matter less than ten microns in size
TAL	Target analyte list
TAT	Turnaround time
TSP	Total suspended particulates

Actual reporting limits achieved for samples from any given monitoring location during any given monitoring event will depend on the actual sample volume collected, which can vary.

6. QUALITY ASSURANCE PLAN

Quality assurance for the Site is described in the Sampling and Analysis Plan (SAP), which is the main document to this Appendix. The program incorporates the following items: standard operating procedures (SOPs), equipment calibration and maintenance, independent audit, field and laboratory quality control (QC) samples, data validation, corrective action, and data completeness.

6.1 Standard Operating Procedures

Calibration, operation, and maintenance of the air monitoring equipment will be conducted in accordance with the manufacturer recommendations. The SOP for calibration, operation, and maintenance of the PM_{10} and TSP air sampling equipment is provided in Attachment B.

6.2 Equipment Calibration

Equipment calibration for the air samplers and meteorological station will be performed in accordance with manufacturer specifications and/or EPA guidance as described below.

6.2.1 Air Samplers

According to the manufacturer, the PQ100 samplers should not need calibration; however, EA will have calibration equipment at the site and will perform calibrations if necessary. Information regarding calibration by the manufacturer is provided below.

> *When using a specific filter and flow rate (i.e. 47 mm Teflon at 16.7 lpm this calibration will be maintained in memory indefinitely. However, calibration should be checked on a yearly basis. Assuming that a typical filter for a target was in place at the time of the calibration, the filter load is compensated for causing the pump to initialize to the proper speed. Once a target has been calibrated it should never have to be re-calibrated unless extreme conditions are expected* (BGI 2008).

6.2.2 Meteorological Station

If recommended by the manufacturer, calibration of the meteorological station will performed at the start of the AQM program.

6.3 Field and Laboratory QC Samples

Field and laboratory QC samples for the AQM program are specified in the SAP, which is the main document to this Appendix. Field QC samples consisting of co-located samples, filter blanks, and field blanks as described below.

For repeatability assessments, EA will co-locate samplers on a frequency rate of approximately one for every 20 samples (up to four total).

Analyses of filter blanks (a.k.a. trip blanks) are used to assess the contamination of samples from the native presence of target analytes in the filters used for air sample collection. A filter blank consists of a clean filter that is transported with associated primary samples, but is never taken out of its protective sleeve. A filter blank will be collected and analyzed for every 20 primary samples (i.e., 5 filter blank samples).

Analyses of field blanks are used to assess the contamination of samples during sample collection. A field blank consists of a clean filter that is placed onto the air sampler and then taken off without running the sampler. A field blank will be collected and analyzed for every 20 primary samples (i.e., 5 field blank samples). All field QC samples will be submitted to the laboratory without designating them as blanks to avoid bias. Field QC samples will be analyzed for the same parameters specified for the associated primary samples. Laboratory QC samples consist of method blanks, laboratory control samples, and laboratory duplicates samples as specified in the SAP, which is the main document to this Appendix.

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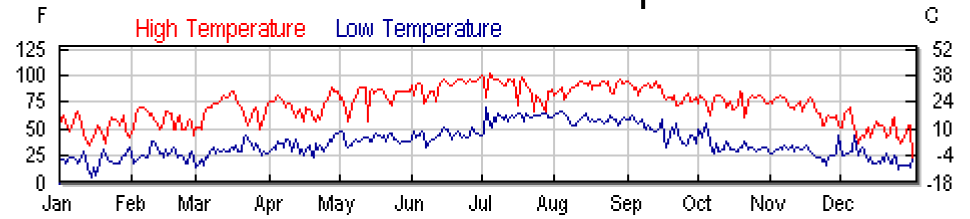
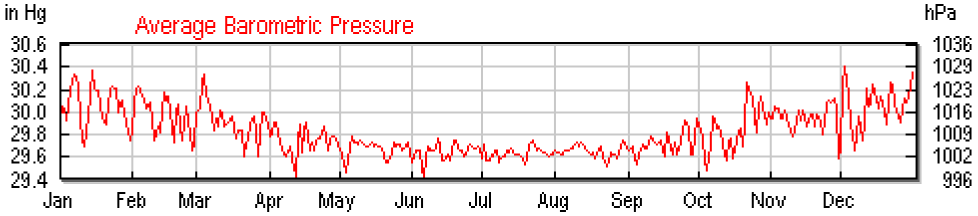
Figures

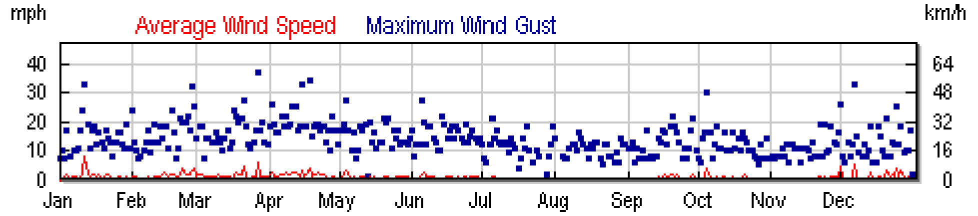
Attachment A

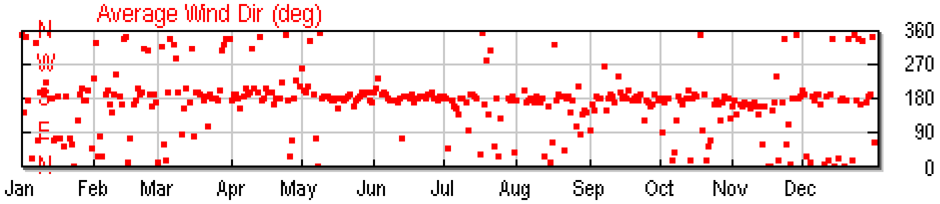
Historical Weather Data for Humboldt, Arizona

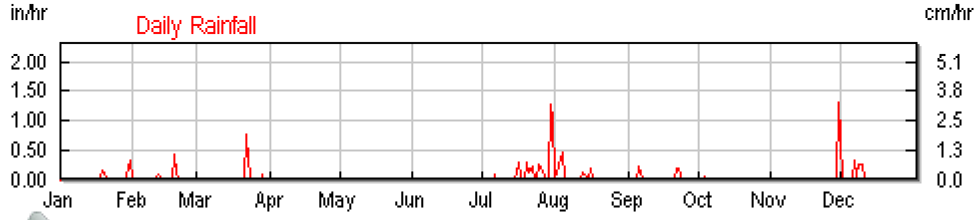
KAZHUMBO1 Weather Graph for 2007











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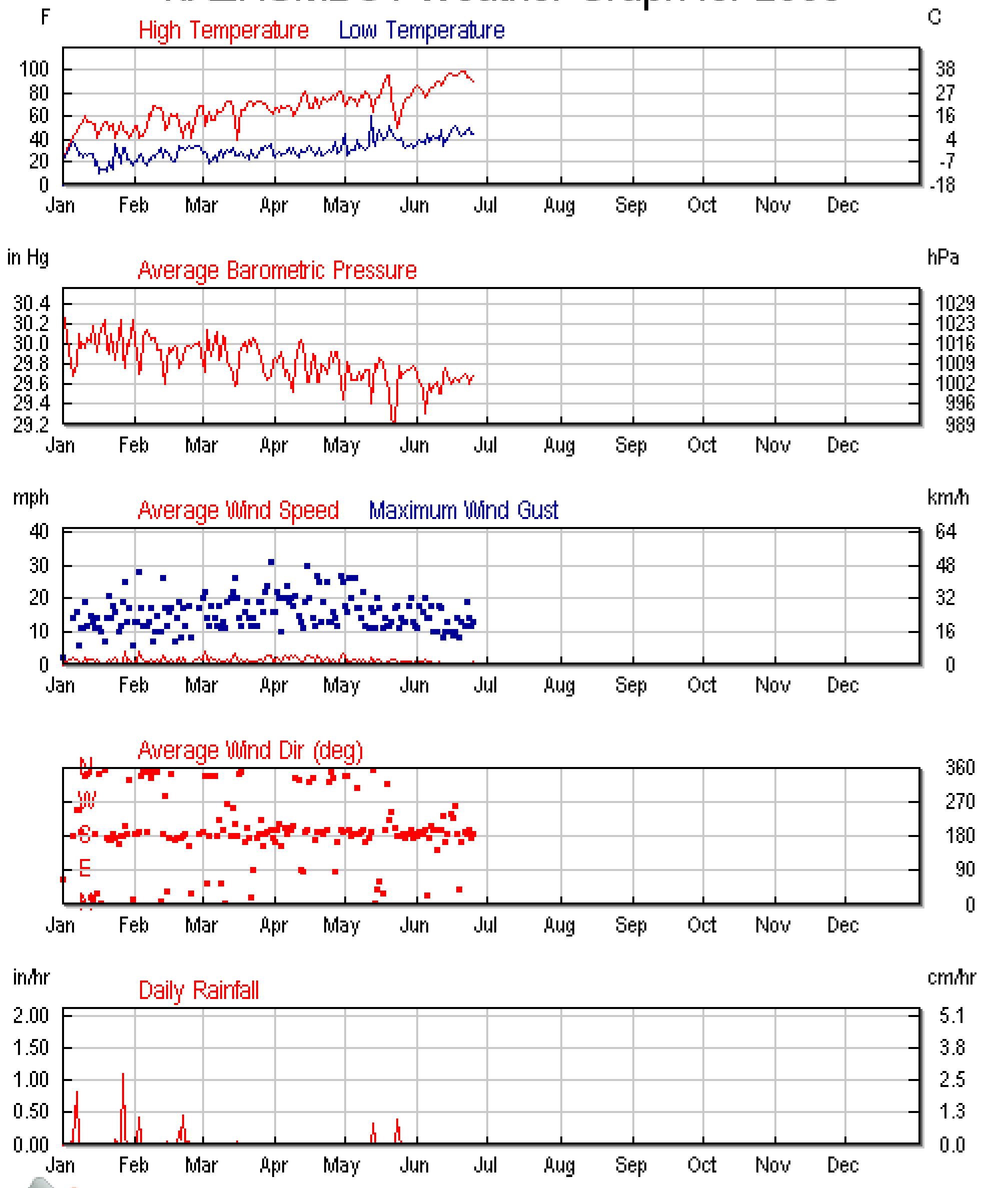
KAZHUMBO1 Weather Graph for 2008



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Attachment B

BGI PQ100 Air Sampler Instruction Manual

PQ100
Air Sampler

INSTRUCTION MANUAL

PM$_{10}$ REFERENCE SAMPLER

DESIGNATION NO. RFPS-1298-124

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Manual Version: 6.24 July 2008

PREFACE

The purpose of this manual is to provide complete operational, calibration and maintenance details for the BGI PQ100 air sampler. This instrument has been specifically designed to meet or exceed the operational requirements of a Reference Method sampling device under 40 CFR Part 50, Appendix J ("Reference Method For The Determination of Particulate Matter as PM-10 in the Atmosphere") and was designated a Federal Reference Method Sampler Number RFPS-1298-124 in December 1998.

SAFETY

The PQ100 should only be operated as described and for its intended use. Because the PQ100 runs primarily from battery power, all of the typical hazards associated with high voltages and internal A.C. wiring have been reduced or eliminated. Personal injury, damage to the instrument, or fire can occur if the following electrical precautions are not observed:

- Caution should always be given when attaching the A.C. mains power connection. Do not attempt to connect main power if the plug or wire are cracked or frayed.
- Do not attempt to connect main power if the power cord, leads, or outlet are wet. Do not immerse power cords in water or other liquids.
- Place power cords away from traffic and do not allow anything to rest on them during operation.
- Do not overload AC outlets.
- Do not attach improperly wired external batteries, solar panels or power sources.
- Do not open the control panel or handle any other of the electrical parts while power is applied to the PQ100. Always disconnect the power supply first.

In addition, personal injury or damage to the instrument could occur if the following precautions are not observed:

- Always operate the PQ100 in a normal, upright position. The legs should be bolted down to prevent tipping in conditions of high winds.
- Do not operate the PQ100 if any of the parts are defective, damaged, or missing.

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1.0 INTRODUCTION

The BGI PQ100 is an "Intelligent Air Pump" that can monitor it's own airflow rate and thereby adjust the pump speed to compensate for changes in load pressure and/or other forces which would otherwise hamper the flow of air through a filter (or sample collector). The PQ100 can be programmed to begin it's sampling job at a specific date and time and stop sampling after the user defined run time is depleted. A 24 character by 2 line Liquid Crystal Display provides the operator with a readout of flow rate, and other useful information.

Events such as the flow being restricted by blocking the inlet, batteries depleted (power failure), pump unable to regulate flow (excess resistance), etc. all force the pump into a shutdown mode which consumes no battery power until the problem causing the shutdown is corrected.

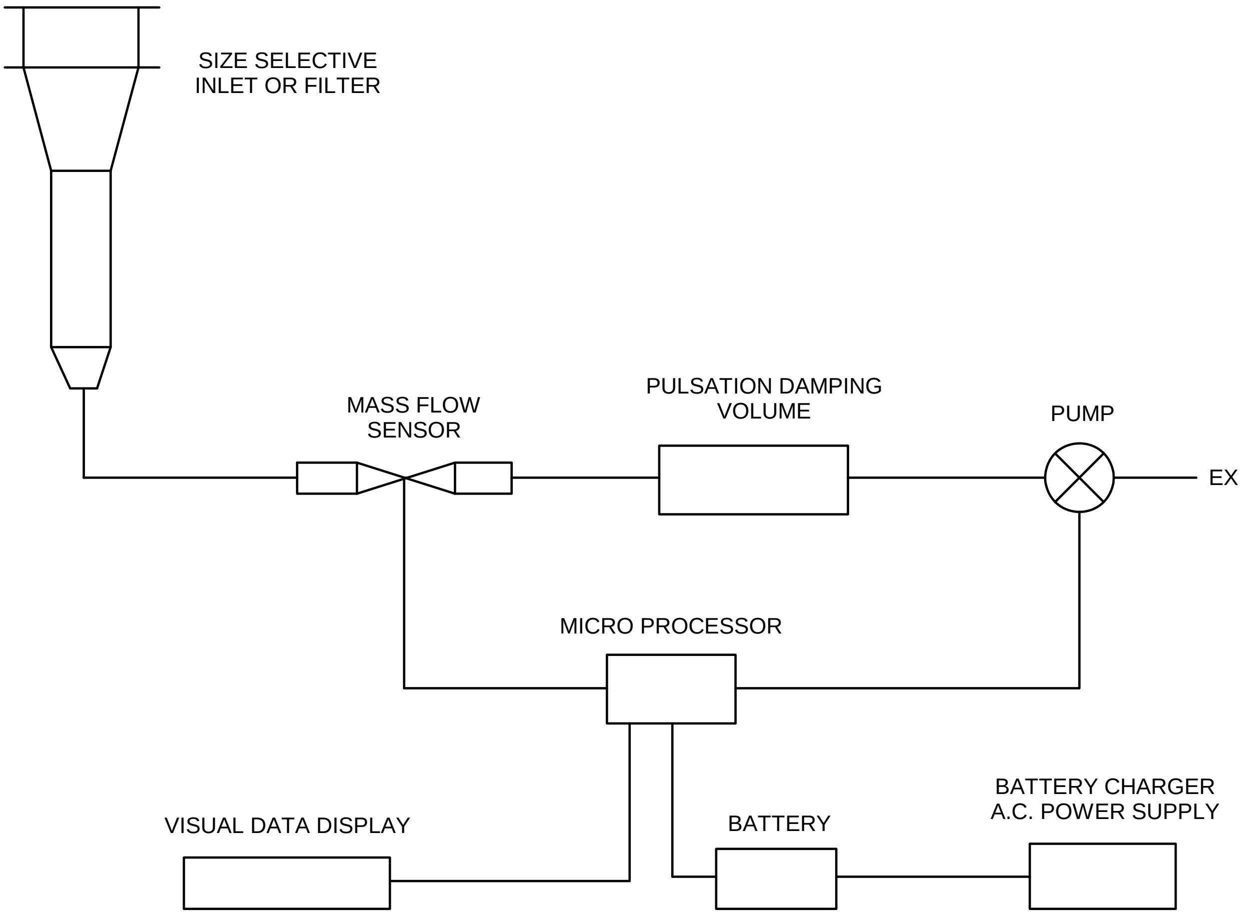
The PQ100 was designed to operate from 1 standard liter per minute (1000 cc per minute) to 25.0 standard liters per minute and is unaffected by changes in ambient temperature and barometric pressure. The flow rate precision is guaranteed 2% of the calibration set point. Standard conditions, for some forms of air sampling, being 20°C, 760 mm of Mercury barometric pressure.

Certain default values in this instrument have been selected to reflect EPA style air sampling procedures. The default "Run Time" is 24 hours. The default "Start Date and Time" is midnight tomorrow.

Principle of Operation

The operating principle of the PQ100 can be appreciated by referring to the block diagram below. Air is drawn by the pump through a size selective inlet device and/or filter. It then passes inside the instrument housing to a Mass Flow Sensor. The signal generated by the sensor is then routed to a microprocessor which determines if the flow is at the set value and adjusts the pump speed to maintain the correct flow rate. Because the flow sensor is extremely sensitive and all pumps produce pulsation to some degree, a pulsation damping volume has been introduced to control this effect. The microprocessor not only controls the flow rate accurately and precisely to the set point but also performs several other functions. These include turning the instrument on at a preselected time and running it for a selected interval. The flow is maintained by the processor to a designated pressure and temperature value. A pulse width modulated signal is configured and sent to the pump motor in a constantly updated manner based on signal information received from the Mass Flow Sensor. The microprocessor also stores all parametric information generated during the run period and configures it for presentation on the visual display and downloading to the software provided with the instrument.

The system is completed by it's 12 volt battery and external battery charger/A.C. power supply. The power supply function permits operation if desired with no battery whatsoever.



SCHEMATIC DIAGRAM OF PQ 100 SYSTEM

1910

2.0 GETTING STARTED CHECKLIST

2.1 Included with the PQ100

1. PQ100 Main Unit
2. PQ101 Battery Charger (120 VAC or 240 VAC)
3. CQ2 PC Communication Adapter Cable
4. PC Software Diskettes - 3 ½", 1.44K
5. PQMAN Manual
6. PQ102 Hose Adapter

2.2 Optional Accessories Available (See Section 5)

1. PQ103 Replacement Battery
2. CQ3 External Battery Adapter Cable
3. SSI-10 Size Selective Inlet (SSI) Kit
4. TP100R Dicot Inlet Rigid Tripod Assembly
5. F20 47mm Filter Holder for BGI16.7
6. F21 Filter Cassette (for use with F20 above)
7. TSP CAP Total Suspended Particulate Inlet

2.3 User Supplied Items

1. A DeltaCal, TetraCal (formally triCal) or Bubble Meter/Calibrator.
   Note: Dry Calibrators and Rotameters are not recommended!
2. A length of rubber hose (about a half meter).
3. A Pinch Clamp or Valve (helpful but not required).
4. Ambient Temperature and Local Barometric Pressure Readings.
5. A Magnehelic Pressure Gauge (helpful but not required).
6. Filter Holder (F20) with Filter Cassettes (F21/2) to collect sample (also protects the PQ100 from damage).

Note: Permanent damage can occur if the PQ100 is operated without a filter in series with the Inlet. If the unit is operated without a SSI head with filter and holder, a suitable filter must be used to prevent damage to the pump and sensors.

3.0 HOW TO USE THE PQ100 IMMEDIATELY

3.1 What the Buttons do

"ON/OFF”	Turns the PQ100 On or Off.
"RESET"	Press after a sampling job to clear all the counters in preparation for the next sampling job.
"RUN/STOP"	Use when the PQ100 has been reset and programmed for another run and you now wish to start the pump.
"+"	Increase
"-"	Decrease
"SETUP"	Traveling from screen to screen and entering the information set on the screen.
"ENTER"	Accepts new setting within the screen.

3.2 Running the PQ100 at 16.7 Liters per Minute

1. Turn the PQ-100 on (Push the "ON/OFF" button). If a message is blinking on the display, press "ENTER" to proceed to the "MAIN IDLE DISPLAY".

2. Before you change any setups and to delete the last run push the "RESET" button. Screen display should be:

   ET0000Min TS00.00M (Date)
   Q(Flow)Lpm T(Time) Bty(Capacity)%

   (Date) - today’s date in military type notation; e.g., 01JAN= January 1st
   (Flow) - the current flow rate selected to be regulated.
   (Time) - military time; e.g., 13:08= 13 Hours 8 Minutes or 1:08 PM
   (Capacity) - remaining charge in the internal battery.

3. Press "SETUP"
Screen reads; "Select FLOW RATE"

To change TARGET FLOW RATE;

* Press ENTER (Whole number value will remain on constant while the tenths still blink); use "+" or "-" to increase or decrease until 16 is displayed.
* Press ENTER (Tenths value will now remain constant while whole number blinks); use "+" or "-" to increase or decrease until .7 is displayed.

Note: If the flow rate displayed is followed by Lpm then the selected flow rate is calibrated and recalibration is not required. If CAL is displayed then calibration should be performed as described in section 7.0.

4. Press "SETUP"
Screen reads; "Set DATE and TIME"

To change the Date and Time;
a. DAY: Press ENTER and change by pressing the + or - key. When the day is correct, press ENTER.
b. MONTH: To change, press + or - key. When correct, press ENTER.
c. YEAR: To change, press + or - key. When correct, press ENTER.
d. TIME (hrs): To change, press + or - key. When correct, press ENTER.
e. TIME (min): To change, press + or - key. When correct, press ENTER.

5. Press "SETUP"
Screen reads; "Set START DATE and TIME"

This determines when you wish to start a sample job. It always defaults to midnight the next day. Should you wish to change it;
a. DAY: Press ENTER and change by pressing the + or - key. When the day is correct, press ENTER.
b. MONTH: To change, press + or - key. When correct, press ENTER.
c. YEAR: To change, press + or - key. When correct, press ENTER.
d. TIME (hrs): To change, press + or - key. When correct, press ENTER.
e. TIME (min): To change, press + or - key. When correct, press ENTER.
f. (enable): This is to turn this function On or Off. If "Off" then a sample job (pump starts running) is initiated as soon as the "RUN/STOP" key is pressed from the "MAIN IDLE DISPLAY". If "On" then the sample job is initiated when the start date and time are achieved. SET THIS FUNCTION TO "OFF" IF YOU WISH TO START SAMPLING NOW. Change by pressing + or - key. When correct, press ENTER. FOR THE PURPOSE OF THIS TUTORIAL, SET TO "OFF".

6. Press "SETUP"
Screen reads; "Set RUN TIME"

This is for when you wish to set the length of time that the pump will run for. (Other than for 24 hrs). It always defaults to 24 hrs 0 min. To change;

a. HOURS: Press ENTER and change by pressing the + or - key. When the hours are correct, press ENTER.
b. MINUTES: To change, press + or - key. When correct, press ENTER.
c. (enable): This is to turn this function On or Off. If "On" then the pump will run for the amount of time specified and then power itself off. SET THIS FUNCTION TO "OFF" IF YOU WISH TO RUN UNTIL THE BATTERIES RUN DOWN. Change by pressing + or - key. When correct, press ENTER. FOR THE PURPOSE OF THIS TUTORIAL, SET TO "OFF".

7. Press "SETUP"
Screen returns to the "MAIN IDLE DISPLAY"

DO NOT PRESS THE RESET BUTTON AT THIS TIME AS THE START TIME AND RUN TIME WILL DEFAULT.

8. Press "RUN/STOP"
If the START TIME ENABLE is set to "OFF" then the pump will begin to run immediately and will run until one of the shutdown causes (explained in APPENDIX E) force the unit to terminate the sample job. During the initial time that the PQ100 requires to stabilize its flow rate, flow will be displayed as --.-Lpm. If the START TIME ENABLE is set to "ON" then the message "Alarm Triggered Run..." followed by "PQ100 Powering Down.." will appear briefly. The PQ100 is now waiting for the internal real time clock to achieve the designated start time and will then power itself on and begin the Air Sample Job.

3.3 Downloading (A Quick Start Overview)

1. Insert the "PQ" software diskette in the "A:" drive of your PC or notebook and type INSTALLC at the A:\> prompt. This will create a subdirectory on your hard drive called PQ and will copy all files from the floppy disk to this subdirectory. After the installation is complete, type PQ at the A:\> prompt to run the program (see section 8.0).

2. From the PQ MAIN MENU, select "b" to begin a job and answer the questions provided or simply press enter for each of the entries.

3. From the PQ MAIN MENU, select "I" to import (download) the data from the PQ100.

4. Connect the cable provided from your computer to the UTILITY ADAPTER port on the front of the PQ100. NOTE: THE PQ100 MUST BE AT THE "MAIN IDLE DISPLAY" FOR THE DOWNLOAD TO WORK.

5. When the download is complete you may then select "s" from the "PQ MAIN MENU" to view the file data.

4.0 SPECIFICATIONS

4.1 Flow Rate Precision, Accuracy and Pulsation

Flow Rate Selections:	1.0 to 25.0 Lpm in .1 Lpm increments
Flow Rate Accuracy:	.5% (When calibrated with a DeltaCal or TetraCal (formally tetraCal))
Flow Rate Precision:	2%

Pulsation for various applications as measured downstream from the filter:

Flow Rate	Media Type	Pulsation
16.7 Lpm	47mm Quartz	4.56%
10.0 Lpm	47mm Quartz	3.84%
10.0 Lpm	47mm Teflo	7.38%
7.0 Lpm	47mm Quartz	5.06%
5.0 Lpm	47mm Quartz	6.13%
4.0 Lpm	47mm Quartz	7.94%
2.2 Lpm	37mm MCE w/BGI-4 Cyclone	4.70%

4.2 Run Times for Various Applications

Flow Rate	Media Type	Pressure Drop	Run Time
25.0 Lpm	47mm Teflo	28.0cm H2O	11.6 Hours
25.0 Lpm	47mm Fiberglass	37.0cm H2O	7.4 Hours
16.7 Lpm	47mm Teflo	10.8cm H2O	33.6 Hours
16.7 Lpm	47mm Fiberglass	25.4cm H2O	32.4 Hours
16.7 Lpm	47mm Quartz	33.0cm H2O	28.4 Hours
14.0 Lpm	37mm MCE .8	112.0cm H2O	13.0 Hours
12.0 Lpm	37mm MCE .8	94.0cm H2O	13.5 Hours
12.0 Lpm	25mm MCE .8	170.0cm H2O	11.6 Hours
10.0 Lpm	37mm MCE .8	66.0cm H2O	19.8 Hours
2.2 Lpm	37mm w/BGI-4 Cyclone	5.0cm H20	67.0 Hours

4.3 Dimensions and Weights (PQ100 Main Unit Only)

Dimensions:

Height:	5.3" (13.46cm)
Width:	9.9" (25.15cm)
Depth:	9.7" (24.64cm)
Weight:	19 Lbs. (8.63Kg)

4.4 Electrical Specifications

Main Battery-	12V 12Ah Short Circuit Protected	
Clock Battery-	3.6V Lithium Cell	
Clock Battery Life-	2 Years	
Motor Drive-	High Efficiency Pulse Width Modulator	
Flow Rate Measurement-	Mass Flow Sensor	
Serial Data Signals:		
	Outputs-	9V Nom.
	Inputs-	30V Max.
Charging System-	120VAC (60 Hz) or 240VAC (50 Hz)	

Note: The PQ100 can run from the Charger.

4.5 Hardware Requirements for PQ Software

IBM XT, AT or 100% Compatible Clone
MS-DOS Operating System version 2.1 or greater
Minimum one 3.5, 5.25, Low or High Density Floppy Drive
COM1 or COM2 RS232 Serial Port for Downloading
(Not required for Correction Calculator)
Any Video Adapter Configuration
Hard Disk is preferred but not required

For Printouts: All printouts are directed to LPT1 as generic ASCII text with no special printer functions. This means that redirection can be accomplished using the MS-DOS function "MODE" and that any printer will work.

4.6 Dimensions, Weights and Flow Specifications for SSI

SSI-10 Inlet Kit (Including Rigid Tripod Assembly)

Flow Rate:	16.7 Lpm 5%
Weight:	16 Lbs. (7.3Kg)
Tripod Diameter Footprint:	51" (1.29M)
Tripod/Inlet Overall Height:	76" (1.93M)

5.0 ACCESSORIES

5.1 Cables

CQ2 Communication Adapter Cable	Connects the PQ100 to a computer for downloading
CQ4 External High Capacity Battery Cable	Use to connect the PQ100 to a large external battery, typically 80 Amp Hour for greater than 48 hour run time

5.2 Inlets, Adapters and Filter Holders

PQ102 Hose Adapter	For attachment of a rubber hose to the PQ100.
SSI-10 Inlet Kit	PM10 Size Selective Inlet for separation and collection of particles with an aerodynamic equivalent of 10 micrometers or less.
F20 47mm Filter Holder	Connects to Dicot Inlet and holds Filter Media, also used as TSP Inlet when used with TSP CAP.
F21/2 Filter Cassette (for use with F20 above)	Plastic Cassette containing a screen and filter media
TSP 100 Micrometer Inlet	(for use with F20 above)

5.3 Batteries and Chargers

PQ101 Battery Charger Auxiliary Power Supply	Used to Recharge system batteries and to power the PQ100 for long run times when AC Power is available.
PQ103 Replacement Battery	

5.4 Miscellaneous

TP100R Rigid Tripod Assembly	Supports Dicot Inlet at EPA recommended height

6.0 OPERATION DETAILS

6.1 Basic Operation

To operate the PQ100 Air Sampler, press the Power "On/Off" pushbutton keyswitch. The unit will beep a few times and display;

BGI PQ100 Air Sampler

and briefly, the unit serial number and firmware revision;

SN:1234   Version 5.23

and then;

Initializing!

During the power-up sequence if it has been determined that the unit had previously shutdown due to one of the shutdown conditions, i.e. "Flow Rate Error", "Low Batteries", "Sample Run Completed" etc. the unit will then flash one of these messages at the display and requires that the user press the "Enter" key to continue on to the MAIN IDLE DISPLAY (See APPENDIX E for a description of all shutdown codes). If the unit was powered down normally, i.e. the power "On/Off" key was previously pressed while at the MAIN IDLE DISPLAY, then it will jump from the above initialization messages directly to the MAIN IDLE DISPLAY and will not display a flashing error message.

6.2 Main Idle Display

ET0000Min TS00.00M 28oct   (or similar)
Q10.0 Lpm T01:00 Bty99%

Where;

ET	is the Elapsed Time of the previous run in minutes.
TS	is the Total Sample of the previous run in cubic meters.
Q	is the selected TARGET flow rate in liters per minute.
Bty	is the percentage of charge stored in the battery.
T	is Time (24:00 hour system)
28oct	is Day Month (year is displayed only on Setup and download).

For power conservation purposes, the PQ100 is equipped with an algorithm which detects inactivity. If the front panel pushbutton switches or the RS232 port are not used within 3 minutes the unit will power itself off.

6.3 What to Do Next

Pressing the "Setup" key steps through the various Menu Selections. Each of the selections are explained in detail, in the order they will be encountered, on the following pages.

6.4 Setting a New Target Flow Rate

From the "MAIN IDLE DISPLAY" press the "Setup" key once until the message below appears;

Select FLOW RATE
Target Q... xx.yLpm

where;

xx = Liters per minute
y = tenths of a Liter per minute

The target flow rate is that which the PQ100 will draw air through the inlet at when a run is initiated.

If the displayed flow rate is acceptable and you do not wish to change it, press the "Setup" key. This action will change nothing and will step the menu to the next selection. If a change is required, press the "Enter" key. You will notice that the whole number value (the value preceding the decimal point) will then remain on while the tenths value continues to flash. The value that remains on is the one that will change when the "+/-" keys are pressed. When the proper value has been reached, pressing the "Enter" key will then select the tenths value (the digit after the decimal point) for editing. After the values have been entered, pressing the "Setup" key will then store the new values in memory and step to the next menu selection.

6.5 Setting the Date and Time

From the "MAIN IDLE DISPLAY" press the "Setup" key twice until the message below appears;

Set DATE and TIME
dd mmm yyyy hh:mm

where;

dd = day of the month
mmm = month
yyyy = year
hh = hour (0-24, 24 hour system) mm = minutes (0-59)

The date and time are read from the real time clock just prior to entering this screen. This action copies the precise date and time data at that instant to temporary memory locations. Once the values have been established in these temporary locations they are then modifiable by the user and will then be flashing on the display.

If all is correct pressing the "Setup" key will change nothing and will step the menu to the next selection. If a change is required, press the "Enter" key. You will notice that the day will then remain on while the rest of the values continue flashing. The value that remains on is the one that will change when the "+/-" keys are pressed. When the proper value has been reached, pressing the "Enter" key will then select the next value for editing. After all the values have been entered, pressing the "Setup" key will then write the new values to the real time clock and step to the next menu selection.

Notes:

1. Seconds will always default to zero. Therefore, if you wish to synchronize the clock exactly, press the "Setup" key at zero seconds.
2. Once the Set Time menu selection is entered, the clock is not read again during this screen. Don't expect the date or time to change while this menu selection is engaged. However, the clock is not halted, and is still keeping time. If the "Enter" key is never pressed while this menu selection is being displayed no changes are made to the date or time even though the time does not appear to change.
3. Century will only change on 12/31/1999 at midnight. Century will then become 2000.

6.6 Setting the Start Date and Time

From the "MAIN IDLE DISPLAY" press the "Setup" key three times until the message below appears;

Set START DATE and TIME
dd mmm hh:mm eee

Where;

dd = day of the month
mmm = month
hh = hour (0-24, 24 hour system) mm = minutes (0-59)
eee = enable "On" or "Off"

Note: If “On” is enabled see the next section for further description of run procedure.

This sets the date and time that the sampler will begin running the pump. If all is acceptable pressing the "Setup" key will change nothing and will step the menu to the next selection. If a change is required, press the "Enter" key. You will notice that the day will then remain on while the rest of the values continue flashing. The value that remains on is the one that will change when the "+/-" keys are pressed. When the proper value has been reached, pressing the "Enter" key will then select the next value for editing. After all the values have been entered, pressing the "Setup" key will then write the new values to the real time clock alarm registers and step to the next menu selection. This function can be disabled. This means that if the Enable (eee) is set to "Off", the PQ100 will begin to run the pump immediately when the "Run/Stop" key is pressed from the "MAIN IDLE DISPLAY" regardless of the start time and date.

IF YOU SIMPLY WANT THE PUMP TO START RUNNING WHEN YOU PRESS THE "RUN/STOP" KEY, THE LOWER RIGHT OF THE DISPLAY SHOULD INDICATE OFF.

Note: When the reset key is pressed to clear the counters this setup will automatically default to Midnight (00:00) of the next day. If some other Date and Time are required you must reset the run first before using this menu selection (See Resetting the Counters).

RESET DOES NOT AFFECT THE ENABLE AND WILL REMAIN UNCHANGED!

6.7 Setting the Run Time

From the "MAIN IDLE DISPLAY" press the "Setup" key four times until the message below appears;

Set RUN TIME
Hours:hh Min:mm eee

Where;

hh = hour (0-99 hours)
mm = minutes (0-59)
eee = enable "On" or "Off"

This sets the length of time that the sampler will run the pump for. If the setting is acceptable, pressing the "Setup" key will change nothing and will step the menu to the next selection. If a change is required, press the "Enter" key. You will notice that the hours will then remain on while the other values continue flashing. The NON-FLASHING value will now change when the "+/-" keys are pressed. When the proper value has been achieved, pressing the "Enter" key will then select the next value for editing. After all the values have been entered, pressing the "Setup" key will then store the new values and step to the "MAIN IDLE DISPLAY".

This function can be disabled thereby allowing the pump to run until some other shutdown such as Low Batteries etc. if the Enable (eee) is off.

IF YOU SIMPLY WANT THE PUMP TO RUN UNTIL SOME OTHER CONDITION SUCH AS BATTERIES TOO LOW CAUSES A SHUTDOWN, THE LOWER RIGHT OF THE DISPLAY SHOULD INDICATE OFF.

Note: When the reset key is pressed to clear the counters this setup will automatically default to 24 Hours. If some other Run Time is required you must reset the run first before using this Mode (See Resetting the Counters).

RESET DOES NOT AFFECT THE ENABLE AND WILL REMAIN UNCHANGED!

Note: If START TIME was enabled, after RUN TIME screen, the unit will not step the screen to the “MAIN IDLE DISPLAY”. Instead, the next screen that appears will state;

To initiate a run,
Press Run/Stop

At this time pressing “Run/Stop” will power the unit off and sampling will commence at the programmed run time. If you simply wish to go to the main idle screen (bypass this function) press “Setup”. This will return you to the “MAIN IDLE DISPLAY”. At this point you can also press “Run/Stop” to initiate the run.

6.8 Running the Pump

6.8.1 Start Time Disabled

To initiate a run, from the "MAIN IDLE DISPLAY", press the "Run/Stop" key. If the START ALARM is disabled (See setting the Start Time and Date) the pump will immediately begin running and the "Q" in the display window will start to flash. This indicates normal operation and the pump will run at the specified Flow Rate until a stop condition is encountered (i.e. Batteries depleted, excess Flow Restriction etc.). If "CAL" is displayed after the Flow Rate in the lower left corner of the display, this target is not calibrated and therefore the Flow Rate indicated is a coarse approximation and is somewhere 10% of that displayed. Use the Calibration Mode to set this to 2%.

During the initial time that the PQ100 requires to stabilize its flow rate, flow will be displayed as --.-Lpm.

6.8.2 Start Time Enabled

To initiate a run, from the "MAIN IDLE DISPLAY", press the "Run/Stop" key. If the Alarm values are correctly set and Enabled, the PQ100 will power itself off (or GO TO SLEEP) until the start date and time have been reached. When the Alarm triggers the PQ100 to "Wake-Up", after the Initialization and diagnostics, the pump will begin to run until a shutdown condition occurs.

6.8.3 Run Time

If the RUN TIME is Enabled ("On"), the pump will run until this shutdown condition occurs. Successful completion is indicated by the following message flashing on the screen when the unit is powered on;

SAMPLE RUN COMPLETED!
Key "Enter" to Continue!

6.8.4 Acoustic Phenomena at High Negative Pressure

When running the PQ100 at very high load pressures (i.e. 150 centimeters of water or better), a metal popping sound may be heard by the user. This is merely the internal pulsation dampner (Plenum) adjusting its chamber area. The PQ100 will alert you as to the nature of any problems via the shutdown messages as described in APPENDIX E.

6.9 Verifying the Flow Rate

To verify the Flow Rate while the Pump is running, a DeltaCal or TetraCal (formally triCal) is highly recommended for Calibration and Verification of the true Actual Flow Rate. Use section 8.7; Appendix A, Equation 2; or the "CORRECT" utility provided on floppy diskette to calculate the corrected flow rate as shown on the Calibration/Verification Standard.

If the flow rate is not within 2% of the "Corrected Flow Rate" a leak in the system is the probable cause and should be inspected.

More information on the DeltaCal or TetraCal (formally triCal) may be found at www.bgiusa.com/cal/index.htm

6.10 Resetting the Run

When a Run has been completed, and all the information from it either recorded or downloaded via the Communications Software, the "Reset" key can be pressed to clear all of the "Run-Time Variables". This action causes the "Elapsed Time" (ET) and the "Total Sample" (TS) to Clear (all zero's) and also causes the Start Time Alarm Clock to default to the next occurrence of Midnight (00:00) and the Run Time to 24 Hours. The Reset Function does not affect the Enables for the Start Time or Run Time. Also, all "Flow Calibrations" remain in memory.

NOTE: IF YOU SIMPLY WISH TO START A NEW RUN WITH NO CHANGES (DEFAULT START TIME, RUN TIME, AND CALIBRATION VALUES ARE ALL ACCEPTABLE) THEN THE ONLY ACTIONS NECESSARY AFTER RECORDING OR DOWNLOADING THE PREVIOUS RUN DATA IS TO PRESS THE "RESET" KEY (CLEARS ALL COUNTERS AND DEFAULTS THE RUN TIME AND START TIME) AND PRESS "RUN/STOP" FROM THE "MAIN IDLE DISPLAY". THIS WILL CAUSE THE PQ100 TO BEGIN A SAMPLING JOB IDENTICAL TO THE PREVIOUS JOB.

7.0 CALIBRATION

7.1 Entering and Using Calibration Mode

From the "MAIN IDLE DISPLAY" press the "Setup" key once until the message below appears;

Select FLOW RATE
Target Q...   xx.yLpm

(See Section 6.4 to select a new target Flow Rate.)

From the "Select FLOW RATE" message screen you must press both the "Reset" key and the "Run/Stop" key simultaneously to enter the calibration mode and the message below will appear;

CALIBRATE Target=qq.qLpm

where;

qq.q = Target Flow Rate to be Calibrated

CAUTION: BE CAREFUL WHEN USING CALIBRATION MODE. IT IS NOT USED TO CHECK CALIBRATION FLOW RATE. INCORRECT USE CAN ERASE A PREVIOUSLY STORED CALIBRATION. IF YOU SIMPLY WISH TO CHECK THE FLOW RATE ACCURACY FOR THE SELECTED TARGET, GO TO THE MAIN IDLE DISPLAY AND PRESS "RUN/STOP". BE CERTAIN THAT THE START DATE ENABLE IS SET TO "OFF" (SECTION 6.9).

This mode is used to Calibrate the PQ100 at a target flow rate. It should be noted here that each individual target has it's own independent calibration storage area and is non-volatile. That means that each and every flow rate from 1.0 LPM to 25.0 LPM can have its own discrete tolerances without approximation and will remain programmed in the instrument even in the event of total battery discharge. Pump speed values are also stored with the calibration data.

Assuming that a typical filter for a target was in place at the time of the calibration, the filter load is compensated for causing the pump to initialize to the proper speed. Once a target has been calibrated it should never have to be re-calibrated unless extreme conditions are expected.

To use this mode, Press the "Run/Stop" key to turn on the pump (pump will start to draw at somewhere in the range of the target flowrate depending on the resistance presented by the filter and calibrating device) and the following message will appear;

Reference Q.. rr.r

Where;

rr.r is an approximate flow rate used only as a visual aid in finding the corrected flow on the calibration device. This value may indicate 5 to 15% error. Don't be concerned! This is for reference only!

Use the "+/-" keys to move the pump speed up or down until the calibration device indicates the "Corrected Flow Rate" value as determined by the Calibration Equations given on the following pages.

HOLDING DOWN THE "RESET" KEY WHILE PRESSING THE "+" OR "-" KEY WILL ALLOW FOR COARSE ADJUSTMENT OF THE PUMP SPEED. WHEN THE PUMP SPEED WILL SEEM TO GO NO HIGHER OR LOWER, THE UPPER AND LOWER LIMITS HAVE BEEN REACHED.

When a good stable reading has been achieved, pressing the "Enter" key will store both the "Actual Sensed Flow Rate" and the pump speed data into the table of non- volatile calibrations where they will remain as "Constants" until a change is required (Only under "Extreme Ambient Conditions" as it should be impervious to moderate changes) and will then exit the Setup menu and return to the "MAIN IDLE DISPLAY".

CALIBRATIONS ARE NOT AFFECTED UNTIL THE ENTER KEY IS PRESSED AND THE PUMP IS RUNNING.

7.2 Using a DeltaCal or TetraCal (formally triCal)

The use of a DeltaCal or TetraCal (formally triCal) is highly recommended for calibration of the PQ100. Connect either unit to the PQ100 just before the filter holder and read the actual flow on the display. More information on the DeltaCal or TetraCal (formally triCal) may be found at www.bgiusa.com/cal/index.htm

7.3 Using a Rotameter

Calibrating the PQ100 Air Sampler with a Rotameter is to be avoided for two reasons. The PQ100 is more accurate (.5% of the expected flow rate) than the typical rotameter (within 3% of Full Scale). Secondly, the rotameter, unlike the bubble meter, has a reference condition calibration and requires a correction for ambient conditions.

The procedure for using a rotameter is best illustrated by example.

Example 4:
Referring to the conditions cited in example 1 (Appendix A), the required set point is 9.74 Lpm. If a rotameter is used, they are typically calibrated at 760 millimeters of Mercury and 70 degrees Fahrenheit (21.11 degrees Celsius or 294.29 degrees Kelvin). The room conditions in Example 1 were 19 degrees Celsius and 765 millimeters of Mercury. The equation for the rotameter correction is;

$$QI = QT \left(\frac{PT}{PI} \times \frac{TI}{TT} \right)^{1/2} \quad \text{Equation \#4}$$

$$QI = 9.74 \left(\frac{760}{765} \times \frac{292.18}{294.93} \right)^{1/2} = 9.66 \text{ Lpm}$$

where;

QT	is the Rotameter Calibration Condition flow rate in Liters per minute (Lpm)
QI	is the calibrator reading (Lpm) at a given Time, Temperature and Barometric Pressure
PT	is the Rotameter Calibration Condition Barometric Pressure (760) in millimeters of mercury (mm of Hg)
PI	is the Indicated Barometric Pressure reading (mm of Hg.) at the time of the calibrator flow reading
TT	is the Rotameter Calibration Condition Temperature (21.11) in degrees Celsius.
TI	is the Indicated Temperature reading (degrees Celsius) at the time of the calibrator flow reading.

However, a 3% accurate rotameter, suitable for reading 10 Lpm, usually reads 2 to 20 Lpm. That means 9.66 Lpm could actually vary from 9.06 to 10.26 Lpm! Therefore, if a rotameter must be used with the PQ100, the corrections are pointless and a straight 10 Lpm read from the rotameter should be utilized. The accuracy of the PQ100 is now degraded to 5%.

7.4 Calibration Notes

1. After a Calibration has been entered, it should be "Run" 15 minutes or so for verification. If the measured flow appears to be offset, determine the amount of offset and jot this number down. Next, Re-enter the Calibration mode and this time, set the calibration high or low depending on the observed offset.

2. If the "Run/Stop" key is pressed to stop the pump for any reason during calibration, the Target location becomes Un-Calibrated. If the "Setup" key is then pressed to exit, the location remains Un-Calibrated.

   THE ONLY WAY TO "ACCEPT" THE VALUE IS TO PRESS THE "ENTER" KEY WHILE THE PUMP IS RUNNING.

3. EACH TARGET FLOW RATE THAT IS TO BE USED SHOULD BE CALIBRATED WITH A FILTER WHOSE PRESSURE DROP IS SIMILAR TO THE TYPE ACTUALLY INTENDED FOR USE.

Failure to follow this procedure will result in an extended time period for the Flow Control System to Equilibrate (1-3 min.)

8.0 INSTALLATION AND USE OF THE PC SOFTWARE

8.1 Supported Hardware

Any IBM PC or compatible running MS-DOS 2.1 or higher with 1 floppy drive and at least 512K of memory. Any video adapter, Color or Monochrome, may be used. A hard drive is useful but not required. One serial communication port must also be available if you intend to use the communication software but is not required for the correction calculator program. For printouts, any printer attached to or redirected from LPT1 will work. All data sent to print are ASCII characters with no special printer functions called out.

8.2 Installation on a Hard Disk System

To install the software onto your C drive (typical installation), insert the supplied floppy disk into drive A of your PC, select drive A and run the "INSTALLC.bat" batch program. The installation utility will then create a subdirectory called "PQ" on the C drive and copy all files to it. Those wishing to install to another Drive such as D, E or F can use the "INSTALL.bat" batch program and specify the drive you want to install on as an argument, e.g., "INSTALL D:”.

8.3 Advanced Installation

For those users who wish to install to other directories from any other floppy drive, the only file supplied on the disk of real importance is "PQ.EXE". You may create any directory you wish and copy this file to it. All files managed by PQ.EXE are, by default, placed in the directory where PQ.EXE resides unless full path names are specified.

8.4 Floppy Based Systems (No Hard Drive)

The Executable program supplied "PQ.EXE" can be run directly from either floppy drive by simply invoking the program from the drive prompt.

```
A:\>PQ
```

8.5 Program Overview

PQ.exe is a menu driven program that utilizes the serial communication port of the PC to download sample data from the PQ Series of Air Sampling Systems and to provide Data logging, Concentration Equations, export to Database, and Chain of Custody applications. PQ allows the user to communicate with the PQ100 Air Sampler and downloads Run Data from the PQ100 to your PC. The data may then at a later time be appended with the measured final filter weight, printed and stored for later use.

The Correction Calculator is also available from the PQ Main Menu and allows the user to determine corrections for calibration and verification of flow rate.

8.6 Running the Program

From the MS-DOS prompt (typically "C:\PQ>") type;

```
PQ [ENTER]
```

if COM1 is to be used or,

```
PQ  -2 [ENTER]
```

if COM2.

where;
[ENTER] is the enter key on the PC Keyboard

The "PQ" Main Menu will then be displayed.

Note: "Ctrl-C" refers to the simultaneous depression of two keys at once on the computer console. To produce a "Ctrl-C", press and hold down the "Ctrl" key on the keyboard. While this key is held down press the "C" key. This action will most always halt the program and return you to the MS-DOS prompt.

8.7 Correct Utility

CORRECT is a utility that will perform the calculations outlined in the CALIBRATION EQUATIONS. From the PQ Main Menu press "c". The resulting screen will present a message that describes this utilities function. You must have the present local barometric pressure reading and the ambient temperature reading of the calibration area. To correct to Engineering Standards answer "y" to the first two questions presented by the utility (See Appendix A for other than Engineering Standard Conditions). Then enter the "Target Flow Rate" in liters per minute. The target flow rate is that which the PQ100 is set to operate at. Then enter your barometric pressure and temperature readings. The results from the correction equations will then be displayed. The Corrected Flow Rate value is that which must be observed on the calibration standard (Bubble Meter) for the given target flow rate. A Printout can then be obtained for reference.

8.8 Beginning a Sample Job

To initiate a run and manage the data generated by the PQ100, a file must be opened at the beginning of a job to store site and other background data along with "Initial Filter Weight". Initial weight is used when the job is complete to determine delta weight (final weight, minus initial weight) and when combined with sample time is used to compute concentration.

From the PQ Main Menu press "b" to Begin a Job File for a Run. The resulting screen requires that you adopt a Job File naming convention.

a. Default method	By pressing enter at the prompt, a unique name will be given to the file based on today's date and run number.
b. Custom method	Type in anything you wish.

Once a file name has been entered, a number of other fields are presented such as Site Name, Station Code, Job Code, Operator, Filter Number, and Initial Filter Weight. You may press enter for each field which will leave it blank. The job file editor provides the means to enter the data later if you wish, however, it is recommended that the fields be filled when beginning the job to avoid confusion and to maintain chain of custody.

8.9 Downloading

When a sample job has been completed, the data pertaining to the run is stored in the PQ100 until it is reset by the user. Prior to resetting the PQ100 for its next run, the data should be downloaded using the PQ software to provide information such as run time, total sample accumulated, cause of the shutdown etc. All of this data is important in determining the particulate concentration and conditions during the prior run.

From the PQ Main Menu press "I" to import data from the PQ100. The resulting screen will prompt you for a file to append the download to. This should be the file that was begun in the previous step to insure file integrity. If you do not remember the name of the file, go back to the MAIN MENU and select "d" to view a directory of current files. If you try to select a file that was already appended with a download, the system will let you know. When the proper file has been selected you are ready to download.

THE CQ2 COMMUNICATION CABLE SHOULD NOW BE ATTACHED TO THE PQ100 AND TO THE PC "COM1" or "COM2" PORT. THE PQ100 MUST BE POWERED ON AND AT THE MAIN IDLE DISPLAY FOR THE DOWNLOAD TO WORK!

8.10 Adding the Final Filter Weight

Upon completion of the sample job, the final filter weight must be determined and this final weight entered in order to compute concentration. From the PQ Main Menu press "a" to Add the final filter weight. Again you are asked for the appropriate file name and again you must be careful to select the proper file. When the file is selected the resulting screen will show the initial weight, final weight, delta weight (difference) and standard concentration. All except for initial weight should display zero. When a final weight is entered, concentration is dynamically computed and displayed. This is to allow for re-entry of the final weight in case concentration computes unbelievable results indicating an error during entry. When the results are as expected press "n" for no new filter weight and the program will exit normally.

8.11 Data Displays

Showing the data on the screen is accomplished by pressing "s" at the MAIN MENU. You can alternately obtain a printout if a printer is attached to your computer. Simply press 'Y' when prompted with "Would you like a printout (y) or (n)?". If a printer is not attached pressing 'Y' will result in the DOS message;

> "Write fault error writing device PRN" "Abort, Retry, Ignore, Fail?"

You must then press 'a' to abort and you will be sent back to the DOS prompt.

8.12 Managing Data Files

Job files can be easily erased when no longer required using the "e"rase function or can be "r"enamed to allow reuse of a particular Job File name while retaining the old data if required. All Job files from the PQ software have the extension ".run" and can be copied to floppy disk using standard MS-DOS functions for archive purposes.

8.13 Spreadsheet Support

Job Files can be exported to a coma delimited file called database.txt. This format is readable by most database programs allowing reports and graphs to be generated for presentation. This function is provided as a tool for users of database programs that are experienced enough with their database program to import from this type of file format.

From the PQ Main Menu press "x" to export the run data to a file. You will be prompted to enter a file name. After entering the file name you will be asked if this is a new database you are generating or appending an old one. If this is a new report that you are generating based on a particular site etc. select "n"ew. If you want to add records to build a database, press "a"ppend.

This is used to combine a number of run files into a multi record database with each job file as a record. For a more detailed description of the use of this type of file refer to the users manual of your database program. If you do not already have a database program, Borland Paradox is recommended as it is the most user friendly and simplest to use.

9.0 A.C. POWER SUPPLY/CHARGER

The PQ100 should be Recharged before use to allow for the greatest available Run Time. Connect the Charger to the PQ100 Utility Adapter socket located on the front panel. Plug the Charger into an appropriate power source. BE SURE TO CHECK CHARGER SPECIFICATIONS FOR CORRECT POWER SOURCE INPUT.

Charging is activated only when AC power is actually applied to the charger. This allows the system to be used in a long run time application where the battery is to be used for power loss protection. While the Charger is engaged the PQ100 will display [DCin] in the lower right corner of the display.

When the battery has reached full charge (16 hours typically), the PQ100 will then display "Charged" in the lower right display.

THE PQ100 SHOULD ALWAYS BE CONNECTED TO THE CHARGER WHEN NOT IN USE! THIS WILL PROVIDE MAXIMUM RUN TIME WHENEVER NEEDED AND WILL NOT HARM THE INTERNAL BATTERY.

10.0 MAINTENANCE AND SERVICE

10.1 Replacement Component List

The following is a list of components for replacement and/or servicing the PQ100 and may be ordered from the factory (Refer to drawing figures 1 thru 7 for identification by Item#);

Item#	Fig.	PN	Description
-------	----	-----	---------------------------------
1	5	SSI-10	Dicot Inlet
3	5	CT16.7	Coupler Tube - Old Model
4	5,4,8	A1752	Filter Holder Top
5	4,8	BUNA135	O-Rings
6	4,8	A1727-L27	Cassette Top - New Model
7	4,8	F1/U	Screen
8	4,8	A1729-L29	Cassette Bottom - New Model
9	5,4,8	B1425	Filter Holder Bottom
10	5	A1446	Holder Hose Adapter - Old Model
11	5,6	TP100	Tripod Assembly
11a	5,6	B1453	Leg Extensions - Old Model
69	5	P1001	Pull Pin
12	5	HS4	1 Meter of Rubber Hose - Old Model
13	5,6	CRPQ1	Cradle Assembly - Old Model
14	5,6,8	PQ100	Main Unit
15	8	B1475	TSP Inlet
16	8	A1474	TSP Cover
17	8	SC0100	#10-32x3/8" Flat Head Screw
18	1	PQ103	Main Battery
19a	1	SC0101	#6-32x1/4" Screw w/ washer
19b	1	WS0100	#6x.372 Flat Washer
20	1	B1412	Pulsation Dampner/Plenum
21	1	HS3	Hose
22	1	PM3026	Pump Assembly
23	1	B1413	Chassis
24	3	SC0107	#4-40 x 1/4" Phillips Pan Head Screws
25a	1	SC0103	#4-40x1 ½" Pan Head Screws
25b	1	WS0101	#4x.372 Flat Washer
26	1	HS2	Hose
27	1	A1416	Sensor tube adapters

Item#	Fig.	PN	Description
28	1	Buna 113	O Rings
29	1	CB1	Clock Battery
30	1	MFS1	Mass Flow Sensor
31	1	HS1	Hose
32	1	PQFP	Front Panel Assembly
33	1	SC0104	#6-32 x 3/8" Flat Head Screws
71	1	BP001	Rubber Bumper
72	1	BATT.PCA	P.C. Ass'y, Battery
34	5	PQ102	Hose Adapter
35	2	B1292	Valve Upper Plate
36	2	B1293	Valve Lower Plate
37	2	A1288	Diaphragm Retainer
38	2	A1281	Diaphragm
39	2	A1289	Diaphragm Retainer Bushing
40	2	B1283	Pump Housing
41	2	A1287	Follower Yoke
42	2	DDRI-6632	Bearing \ as assembly only
43	2	A1294	Eccentric /
44	2	SC0105	Set Screw
45	2	SC0106	#2.5x8mm CheeseHead Screw
46	2	A1290	Motor Mount
47	2	PQMOTOR	Motor
48	2	BUNA010	O-Rings
49	2	A1402	Locating Pins
50	2	B1408	Valves
51	3	SC4014	#4-40x1/2" Phillips Pan Head
52	3	Nt3006	#4-40 Hex Nut w/ Captive Washer
53	3	SC2001	#4-40x3/8" Screw w/ Washer
54a	3	SC3014	#8-32 Phillips Pan Head
54b	3	LW4001	#8 Internal Tooth Lock Washer
55	3	SC3028	#10-32x1/2" Slotted
56	3	NT3027	7/16" Panel Nut
57	3	ICA001	Utility Connector/Cable Assembly
58	3	DSP001	Display Assembly
59	3	PQ100PC	P.C. Assembly
60	3	B1417	Front Panel
61	3	B1409	Graphic Faceplate
62	3	H9111B	Handle
63	3	A1419,A1420	Exhaust Port
64	3	A1418	Inlet Receptacle
65	3	CCC001	Cap and Chain

Item#	Fig.	PN	Description
-------	----	-----	--------------------------------
66	3	A1483	Connector Gasket
67	3,5	BUNA116	O-Ring
86	2	SC1014	#8x1" Sheet Metal Screws
87	2	A1403	Inlet/Outlet Tube
88	2	SC1013	#8x1/2" Sheet Metal Screws
146	7	SC3030	#6-32 x 3/8" Philips pan head screw
147	7	1705-L5	10 micron inlet top
148	7	1709-L9	Spacer
149	7	1709-L8	Screen
150	7	1711-L11	10 micron inlet sub top
151	7	1712-L12	10 micron inlet body
152	7	Viton-036	O-ring
153	7	DI1013	10 micron inlet tube
154	7	SC3031	1/4 x 3/8 NPT adapter (Old Style)
155	7	SC3032	1/4 NPT nipple (Old Style)
156	7	JC3033	Jar top
157	7	SC3034	1/4 NPT plug (Old Style)
158	7	JR3035	Glass jar
159	7	Buna-026	O-ring
--	-	ICA002	Internal Battery Cable Assembly
--	-	ICA003	Flow Sensor Cable Assembly
164	7	SC3036	1/4" NPT Hex Nipple

10.2 Rebuilding the Pump after 5000 Hours

To determine "Pump Cumulative Time" you must use the PQ software to obtain a download from the PQ100 (See Section 8.9). Pump Cumulative time is the number of actual service hours of the dual diaphragm pump and is shown when either printing or screen viewing a download. When this time exceeds 5000 hours the pump should be rebuilt. The rebuild is a relatively easy task and requires the replacement of the diaphragms, valves, and bearing. A kit of parts is available from the factory and includes instructions. Service can also be performed by the factory.

Kit #	Description
X014	Pump Rebuild Kit (Includes valves, diaphragms and “o” rings)
X015	Advanced Pump Rebuild Kit (Includes X014 with bearing)
X016	Total Pump Rebuild Kit (Includes X014 with bearing and motor)
X017	Pump Diaphragms Only

10.3 Replacement of the Mass Flow Sensor

As each mass flow sensor is unique and will present variations in operation, all stored calibrations are obsolete when the sensor is replaced. Each flow sensor replacement kit contains an 8 pin DIP Integrated Circuit (I.C.) that must be replaced (socketed) on the main printed circuit board. This will clear all calibrations and will require that a new set of calibrations must be entered for the new sensor.

11.0 OPERATIONAL THEORY

When first powered on, the micro controller runs through some initialization and diagnostic routines. When completed, data stored as "Run-Time information" is then read from the non-volatile (EEPROM) memory device. Amongst this data is a single byte flag called the "shutdown code". If this code indicates that the system was shutdown normally (i.e. power-off button was pressed) it will proceed to the "IDLE MODE" display screen which contains all the pertinent run-time information such as Elapsed Time, Total Sample, Battery condition, last known Flow Rate when halted etc. If the shutdown code indicates that some other event has caused the system to power down such as Flow Restricted, Excess Flow Resistance, Batteries Too Low, Sample run time Completed, an appropriate message will be displayed to the operator indicating the cause of the stoppage and requires operator intervention to proceed to the "IDLE MODE" display. From the "IDLE MODE" display the active keys are "Reset" (all run parameters to their default conditions), "Run/Stop"- runs the pump at the last selected flow rate and continues the previously setup run (if a start time was programmed then the pump will not begin to run until the start time has been achieved), and "Setup" allows for programming the user definable run parameters such as target Flow Rate, Start time, Run time, Date & Time, and also provides a calibration mode. If Run/Stop is pressed at this time the pump will begin to run and attempt to match the target, pre-programmed Flow Rate.

12.0 WARRANTY INFORMATION

BGI Incorporated warrants equipment of its manufacture and bearing its nameplate to be free from defects in workmanship and material. We make no warranty, express or implied, except as set forth herein. BGI's liability under this warranty extends for a period of one (1) year from the date of BGI's shipment. It is expressly limited to repairing or replacing at the factory during this period and at BGI's option, any device or part which shall within one year of delivery to the original purchaser, be returned to the factory, transportation prepaid and which on examination shall in fact be proved defective.

BGI assumes no liability for consequential damages of any kind. The purchaser, by acceptance of this equipment, shall assume all liability for consequences of its misuse by the purchaser, his employees or others. This warranty will be void if the equipment is not handled, installed, or operated in accordance with our instructions. If damage occurs during transportation to the purchaser, BGI must be notified immediately upon arrival of the equipment. Return transportation charges are collect.

A defective part in the meaning of this warranty shall not, when such part is capable of being repaired or replaced, constitute a reason for considering the complete equipment defective. Acknowledgment and approval must be received from BGI prior to returning parts or equipment for credit. BGI Incorporated makes engineering changes and improvements from time to time on instruments of its manufacture. We are under no obligation to retrofit these improvements and/or changes into instruments which have already been purchased.

No representative of ours has the authority to change or modify this warranty in any respect.

APPENDIX A. CALIBRATION EQUATIONS

Because the PQ100 uses a "Through Stream" mass flow sensor, the mass flow is not affected by pressure and temperature. However, the velocity (flow rate) through a fixed area nozzle will vary with atmospheric conditions. When work is carried out in an area with conditions other than Engineering Standard Conditions the "Corrected Flow Rate" is that which is measured on the calibration device for these new conditions.

The following equations are used to determine the "Corrected Flow Rate" that should be set on the PQ100 for atmospheric conditions other than "Engineering Standard Conditions" of 20 degrees Celsius (293.18 degrees Kelvin) and 760 millimeters of Mercury. They are provided for users who do not have access to an IBM PC or Compatible and can not use the "CORRECT" utility provided on the floppy disk.

These equations and recommendations have been prepared for Investigators with an advanced understanding of atmospheric sampling procedures. It is not our intention to justify every equation and procedure set down below to the uninitiated. For this reason, the "Correct" program supplied with the instrument is highly recommended.

To set up a calibration on the PQ100 to "Engineering Standard Conditions" the following applies;

$$QI = QS \left(\frac{PS}{PI} \times \frac{TI}{TS} \right) \text{ Equation \#1}$$

where;

QS	is the Standard Condition (PQ100 Target) flow rate in Liters per minute (Lpm)
QI	is the calibrator reading (Lpm) at a given Time, Temperature and Barometric Pressure
PS	is the Standard Condition Barometric Pressure (760) in millimeters of mercury (mm of Hg) (Equal to 1013.25 HectoPascals)
PI	is the Indicated Barometric Pressure reading (mm of Hg.) at the time of the calibrator flow reading
TS	is the Standard Condition Temperature (20) in degrees Celsius
TI	is the Indicated Temperature reading (degrees Celsius) at the time of the calibrator flow reading

Therefore, for Standard Conditions;

$$QI = QS\left(\frac{760}{PI} \times \frac{TI}{293.18}\right)$$

$$QI = 2.592 \quad QS \left(\frac{TI}{PI}\right) \text{ Equation \#2}$$

Example 1:
The instrument is being set up to run at 10 Lpm at Standard Conditions with a flow meter. The ambient conditions in the set up location are 19 degrees Celsius (292.18 degrees Kelvin) and 765 millimeters of Mercury.

Then;

$$QI = 2.592 \quad 10.0 \left(\frac{292.18}{765}\right) = 9.899 \text{ Liters per minute}$$

Therefore, if you set a Target Flow of 10.0 Lpm on the PQ100 and 9.90 Lpm on the flow meter, you will always be sampling at 10.0 Lpm to Standard Conditions regardless of changes in the weather (i.e. regardless of changes in air density). At a later date when you wish to check the calibration, Equation #2 still applies as in Example 2.

Example 2:
The instrument was set as detailed in Example 1. You are now out of doors at a sampling site. The conditions are TI = 27 degrees Celsius (300.18 degrees Kelvin) and PI = 750 millimeters of Mercury.

From Equation #2;

$$QI = 2.549 \quad 10.0 \left(\frac{300.18}{750}\right) = 10.37 \text{ Liters per minute}$$

Therefore, if the PQ100 reads 10.00 Lpm and the bubble meter reads 10.37 Lpm the PQ100 is still in calibration and is sampling 10.0 Lpm at Standard Conditions.

On July 18, 1997, U.S. EPA changed the regulations for the operation of mass flow controlled instruments (e.g., the PQ100). Previously, EPA specified a set of "EPA Standard Conditions", which were 25 degrees C and 760 mm of Hg.

Now, mass flow controlled instruments are to be run in "volumetric mode". The details of EPA's recommended calibration procedure may be found in general form 40 CFR Part 50, Appendix M, 8.2.4 July 18, 1997. When applying these instructions to the PQ100, the following steps are suggested:

1. Place a clean filter of the type to be used for the sampling in the PQ100 filter holder.

2. Remove the PM10 inlet and connect a bubble meter to the filter holder. BGI adaptor (P/N L-30) is convenient for this purpose.

3. Enter the calibration mode and adjust the flow up or down until the flow meter reads 16.67 LPM and lock the flow rate.

4. Record the barometric pressure and temperature at the time of calibration.

5. This procedure provides volumetric flow rate control as long as there are no shifts in temperature. EPA recommends the use of seasonal average values. In the case of the PQ100, this requires calibration for each season of intended use. Since it is not practical to be out of doors to perform the calibration, a facility has been provided in the calculation section of our software supplied with the PQ100.

6. In software, selection the correction calculator. Then select (C) "EPA volumetric or user defined conditions".

   For T insert average seasonal local temperature
   For P insert average seasonal local barometric pressure
   For sample target flow rate enter 16.67 lpm
   Enter Pstd at calibration location (local)
   Enter Tstd at calibration location (local)

   The program will return the flow rate which is to be observed on the flow meter in order to be running in the field at 16.67 lpm.

EPA regulations require that you calibrate at 3 flow rates. The other two flow rates selected are generally in the range of 15 lpm and 18.4 lpm (± 10%). This procedure serves no particular purpose with the PQ100 which is microprocessor controlled. However, it is a statutory requirement and must be performed for concentration measurements to be compliant. An example of the calibration procedure is illustrative:

Tstd = 10°C, outdoor location, seasonal average

Pstd = 720 mm of Hg
Target flow rate = 16.67 lpm (desired volumetric flow at above conditions)
Tlab = 22°C (conditions in calibration location)
Plab = 760 mm of Hg

Corrected flow rate = 16.95 lpm (flow in calibration location)

In the event that a computer is unavailable, the above example may be calculated manually:

$$\text{Corrected Q} = \text{Qtarget} \left(\frac{\text{Plab}}{\text{Pstd}} \times \frac{\text{Tstd}}{\text{Tlab}} \right)$$

APPENDIX B. TROUBLESHOOTING

Problem: Pressing the "Run/Stop" key causes the unit to shutdown.

Answer: This indicates that the PQ100 is now powered off and ready to begin a sample run at the designated Start Date and Time. It means that the enable for the Start Date and Time is set to "On" (See Section 6.1). Be sure that the Start Date and Time are set correctly.

Problem: The Actual Flow Rate is not what is indicated in the Display.

Answer: Variations in Atmospheric Conditions (B.P. and Temp.) will cause slight variations in flow as displayed on the Calibration Device however the PQ100 will be displaying "True Flow Rate". If large variations exist, or if the variation is different from that of the calculated "Corrected Flow Rate" as described in the Calibration Equations Section of this manual then, the unit requires service.

Problem: I hear a popping metal sound as the PQ100 load pressure increases.

Answer: When running the PQ100 at very high load pressures (i.e. 150 centimeters of water or better), a strange metal popping sound may be heard by the user. Do not be concerned! This is merely the internal pulsation dampner (Plenum) adjusting its chamber area. The PQ100 will alert you as to the nature of any problems via the shutdown messages as described in APPENDIX E.

Problem: The flow rate does not seem to hold when additional pressure is added to the load (usually tested using a pinch clamp).

Answer: This is usually caused by a leak somewhere between the PQ100 Inlet and the calibration measuring device. Make sure that the hose adapter is firmly tightened in the PQ100 inlet, check the inlet mechanism and filter holder. You can usually isolate the suspect device by starting at the PQ100 inlet and working your way out.

APPENDIX C. SYSTEM BATTERIES

MAIN INTERNAL BATTERY
If the Internal Battery should ever require replacement, use ONLY the proper BGI Battery (PQ103).

EXTERNAL BATTERY
The External Battery is used to provide double the Run Time Capacity of the PQ100.

CAUTION: REVERSAL OF THE BATTERY LEADS CAN CAUSE IRREPARABLE DAMAGE TO THE PQ100.

CLOCK BATTERY
The Real Time Clock/Calender is backed-up by a Lithium Cell that will require changing once every 2 years. It also provides power to the Alarm Clock wake-up circuit. The PQ100 will let you know when this battery requires changing by providing a warning just prior to shutdown or when powered on and must be acknowledged by the user. You can temporarily ignore the warnings but a replacement should be acquired from the factory immediately. If the battery is allowed to get too low (ignoring the warnings) you may not be able to power off the PQ100 (It will keep waking up after a shutdown).

IF "REPLACE CLOCK BATTERY" MESSAGE IS ENCOUNTERED YOU MUST REPLACE THE CLOCK BATTERY IMMEDIATELY FOR CONTINUED OPERATION. IGNORING THIS MESSAGE MAY PRODUCE ERRATIC OPERATION.

APPENDIX D. MILITARY TIME CHART

The following chart is supplied for users who are unfamiliar with a 24 hour Military type time system.

00:00	12:00 Midnight
01:00	1:00 AM
02:00	2:00 AM
03:00	3:00 AM
04:00	4:00 AM
05:00	5:00 AM
06:00	6:00 AM
07:00	7:00 AM
08:00	8:00 AM
09:00	9:00 AM
10:00	10:00 AM
11:00	11:00 AM
12:00	12:00 Noon
13:00	1:00 PM
14:00	2:00 PM
15:00	3:00 PM
16:00	4:00 PM
17:00	5:00 PM
18:00	6:00 PM
19:00	7:00 PM
20:00	8:00 PM
21:00	9:00 PM
22:00	10:00 PM
23:00	11:00 PM

APPENDIX E. SHUTDOWN MESSAGES

The following is a description of the various messages that can be displayed by the PQ100 or the PQ Software to indicate the reason for sample job termination or current status of the PQ100;

00 Download not yet Appended! PQ Software

* Indicates that a previously created job file has yet to receive a download from a PQ100 Sampler.

01 LOW BATTERY SHUTDOWN! PQ100
Low Batteries! PQ Software

* Indicates that the sample job was terminated when the battery power had been depleted and should now be recharged.

02 SAMPLE RUN COMPLETED! PQ100
Run Completed! PQ Software

* Indicates that the sample job was terminated when the RUN TIME had been depleted (See Section 6.7 or Section 6.8.3).

03,04 FLOW RESTRICTED! PQ100
Flow Restricted! PQ Software

* Indicates that the sample job was terminated due to a flow rate transient of 50% of the target flow rate and is usually caused by a kinked or broken hose, filter load removal etc.

During the initial time that the PQ100 requires to stabilize its flow rate, flow will be displayed as --.-Lpm. During this stabilization period, flow rate is allowed to vary more than 50% for a maximum of one minute. After one minute the flow is considered restricted causing the above shutdown. Once the flow rate has stabilized, the flow rate will appear and response to transients greater than 50% is instantaneous.

05 Counters Reset, Awaiting new Run! PQ Software

* Indicates that the PQ100 has been "Reset" and is now ready for a new sample job.

06 Powered Off Normally! PQ Software

* Indicates that the PQ100 had last been powered off by pressing the "ON/OFF" button. If you simply allow the PQ100 to power itself off (automatic after approximately 3 minutes of no user activity such as key presses or downloads) then the last Shutdown code is retained.

07 Waiting for Alarm Event! PQ Software

* Indicates that the PQ100 has been programmed to start a sampling job at some future time and is waiting for this occurrence.

08 MAXIMUM LOAD EXCEEDED! PQ100
Maximum Load Exceeded! PQ Software

* Indicates that the sample job was terminated because the PQ100 could not force the pump to run any faster to regulate flow rate. This can happen when a large load pressure is developed and the battery voltage drops. To eliminate this problem you can run from the charger, recharge the batteries or try a different filter media.

09 Run Terminated by Operator! PQ Software

* Indicates that the sample job was terminated when an operator has pressed the "RUN/STOP" button while a sample job was in progress.

10 RUN TIME EXCEEDED! PQ100

* Indicates that the PQ100 can not initiate a run as the RUN TIME (See Section 6.7) has not been reset.

11 REPLACE CLOCK BATTERY! PQ100

* Indicates that the internal clock battery now requires replacement (See Appendix C).

APPENDIX F. ASSEMBLING THE PQ167 PM10 AIR SAMPLING SYSTEM

Included with your PQ167 PM10 Air Sampler System are the following items (Item#'s are indicated on the appended drawings);

Item#	Qty..	PN	Description
14	1	PQ100	Air Sampler Main Unit
*	1	PQ101	Battery Charger (specify 120 VAC or 240 VAC)
34	1	PQ102	Hose Adapter
*	1	CQ2	PC Communication Adapter Cable
*	1	PQMAN	Manual
12	1	HS4	1 Meter of Rubber Hose
11	1	TP100	Tripod Frame
*	3	B1453	Leg Extensions
13	1	CRPQ1	PQ Series Sampler Cradle
01	1	SSI-10	Inlet
2,3	1	JR3035	Water Jar w/ 2.5" Coupler
4,5,9,10	1	F20	Filter Holder (Requires F21/2 Cassette)
6,7,8	2	F21/2	47mm Filter Adapter Cassette w/Screen
*	1	QD3	3.5" PQ Software Diskette

FOR COMPLETE SYSTEM ASSEMBLY PLEASE REFER TO FIGURES 4, 5 AND 6.

APPENDIX G. ASSEMBLING THE BGITSP AIR SAMPLING SYSTEM

Included with your PQTSP Air Sampler System are the following items (Item#'s are indicated on the appended drawings);

Item#	Qty.	PN	Description
14	1	PQ100	Air Sampler Main Unit
*	1	PQ101	Battery Charger (specify 120 VAC or 240 VAC)
34	1	PQ102	Hose Adapter
*	1	CQ2	PC Communication Adapter Cable
*	1	PQMAN	Manual
4,5,9,10	1	F20	Filter Holder (Requires F21 Cassette)
6,7,8	2	F21/2	47mm Filter Adapter Cassette w/Screen
15,16,17	1	TSP	TSP Inlet Adapter Cap
*	1	QD3	3.5" PQ Software Diskette

FOR COMPLETE SYSTEM ASSEMBLY PLEASE REFER TO FIGURES 4, AND 8.

APPENDIX H. INSTALLING FILTER MEDIA

Referring to Figure 4, the filter media is placed on screen (7) and placed on the inner lip of cassette base (8). Cassette top (6) is then inserted into cassette base when pin of base is aligned with locating hole on cassette top. Holder base (9) and holder top (4) are supplied with O-Rings (5) already installed. Loaded cassette is then inserted into base (9) with the screen side down and holder top (4) is then screwed into base (9) firmly as to insure against leaks.

APPENDIX I. CONCENTRATION EQUATION

For reference, the following is the formula for Concentration used by the PQ Software;

$$\frac{\text{CONTAMINANT WEIGHT (mg) x 1000}}{\text{TOTAL SAMPLE VOLUME } (m^3)} = \text{CONCENTRATION } \left(\frac{\text{micrograms}}{m^3}\right)$$

Where;

(CONTAMINANT WEIGHT)	is the difference between initial filter weight and final filter weight
(TOTAL SAMPLE VOLUME)	is the Volume of air passed through the filter in cubic meters
(CONCENTRATION)	is the quantity of particulate matter in micrograms per cubic meter

APPENDIX J. FLOW RATE STABILITY

EPA Regulations 40 CFR part 53.43 (July 1987) require measurement of flow rate stability during the testing of an instrument for reference or equivalency. This test is permanently incorporated into the PQ100 firmware. The flow rate through the instrument is measured and stored automatically while the run is in progress. The initial flow rate is measured one minute after the instrument has stabilized the flow rate (The flow rate is stable when the PQ100 visual display shows the actual flow rate instead of "Q--.-"). The flow rate is then sampled once every hour thereafter until the completion of the run with a maximum capability of 30 readings after the initial.

NOTE: THE RUN MUST BE CONTINUOUS IN ORDER FOR THE READINGS TO BE TRUE. IN OTHER WORDS, IF A RUN IS HALTED FOR ANY REASON THE PQ100 MUST BE RESET TO INSURE THAT THE READINGS ARE STORED IN THE PROPER SEQUENCE.

The Flow Rate Stability Report is generated after a run is completed and the data has been downloaded as previously described by the PQ Software. The report is shown as a second page after a run has been "Screened". The option of obtaining a printout is given for each screen after viewing the data.

The following is a description of the equations used to calculate flow rate stability as shown in the report;

$$\bar{F} = \frac{F(1) + F(2) + F(3) + \ldots F(n)}{n}$$

where;

$\bar{F}$ = Average Flow Rate in Liters per Minute
n = Total number of readings taken
F(1) = Initial Flow Rate reading 1 minute after flow has stabilized
F(2) = Flow Rate 1 Hour after Initial Flow Rate reading
F(n) = Flow Rate (n-1) Hours after Initial reading

The first EPA indicator of flow rate stability is the percent of difference between average flow rate and initial flow rate.

$$= \frac{\bar{F} - F(1)}{F(1)} \times 100$$

where;

% difference between average and initial flow rate.
This may be a plus or minus value and may not exceed 5% (EPA).

The second EPA indicator of flow rate stability is the percent of difference between each hourly flow rate reading and the initial flow rate.

$$(t) = \frac{F(t) - F(1)}{F(1)}$$

where;

F(t) = hourly flow rate readings F(2), F(3), F(4) etc.
(t) = % difference between individual hourly readings and initial flow rate.
This may be a plus or minus value and no value may exceed 10%.

In reality all displayed values should be expected to be typically less than 1% and should not exceed 2%. Values more than 2% should be investigated. A blocked or restricted inlet, hose, etc. at precisely the time the PQ100 takes a reading internally should be suspected.

APPENDIX K. FIGURES

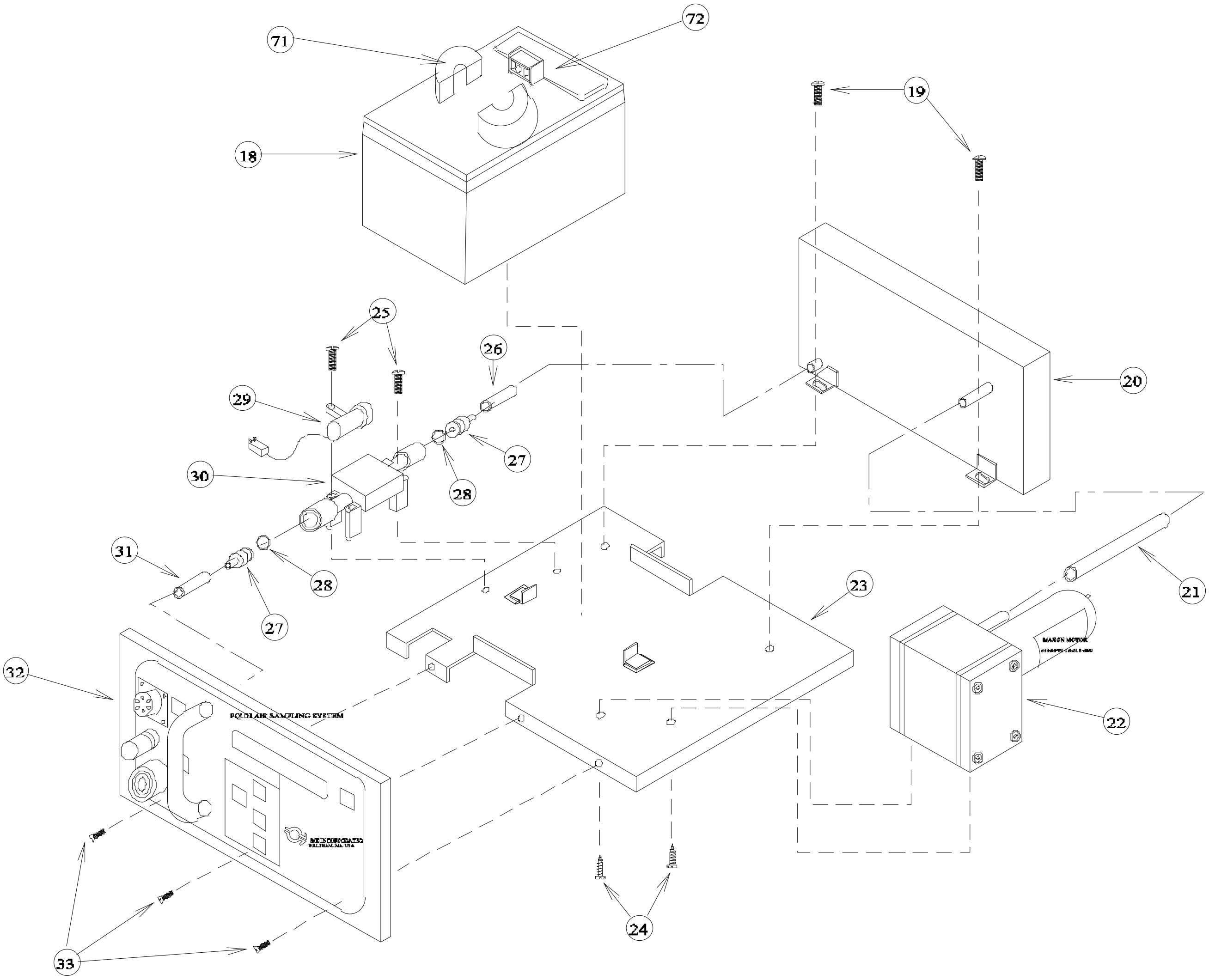


Figure 1. Exploded Assembly View

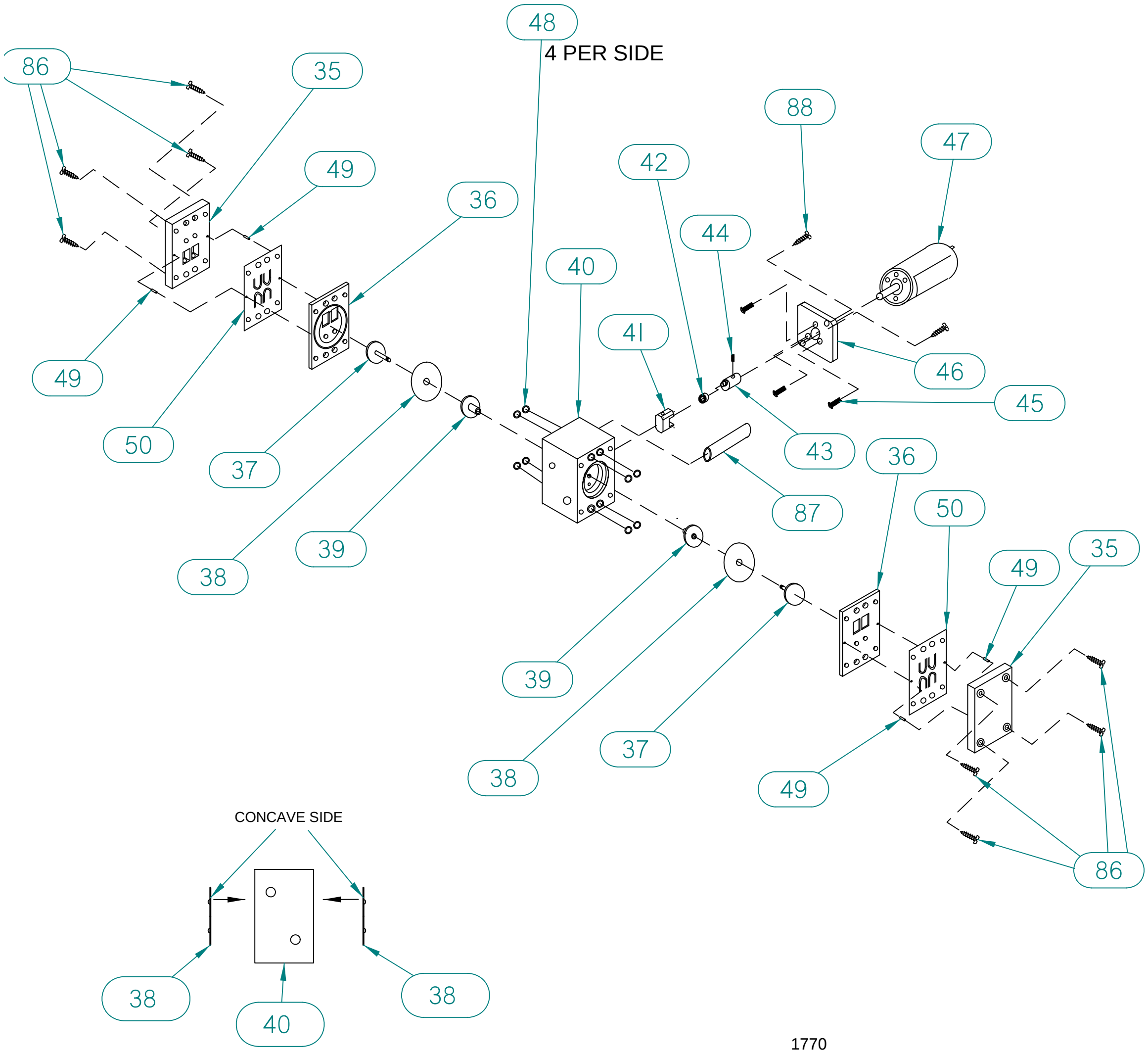


Figure 2. Exploded View of Pump

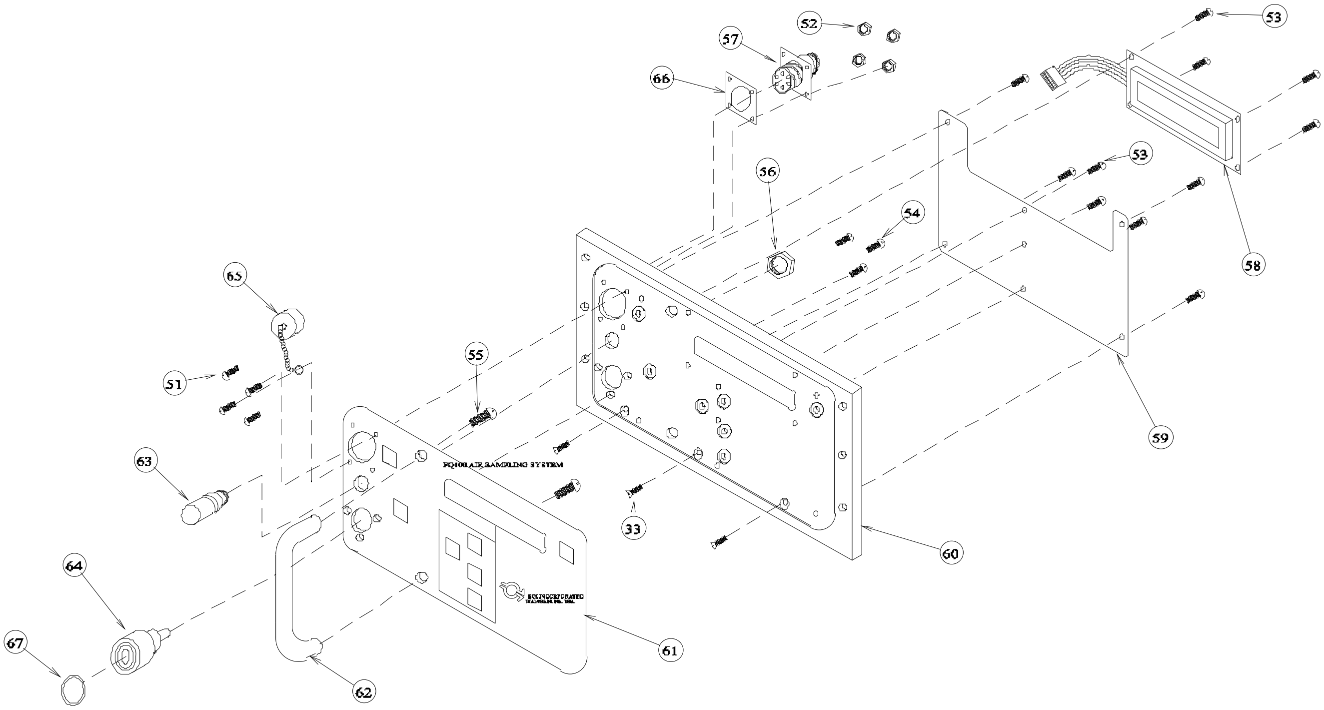


Figure 3. exploded View of Front of PQ100

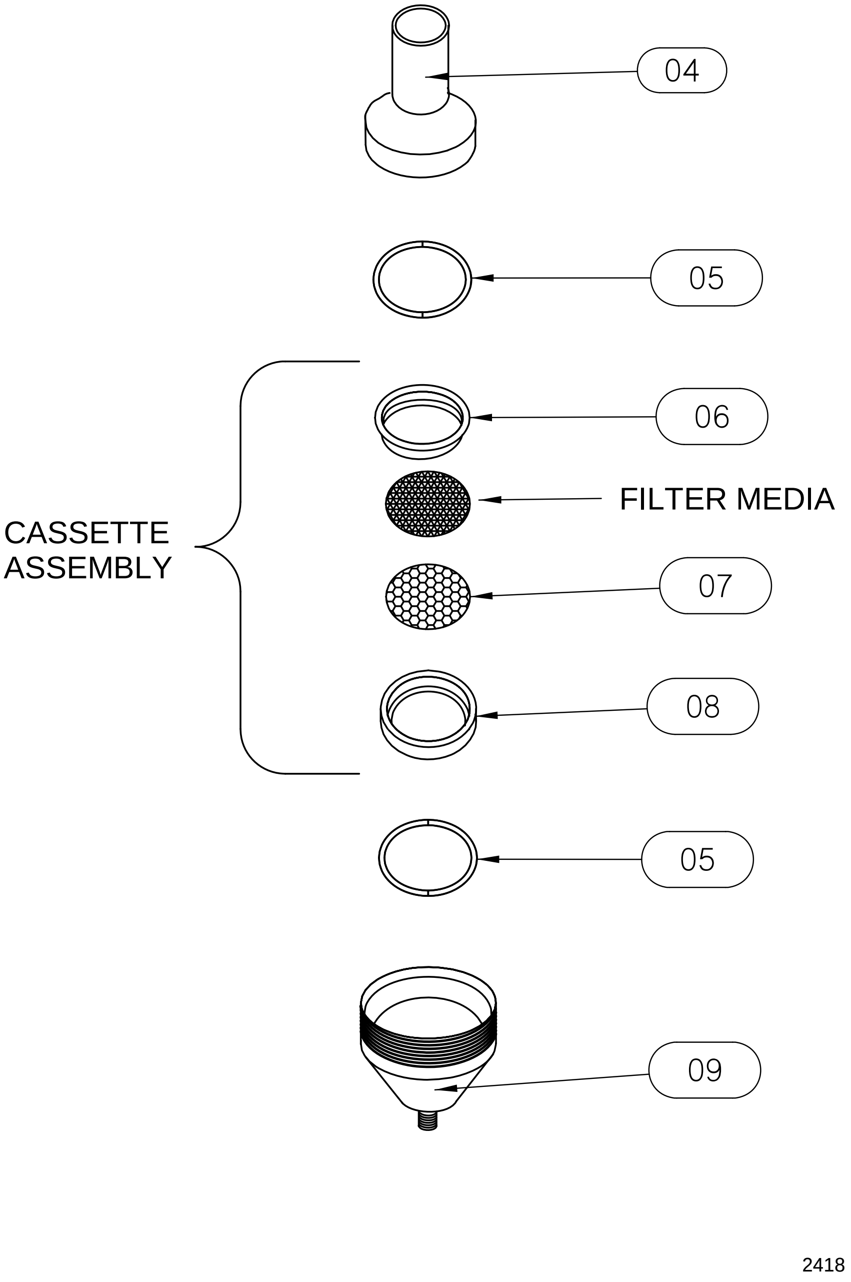


Figure 4. Exploded View of Filter Cassette and Filter Holder

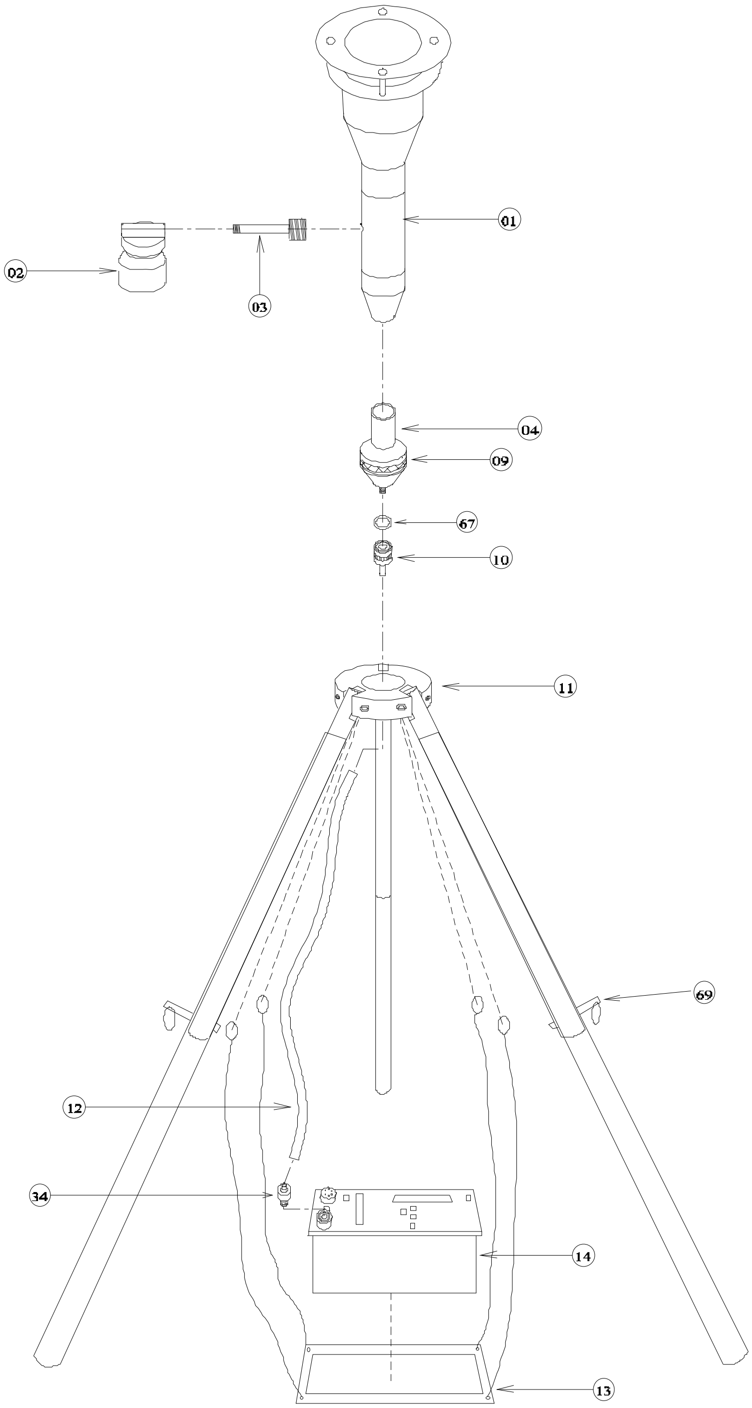


Figure 5. Exploded Assembly with Inlet and tripod

(January 2000: OBSOLETE> Parts subject to stock on hand. See Appendix O)

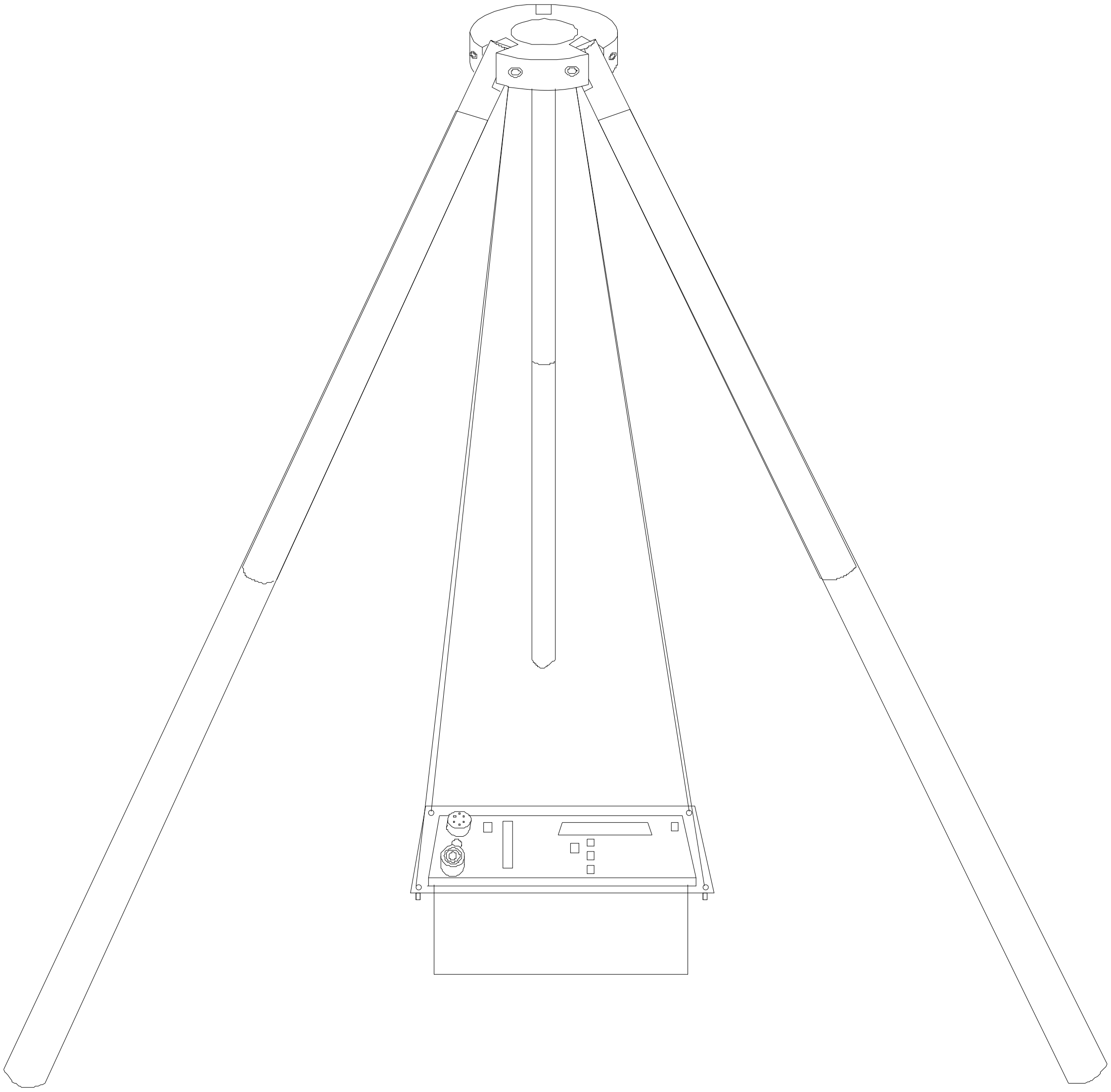


Figure 6. assembled PQ100 Tripod.

(January 2000: OBSOLETE> Parts subject to stock on hand. See Appendix O)

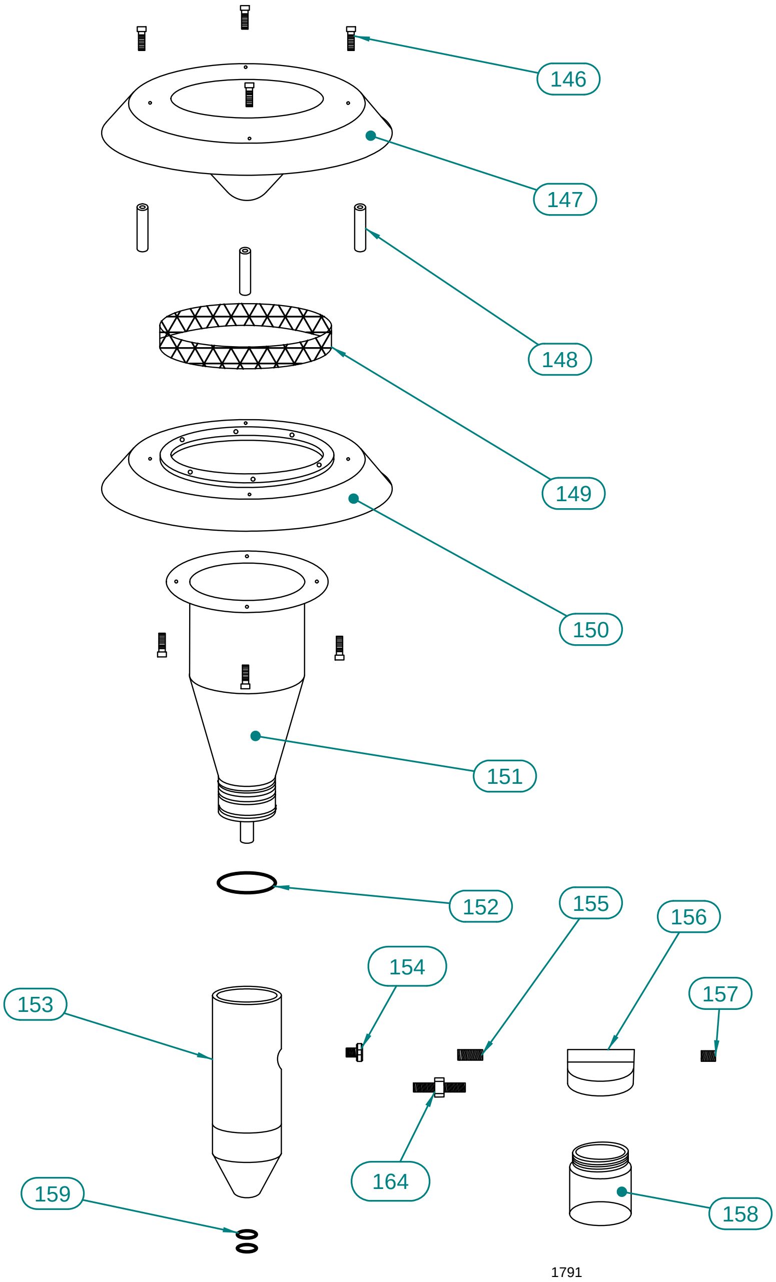


Figure 7. Exploded View of PM10 Inlet

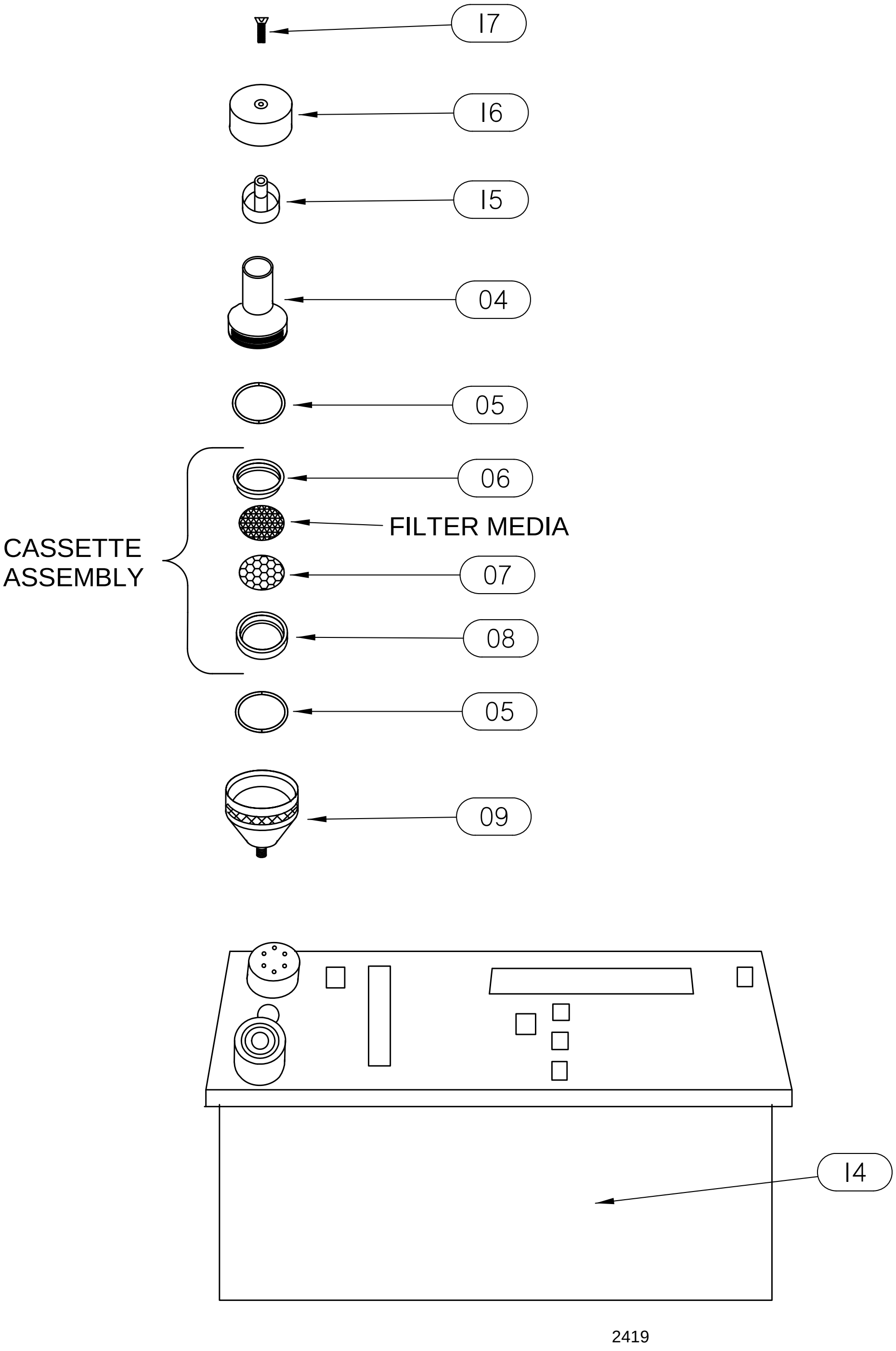


Figure 8. PQ100 Front with Filter Assembly

APPENDIX L. FILTER HANDLING AND WEIGHING

Note: The following guidelines are based on the regulations developed for sampling PM2.5. It is recommended that these guidelines be followed for PM_{10} sampling using the PQ100.

Filter Specifications

For exact compliance with EPA procedures for PM2.5, refer to 40 CFR Part 50, Appendix L, and Section 2.12 of EPA's Quality Assurance Handbook.

In brief, the filter should have the following characteristics:

Size: Circular, 46.2 mm diameter ± 0.25 mm. Medium. Polytetrafluoroethylene (PTFE Teflon), with integral support ring.

Support ring: Polymethylpentene (PMP) or equivalent inert material, 0.38 ± 0.04 mm thick, outer diameter 46.2 mm ± 0.25 mm, and a width of 3.68 mm (+0.00 mm, -0.51mm).

Pore size: 2µm as measured by ASTM F316.94.

Filter thickness: 30 to 50 µm.

Maximum pressure drop (clean filter): 30 cm H_2O column @ 16.67 Lpm clean air flow.

Maximum moisture pickup: Not more than 10 µg weight increase after 24-hour exposure to air of 40 percent relative humidity, relative to weight after 24-hour exposure to air of 35 percent relative humidity.

Collection efficiency: Greater than 99.7 percent, as measured by the DOP test (ASTM D 2986-91) with 0.3 µm particles at the sampler's operating face velocity.

Alkalinity: Less than 25 microequivalents/gram of filter, as measured by the guidance given in reference 2 in section 13.0 of this appendix.

One current source of these filters is Pallflex Products Corp. Of Putnam, CT, USA; Type TK15-S3M.

Filter Handling

Filters should be handled delicately using non-serrated forceps, never using fingers (even in laboratory gloves) to touch any part of the filter. When not in use, filters should be stored in protective cartons in conditions of moderated temperature and relative humidity. Filters should from the always be transported from the laboratory to the sampling location in the filter cassette, which should be protected within a metal canister. These canisters may be ordered directly from BGI.

Filter Cassette Handling

The filter cassettes provided for use with the PQ100 have been designed with an interference fit to prevent the cassette from coming apart easily, therefore some care must be exercised when opening and closing the cassette, especially when a filter is inside. Always maintain the cassette in an upright position, especially if the filter has already been used to collect particles. To open, place a clean, flat blade device (knife edge, screwdriver blade) against the outside edge of the cassette between the upper and lower halves and gently wedge them apart. DO NOT TWIST THEM APART, this could tear the filter. Set the upper half of the cassette aside.

To close the cassette, place it the upper and lower halves together and gently press them together, being careful not to twist them. When closed, the two halves should seat snugly together with the backing screen securely held in place between the two halves.

Filter Weighing

Because of the small amounts of material collected, an extremely high quality microbalance and carefully, temperature and humidity controlled filter weighing room are recommended. For complete EPA recommended details, consult 40 CFR 50 Appendix L8.0, Federal Register, July 18, 1997, and Section 2.12 of EPA's Quality Assurance Handbook.

The analytical balance used to weigh filters must be suitable for weighing the type and size of filters specified and have a readability of ±1μg. The balance should be calibrated as specified by the manufacturer at installation and should be recalibrated immediately prior to each weighing session.

APPENDIX M. EXTERNAL DATALOGGER

Effective Oct. 10, 2003
This section is retained for reference purposes only.
Pleas refer to the BGI Website at:
www.bgiusa.com/aam/pocketpc.pdf
for our newer downloading equipment.

The BGI Datatrans is a “Download Data Collector” designed to extract the “Data Download” from a PQ100 at the end of its sample period and store it until it can be uploaded to a personal computer running BGI PQ software, for more permanent storage. This device facilitates rapid “Filter and Data” collection in the field while providing trouble free data collection at extended temperature range (-30° to +60°C). The Datatrans was designed specifically to address the problem of field data collection at these extended temperatures where notebook, laptop or palmtop computers are not designed to operate below 0°C.

To use the Datatrans

1. Turn the unit on with the power switch on the front panel (See Figure M1).
2. The following light sequence should be observed: red, yellow then green.
3. The green light will remain on (This indicates a ready condition). If the yellow light is also illuminated, one or more runs are currently stored in the Datatrans and it should either be downloaded or erased as described below.

NOTE: The Datatrans should be fitted with a fresh, new 9-Volt battery prior to each field use.

Downloading the PQ100

1. Place the connection switch, located on the front panel of the Datatrans, in the “Samp” (sampler) position.
2. Insure the PQ100 Sampler is powered on and at the Main Idle Screen.
3. Attach the PQ100 Adapter to the Datatrans (See Figure M2) and plug the other end of the adapter into the Utility Port on the front panel of the PQ100.
4. Press and hold the pushbutton on the front of the Datatrans.
5. The red light will turn on, the green light will turn off and if communication is successful the yellow light will flash for each line of data received. When the download is complete, the yellow light will remain on, the red light will stop flashing and turn off and the green light will turn on.

Note that the PQ100 takes less than 5 seconds to download.

6. Repeat the above steps for each sample run that is to be collected (multiple samplers) realizing that the “Runs” are stacked up using **First In, Last Out methodology**.

NOTE: You must remember how many runs that you've stored in the Datatrans. 20 is the maximum. If you try to store 21 runs, the Datatrans will not accept the 21st run. You will notice that the yellow light flashes while data is transferring. When memory becomes full, the red light will not flash indicating that the run was not accepted.

7. It is now safe to turn the unit off.

NOTE: The data will be retained in the Datatrans, even if the 9-Volt battery fails, until it has been uploaded into a computer and the unit is erased using the data deletion procedure described below.

To upload to the Computer

1. Plug the Datatrans into the RS232 serial port of the computer.
2. Turn on the power switch and observe the following light sequence: red, yellow then green. (Green light indicates unit is ready and yellow on indicates Runs are stored). Red light turns off.
3. Place the connection switch, located on the front panel, in the **(Comp)** computer position.
4. Insure the computer is running BGI PQ Software for DOS. (B)egin a new job, then import data from the sampler should be selected and should be ready to receive data as if it were attached directly to the sampler.
5. Press any key on the computer keyboard to initiate the transfer.
6. Green light will turn off, Red Light will turn on and "Run Data" will be stored in the Datatrans.
7. When the transfer is complete, the software will step to the next screen indicating that the "Run" has been transferred.
8. If multiple runs have been stored in the Datatrans, the last run captured is the current resident run. While a run is resident, the Datatrans retains the characteristics of the sampler type it was captured from. To step the Datatrans to the next run, you must first download the current run and then press the pushbutton. Repeat for multiple runs pushing the Datatrans button after each sample is uploaded. You must "Begin" a new run for each sample run to be uploaded to the computer. When all runs have been uploaded, the yellow light will remain off.
9. To use the device again for new runs from the field, you must erase it as described below:

NOTE: TO RECYCLE SAMPLE RUNS:

If after all runs have been downloaded, a lost file, mistake or a problem is discovered and you must download a run again, the Datatrans allows the runs to be recycled as long as it has not yet been erased as described in the Erasure Procedure below.

AFTER GREEN LIGHT GOES OFF, INDICATING ALL RUNS HAVE BEEN DOWNLOADED, PRESSING BUTTON WILL RETRIEVE THE SERIES OF

RUNS AND REMAIN UNTIL DELETED.

THIS IS HELPFUL IF YOU ARE UNSURE OF AN UPLOADED RUN.

DATA DELETION PROCEDURE (TO ERASE THE DATATRANS AFTER ALL RUNS HAVE BEEN TRANSFERRED)

1. Turn the power switch off.
2. Hold down the pushbutton.
3. While holding the pushbutton down, turn the power switch On.
4. The Red light will turn on, now release the button.
5. When erased, all three lights will flash 2 times in unison and 1 time in series.
6. Unit is now cleared and ready for new downloads.

Maintenance

The Datatrans requires no maintenance except for replacement of the 9-volt battery. A spare, fresh battery should always be taken to the field.

Troubleshooting

Most of the problems that occur with the device can be traced to a bad 9-Volt battery. It is recommended that the user purchase Duracell Alkaline Batteries which come packaged with a cell tester. Follow the instructions given on the box or cell and determine if the cell requires replacement or not. It is highly recommended that the user install a brand new, fresh cell before each field use (If you forget to turn the unit off for some reason, you will have about 18 full hours of battery use).

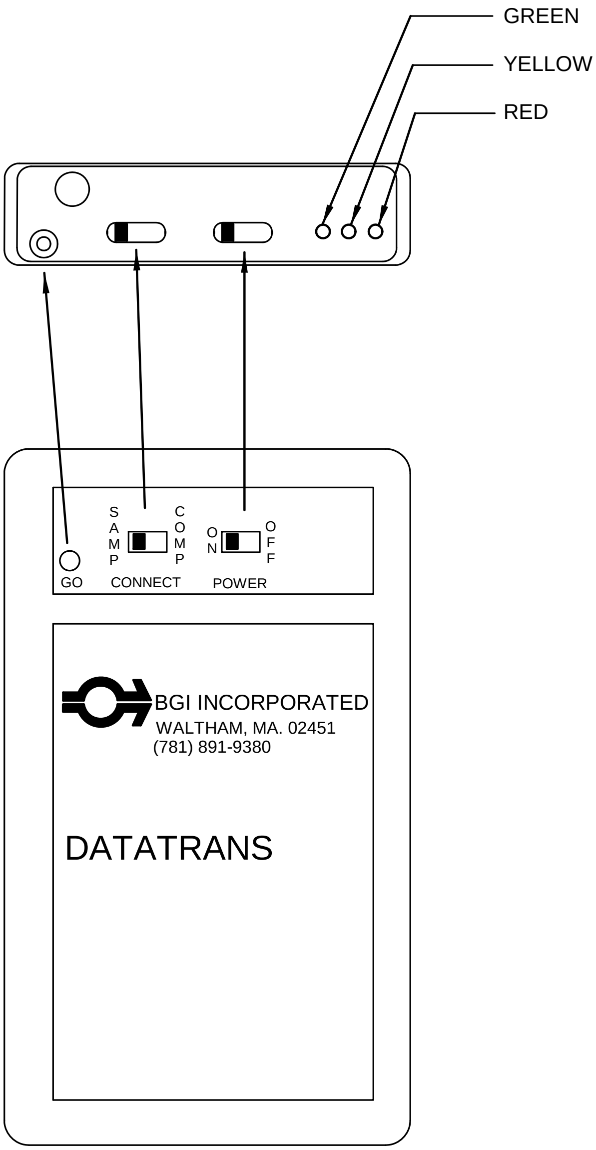


Figure M1. Schematic Diagram of Datatrans

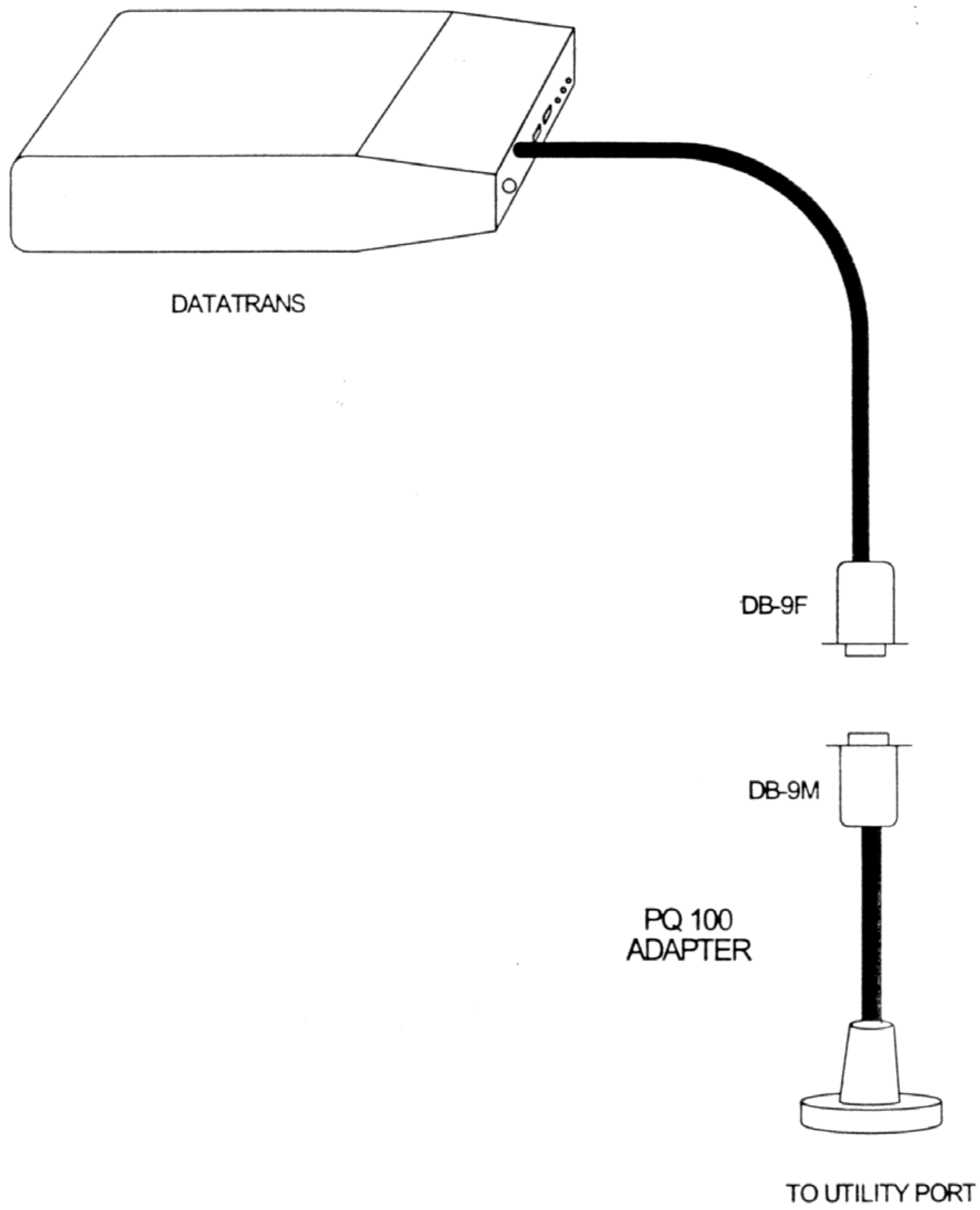


Figure M2. Datatrans with Adapter for use with PQ100

APPENDIX N. SOLAR PANEL POWER SUPPLY

Introduction

The SP32, solar panel kit is intended to permit the PQ100 to run for extended or, indefinite periods of time depending on the available sunlight (solar radiation) at a given location. The solar panel may only be used as the sole source of power for a U.S. EPA-designated instrument if sampling is not being performed every day (i.e., continuously).

Because of the low current draw of the instruments they are highly amenable to this technique. Given sufficient sunlight, they may be deployed in locations where no line power is available. The basic components of the solar kit are:

1. 32-watt solar panel with mounting brackets.
2. Built in voltage regulator.
3. 100+ amp hour (approx.) ballast battery. (User supplied).

The purpose of the external high capacity battery is to provide back up power on days when there is little or no sunlight. The recommended battery capacity will provide 7-8 days run time with little or no sunlight. It will recharge, almost completely, after one days' use during a day of full sunlight while the instrument is non-operational. Complete recharging of a fully depleted system would require 10 days.

This type of system should not be considered for latitudes higher than 45-50° N or S, or particularly overcast regions.

Operational Considerations

While the use of solar power is highly desirable from the standard of utilizing a renewable energy source and being freed from the need to locate a source of power in difficult situations, there are some preliminary considerations. Clearly, the PQ100 is not operating directly from the received energy of the sun but rather from a battery, which has been charged by that energy. If a PQ100 were to be run continuously from the internal and (recommended) external battery, 7 to 8 days run time could be achieved. However, considering only EPA designated sampling conditions, i.e. sampling from midnight to midnight, then it would be possible to run on alternate days yielding one day to replenish the energy used. Given that this is accomplished in full sunlight while the instrument is running, the extra day recovery reduces the need for full sunlight by 50%. If the popular, one in 3 days, or one is 6 days schedule is utilized, the probability of complete replenishment is greatly increased.

Experience has shown that on cloudless days in the Boston area, 5 Kwh/M^2 insolation will replenish the energy used by a PQ100. In order to determine the suitability of the PQ100 solar system for a given location, Appendix A of the cited reference gives the insolation index for 54 locations in the US and other places throughout the world. Given a one in 6 day sampling schedule; only Fairbanks Alaska is unsuitable for solar application in the months of November, December and January. These are clear sky tables and seasonal overcast must be considered in individual locals. Table N1 comprises locations at various US latitudes and indicates operational months vs. sampling schedules.

There are other factors which will reduce the energy replenishment of the system and make accurate performance predictions difficult. Amongst these are:

1. Dirt on the solar panel.
2. Extreme cold weather affecting battery performance.
3. Extremely high particulate loadings causing high filter resistance and consequent high current drain.
4. Old “used up” batteries -- more than two years old.

While all the preceding factors are to be considered in the deployment of a solar powered PQ100. They are not easy to quantitate. The effect of too little sunlight will be noticed on the “percent charge remaining” on the PQ100's main screen. Given perfect replenishment, it will always read 99%. If at any time it falls below 50% it is well to consider replacing the large battery with a fully charged one. At a minimum, given winter gloom, a fully charged battery and an every other day sampling schedule, a one month operating period is achievable at any location below 45° latitude.

Setting up

Subsequent to unpacking a new unit, it is attached to the rear leg of the PQ100 as shown in Figure N1. It is important that the board provided be located as shown in the figure with the battery placed on top of it. This serves to anchor the lower end of the panel to prevent its lifting during high winds. Failure to do so could result in damage to the solar panel and the PQ100. **NOTE:** In due consideration of weight, shipping expense and ready, local availability, a battery is not furnished with the solar panel kit.

However, the recommended battery is known as a “trolling motor” battery. This is a marine type battery used for low speed, electric outboard motors. They are equipped with handles and 5/16 inch binding posts with wing nuts. Because of their marine specifications, they are a “deep discharge” battery, which is also the type recommended for solar panel applications(1).

Direction

The direction of the solar panel will be with its long axis from the north to south, with the foot (low) end of the panel to the south. Inasmuch as the cell will be attached to the rear leg of the PQ100, this means that the back of the PQ100 is pointing due south and the front of the instrument is due North as illustrated in Figure N2.

Tilt Angle

The tilt angle is defined as the angle of inclination of a solar collector measured from the horizontal. The reason for tilt angle is because of the suns' elevation will vary over a range of 47^{O} from winter solstice to summer solstice (1).

For the greatest annual energy production, the tilt angle should equal the latitude at the location of deployment. For best energy production, the wintertime the angle should be the latitude plus 15^{O}. The maximum summertime production is obtained at latitude minus 15^{O}. The tilt angle and one method of setting is shown in Figure N3.

It may also be set with a user supplied protractor/bubble level.

Wiring Connections

On the back of the solar panel is a rectangular box from which two cables exit as shown if Figure N4. The cable with 5/16 inch ring terminals is intended to connect to the external battery described in section N 2. The white wire is positive (+). The black wire is negative (-) and the green wire, with the tinned end is ground. A 12-inch ground spike and terminal is provided.

The other wire emanating from the box is equipped with a CPC connector. This wire is installed on the PQ100 panel normally used for the power supply cable. This wire is installed in place of the power supply cable when running on solar power.

Overall Operation and Troubleshooting

Prior to deploying a PQ100 with solar panel, it is prudent to ensure that the internal battery is fully charged. This is accomplished by plugging the PQ100's power supply into a source of line current for 16 hours. Full internal battery charge will be indicated on the main menu display as 99% or charged when the battery is full charged and the power supply is disconnected.

The external solar panel battery may be initially charged from any automotive battery charger. Alternatively, the PQ100 may simply set in a sunny location or the actual field sampling site and not run for 10 days. The solar panel will fully charge both batteries.

Troubleshooting

Battery is not maintaining at least 50% charge – caused by inclement weather or excessive current drain. Excessive current drain is caused by an excessively dirty filter or a worn out pump. After installing a new filter, if problem persists, check for worn pump valves or diaphragms.

If either battery is in excess of two years old – replace.

Reference

(1) Stand-Alone Photovoltaic Systems, A Handbook of Recommended Design Practice. Available from National Technical Information Service
US Department of Commerce
5285 Port Royal Road
Springfield, VA 22161
Document No. SAND87-7023

Solar Panel Parts List

Quantity	Figure	Part Number	Description
1	N 1	SP-21	Solar panel assembly
1	N 4	A1920	PQ100 adapter cable

TABLE N1. Clear Sky Insolation Data from Northernmost to Southernmost U.S. cities[1].

Months wherein full charge can be maintained.

City	N. Latitude	Continuous Sampling	Every other day Sampling	Third day Sampling	Sixth day Sampling
Caribou, ME	46° 52'	Mar-Aug	Jan-Oct	Jan-Dec	Jan-Dec
Boston, MA	41° 40'	May-Sept	Jan-Nov	Jan-Dec	Jan-Dec
Raleigh-Durham, NC	35° 52'	Apr-Aug	Jan-Dec	Jan-Dec	Jan-Dec
Miami, FL	25° 48'	Feb-Sep	Jan-Dec	Jan-Dec	Jan-Dec

NOTE: This approximation is based upon 5 Kwh/M^2 received, as being necessary to fully restore the PQ100 system whilst drawing 500 MA (typical).

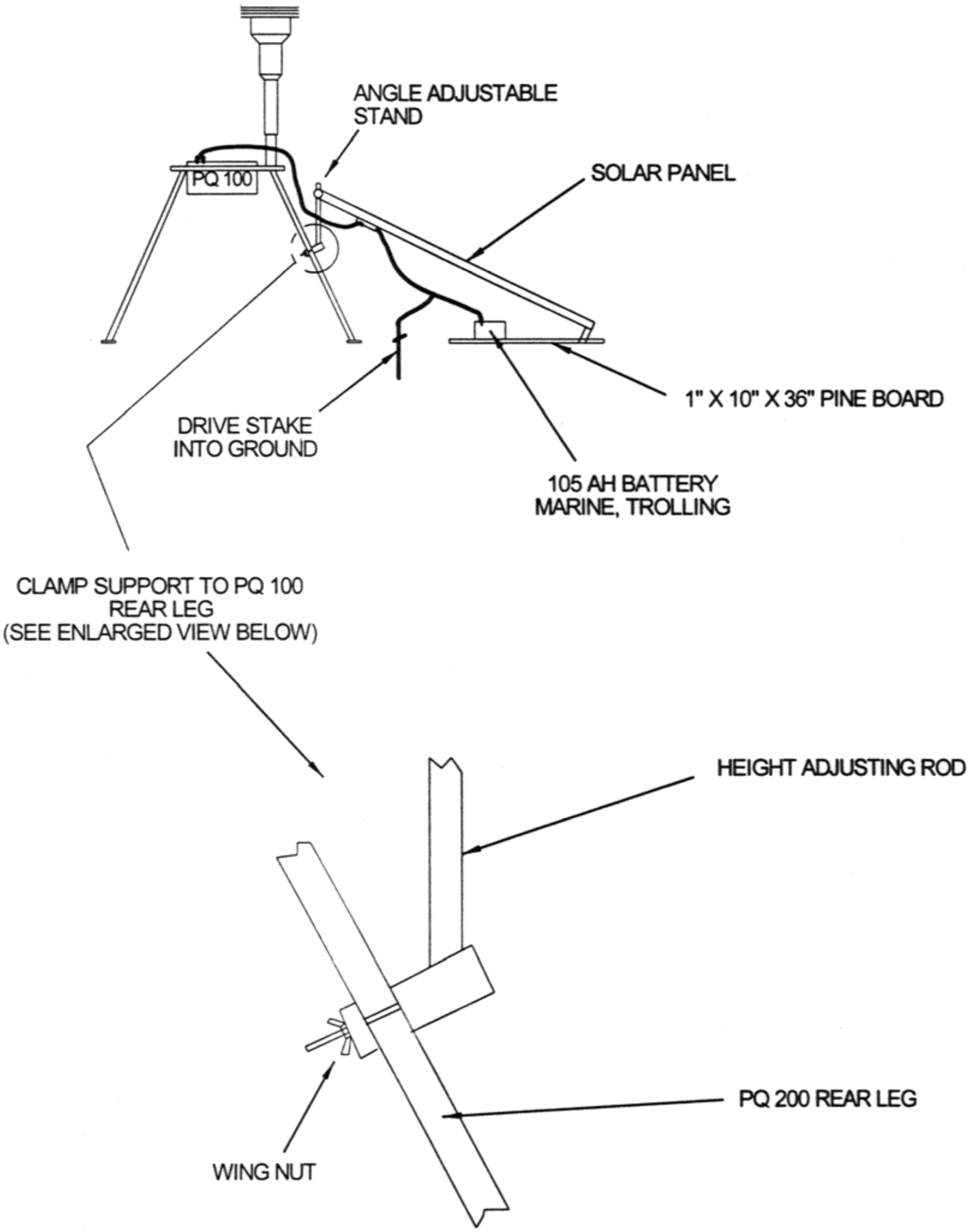


Figure N1. Setup of Solar Panel

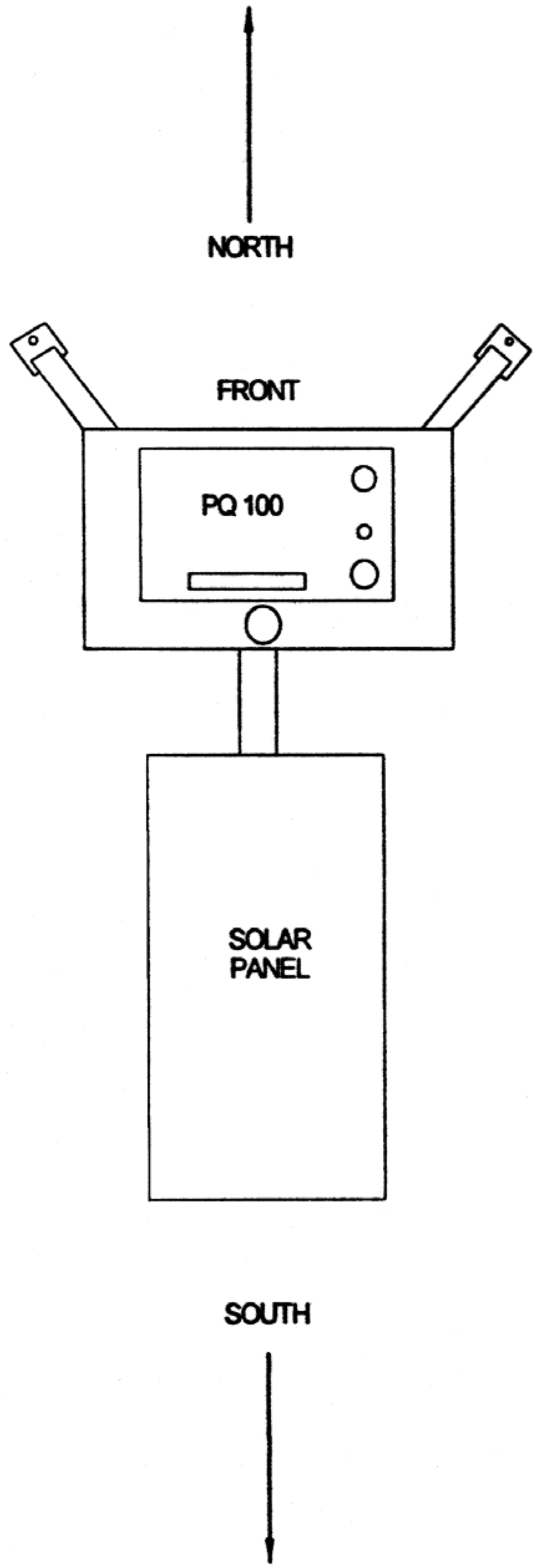
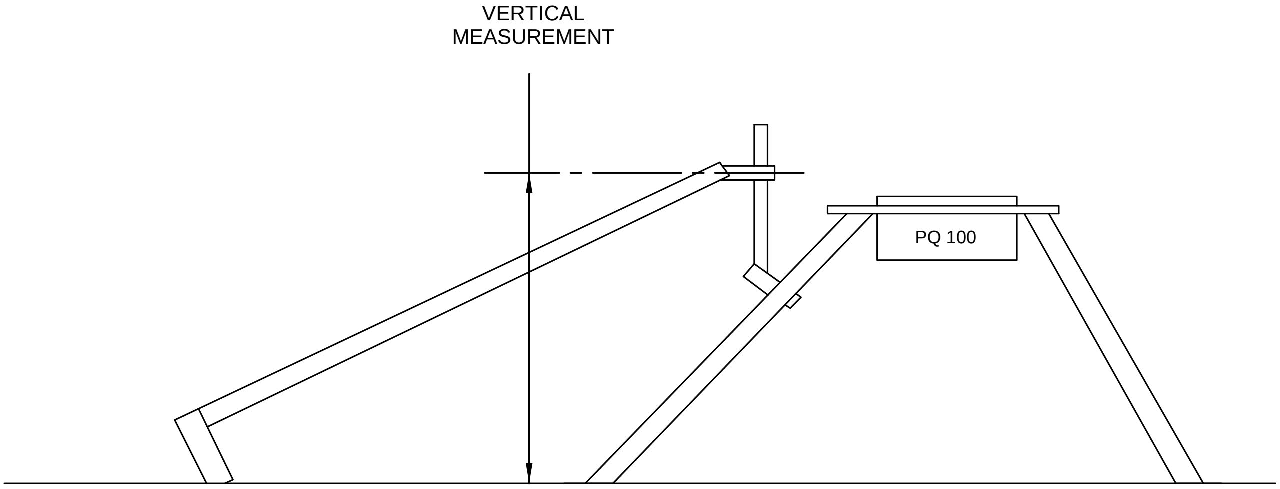


Figure N2. Orientation



BEFORE USING THE CHART BELOW DETERMINE WHETHER YOU HAVE THE
LONG STYLE (13" WIDE x 51" LONG) OR THE SHORT STYLE (21" WIDE x 25" LONG)
SOLAR PANEL

VERTICAL MEASUREMENT				TILT ANGLE
SHORT STYLE (21"x25")		LONG STYLE (13"x51")		
INCHES	CM	INCHES	CM	DEGREES
12.2	30.0	18.7	47.5	15
16.1	40.9	27.5	69.8	25
19.8	50.3	35.2	89.4	35
22.3	56.6	42.2	107.2	45
24.5	62.2	48.0	121.9	55
25.5	64.8	51.8	131.6	65

Figure N3. Setting Tilt Angle

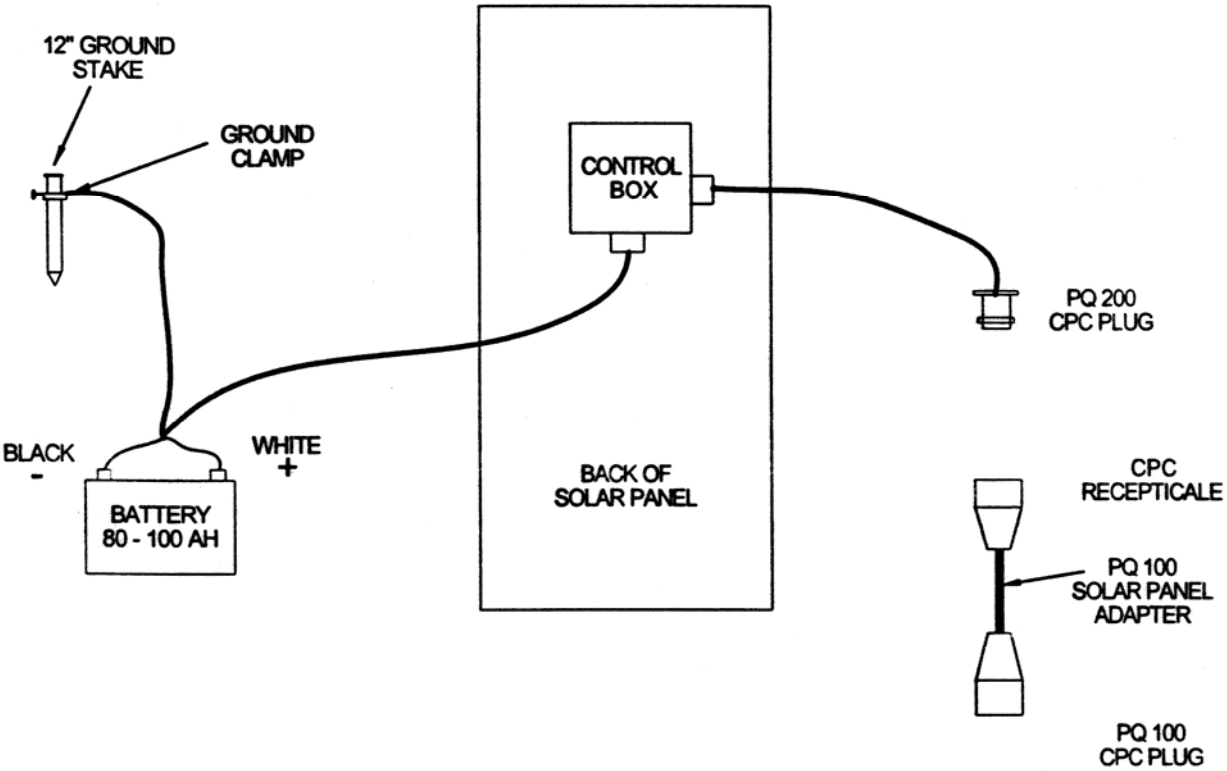


FIGURE N4 WIRING CONNECTIONS

APPENDIX O. RIGID MOUNTING ASSEMBLY

Introduction

The original PQ167 utilized a tripod assembly, which held the PQ100 pump in a swinging cradle. This assembly, now designated PQ167S, is detailed in Figures 4, 5, and 6. A new, improved rigid assembly is available designated PQ167R. Details of this new assembly are shown in Figures O.1 and O.2. *(January 2000: Only PQ167R is now in production.)*

Description

The inlet is still maintained at a height of two meters above the ground, with the filter holder plugged directly into the bottom of the PM10 inlet, as previously done.

An outlet cap for the bottom of the filter holder has been designed which is similar to the EPA L30 component with the addition of an "O" ring. This allows the filter holder to be placed onto a down tube which is a longer version of the EPA designed L19 component. Inasmuch as particulate matter is removed from the air stream prior to passage through the tube its increased length is not a consideration.

The downtube slips over a support member welded into a plate, which serves multiple functions. The support member serves as a water trap and is fitted with the same drain valve as is used in the PQ200 water trap. The support plate has a rectangular slot into which the PQ100 pump module can be placed, this supports the PQ100 at waist height for ease of use. Three stub legs are welded to the bottom of the support plate, which permits the attachment of 3 legs, which are interchangeable with the legs on the PQ200.

ASSEMBLING THE PQ167R PM10 AIR SAMPLING SYSTEM

Included with your PQ167R PM10 Air Sampler System are the following items. Item #'s are indicated on the appended drawings.

Item #	**Quantity**	Part Number	Description
14	1	PQ100	Air Sampler Main Unit
*	1	PQ101	Battery Charger/Auxiliary Power Supply
34	1	PQ102	Hose Adapter
*	1	CQ1	Charger/External Battery Cable
*	1	CQ2	PC Communication Adapter Cable
*	1	PQMAN	Manual
12	1	HS5	1 foot; Rubber Hose
11A	1	TP100R	Tripod Frame
*	3	A1634	Legs
01	1	SSI-2.5	Inlet
3	1	JR3035	Water Jar
4,5,9,10	1	F20	Filter Holder (Requires F21 Cassette)
6,7,8	2	F21	47mm Filter Adapter Cassette w/Screen
162	1	A1741	Long Down Tube
161	1	A1904	Filter Adapter
*	1	QD3	3.5" PQ Software Diskette

For complete system assembly refer to Figures 4, 5, 6, O.1 and O.2.

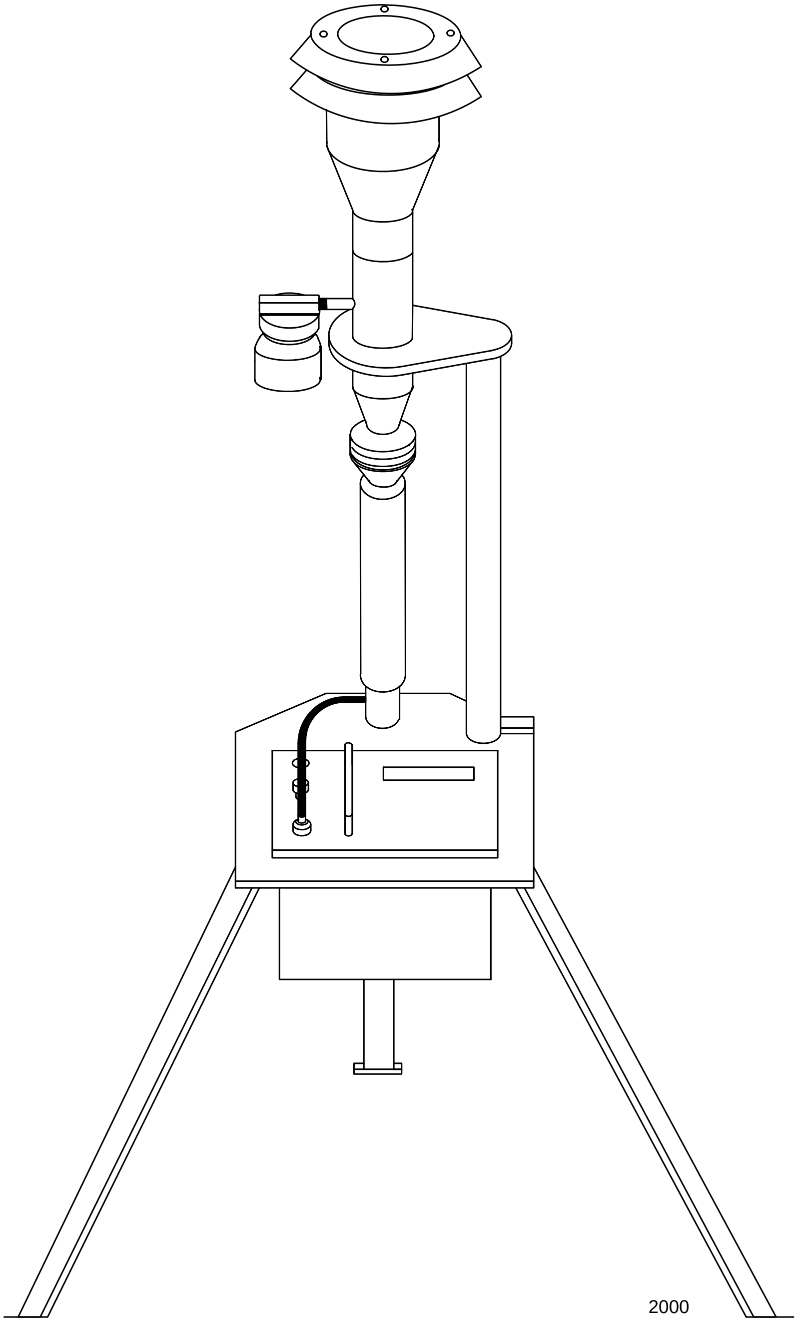


FIGURE 0.1 PQ167R Rigid Mounting Stand

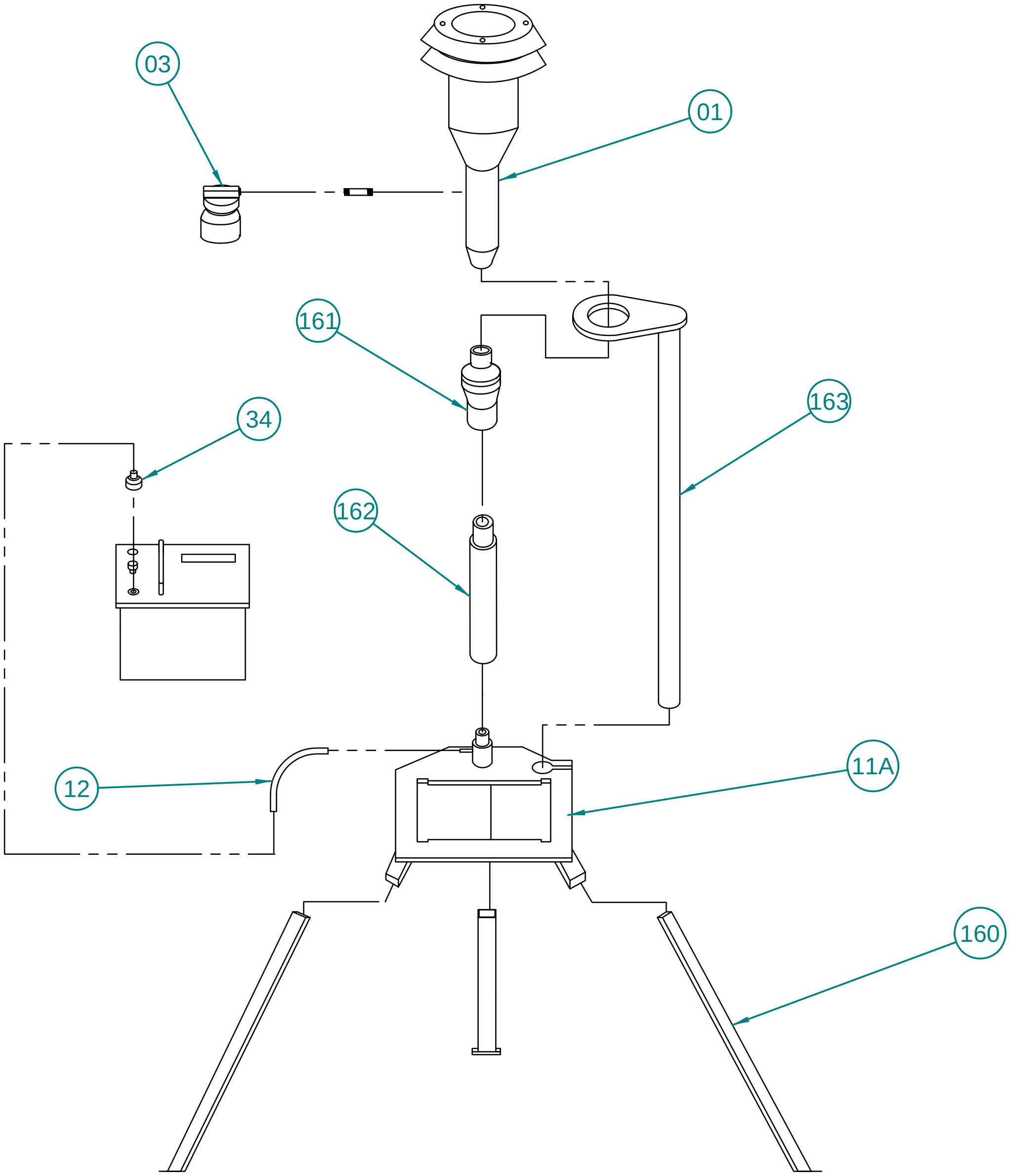


FIGURE 0.2 EXPLODED VIEW OF PQ167R STAND

APPENDIX P. PQ167 High Altitude (*mini*PM Inlet)

IMPORTANT: FLOW RATE MUST BE SET FOR 5 lpm

1.0 Size selective inlet

The size selective inlet will be familiar to all who have had experience with the Standard EPA Louvered Inlet in its original 16.7 lpm configuration. The only two differences are that it has been scaled down to 1/3 its original dimensions and the acceleration jet in the impactor is changeable over five size ranges. An exploded diagram of the inlet is shown in Figure 9 with all parts identified.

2.0 Jet Differential

If a Size Selective Jet (SSJ) other than PM10 was ordered/furnished with your instrument it was furnished as a separate item. The individual jets are hand detachable and removed/installed by screwing in and out. A light grease should be applied to the threads to prevent seizure. Jets manufactured prior to May,2005 were not marked. As a guide to their functional size refer to the table of approximate internal dimensions below. Later jets were color coded and their functional size can also be found in the following table.

Function	P/N	I.D. (In.)	I.D. (mm)	Color
TSP	2599	0.38	9.6	Clear
PM 10	2616	0.26	6.6	Blue
PM 4.0	2741	0.14	3.6	Green
PM 2.5	2617	0.11	2.8	Red
PM 1.0	2618	2 holes	2 holes	Black

3.0 Maintenance

Items which require cleaning and maintenance are common to all ambient air sampling devices fitted with size selective inlets. The inlet and the sampler may be considered two separate items for cleaning and maintenance purposes.

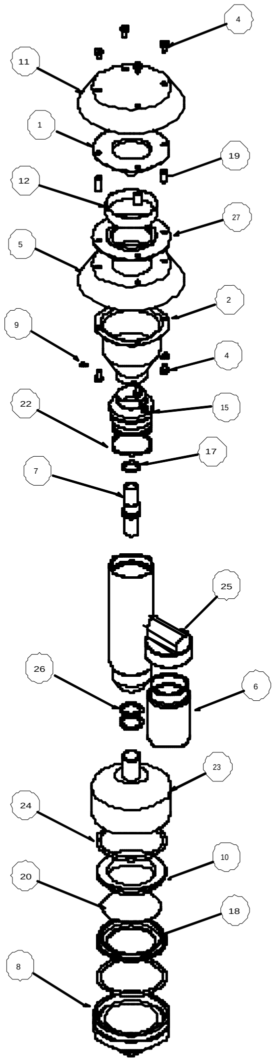
Cleaning should occur once every 90 days or sooner in highly polluted environments. Until such time as sufficient experience has been gathered, the unit should be inspected once a month. In order to perform an inspection it is only necessary, after removing the inlet from the top of the filter holder to unscrew the top from the bullet as shown in Figure 10.

Normal cleaning of air sampling inlets is generally, best done with clean water and lint free wiping cloths. If an ultrasonic cleaner is available it is the preferred device as it will remove dirt from deep corners and pockets, avoiding the need for further disassembly. After ultrasonic, or any liquid cleaning, be certain to dry thoroughly before reassembling and placing in service.

Summary of Maintenance Items:

Frequency*	**Maintenance item**
Every 5 sampling days	1. Service water collector bottle
Monthly	1. Clean inlet surfaces 2. Check inlet screen for any clogging
Quarterly (every 3 months)	1. Inspect O-rings. Remove and lightly coat them with Vacuum grease. 2. Clean impaction surface.

*Frequency may vary depending on climate, amount of particulate matter in the air, weather, and so on.



Detail #	Part #	Qty.	Description
1	2585	1	2585 WIND DEFLECTOR
2	2583	1	2583 NOZZLE ENTRY
3	2602	1	2602 EXIT ADAPTER
4		8	4-40 x 1-4 PAN HEAD
5	2586	1	2586 LOWER PLATE
6		1	JAR
7	2617	1	2617 NOZZLE INSERT, PM 2.5
8		1	1425 FILTER HOLDER, LOWER
9		3	2-56 x 1-8 PAN HEAD
10		1	1727-L27 CASSETTE UPPER SECTION
11	2584	1	2584 TOP
12	2589	1	2589 SCREEN
13	2596	3	2596 RECEIVER TUBE
14	2595	1	2595 TARGET PLATE
15	2598	1	2598 IMPACTOR NOZZLE
16		1	NIPPLE
17	013 ORING	1	013 ORING
18		1	1729-L29 CASSETTE LOWER SECTION
19	2588	4	2588 SPACER
20		1	1728 FILTER SCREEN
21	2597	1	2597 OUTER TUBE
22	024 BUNA	1	024 ORING
23	2672	1	2672 UPPER FILTER HOLDER
24		2	135 ORING
25		1	JAR TOP
26	015 BUNA	2	015 ORING
27	2587	1	2587 RAIN DEFLECTOR

Fig. 9 Exploded Diagram of Inlet with Filter Holder

Figure 10: Photo of Initial Disassembly of Inlet

The jet may also be removed from the top of the inlet as shown in Figure 11.

Figure 11: Photo of Jet Removed for Cleaning or Size Change

PQ100 Instruction Manual Revision History

Version 5.0	Updated to WP6.0 format	March 1998
Version 6.0	Added Preface, Safety, Appendix L, M, N, and O Added Designation Information	December 1998
Version 6.01	Corrections to Replacement Component List	February 1999
Version 6.02	Corrections to Appendix M	April 1999
Version 6.03	Corrections to Appendix N	January 2000
Version 6.1	Miscellaneous corrections	January 2000
Version 6.2	Miscellaneous corrections	May 2002
Version 6.21	Added note to Appendix M	October 2003
Version 6.22	Added Appendix P	September, 2005
Version 6.23	Ch’d tetraCal to TetraCal	May, 2007

Appendix E

Visual Sample Plan Results

Systematic sampling locations for comparing a mean with a fixed threshold (nonparametric)

Summary

This report summarizes the sampling design used, associated statistical assumptions, as well as general guidelines for conducting post-sampling data analysis. Sampling plan components presented here include how many sampling locations to choose and where within the sampling area to collect those samples. The type of medium to sample (i.e., soil, groundwater, etc.) and how to analyze the samples (in-situ, fixed laboratory, etc.) are addressed in other sections of the sampling plan.

The following table summarizes the sampling design developed. A figure that shows sampling locations in the field and a table that lists sampling location coordinates are also provided below.

SUMMARY OF SAMPLING DESIGN	
Primary Objective of Design	Compare a site mean or median to a fixed threshold
Type of Sampling Design	Nonparametric
Sample Placement (Location) in the Field	Systematic with a random start location
Working (Null) Hypothesis	The median(mean) value at the site exceeds the threshold
Formula for calculating number of sampling locations	Wilcoxon signed ranks test
Calculated total number of samples	12
Number of samples on map [a]	12
Number of selected sample areas [b]	1
Specified sampling area [c]	4009010.17 m^2
Size of grid / Area of grid cell [d]	2037.73 feet / 3.59605e+006 ft^2
Grid pattern	Triangular
Total cost of sampling [e]	$7,000.00

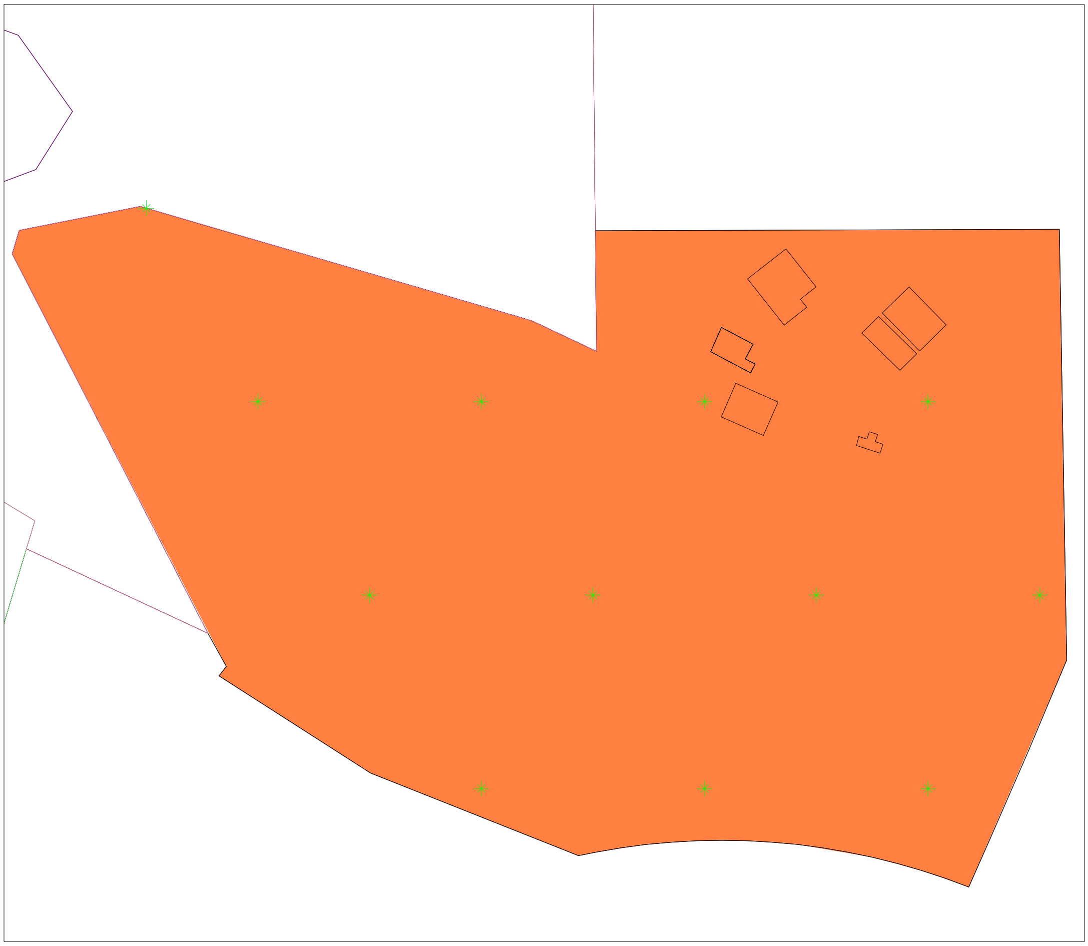
[a] This number may differ from the calculated number because of 1) grid edge effects, 2) adding judgment samples, or 3) selecting or unselecting sample areas.

[b] The number of selected sample areas is the number of colored areas on the map of the site. These sample areas contain the locations where samples are collected.

[c] The sampling area is the total surface area of the selected colored sample areas on the map of the site.

[d] Size of grid / Area of grid cell gives the linear and square dimensions of the grid used to systematically place samples.

[e] Including measurement analyses and fixed overhead costs. See the Cost of Sampling section for an explanation of the costs presented here.



Area: Iron King Proper Area					
X Coord	**Y Coord**	**Label**	**Value**	**Type**	**Historical**
598941.4313	1272858.0114		0	Systematic	
599562.5329	1272858.0114		0	Systematic	
600183.6345	1272858.0114		0	Systematic	
598630.8805	1273395.9012		0	Systematic	
599251.9821	1273395.9012		0	Systematic	
599873.0837	1273395.9012		0	Systematic	
600494.1853	1273395.9012		0	Systematic	
598320.3297	1273933.7910		0	Systematic	
598941.4313	1273933.7910		0	Systematic	
599562.5329	1273933.7910		0	Systematic	
600183.6345	1273933.7910		0	Systematic	
598009.7789	1274471.6807		0	Systematic	

Primary Sampling Objective
The primary purpose of sampling at this site is to compare a median or mean value with a fixed threshold. The working hypothesis (or 'null' hypothesis) is that the median(mean) value at the site is equal to or exceeds the threshold. The alternative hypothesis is that the median(mean) value is less than the threshold. VSP calculates the number of samples required to reject the null hypothesis in favor of the alternative one, given a selected sampling approach and inputs to the

associated equation.

Selected Sampling Approach
A nonparametric systematic sampling approach with a random start was used to determine the number of samples and to specify sampling locations. A nonparametric formula was chosen because the conceptual model and historical information (e.g., historical data from this site or a very similar site) indicate that typical parametric assumptions may not be true.

Both parametric and non-parametric equations rely on assumptions about the population. Typically, however, non-parametric equations require fewer assumptions and allow for more uncertainty about the statistical distribution of values at the site. The trade-off is that if the parametric assumptions are valid, the required number of samples is usually less than if a non-parametric equation was used.

Locating the sample points over a systematic grid with a random start ensures spatial coverage of the site. Statistical analyses of systematically collected data are valid if a random start to the grid is used. One disadvantage of systematically collected samples is that spatial variability or patterns may not be discovered if the grid spacing is large relative to the spatial patterns.

Number of Total Samples: Calculation Equation and Inputs
The equation used to calculate the number of samples is based on a Wilcoxon Signed Ranks test. For this site, the null hypothesis is rejected in favor of the alternative one if the sample median(mean) is sufficiently smaller than the threshold. The number of samples to collect is calculated so that if the inputs to the equation are true, the calculated number of samples will cause the null hypothesis to be rejected.

The formula used to calculate the number of samples is:

$$n = 1.16\left[\frac{\left(S_{sample}^2 + \frac{S_{analytical}^2}{r}\right)}{\Delta^2}\left(Z_{1-\alpha} + Z_{1-\beta}\right)^2 + 0.5Z_{1-\alpha}^2\right]$$

where
n is the number of samples,
S is the estimated standard deviation of the measured values including analytical error,
Δ is the width of the gray region,
α is the acceptable probability of incorrectly concluding the site median(mean) is less than the threshold,
β is the acceptable probability of incorrectly concluding the site median(mean) exceeds the threshold,
$Z_{1-\alpha}$ is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\alpha}$ is $1-\alpha$,
$Z_{1-\beta}$ is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\beta}$ is $1-\beta$.

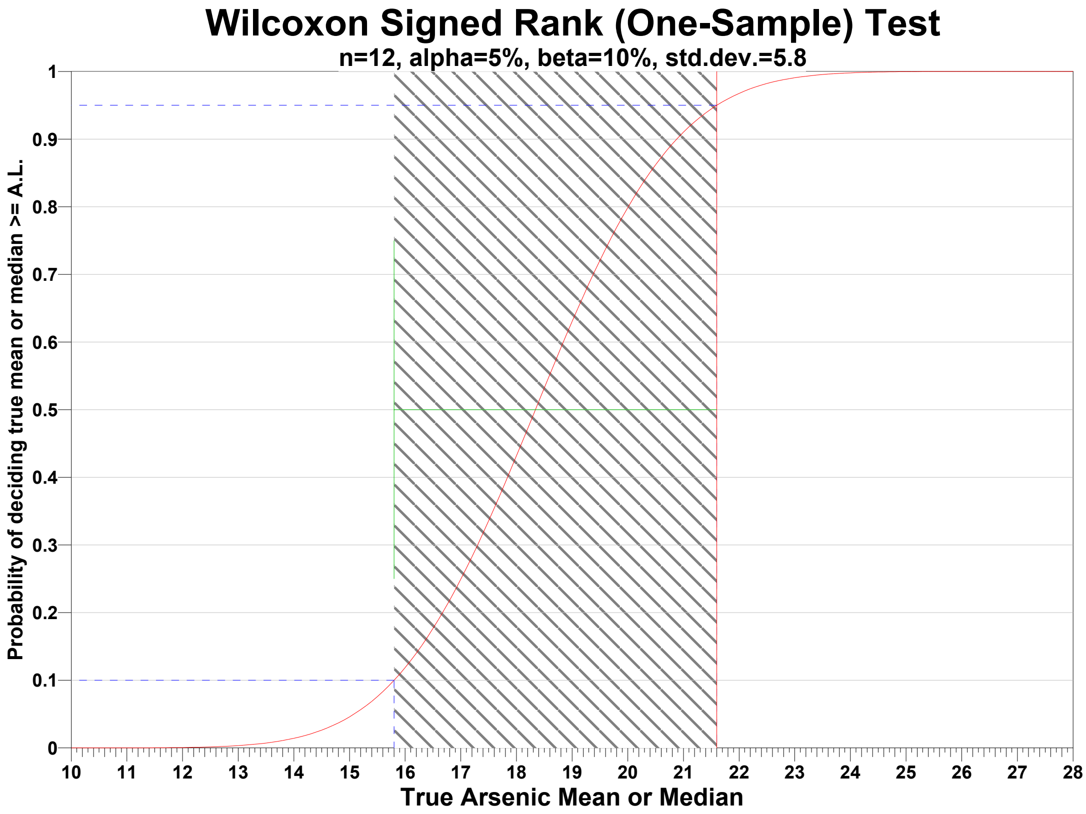
The values of these inputs that result in the calculated number of sampling locations are:

Analyte	n	Parameter					
		S	Δ	α	β	$Z_{1-\alpha}$ [a]	$Z_{1-\beta}$ [b]
Arsenic	12	5.8	5.8	0.05	0.1	1.64485	1.28155

[a] This value is automatically calculated by VSP based upon the user defined value of α.
[b] This value is automatically calculated by VSP based upon the user defined value of β.

The following figure is a performance goal diagram, described in EPA's QA/G-4 guidance (EPA, 2000). It shows the probability of concluding the sample area is dirty on the vertical axis versus a range of possible true median(mean) values for the site on the horizontal axis. This graph contains all of the inputs to the number of samples equation and pictorially represents the calculation.

The red vertical line is shown at the threshold (action limit) on the horizontal axis. The width of the gray shaded area is equal to Δ; the upper horizontal dashed blue line is positioned at $1-\alpha$ on the vertical axis; the lower horizontal dashed blue line is positioned at β on the vertical axis. The vertical green line is positioned at one standard deviation below the threshold. The shape of the red curve corresponds to the estimates of variability. The calculated number of samples results in the curve that passes through the lower bound of Δ at β and the upper bound of Δ at 1-α. If any of the inputs change, the number of samples that result in the correct curve changes.



Statistical Assumptions
The assumptions associated with the formulas for computing the number of samples are:

1. the data originate from a symmetric (but not necessarily normal) population,
2. the variance estimate, S^2, is reasonable and representative of the population being sampled,
3. the population values are not spatially or temporally correlated, and
4. the sampling locations will be selected probabilistically.

The first three assumptions will be assessed in a post data collection analysis. The last assumption is valid because the gridded sample locations were selected based on a random start.

Sensitivity Analysis
The sensitivity of the calculation of number of samples was explored by varying the standard deviation, lower bound of gray region (% of action level), beta (%), probability of mistakenly concluding that μ > action level and alpha (%), probability of mistakenly concluding that μ < action level. The following table shows the results of this analysis.

Number of Samples							
AL=21.6		α=5		α=10		α=15	
		s=11.6	**s=5.8**	**s=11.6**	**s=5.8**	**s=11.6**	**s=5.8**
LBGR=90	β=5	364	93	288	73	242	61
	β=10	289	74	221	56	181	46
	β=15	243	62	181	46	145	37
LBGR=80	β=5	93	25	73	19	61	16
	β=10	74	20	56	15	46	12

	β=15	62	17	46	13	37	10
LBGR=70	**β=5**	42	12	33	9	28	8
	β=10	34	10	26	8	21	6
	β=15	29	9	21	6	17	5

s = Standard Deviation
LBGR = Lower Bound of Gray Region (% of Action Level)
β = Beta (%), Probability of mistakenly concluding that μ > action level
α = Alpha (%), Probability of mistakenly concluding that μ < action level
AL = Action Level (Threshold)

Cost of Sampling

The total cost of the completed sampling program depends on several cost inputs, some of which are fixed, and others that are based on the number of samples collected and measured. Based on the numbers of samples determined above, the estimated total cost of sampling and analysis at this site is $7,000.00, which averages out to a per sample cost of $583.33. The following table summarizes the inputs and resulting cost estimates.

COST INFORMATION			
Cost Details	**Per Analysis**	**Per Sample**	**12 Samples**
Field collection costs		$100.00	$1,200.00
Analytical costs	$400.00	$400.00	$4,800.00
Sum of Field & Analytical costs		**$500.00**	**$6,000.00**
Fixed planning and validation costs			$1,000.00
Total cost			**$7,000.00**

Data Analysis for Arsenic

The following data points were entered by the user for analysis.

Arsenic										
Rank	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
0	0	0	0	0	0	0	0	0	0	0
10	0	0								

SUMMARY STATISTICS for Arsenic	
n	12
Min	0
Max	0
Range	0
Mean	0
Median	0
Variance	0
StdDev	0
Std Error	0
Skewness	-1.#IND
Interquartile Range	0

Systematic sampling locations for comparing a mean with a fixed threshold (nonparametric)

Summary

This report summarizes the sampling design used, associated statistical assumptions, as well as general guidelines for conducting post-sampling data analysis. Sampling plan components presented here include how many sampling locations to choose and where within the sampling area to collect those samples. The type of medium to sample (i.e., soil, groundwater, etc.) and how to analyze the samples (in-situ, fixed laboratory, etc.) are addressed in other sections of the sampling plan.

The following table summarizes the sampling design developed. A figure that shows sampling locations in the field and a table that lists sampling location coordinates are also provided below.

SUMMARY OF SAMPLING DESIGN	
Primary Objective of Design	Compare a site mean or median to a fixed threshold
Type of Sampling Design	Nonparametric
Sample Placement (Location) in the Field	Systematic with a random start location
Working (Null) Hypothesis	The median(mean) value at the site exceeds the threshold
Formula for calculating number of sampling locations	Wilcoxon signed ranks test
Calculated total number of samples	5
Number of samples on map [a]	5
Number of selected sample areas [b]	1
Specified sampling area [c]	223085.22 ft^2
Size of grid / Area of grid cell [d]	226.979 feet / 44617 ft^2
Grid pattern	Triangular
Total cost of sampling [e]	$3,500.00

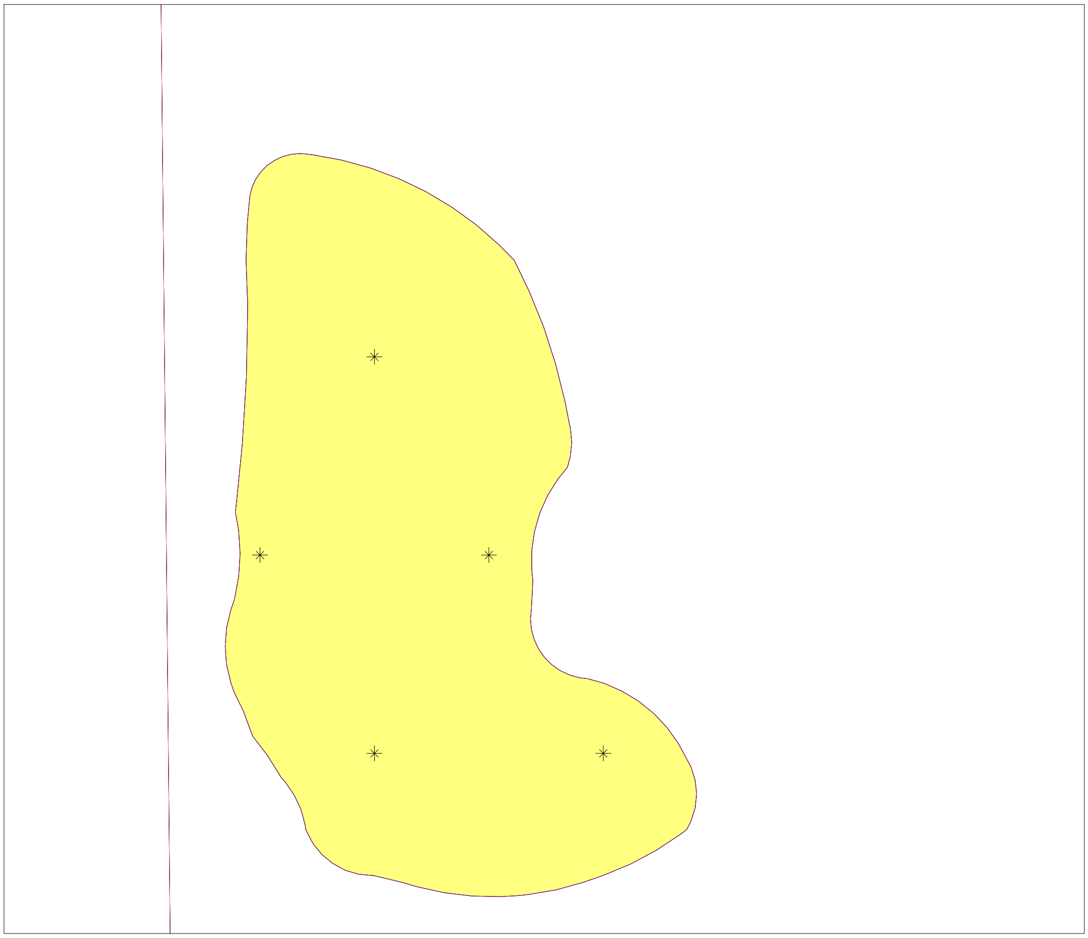
[a] This number may differ from the calculated number because of 1) grid edge effects, 2) adding judgment samples, or 3) selecting or unselecting sample areas.

[b] The number of selected sample areas is the number of colored areas on the map of the site. These sample areas contain the locations where samples are collected.

[c] The sampling area is the total surface area of the selected colored sample areas on the map of the site.

[d] Size of grid / Area of grid cell gives the linear and square dimensions of the grid used to systematically place samples.

[e] Including measurement analyses and fixed overhead costs. See the Cost of Sampling section for an explanation of the costs presented here.



Area: Small Tailings Pile					
X Coord	**Y Coord**	**Label**	**Value**	**Type**	**Historical**
599460.6324	1274605.4258		0	Systematic	
599687.6111	1274605.4258		0	Systematic	
599347.1431	1274801.9951		0	Systematic	
599574.1218	1274801.9951		0	Systematic	
599460.6324	1274998.5644		0	Systematic	

Primary Sampling Objective
The primary purpose of sampling at this site is to compare a median or mean value with a fixed threshold. The working hypothesis (or 'null' hypothesis) is that the median(mean) value at the site is equal to or exceeds the threshold. The alternative hypothesis is that the median(mean) value is less than the threshold. VSP calculates the number of samples required to reject the null hypothesis in favor of the alternative one, given a selected sampling approach and inputs to the associated equation.

Selected Sampling Approach
A nonparametric systematic sampling approach with a random start was used to determine the number of samples and to specify sampling locations. A nonparametric formula was chosen because the conceptual model and historical information (e.g., historical data from this site or a very similar site) indicate that typical parametric assumptions may not be true.

Both parametric and non-parametric equations rely on assumptions about the population. Typically, however, non-parametric equations require fewer assumptions and allow for more uncertainty about the statistical distribution of values at the site. The trade-off is that if the parametric assumptions are valid, the required number of samples is usually less than if a non-parametric equation was used.

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The formula used to calculate the number of samples is:

$$n = 1.16\left[\frac{\left(S_{sample}^{2} + \frac{S_{analytical}^{2}}{r}\right)}{\Delta^{2}}\left(Z_{1-\alpha} + Z_{1-\beta}\right)^{2} + 0.5Z_{1-\alpha}^{2}\right]$$

where

n	is the number of samples,
S	is the estimated standard deviation of the measured values including analytical error,
Δ	is the width of the gray region,
α	is the acceptable probability of incorrectly concluding the site median(mean) is less than the threshold,
β	is the acceptable probability of incorrectly concluding the site median(mean) exceeds the threshold,
$Z_{1-\alpha}$	is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\alpha}$ is $1-\alpha$,
$Z_{1-\beta}$	is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\beta}$ is $1-\beta$.

The values of these inputs that result in the calculated number of sampling locations are:

Analyte	**n**	**Parameter**					
		S	**Δ**	**α**	**β**	**$Z_{1-\alpha}$** [a]	**$Z_{1-\beta}$** [b]
Arsenic	5	5.8	11.6	0.05	0.1	1.64485	1.28155

[a] This value is automatically calculated by VSP based upon the user defined value of α.
[b] This value is automatically calculated by VSP based upon the user defined value of β.

The following figure is a performance goal diagram, described in EPA's QA/G-4 guidance (EPA, 2000). It shows the probability of concluding the sample area is dirty on the vertical axis versus a range of possible true median(mean) values for the site on the horizontal axis. This graph contains all of the inputs to the number of samples equation and pictorially represents the calculation.

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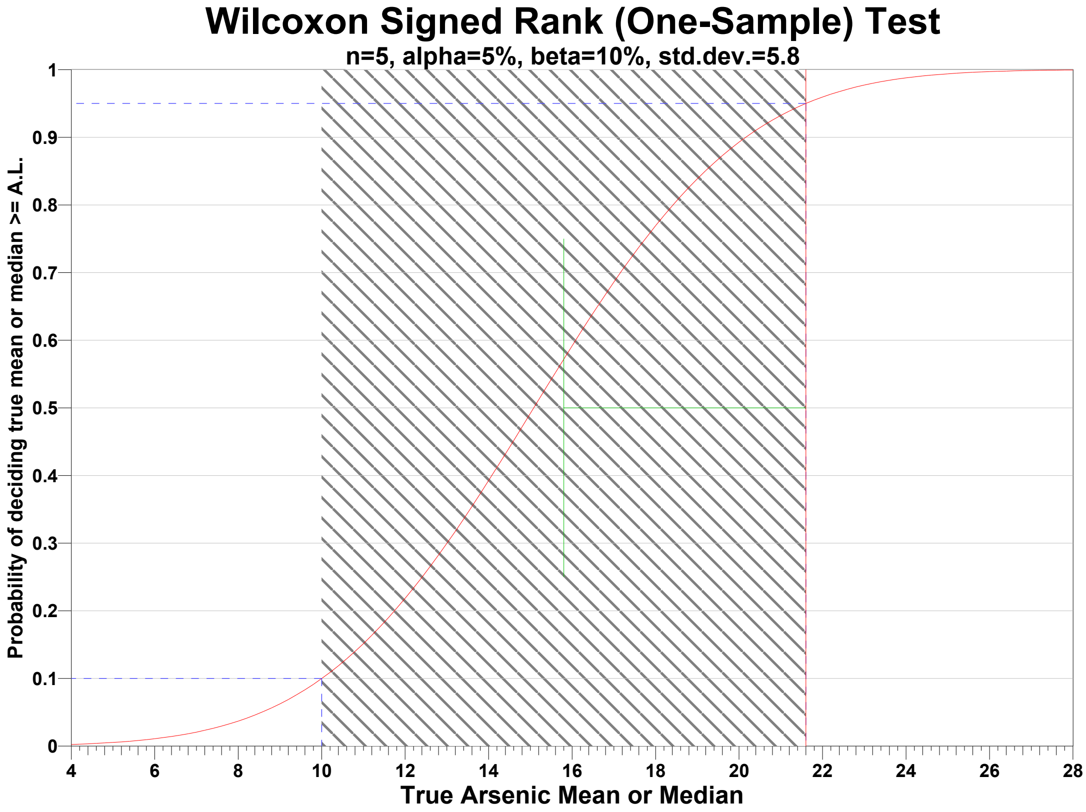

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Sensitivity Analysis

The sensitivity of the calculation of number of samples was explored by varying the lower bound of gray region (% of action level), beta (%), probability of mistakenly concluding that μ > action level and alpha (%), probability of mistakenly concluding that μ < action level. The following table shows the results of this analysis.

Number of Samples				
AL=21.6		**α=5**	**α=10**	**α=15**
LBGR=90	**β=5**	93	73	61
	β=10	74	56	46
	β=15	62	46	37
LBGR=80	**β=5**	25	19	16
	β=10	20	15	12
	β=15	17	13	10
LBGR=70	**β=5**	12	9	8
	β=10	10	8	6
	β=15	9	6	5

LBGR = Lower Bound of Gray Region (% of Action Level)
β = Beta (%), Probability of mistakenly concluding that μ > action level
α = Alpha (%), Probability of mistakenly concluding that μ < action level
AL = Action Level (Threshold)

Cost of Sampling
The total cost of the completed sampling program depends on several cost inputs, some of which are fixed, and others that are based on the number of samples collected and measured. Based on the numbers of samples determined above, the estimated total cost of sampling and analysis at this site is $3,500.00, which averages out to a per sample cost of $700.00. The following table summarizes the inputs and resulting cost estimates.

COST INFORMATION			
Cost Details	**Per Analysis**	**Per Sample**	**5 Samples**
Field collection costs		$100.00	$500.00
Analytical costs	$400.00	$400.00	$2,000.00
Sum of Field & Analytical costs		**$500.00**	**$2,500.00**
Fixed planning and validation costs			$1,000.00
Total cost			**$3,500.00**

Data Analysis for Arsenic
The following data points were entered by the user for analysis.

Arsenic										
Rank	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0
40	0	0								

SUMMARY STATISTICS for Arsenic								
n	42							
Min	0							
Max	0							
Range	0							
Mean	0							
Median	0							
Variance	0							
StdDev	0							
Std Error	0							
Skewness	-1.#IND							
Interquartile Range	0							
Percentiles								
1%	**5%**	**10%**	**25%**	**50%**	**75%**	**90%**	**95%**	**99%**

Systematic sampling locations for comparing a mean with a fixed threshold (nonparametric)

Summary

This report summarizes the sampling design used, associated statistical assumptions, as well as general guidelines for conducting post-sampling data analysis. Sampling plan components presented here include how many sampling locations to choose and where within the sampling area to collect those samples. The type of medium to sample (i.e., soil, groundwater, etc.) and how to analyze the samples (in-situ, fixed laboratory, etc.) are addressed in other sections of the sampling plan.

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Primary Objective of Design	Compare a site mean or median to a fixed threshold
Type of Sampling Design	Nonparametric
Sample Placement (Location) in the Field	Systematic with a random start location
Working (Null) Hypothesis	The median(mean) value at the site exceeds the threshold
Formula for calculating number of sampling locations	Wilcoxon signed ranks test
Calculated total number of samples	12
Number of samples on map [a]	12
Number of selected sample areas [b]	1
Specified sampling area [c]	4405993.68 m^2
Size of grid / Area of grid cell [d]	2136.24 feet / 3.95214e+006 ft^2
Grid pattern	Triangular
Total cost of sampling [e]	$7,000.00

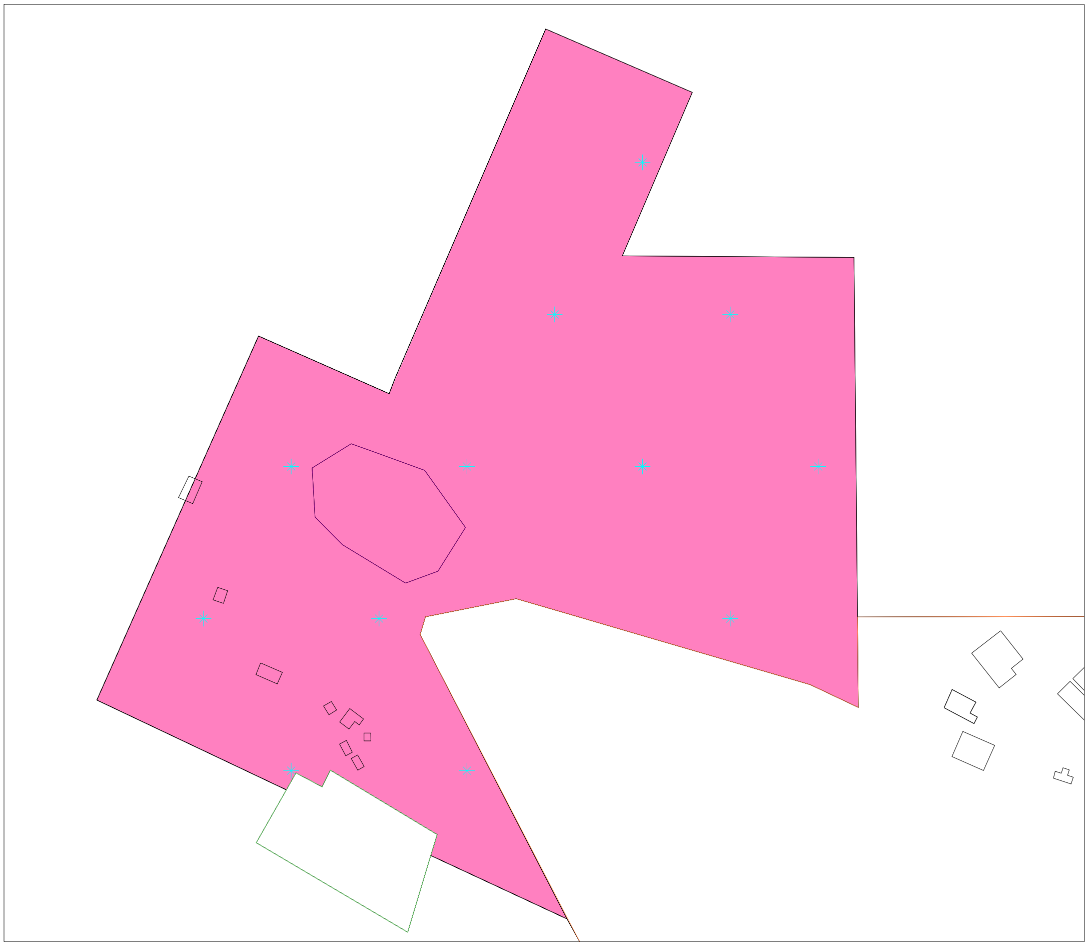
[a] This number may differ from the calculated number because of 1) grid edge effects, 2) adding judgment samples, or 3) selecting or unselecting sample areas.

[b] The number of selected sample areas is the number of colored areas on the map of the site. These sample areas contain the locations where samples are collected.

[c] The sampling area is the total surface area of the selected colored sample areas on the map of the site.

[d] Size of grid / Area of grid cell gives the linear and square dimensions of the grid used to systematically place samples.

[e] Including measurement analyses and fixed overhead costs. See the Cost of Sampling section for an explanation of the costs presented here.



Area: Iron King Operations Area					
X Coord	**Y Coord**	**Label**	**Value**	**Type**	**Historical**
597158.7652	1273839.7121		0	Systematic	
597809.8926	1273839.7121		0	Systematic	
596833.2015	1274403.6050		0	Systematic	
597484.3289	1274403.6050		0	Systematic	
598786.5838	1274403.6050		0	Systematic	
597158.7652	1274967.4979		0	Systematic	
597809.8926	1274967.4979		0	Systematic	
598461.0201	1274967.4979		0	Systematic	
599112.1475	1274967.4979		0	Systematic	
598135.4563	1275531.3909		0	Systematic	
598786.5838	1275531.3909		0	Systematic	
598461.0201	1276095.2838		0	Systematic	

Primary Sampling Objective

The primary purpose of sampling at this site is to compare a median or mean value with a fixed threshold. The working hypothesis (or 'null' hypothesis) is that the median(mean) value at the site is equal to or exceeds the threshold. The alternative hypothesis is that the median(mean) value is less than the threshold. VSP calculates the number of samples required to reject the null hypothesis in favor of the alternative one, given a selected sampling approach and inputs to the associated equation.

Selected Sampling Approach
A nonparametric systematic sampling approach with a random start was used to determine the number of samples and to specify sampling locations. A nonparametric formula was chosen because the conceptual model and historical information (e.g., historical data from this site or a very similar site) indicate that typical parametric assumptions may not be true.

Both parametric and non-parametric equations rely on assumptions about the population. Typically, however, non-parametric equations require fewer assumptions and allow for more uncertainty about the statistical distribution of values at the site. The trade-off is that if the parametric assumptions are valid, the required number of samples is usually less than if a non-parametric equation was used.

Locating the sample points over a systematic grid with a random start ensures spatial coverage of the site. Statistical analyses of systematically collected data are valid if a random start to the grid is used. One disadvantage of systematically collected samples is that spatial variability or patterns may not be discovered if the grid spacing is large relative to the spatial patterns.

Number of Total Samples: Calculation Equation and Inputs
The equation used to calculate the number of samples is based on a Wilcoxon Signed Ranks test. For this site, the null hypothesis is rejected in favor of the alternative one if the sample median(mean) is sufficiently smaller than the threshold. The number of samples to collect is calculated so that if the inputs to the equation are true, the calculated number of samples will cause the null hypothesis to be rejected.

The formula used to calculate the number of samples is:

$$n = 1.16\left[\frac{\left(S^2_{sample} + \frac{S^2_{analytical}}{r}\right)}{\Delta^2}\left(Z_{1-\alpha} + Z_{1-\beta}\right)^2 + 0.5Z^2_{1-\alpha}\right]$$

where

n	is the number of samples,
S	is the estimated standard deviation of the measured values including analytical error,
Δ	is the width of the gray region,
α	is the acceptable probability of incorrectly concluding the site median(mean) is less than the threshold,
β	is the acceptable probability of incorrectly concluding the site median(mean) exceeds the threshold,
$Z_{1-\alpha}$	is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\alpha}$ is 1-α,
$Z_{1-\beta}$	is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\beta}$ is 1-β.

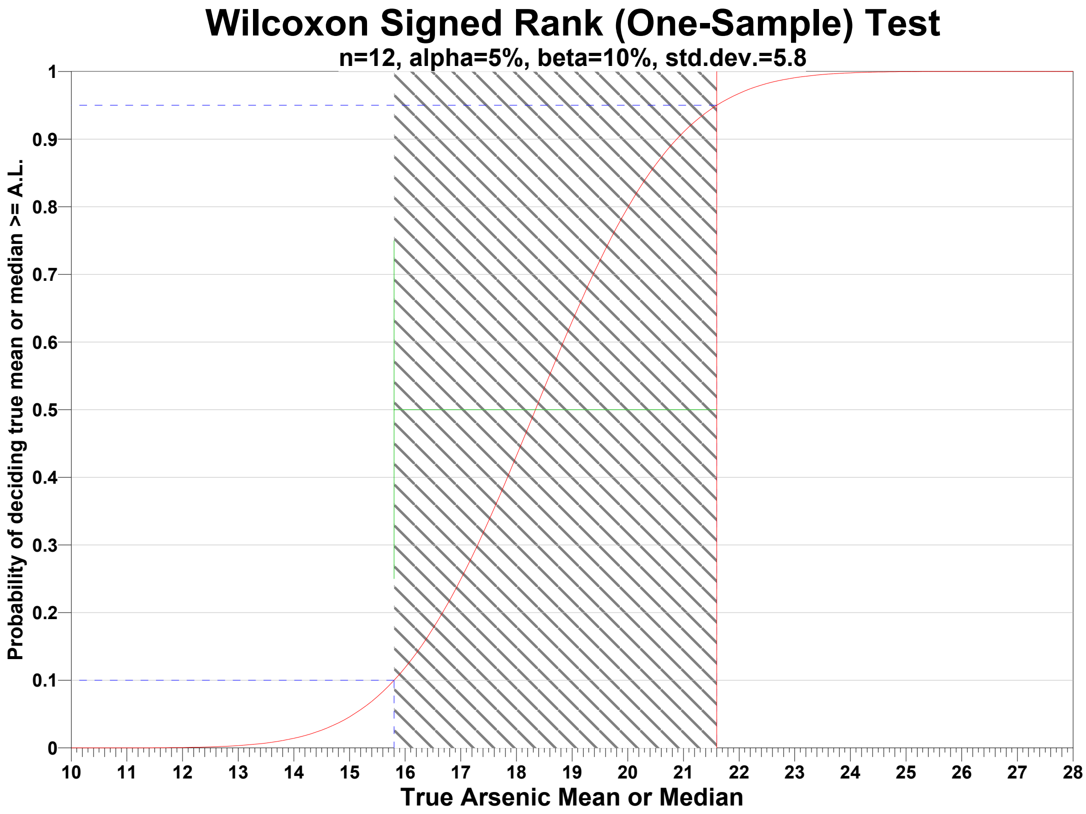
The values of these inputs that result in the calculated number of sampling locations are:

Analyte	n	Parameter					
		S	Δ	α	β	$Z_{1-\alpha}$ [a]	$Z_{1-\beta}$ [b]
Arsenic	12	5.8	5.8	0.05	0.1	1.64485	1.28155

[a] This value is automatically calculated by VSP based upon the user defined value of α.
[b] This value is automatically calculated by VSP based upon the user defined value of β.

The following figure is a performance goal diagram, described in EPA's QA/G-4 guidance (EPA, 2000). It shows the probability of concluding the sample area is dirty on the vertical axis versus a range of possible true median(mean) values for the site on the horizontal axis. This graph contains all of the inputs to the number of samples equation and pictorially represents the calculation.

The red vertical line is shown at the threshold (action limit) on the horizontal axis. The width of the gray shaded area is equal to Δ; the upper horizontal dashed blue line is positioned at 1-α on the vertical axis; the lower horizontal dashed blue line is positioned at β on the vertical axis. The vertical green line is positioned at one standard deviation below the threshold. The shape of the red curve corresponds to the estimates of variability. The calculated number of samples results in the curve that passes through the lower bound of Δ at β and the upper bound of Δ at 1-α. If any of the inputs change, the number of samples that result in the correct curve changes.



Statistical Assumptions

The assumptions associated with the formulas for computing the number of samples are:

1. the data originate from a symmetric (but not necessarily normal) population,
2. the variance estimate, S^2, is reasonable and representative of the population being sampled,
3. the population values are not spatially or temporally correlated, and
4. the sampling locations will be selected probabilistically.

The first three assumptions will be assessed in a post data collection analysis. The last assumption is valid because the gridded sample locations were selected based on a random start.

Sensitivity Analysis

The sensitivity of the calculation of number of samples was explored by varying the standard deviation, lower bound of gray region (% of action level), beta (%), probability of mistakenly concluding that μ > action level and alpha (%), probability of mistakenly concluding that μ < action level. The following table shows the results of this analysis.

Number of Samples							
AL=21.6		α=5		α=10		α=15	
		s=11.6	s=5.8	s=11.6	s=5.8	s=11.6	s=5.8
LBGR=90	β=5	364	93	288	73	242	61
	β=10	289	74	221	56	181	46
	β=15	243	62	181	46	145	37
LBGR=80	β=5	93	25	73	19	61	16
	β=10	74	20	56	15	46	12

	β=15	62	17	46	13	37	10
LBGR=70	**β=5**	42	12	33	9	28	8
	β=10	34	10	26	8	21	6
	β=15	29	9	21	6	17	5

s = Standard Deviation
LBGR = Lower Bound of Gray Region (% of Action Level)
β = Beta (%), Probability of mistakenly concluding that μ > action level
α = Alpha (%), Probability of mistakenly concluding that μ < action level
AL = Action Level (Threshold)

Cost of Sampling

The total cost of the completed sampling program depends on several cost inputs, some of which are fixed, and others that are based on the number of samples collected and measured. Based on the numbers of samples determined above, the estimated total cost of sampling and analysis at this site is $7,000.00, which averages out to a per sample cost of $583.33. The following table summarizes the inputs and resulting cost estimates.

COST INFORMATION			
Cost Details	**Per Analysis**	**Per Sample**	**12 Samples**
Field collection costs		$100.00	$1,200.00
Analytical costs	$400.00	$400.00	$4,800.00
Sum of Field & Analytical costs		**$500.00**	**$6,000.00**
Fixed planning and validation costs			$1,000.00
Total cost			**$7,000.00**

Data Analysis for Arsenic

The following data points were entered by the user for analysis.

Arsenic										
Rank	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
0	0	0	0	0	0	0	0	0	0	0
10	0	0								

SUMMARY STATISTICS for Arsenic	
n	12
Min	0
Max	0
Range	0
Mean	0
Median	0
Variance	0
StdDev	0
Std Error	0
Skewness	-1.#IND
Interquartile Range	0

Systematic sampling locations for comparing a mean with a fixed threshold (nonparametric)

Summary

This report summarizes the sampling design used, associated statistical assumptions, as well as general guidelines for conducting post-sampling data analysis. Sampling plan components presented here include how many sampling locations to choose and where within the sampling area to collect those samples. The type of medium to sample (i.e., soil, groundwater, etc.) and how to analyze the samples (in-situ, fixed laboratory, etc.) are addressed in other sections of the sampling plan.

The following table summarizes the sampling design developed. A figure that shows sampling locations in the field and a table that lists sampling location coordinates are also provided below.

SUMMARY OF SAMPLING DESIGN	
Primary Objective of Design	Compare a site mean or median to a fixed threshold
Type of Sampling Design	Nonparametric
Sample Placement (Location) in the Field	Systematic with a random start location
Working (Null) Hypothesis	The median(mean) value at the site exceeds the threshold
Formula for calculating number of sampling locations	Wilcoxon signed ranks test
Calculated total number of samples	5
Number of samples on map [a]	5
Number of selected sample areas [b]	1
Specified sampling area [c]	187521.99 m^2
Size of grid / Area of grid cell [d]	682.749 feet / 403694 ft^2
Grid pattern	Triangular
Total cost of sampling [e]	$3,500.00

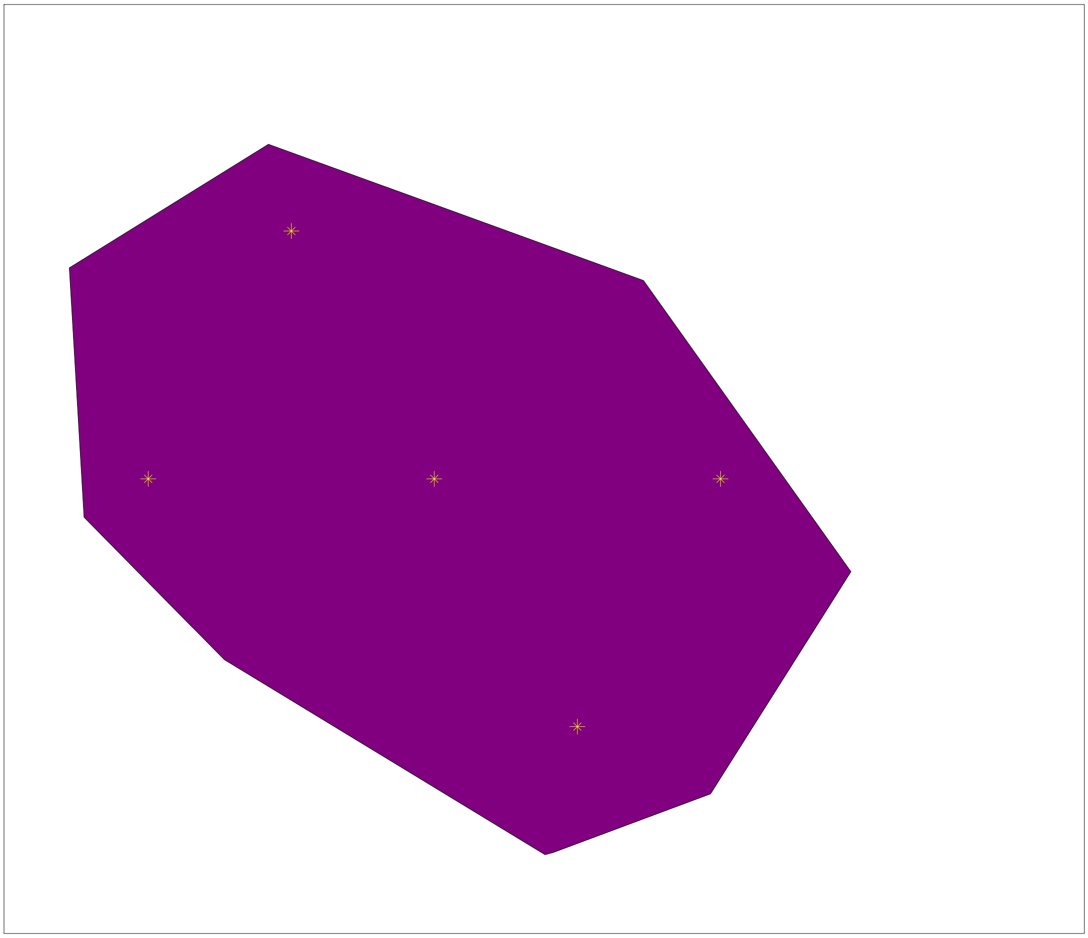
[a] This number may differ from the calculated number because of 1) grid edge effects, 2) adding judgment samples, or 3) selecting or unselecting sample areas.

[b] The number of selected sample areas is the number of colored areas on the map of the site. These sample areas contain the locations where samples are collected.

[c] The sampling area is the total surface area of the selected colored sample areas on the map of the site.

[d] Size of grid / Area of grid cell gives the linear and square dimensions of the grid used to systematically place samples.

[e] Including measurement analyses and fixed overhead costs. See the Cost of Sampling section for an explanation of the costs presented here.



Area: Glory Hole					
X Coord	**Y Coord**	**Label**	**Value**	**Type**	**Historical**
597605.6689	1274628.2573		0	Systematic	
597293.5162	1274808.4787		0	Systematic	
597501.6180	1274808.4787		0	Systematic	
597709.7198	1274808.4787		0	Systematic	
597397.5671	1274988.7002		0	Systematic	

Primary Sampling Objective

The primary purpose of sampling at this site is to compare a median or mean value with a fixed threshold. The working hypothesis (or 'null' hypothesis) is that the median(mean) value at the site is equal to or exceeds the threshold. The alternative hypothesis is that the median(mean) value is less than the threshold. VSP calculates the number of samples required to reject the null hypothesis in favor of the alternative one, given a selected sampling approach and inputs to the associated equation.

Selected Sampling Approach

A nonparametric systematic sampling approach with a random start was used to determine the number of samples and to specify sampling locations. A nonparametric formula was chosen because the conceptual model and historical information (e.g., historical data from this site or a very similar site) indicate that typical parametric assumptions may not be true.

Both parametric and non-parametric equations rely on assumptions about the population. Typically, however, non-parametric equations require fewer assumptions and allow for more uncertainty about the statistical distribution of values at the site. The trade-off is that if the parametric assumptions are valid, the required number of samples is usually less than if a non-parametric equation was used.

Locating the sample points over a systematic grid with a random start ensures spatial coverage of the site. Statistical analyses of systematically collected data are valid if a random start to the grid is used. One disadvantage of systematically collected samples is that spatial variability or patterns may not be discovered if the grid spacing is large relative to the spatial patterns.

Number of Total Samples: Calculation Equation and Inputs
The equation used to calculate the number of samples is based on a Wilcoxon Signed Ranks test. For this site, the null hypothesis is rejected in favor of the alternative one if the sample median(mean) is sufficiently smaller than the threshold. The number of samples to collect is calculated so that if the inputs to the equation are true, the calculated number of samples will cause the null hypothesis to be rejected.

The formula used to calculate the number of samples is:

$$n = 1.16\left[\frac{\left(S_{sample}^{2} + \frac{S_{analytical}^{2}}{r}\right)}{\Delta^{2}}\left(Z_{1-\alpha} + Z_{1-\beta}\right)^{2} + 0.5 Z_{1-\alpha}^{2}\right]$$

where

n	is the number of samples,
S	is the estimated standard deviation of the measured values including analytical error,
Δ	is the width of the gray region,
α	is the acceptable probability of incorrectly concluding the site median(mean) is less than the threshold,
β	is the acceptable probability of incorrectly concluding the site median(mean) exceeds the threshold,
$Z_{1-\alpha}$	is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\alpha}$ is 1-α,
$Z_{1-\beta}$	is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\beta}$ is 1-β.

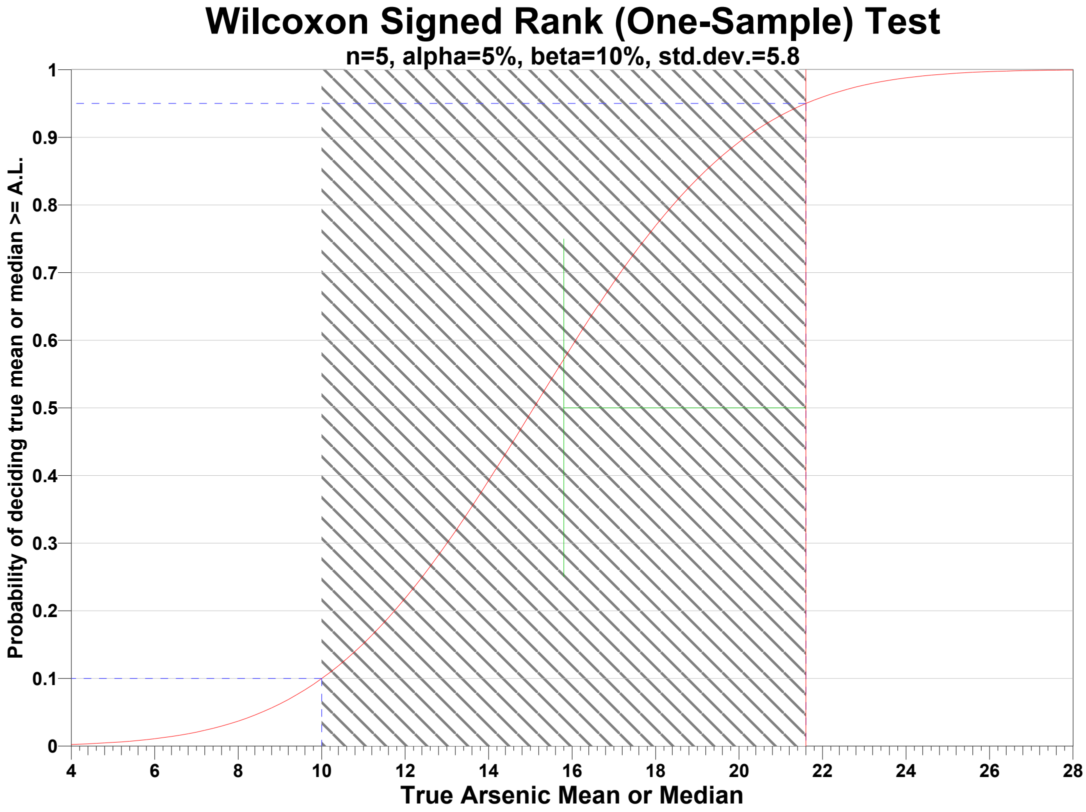
The values of these inputs that result in the calculated number of sampling locations are:

Analyte	n	Parameter					
		S	Δ	α	β	**$Z_{1-\alpha}$** [a]	**$Z_{1-\beta}$** [b]
Arsenic	5	5.8	11.6	0.05	0.1	1.64485	1.28155

[a] This value is automatically calculated by VSP based upon the user defined value of α.
[b] This value is automatically calculated by VSP based upon the user defined value of β.

The following figure is a performance goal diagram, described in EPA's QA/G-4 guidance (EPA, 2000). It shows the probability of concluding the sample area is dirty on the vertical axis versus a range of possible true median(mean) values for the site on the horizontal axis. This graph contains all of the inputs to the number of samples equation and pictorially represents the calculation.

The red vertical line is shown at the threshold (action limit) on the horizontal axis. The width of the gray shaded area is equal to Δ; the upper horizontal dashed blue line is positioned at 1-α on the vertical axis; the lower horizontal dashed blue line is positioned at β on the vertical axis. The vertical green line is positioned at one standard deviation below the threshold. The shape of the red curve corresponds to the estimates of variability. The calculated number of samples results in the curve that passes through the lower bound of Δ at β and the upper bound of Δ at 1-α. If any of the inputs change, the number of samples that result in the correct curve changes.



Statistical Assumptions

The assumptions associated with the formulas for computing the number of samples are:

1. the data originate from a symmetric (but not necessarily normal) population,
2. the variance estimate, S^2, is reasonable and representative of the population being sampled,
3. the population values are not spatially or temporally correlated, and
4. the sampling locations will be selected probabilistically.

The first three assumptions will be assessed in a post data collection analysis. The last assumption is valid because the gridded sample locations were selected based on a random start.

Sensitivity Analysis

The sensitivity of the calculation of number of samples was explored by varying the standard deviation, lower bound of gray region (% of action level), beta (%), probability of mistakenly concluding that μ > action level and alpha (%), probability of mistakenly concluding that μ < action level. The following table shows the results of this analysis.

Number of Samples							
AL=21.6		**α=5**		**α=10**		**α=15**	
		s=11.6	**s=5.8**	**s=11.6**	**s=5.8**	**s=11.6**	**s=5.8**
LBGR=90	**β=5**	364	93	288	73	242	61
	β=10	289	74	221	56	181	46
	β=15	243	62	181	46	145	37
LBGR=80	**β=5**	93	25	73	19	61	16
	β=10	74	20	56	15	46	12
	β=15	62	17	46	13	37	10
LBGR=70	**β=5**	42	12	33	9	28	8
	β=10	34	10	26	8	21	6
	β=15	29	9	21	6	17	5

s = Standard Deviation
LBGR = Lower Bound of Gray Region (% of Action Level)
β = Beta (%), Probability of mistakenly concluding that μ > action level
α = Alpha (%), Probability of mistakenly concluding that μ < action level
AL = Action Level (Threshold)

Cost of Sampling
The total cost of the completed sampling program depends on several cost inputs, some of which are fixed, and others that are based on the number of samples collected and measured. Based on the numbers of samples determined above, the estimated total cost of sampling and analysis at this site is $3,500.00, which averages out to a per sample cost of $700.00. The following table summarizes the inputs and resulting cost estimates.

COST INFORMATION			
Cost Details	**Per Analysis**	**Per Sample**	**5 Samples**
Field collection costs		$100.00	$500.00
Analytical costs	$400.00	$400.00	$2,000.00
Sum of Field & Analytical costs		**$500.00**	**$2,500.00**
Fixed planning and validation costs			$1,000.00
Total cost			**$3,500.00**

Data Analysis for Arsenic
The following data points were entered by the user for analysis.

Arsenic										
Rank	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
0	0	0	0	0	0					

SUMMARY STATISTICS for Arsenic	
n	5
Min	0
Max	0
Range	0
Mean	0
Median	0
Variance	0
StdDev	0
Std Error	0
Skewness	-1.#IND
Interquartile Range	0

Percentiles								
1%	**5%**	**10%**	**25%**	**50%**	**75%**	**90%**	**95%**	**99%**
0	0	0	0	0	0	0	0	0

Data Plots
Three graphical displays of the data are shown below: the Histogram, the Box and Whiskers plot, and the

Systematic sampling locations for comparing a mean with a fixed threshold (nonparametric)

Summary

This report summarizes the sampling design used, associated statistical assumptions, as well as general guidelines for conducting post-sampling data analysis. Sampling plan components presented here include how many sampling locations to choose and where within the sampling area to collect those samples. The type of medium to sample (i.e., soil, groundwater, etc.) and how to analyze the samples (in-situ, fixed laboratory, etc.) are addressed in other sections of the sampling plan.

The following table summarizes the sampling design developed. A figure that shows sampling locations in the field and a table that lists sampling location coordinates are also provided below.

SUMMARY OF SAMPLING DESIGN	
Primary Objective of Design	Compare a site mean or median to a fixed threshold
Type of Sampling Design	Nonparametric
Sample Placement (Location) in the Field	Systematic with a random start location
Working (Null) Hypothesis	The median(mean) value at the site exceeds the threshold
Formula for calculating number of sampling locations	Wilcoxon signed ranks test
Calculated total number of samples	5
Number of samples on map [a]	5
Number of selected sample areas [b]	1
Specified sampling area [c]	217920.95 m^2
Size of grid / Area of grid cell [d]	736.011 feet / 469136 ft^2
Grid pattern	Triangular
Total cost of sampling [e]	$3,500.00

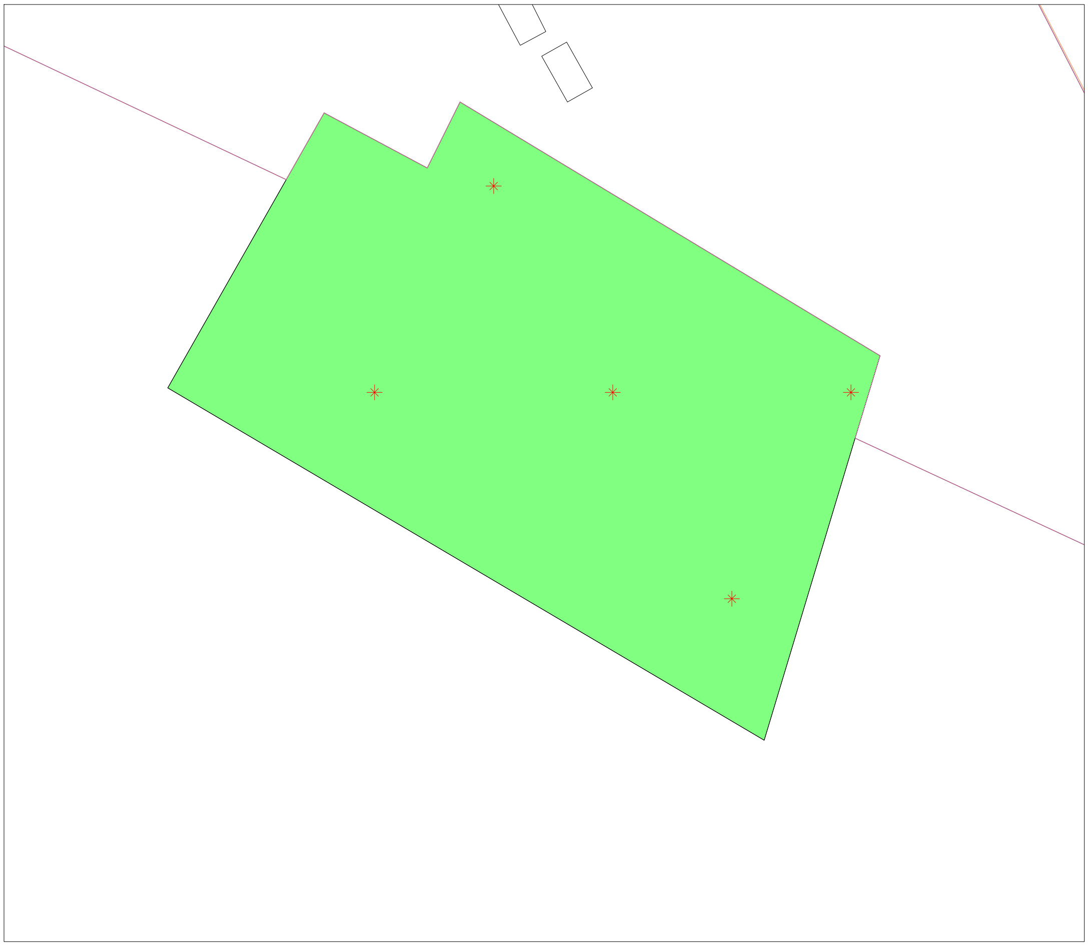
[a] This number may differ from the calculated number because of 1) grid edge effects, 2) adding judgment samples, or 3) selecting or unselecting sample areas.

[b] The number of selected sample areas is the number of colored areas on the map of the site. These sample areas contain the locations where samples are collected.

[c] The sampling area is the total surface area of the selected colored sample areas on the map of the site.

[d] Size of grid / Area of grid cell gives the linear and square dimensions of the grid used to systematically place samples.

[e] Including measurement analyses and fixed overhead costs. See the Cost of Sampling section for an explanation of the costs presented here.



Area: Former Fertilizer Plant Area					
X Coord	**Y Coord**	**Label**	**Value**	**Type**	**Historical**
597560.1041	1273373.8322		0	Systematic	
597223.5999	1273568.1130		0	Systematic	
597447.9360	1273568.1130		0	Systematic	
597672.2721	1273568.1130		0	Systematic	
597335.7680	1273762.3937		0	Systematic	

Primary Sampling Objective

The primary purpose of sampling at this site is to compare a median or mean value with a fixed threshold. The working hypothesis (or 'null' hypothesis) is that the median(mean) value at the site is equal to or exceeds the threshold. The alternative hypothesis is that the median(mean) value is less than the threshold. VSP calculates the number of samples required to reject the null hypothesis in favor of the alternative one, given a selected sampling approach and inputs to the associated equation.

Selected Sampling Approach

A nonparametric systematic sampling approach with a random start was used to determine the number of samples and to specify sampling locations. A nonparametric formula was chosen because the conceptual model and historical information (e.g., historical data from this site or a very similar site) indicate that typical parametric assumptions may not be true.

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Number of Total Samples: Calculation Equation and Inputs
The equation used to calculate the number of samples is based on a Wilcoxon Signed Ranks test. For this site, the null hypothesis is rejected in favor of the alternative one if the sample median(mean) is sufficiently smaller than the threshold. The number of samples to collect is calculated so that if the inputs to the equation are true, the calculated number of samples will cause the null hypothesis to be rejected.

The formula used to calculate the number of samples is:

$$n = 1.16\left[\frac{\left(S_{sample}^{2} + \frac{S_{analytical}^{2}}{r}\right)}{\Delta^{2}}\left(Z_{1-\alpha} + Z_{1-\beta}\right)^{2} + 0.5Z_{1-\alpha}^{2}\right]$$

where

n	is the number of samples,
S	is the estimated standard deviation of the measured values including analytical error,
Δ	is the width of the gray region,
α	is the acceptable probability of incorrectly concluding the site median(mean) is less than the threshold,
β	is the acceptable probability of incorrectly concluding the site median(mean) exceeds the threshold,
$Z_{1-\alpha}$	is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\alpha}$ is $1-\alpha$,
$Z_{1-\beta}$	is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\beta}$ is $1-\beta$.

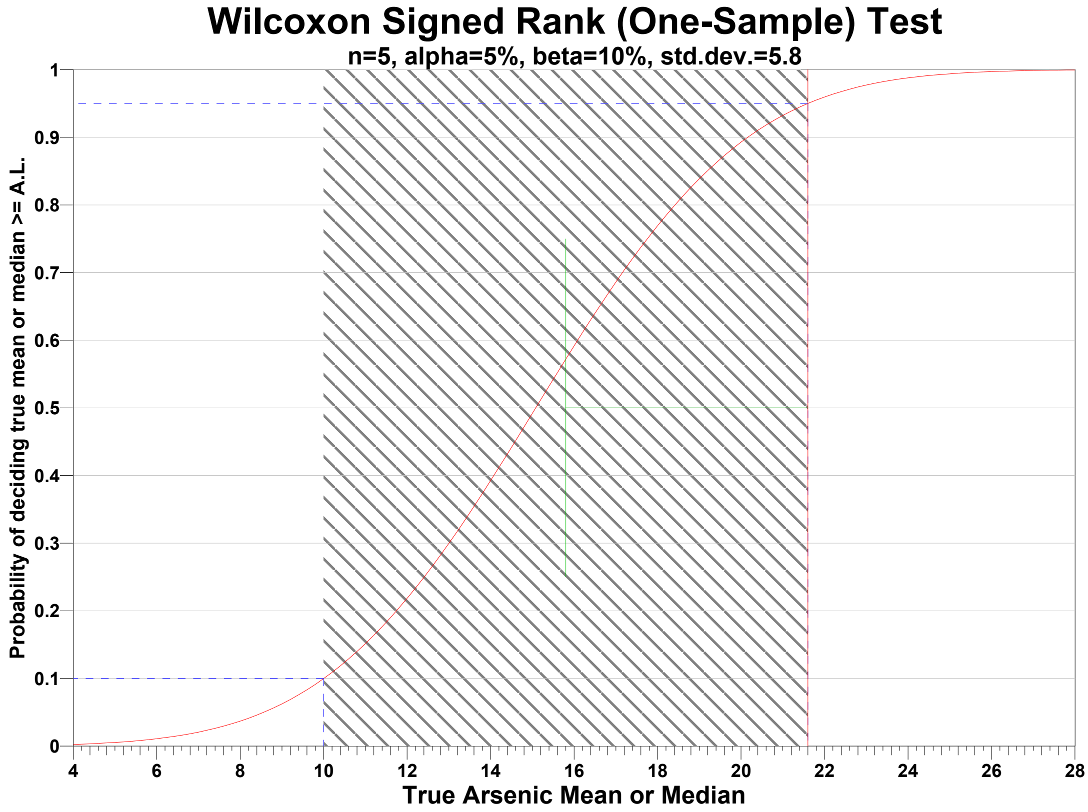
The values of these inputs that result in the calculated number of sampling locations are:

Analyte	**n**	**Parameter**					
		S	Δ	α	β	$Z_{1-\alpha}$ [a]	$Z_{1-\beta}$ [b]
Arsenic	5	5.8	11.6	0.05	0.1	1.64485	1.28155

[a] This value is automatically calculated by VSP based upon the user defined value of α.
[b] This value is automatically calculated by VSP based upon the user defined value of β.

The following figure is a performance goal diagram, described in EPA's QA/G-4 guidance (EPA, 2000). It shows the probability of concluding the sample area is dirty on the vertical axis versus a range of possible true median(mean) values for the site on the horizontal axis. This graph contains all of the inputs to the number of samples equation and pictorially represents the calculation.

The red vertical line is shown at the threshold (action limit) on the horizontal axis. The width of the gray shaded area is equal to Δ; the upper horizontal dashed blue line is positioned at $1-\alpha$ on the vertical axis; the lower horizontal dashed blue line is positioned at β on the vertical axis. The vertical green line is positioned at one standard deviation below the threshold. The shape of the red curve corresponds to the estimates of variability. The calculated number of samples results in the curve that passes through the lower bound of Δ at β and the upper bound of Δ at $1-\alpha$. If any of the inputs change, the number of samples that result in the correct curve changes.



Statistical Assumptions
The assumptions associated with the formulas for computing the number of samples are:

1. the data originate from a symmetric (but not necessarily normal) population,
2. the variance estimate, S^2, is reasonable and representative of the population being sampled,
3. the population values are not spatially or temporally correlated, and
4. the sampling locations will be selected probabilistically.

The first three assumptions will be assessed in a post data collection analysis. The last assumption is valid because the gridded sample locations were selected based on a random start.

Sensitivity Analysis
The sensitivity of the calculation of number of samples was explored by varying the standard deviation, lower bound of gray region (% of action level), beta (%), probability of mistakenly concluding that μ > action level and alpha (%), probability of mistakenly concluding that μ < action level. The following table shows the results of this analysis.

Number of Samples							
AL=21.6		**α=5**		**α=10**		**α=15**	
		s=11.6	**s=5.8**	**s=11.6**	**s=5.8**	**s=11.6**	**s=5.8**
LBGR=90	**β=5**	364	93	288	73	242	61
	β=10	289	74	221	56	181	46
	β=15	243	62	181	46	145	37
LBGR=80	**β=5**	93	25	73	19	61	16
	β=10	74	20	56	15	46	12
	β=15	62	17	46	13	37	10
LBGR=70	**β=5**	42	12	33	9	28	8
	β=10	34	10	26	8	21	6
	β=15	29	9	21	6	17	5

s = Standard Deviation
LBGR = Lower Bound of Gray Region (% of Action Level)
β = Beta (%), Probability of mistakenly concluding that μ > action level
α = Alpha (%), Probability of mistakenly concluding that μ < action level
AL = Action Level (Threshold)

Cost of Sampling

The total cost of the completed sampling program depends on several cost inputs, some of which are fixed, and others that are based on the number of samples collected and measured. Based on the numbers of samples determined above, the estimated total cost of sampling and analysis at this site is $3,500.00, which averages out to a per sample cost of $700.00. The following table summarizes the inputs and resulting cost estimates.

<table>
<tr><th colspan="4">COST INFORMATION</th></tr>
<tr><th>Cost Details</th><th>Per Analysis</th><th>Per Sample</th><th>5 Samples</th></tr>
<tr><td>Field collection costs</td><td></td><td>$100.00</td><td>$500.00</td></tr>
<tr><td>Analytical costs</td><td>$400.00</td><td>$400.00</td><td>$2,000.00</td></tr>
<tr><td>Sum of Field & Analytical costs</td><td></td><td>$500.00</td><td>$2,500.00</td></tr>
<tr><td>Fixed planning and validation costs</td><td></td><td></td><td>$1,000.00</td></tr>
<tr><td>Total cost</td><td></td><td></td><td>$3,500.00</td></tr>
</table>

Data Analysis for Arsenic

The following data points were entered by the user for analysis.

<table>
<tr><th colspan="11">Arsenic</th></tr>
<tr><th>Rank</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>9</th><th>10</th></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

<table>
<tr><th colspan="9">SUMMARY STATISTICS for Arsenic</th></tr>
<tr><td colspan="4">n</td><td colspan="5">5</td></tr>
<tr><td colspan="4">Min</td><td colspan="5">0</td></tr>
<tr><td colspan="4">Max</td><td colspan="5">0</td></tr>
<tr><td colspan="4">Range</td><td colspan="5">0</td></tr>
<tr><td colspan="4">Mean</td><td colspan="5">0</td></tr>
<tr><td colspan="4">Median</td><td colspan="5">0</td></tr>
<tr><td colspan="4">Variance</td><td colspan="5">0</td></tr>
<tr><td colspan="4">StdDev</td><td colspan="5">0</td></tr>
<tr><td colspan="4">Std Error</td><td colspan="5">0</td></tr>
<tr><td colspan="4">Skewness</td><td colspan="5">-1.#IND</td></tr>
<tr><td colspan="4">Interquartile Range</td><td colspan="5">0</td></tr>
<tr><th colspan="9">Percentiles</th></tr>
<tr><th>1%</th><th>5%</th><th>10%</th><th>25%</th><th>50%</th><th>75%</th><th>90%</th><th>95%</th><th>99%</th></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
</table>

Data Plots

Three graphical displays of the data are shown below: the Histogram, the Box and Whiskers plot, and the

Systematic sampling locations for comparing a mean with a fixed threshold (nonparametric)

Summary

This report summarizes the sampling design used, associated statistical assumptions, as well as general guidelines for conducting post-sampling data analysis. Sampling plan components presented here include how many sampling locations to choose and where within the sampling area to collect those samples. The type of medium to sample (i.e., soil, groundwater, etc.) and how to analyze the samples (in-situ, fixed laboratory, etc.) are addressed in other sections of the sampling plan.

The following table summarizes the sampling design developed. A figure that shows sampling locations in the field and a table that lists sampling location coordinates are also provided below.

SUMMARY OF SAMPLING DESIGN	
Primary Objective of Design	Compare a site mean or median to a fixed threshold
Type of Sampling Design	Nonparametric
Sample Placement (Location) in the Field	Systematic with a random start location
Working (Null) Hypothesis	The median(mean) value at the site exceeds the threshold
Formula for calculating number of sampling locations	Wilcoxon signed ranks test
Calculated total number of samples	12
Number of samples on map [a]	12
Number of selected sample areas [b]	1
Specified sampling area [c]	7483702.20 m^2
Size of grid / Area of grid cell [d]	2784.12 feet / 6.71282e+006 ft^2
Grid pattern	Triangular
Total cost of sampling [e]	$7,000.00

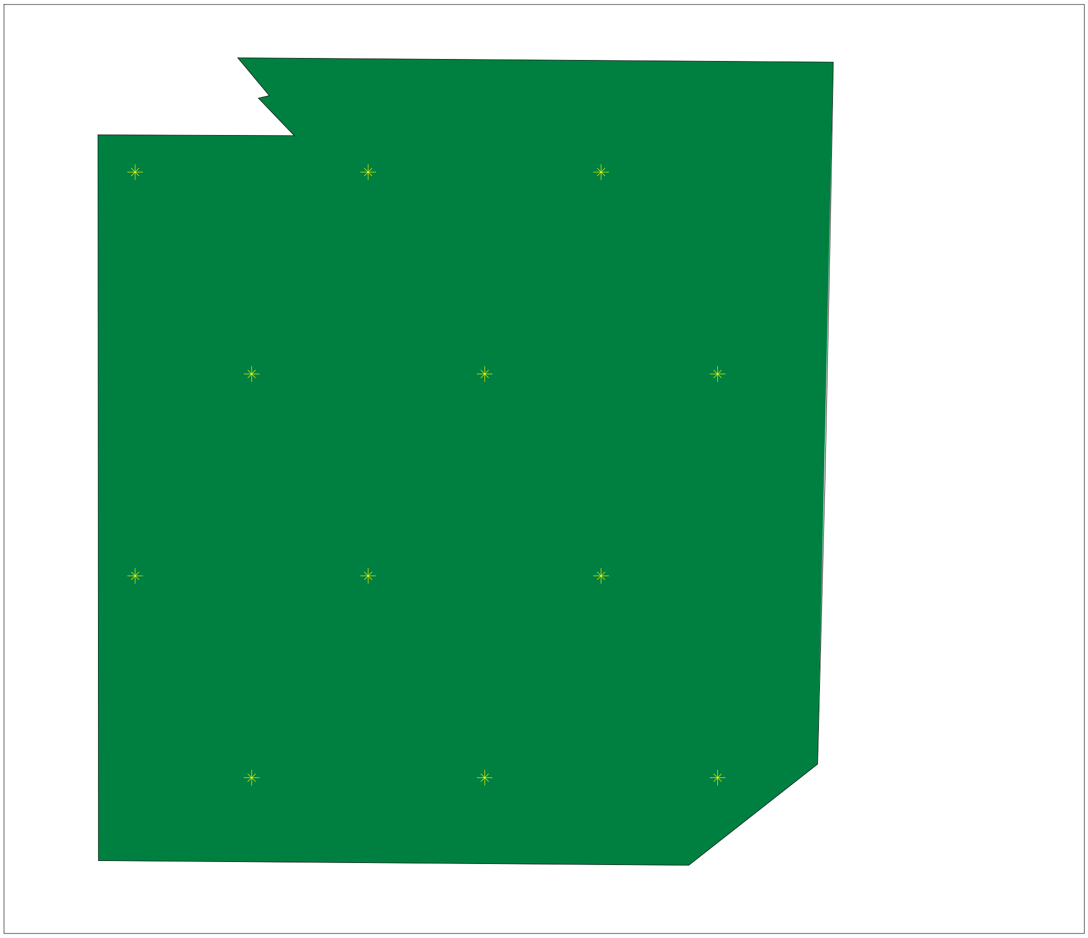
[a] This number may differ from the calculated number because of 1) grid edge effects, 2) adding judgment samples, or 3) selecting or unselecting sample areas.

[b] The number of selected sample areas is the number of colored areas on the map of the site. These sample areas contain the locations where samples are collected.

[c] The sampling area is the total surface area of the selected colored sample areas on the map of the site.

[d] Size of grid / Area of grid cell gives the linear and square dimensions of the grid used to systematically place samples.

[e] Including measurement analyses and fixed overhead costs. See the Cost of Sampling section for an explanation of the costs presented here.



Area: Humboldt Smelter					
X Coord	**Y Coord**	**Label**	**Value**	**Type**	**Historical**
603746.2754	1270773.1332		0	Systematic	
604594.8740	1270773.1332		0	Systematic	
605443.4726	1270773.1332		0	Systematic	
603321.9761	1271508.0412		0	Systematic	
604170.5747	1271508.0412		0	Systematic	
605019.1733	1271508.0412		0	Systematic	
603746.2754	1272242.9491		0	Systematic	
604594.8740	1272242.9491		0	Systematic	
605443.4726	1272242.9491		0	Systematic	
603321.9761	1272977.8571		0	Systematic	
604170.5747	1272977.8571		0	Systematic	
605019.1733	1272977.8571		0	Systematic	

Primary Sampling Objective
The primary purpose of sampling at this site is to compare a median or mean value with a fixed threshold. The working hypothesis (or 'null' hypothesis) is that the median(mean) value at the site is equal to or exceeds the threshold. The alternative hypothesis is that the median(mean) value is less than the threshold. VSP calculates the number of samples required to reject the null hypothesis in favor of the alternative one, given a selected sampling approach and inputs to the associated equation.

Selected Sampling Approach

A nonparametric systematic sampling approach with a random start was used to determine the number of samples and to specify sampling locations. A nonparametric formula was chosen because the conceptual model and historical information (e.g., historical data from this site or a very similar site) indicate that typical parametric assumptions may not be true.

Both parametric and non-parametric equations rely on assumptions about the population. Typically, however, non-parametric equations require fewer assumptions and allow for more uncertainty about the statistical distribution of values at the site. The trade-off is that if the parametric assumptions are valid, the required number of samples is usually less than if a non-parametric equation was used.

Locating the sample points over a systematic grid with a random start ensures spatial coverage of the site. Statistical analyses of systematically collected data are valid if a random start to the grid is used. One disadvantage of systematically collected samples is that spatial variability or patterns may not be discovered if the grid spacing is large relative to the spatial patterns.

Number of Total Samples: Calculation Equation and Inputs

The equation used to calculate the number of samples is based on a Wilcoxon Signed Ranks test. For this site, the null hypothesis is rejected in favor of the alternative one if the sample median(mean) is sufficiently smaller than the threshold. The number of samples to collect is calculated so that if the inputs to the equation are true, the calculated number of samples will cause the null hypothesis to be rejected.

The formula used to calculate the number of samples is:

$$n = 1.16\left[\frac{\left(S_{sample}^2 + \frac{S_{analytical}^2}{r}\right)}{\Delta^2}\left(Z_{1-\alpha} + Z_{1-\beta}\right)^2 + 0.5 Z_{1-\alpha}^2\right]$$

where

n is the number of samples,

S is the estimated standard deviation of the measured values including analytical error,

Δ is the width of the gray region,

α is the acceptable probability of incorrectly concluding the site median(mean) is less than the threshold,

β is the acceptable probability of incorrectly concluding the site median(mean) exceeds the threshold,

$Z_{1-\alpha}$ is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\alpha}$ is $1-\alpha$,

$Z_{1-\beta}$ is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\beta}$ is $1-\beta$.

The values of these inputs that result in the calculated number of sampling locations are:

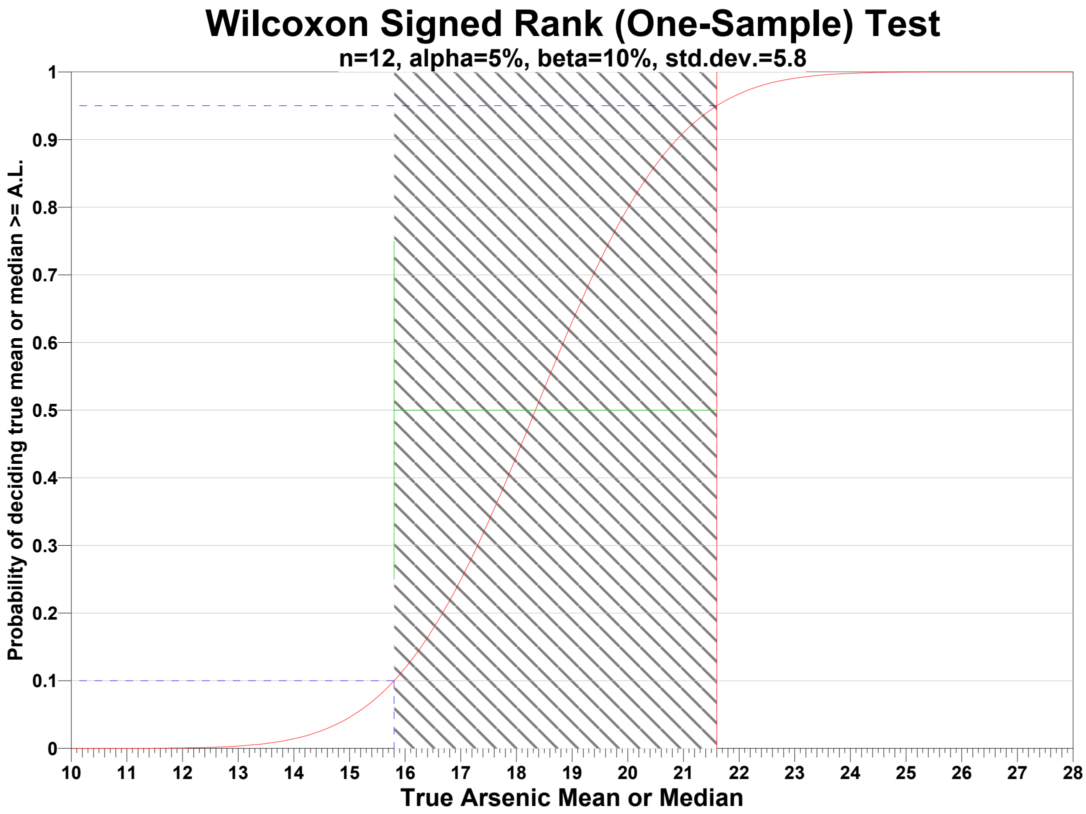
Analyte	n	Parameter					
		S	Δ	α	β	**$Z_{1-\alpha}$** [a]	**$Z_{1-\beta}$** [b]
Arsenic	12	5.8	5.8	0.05	0.1	1.64485	1.28155

[a] This value is automatically calculated by VSP based upon the user defined value of α.

[b] This value is automatically calculated by VSP based upon the user defined value of β.

The following figure is a performance goal diagram, described in EPA's QA/G-4 guidance (EPA, 2000). It shows the probability of concluding the sample area is dirty on the vertical axis versus a range of possible true median(mean) values for the site on the horizontal axis. This graph contains all of the inputs to the number of samples equation and pictorially represents the calculation.

The red vertical line is shown at the threshold (action limit) on the horizontal axis. The width of the gray shaded area is equal to Δ; the upper horizontal dashed blue line is positioned at $1-\alpha$ on the vertical axis; the lower horizontal dashed blue line is positioned at β on the vertical axis. The vertical green line is positioned at one standard deviation below the threshold. The shape of the red curve corresponds to the estimates of variability. The calculated number of samples results in the curve that passes through the lower bound of Δ at β and the upper bound of Δ at $1-\alpha$. If any of the inputs change, the number of samples that result in the correct curve changes.



Statistical Assumptions

The assumptions associated with the formulas for computing the number of samples are:

1. the data originate from a symmetric (but not necessarily normal) population,
2. the variance estimate, S^2, is reasonable and representative of the population being sampled,
3. the population values are not spatially or temporally correlated, and
4. the sampling locations will be selected probabilistically.

The first three assumptions will be assessed in a post data collection analysis. The last assumption is valid because the gridded sample locations were selected based on a random start.

Sensitivity Analysis

The sensitivity of the calculation of number of samples was explored by varying the standard deviation, lower bound of gray region (% of action level), beta (%), probability of mistakenly concluding that μ > action level and alpha (%), probability of mistakenly concluding that μ < action level. The following table shows the results of this analysis.

Number of Samples							
AL=21.6		**α=5**		**α=10**		**α=15**	
		s=11.6	**s=5.8**	**s=11.6**	**s=5.8**	**s=11.6**	**s=5.8**
LBGR=90	**β=5**	364	93	288	73	242	61
	β=10	289	74	221	56	181	46
	β=15	243	62	181	46	145	37
LBGR=80	**β=5**	93	25	73	19	61	16
	β=10	74	20	56	15	46	12
	β=15	62	17	46	13	37	10
LBGR=70	**β=5**	42	12	33	9	28	8

	β=10	34	10	26	8	21	6
	β=15	29	9	21	6	17	5

s = Standard Deviation
LBGR = Lower Bound of Gray Region (% of Action Level)
β = Beta (%), Probability of mistakenly concluding that μ > action level
α = Alpha (%), Probability of mistakenly concluding that μ < action level
AL = Action Level (Threshold)

Cost of Sampling

The total cost of the completed sampling program depends on several cost inputs, some of which are fixed, and others that are based on the number of samples collected and measured. Based on the numbers of samples determined above, the estimated total cost of sampling and analysis at this site is $7,000.00, which averages out to a per sample cost of $583.33. The following table summarizes the inputs and resulting cost estimates.

COST INFORMATION			
Cost Details	**Per Analysis**	**Per Sample**	**12 Samples**
Field collection costs		$100.00	$1,200.00
Analytical costs	$400.00	$400.00	$4,800.00
Sum of Field & Analytical costs		**$500.00**	**$6,000.00**
Fixed planning and validation costs			$1,000.00
Total cost			**$7,000.00**

Data Analysis for Arsenic

The following data points were entered by the user for analysis.

Arsenic										
Rank	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0
40	0	0								

SUMMARY STATISTICS for Arsenic	
n	42
Min	0
Max	0
Range	0
Mean	0
Median	0
Variance	0
StdDev	0
Std Error	0
Skewness	-1.#IND

Systematic sampling locations for comparing a mean with a fixed threshold (nonparametric)

Summary

This report summarizes the sampling design used, associated statistical assumptions, as well as general guidelines for conducting post-sampling data analysis. Sampling plan components presented here include how many sampling locations to choose and where within the sampling area to collect those samples. The type of medium to sample (i.e., soil, groundwater, etc.) and how to analyze the samples (in-situ, fixed laboratory, etc.) are addressed in other sections of the sampling plan.

The following table summarizes the sampling design developed. A figure that shows sampling locations in the field and a table that lists sampling location coordinates are also provided below.

SUMMARY OF SAMPLING DESIGN	
Primary Objective of Design	Compare a site mean or median to a fixed threshold
Type of Sampling Design	Nonparametric
Sample Placement (Location) in the Field	Systematic with a random start location
Working (Null) Hypothesis	The median(mean) value at the site exceeds the threshold
Formula for calculating number of sampling locations	Wilcoxon signed ranks test
Calculated total number of samples	5
Number of samples on map [a]	5
Number of selected sample areas [b]	1
Specified sampling area [c]	850721.28 ft^2
Size of grid / Area of grid cell [d]	443.244 feet / 170144 ft^2
Grid pattern	Triangular
Total cost of sampling [e]	$3,500.00

[a] This number may differ from the calculated number because of 1) grid edge effects, 2) adding judgment samples, or 3) selecting or unselecting sample areas.

[b] The number of selected sample areas is the number of colored areas on the map of the site. These sample areas contain the locations where samples are collected.

[c] The sampling area is the total surface area of the selected colored sample areas on the map of the site.

[d] Size of grid / Area of grid cell gives the linear and square dimensions of the grid used to systematically place samples.

[e] Including measurement analyses and fixed overhead costs. See the Cost of Sampling section for an explanation of the costs presented here.

Area: Humboldt Smelter - Tailings					
X Coord	**Y Coord**	**Label**	**Value**	**Type**	**Historical**
604461.8107	1271154.5900		0	Systematic	
603796.9440	1271538.4509		0	Systematic	
603575.3218	1271922.3119		0	Systematic	
603796.9440	1272306.1729		0	Systematic	
603575.3218	1272690.0339		0	Systematic	

Primary Sampling Objective

The primary purpose of sampling at this site is to compare a median or mean value with a fixed threshold. The working hypothesis (or 'null' hypothesis) is that the median(mean) value at the site is equal to or exceeds the threshold. The alternative hypothesis is that the median(mean) value is less than the threshold. VSP calculates the number of samples required to reject the null hypothesis in favor of the alternative one, given a selected sampling approach and inputs to the associated equation.

Selected Sampling Approach

A nonparametric systematic sampling approach with a random start was used to determine the number of samples and to specify sampling locations. A nonparametric formula was chosen because the conceptual model and historical information (e.g., historical data from this site or a very similar site) indicate that typical parametric assumptions may not be true.

Both parametric and non-parametric equations rely on assumptions about the population. Typically, however, non-parametric equations require fewer assumptions and allow for more uncertainty about the statistical distribution of values at the site. The trade-off is that if the parametric assumptions are valid, the required number of samples is usually less than if a non-parametric equation was used.

Locating the sample points over a systematic grid with a random start ensures spatial coverage of the site. Statistical analyses of systematically collected data are valid if a random start to the grid is used. One disadvantage of systematically collected samples is that spatial variability or patterns may not be discovered if the grid spacing is large relative to the spatial patterns.

Number of Total Samples: Calculation Equation and Inputs

The equation used to calculate the number of samples is based on a Wilcoxon Signed Ranks test. For this site, the null hypothesis is rejected in favor of the alternative one if the sample median(mean) is sufficiently smaller than the threshold. The number of samples to collect is calculated so that if the inputs to the equation are true, the calculated number of samples will cause the null hypothesis to be rejected.

The formula used to calculate the number of samples is:

$$n = 1.16\left[\frac{\left(S_{sample}^{2} + \frac{S_{analytical}^{2}}{r}\right)}{\Delta^{2}}\left(Z_{1-\alpha} + Z_{1-\beta}\right)^{2} + 0.5Z_{1-\alpha}^{2}\right]$$

where

n	is the number of samples,
S	is the estimated standard deviation of the measured values including analytical error,
Δ	is the width of the gray region,
α	is the acceptable probability of incorrectly concluding the site median(mean) is less than the threshold,
β	is the acceptable probability of incorrectly concluding the site median(mean) exceeds the threshold,
$Z_{1-\alpha}$	is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\alpha}$ is 1-α,
$Z_{1-\beta}$	is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\beta}$ is 1-β.

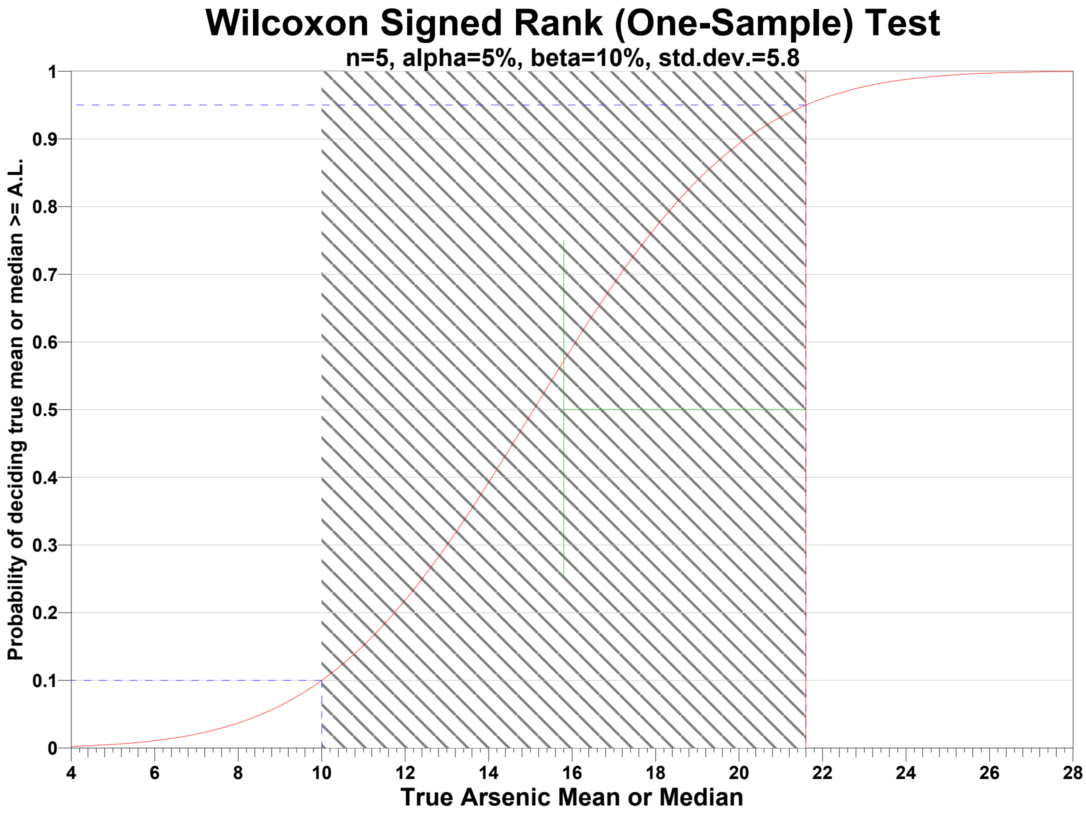
The values of these inputs that result in the calculated number of sampling locations are:

Analyte	**n**	**Parameter**					
		S	Δ	α	β	$Z_{1-\alpha}$ [a]	$Z_{1-\beta}$ [b]
Arsenic	5	5.8	11.6	0.05	0.1	1.64485	1.28155

[a] This value is automatically calculated by VSP based upon the user defined value of α.
[b] This value is automatically calculated by VSP based upon the user defined value of β.

The following figure is a performance goal diagram, described in EPA's QA/G-4 guidance (EPA, 2000). It shows the probability of concluding the sample area is dirty on the vertical axis versus a range of possible true median(mean) values for the site on the horizontal axis. This graph contains all of the inputs to the number of samples equation and pictorially represents the calculation.

The red vertical line is shown at the threshold (action limit) on the horizontal axis. The width of the gray shaded area is equal to Δ; the upper horizontal dashed blue line is positioned at 1-α on the vertical axis; the lower horizontal dashed blue line is positioned at β on the vertical axis. The vertical green line is positioned at one standard deviation below the threshold. The shape of the red curve corresponds to the estimates of variability. The calculated number of samples results in the curve that passes through the lower bound of Δ at β and the upper bound of Δ at 1-α. If any of the inputs change, the number of samples that result in the correct curve changes.



Statistical Assumptions

The assumptions associated with the formulas for computing the number of samples are:

1. the data originate from a symmetric (but not necessarily normal) population,
2. the variance estimate, S^2, is reasonable and representative of the population being sampled,
3. the population values are not spatially or temporally correlated, and
4. the sampling locations will be selected probabilistically.

The first three assumptions will be assessed in a post data collection analysis. The last assumption is valid because the gridded sample locations were selected based on a random start.

Sensitivity Analysis

The sensitivity of the calculation of number of samples was explored by varying the lower bound of gray region (% of action level), beta (%), probability of mistakenly concluding that μ > action level and alpha (%), probability of mistakenly concluding that μ < action level. The following table shows the results of this analysis.

Number of Samples				
AL=21.6		**α=5**	**α=10**	**α=15**
LBGR=90	**β=5**	93	73	61
	β=10	74	56	46
	β=15	62	46	37
LBGR=80	**β=5**	25	19	16
	β=10	20	15	12
	β=15	17	13	10
LBGR=70	**β=5**	12	9	8
	β=10	10	8	6
	β=15	9	6	5

LBGR = Lower Bound of Gray Region (% of Action Level)
β = Beta (%), Probability of mistakenly concluding that μ > action level
α = Alpha (%), Probability of mistakenly concluding that μ < action level
AL = Action Level (Threshold)

Cost of Sampling
The total cost of the completed sampling program depends on several cost inputs, some of which are fixed, and others that are based on the number of samples collected and measured. Based on the numbers of samples determined above, the estimated total cost of sampling and analysis at this site is $3,500.00, which averages out to a per sample cost of $700.00. The following table summarizes the inputs and resulting cost estimates.

COST INFORMATION			
Cost Details	**Per Analysis**	**Per Sample**	**5 Samples**
Field collection costs		$100.00	$500.00
Analytical costs	$400.00	$400.00	$2,000.00
Sum of Field & Analytical costs		**$500.00**	**$2,500.00**
Fixed planning and validation costs			$1,000.00
Total cost			**$3,500.00**

Data Analysis for Arsenic
The following data points were entered by the user for analysis.

Arsenic										
Rank	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0
40	0	0								

SUMMARY STATISTICS for Arsenic								
n	42							
Min	0							
Max	0							
Range	0							
Mean	0							
Median	0							
Variance	0							
StdDev	0							
Std Error	0							
Skewness	-1.#IND							
Interquartile Range	0							
Percentiles								
1%	**5%**	**10%**	**25%**	**50%**	**75%**	**90%**	**95%**	**99%**

Systematic sampling locations for comparing a mean with a fixed threshold (nonparametric)

Summary

This report summarizes the sampling design used, associated statistical assumptions, as well as general guidelines for conducting post-sampling data analysis. Sampling plan components presented here include how many sampling locations to choose and where within the sampling area to collect those samples. The type of medium to sample (i.e., soil, groundwater, etc.) and how to analyze the samples (in-situ, fixed laboratory, etc.) are addressed in other sections of the sampling plan.

The following table summarizes the sampling design developed. A figure that shows sampling locations in the field and a table that lists sampling location coordinates are also provided below.

SUMMARY OF SAMPLING DESIGN	
Primary Objective of Design	Compare a site mean or median to a fixed threshold
Type of Sampling Design	Nonparametric
Sample Placement (Location) in the Field	Systematic with a random start location
Working (Null) Hypothesis	The median(mean) value at the site exceeds the threshold
Formula for calculating number of sampling locations	Wilcoxon signed ranks test
Calculated total number of samples	5
Number of samples on map [a]	5
Number of selected sample areas [b]	1
Specified sampling area [c]	364278.91 ft^2
Size of grid / Area of grid cell [d]	290.046 feet / 72855.8 ft^2
Grid pattern	Triangular
Total cost of sampling [e]	$3,500.00

[a] This number may differ from the calculated number because of 1) grid edge effects, 2) adding judgment samples, or 3) selecting or unselecting sample areas.

[b] The number of selected sample areas is the number of colored areas on the map of the site. These sample areas contain the locations where samples are collected.

[c] The sampling area is the total surface area of the selected colored sample areas on the map of the site.

[d] Size of grid / Area of grid cell gives the linear and square dimensions of the grid used to systematically place samples.

[e] Including measurement analyses and fixed overhead costs. See the Cost of Sampling section for an explanation of the costs presented here.

Area: Slag					
X Coord	**Y Coord**	**Label**	**Value**	**Type**	**Historical**
605613.7083	1272229.5072		0	Systematic	
605468.6854	1272480.6943		0	Systematic	
605758.7313	1272480.6943		0	Systematic	
605323.6625	1272731.8814		0	Systematic	
605178.6395	1272983.0685		0	Systematic	

Primary Sampling Objective
The primary purpose of sampling at this site is to compare a median or mean value with a fixed threshold. The working hypothesis (or 'null' hypothesis) is that the median(mean) value at the site is equal to or exceeds the threshold. The alternative hypothesis is that the median(mean) value is less than the threshold. VSP calculates the number of samples required to reject the null hypothesis in favor of the alternative one, given a selected sampling approach and inputs to the associated equation.

Selected Sampling Approach
A nonparametric systematic sampling approach with a random start was used to determine the number of samples and to specify sampling locations. A nonparametric formula was chosen because the conceptual model and historical information (e.g., historical data from this site or a very similar site) indicate that typical parametric assumptions may not be true.

Both parametric and non-parametric equations rely on assumptions about the population. Typically, however, non-parametric equations require fewer assumptions and allow for more uncertainty about the statistical distribution of values at the site. The trade-off is that if the parametric assumptions are valid, the required number of samples is usually less than if a non-parametric equation was used.

Locating the sample points over a systematic grid with a random start ensures spatial coverage of the site. Statistical analyses of systematically collected data are valid if a random start to the grid is used. One disadvantage of systematically collected samples is that spatial variability or patterns may not be discovered if the grid spacing is large relative to the spatial patterns.

Number of Total Samples: Calculation Equation and Inputs

The equation used to calculate the number of samples is based on a Wilcoxon Signed Ranks test. For this site, the null hypothesis is rejected in favor of the alternative one if the sample median(mean) is sufficiently smaller than the threshold. The number of samples to collect is calculated so that if the inputs to the equation are true, the calculated number of samples will cause the null hypothesis to be rejected.

The formula used to calculate the number of samples is:

$$n = 1.16\left[\frac{\left(S_{sample}^{2} + \frac{S_{analytical}^{2}}{r}\right)}{\Delta^{2}}\left(Z_{1-\alpha} + Z_{1-\beta}\right)^{2} + 0.5Z_{1-\alpha}^{2}\right]$$

where

n	is the number of samples,
S	is the estimated standard deviation of the measured values including analytical error,
Δ	is the width of the gray region,
α	is the acceptable probability of incorrectly concluding the site median(mean) is less than the threshold,
β	is the acceptable probability of incorrectly concluding the site median(mean) exceeds the threshold,
$Z_{1-\alpha}$	is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\alpha}$ is 1-α,
$Z_{1-\beta}$	is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\beta}$ is 1-β.

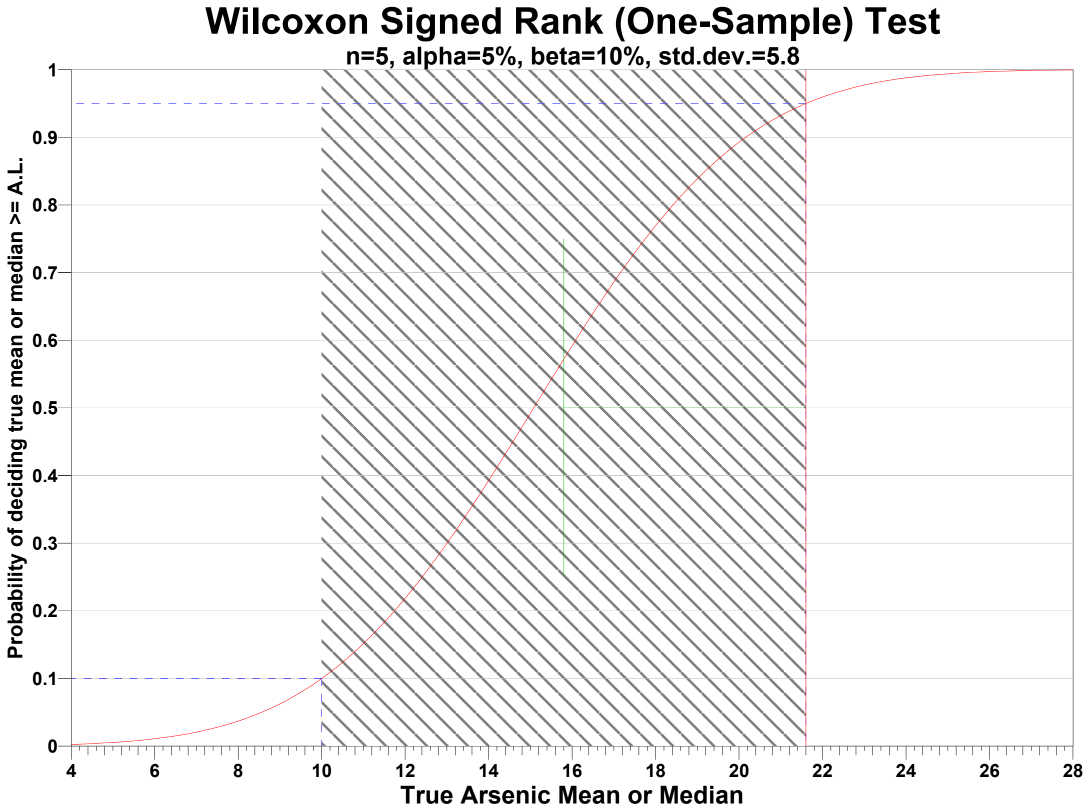
The values of these inputs that result in the calculated number of sampling locations are:

Analyte	**n**	**Parameter**					
		S	Δ	α	β	$Z_{1-\alpha}$ [a]	$Z_{1-\beta}$ [b]
Arsenic	5	5.8	11.6	0.05	0.1	1.64485	1.28155

[a] This value is automatically calculated by VSP based upon the user defined value of α.
[b] This value is automatically calculated by VSP based upon the user defined value of β.

The following figure is a performance goal diagram, described in EPA's QA/G-4 guidance (EPA, 2000). It shows the probability of concluding the sample area is dirty on the vertical axis versus a range of possible true median(mean) values for the site on the horizontal axis. This graph contains all of the inputs to the number of samples equation and pictorially represents the calculation.

The red vertical line is shown at the threshold (action limit) on the horizontal axis. The width of the gray shaded area is equal to Δ; the upper horizontal dashed blue line is positioned at 1-α on the vertical axis; the lower horizontal dashed blue line is positioned at β on the vertical axis. The vertical green line is positioned at one standard deviation below the threshold. The shape of the red curve corresponds to the estimates of variability. The calculated number of samples results in the curve that passes through the lower bound of Δ at β and the upper bound of Δ at 1-α. If any of the inputs change, the number of samples that result in the correct curve changes.



Statistical Assumptions

The assumptions associated with the formulas for computing the number of samples are:

1. the data originate from a symmetric (but not necessarily normal) population,
2. the variance estimate, S^2, is reasonable and representative of the population being sampled,
3. the population values are not spatially or temporally correlated, and
4. the sampling locations will be selected probabilistically.

The first three assumptions will be assessed in a post data collection analysis. The last assumption is valid because the gridded sample locations were selected based on a random start.

Sensitivity Analysis

The sensitivity of the calculation of number of samples was explored by varying the lower bound of gray region (% of action level), beta (%), probability of mistakenly concluding that μ > action level and alpha (%), probability of mistakenly concluding that μ < action level. The following table shows the results of this analysis.

Number of Samples				
AL=21.6		α=5	α=10	α=15
LBGR=90	β=5	93	73	61
	β=10	74	56	46
	β=15	62	46	37
LBGR=80	β=5	25	19	16
	β=10	20	15	12
	β=15	17	13	10
LBGR=70	β=5	12	9	8
	β=10	10	8	6
	β=15	9	6	5

LBGR = Lower Bound of Gray Region (% of Action Level)
β = Beta (%), Probability of mistakenly concluding that μ > action level
α = Alpha (%), Probability of mistakenly concluding that μ < action level
AL = Action Level (Threshold)

Cost of Sampling

The total cost of the completed sampling program depends on several cost inputs, some of which are fixed, and others that are based on the number of samples collected and measured. Based on the numbers of samples determined above, the estimated total cost of sampling and analysis at this site is $3,500.00, which averages out to a per sample cost of $700.00. The following table summarizes the inputs and resulting cost estimates.

COST INFORMATION			
Cost Details	**Per Analysis**	**Per Sample**	**5 Samples**
Field collection costs		$100.00	$500.00
Analytical costs	$400.00	$400.00	$2,000.00
Sum of Field & Analytical costs		**$500.00**	**$2,500.00**
Fixed planning and validation costs			$1,000.00
Total cost			**$3,500.00**

Data Analysis for Arsenic

The following data points were entered by the user for analysis.

Arsenic										
Rank	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0
40	0	0								

SUMMARY STATISTICS for Arsenic								
n	42							
Min	0							
Max	0							
Range	0							
Mean	0							
Median	0							
Variance	0							
StdDev	0							
Std Error	0							
Skewness	-1.#IND							
Interquartile Range	0							
Percentiles								
1%	**5%**	**10%**	**25%**	**50%**	**75%**	**90%**	**95%**	**99%**

Systematic sampling locations for comparing a mean with a fixed threshold (nonparametric)

Summary

This report summarizes the sampling design used, associated statistical assumptions, as well as general guidelines for conducting post-sampling data analysis. Sampling plan components presented here include how many sampling locations to choose and where within the sampling area to collect those samples. The type of medium to sample (i.e., soil, groundwater, etc.) and how to analyze the samples (in-situ, fixed laboratory, etc.) are addressed in other sections of the sampling plan.

The following table summarizes the sampling design developed. A figure that shows sampling locations in the field and a table that lists sampling location coordinates are also provided below.

SUMMARY OF SAMPLING DESIGN	
Primary Objective of Design	Compare a site mean or median to a fixed threshold
Type of Sampling Design	Nonparametric
Sample Placement (Location) in the Field	Systematic with a random start location
Working (Null) Hypothesis	The median(mean) value at the site exceeds the threshold
Formula for calculating number of sampling locations	Wilcoxon signed ranks test
Calculated total number of samples	5
Number of samples on map [a]	5
Number of selected sample areas [b]	1
Specified sampling area [c]	613727.59 ft^2
Size of grid / Area of grid cell [d]	376.476 feet / 122746 ft^2
Grid pattern	Triangular
Total cost of sampling [e]	$3,500.00

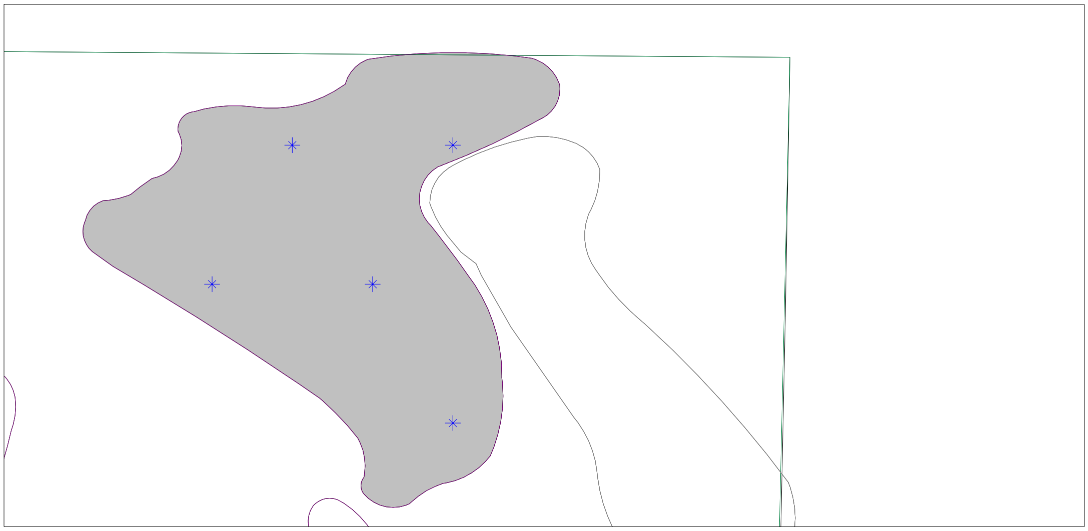
[a] This number may differ from the calculated number because of 1) grid edge effects, 2) adding judgment samples, or 3) selecting or unselecting sample areas.

[b] The number of selected sample areas is the number of colored areas on the map of the site. These sample areas contain the locations where samples are collected.

[c] The sampling area is the total surface area of the selected colored sample areas on the map of the site.

[d] Size of grid / Area of grid cell gives the linear and square dimensions of the grid used to systematically place samples.

[e] Including measurement analyses and fixed overhead costs. See the Cost of Sampling section for an explanation of the costs presented here.



Area: Ash					
X Coord	**Y Coord**	**Label**	**Value**	**Type**	**Historical**
605073.7669	1272520.2746		0	Systematic	
604509.0526	1272846.3125		0	Systematic	
604885.5288	1272846.3125		0	Systematic	
604697.2907	1273172.3505		0	Systematic	
605073.7669	1273172.3505		0	Systematic	

Primary Sampling Objective
The primary purpose of sampling at this site is to compare a median or mean value with a fixed threshold. The working hypothesis (or 'null' hypothesis) is that the median(mean) value at the site is equal to or exceeds the threshold. The alternative hypothesis is that the median(mean) value is less than the threshold. VSP calculates the number of samples required to reject the null hypothesis in favor of the alternative one, given a selected sampling approach and inputs to the associated equation.

Selected Sampling Approach
A nonparametric systematic sampling approach with a random start was used to determine the number of samples and to specify sampling locations. A nonparametric formula was chosen because the conceptual model and historical information (e.g., historical data from this site or a very similar site) indicate that typical parametric assumptions may not be true.

Both parametric and non-parametric equations rely on assumptions about the population. Typically, however, non-parametric equations require fewer assumptions and allow for more uncertainty about the statistical distribution of values at the site. The trade-off is that if the parametric assumptions are valid, the required number of samples is usually less than if a non-parametric equation was used.

Locating the sample points over a systematic grid with a random start ensures spatial coverage of the site. Statistical analyses of systematically collected data are valid if a random start to the grid is used. One disadvantage of systematically collected samples is that spatial variability or patterns may not be discovered if the grid spacing is large relative to the spatial patterns.

Number of Total Samples: Calculation Equation and Inputs
The equation used to calculate the number of samples is based on a Wilcoxon Signed Ranks test. For this site, the null hypothesis is rejected in favor of the alternative one if the sample median(mean) is sufficiently smaller than the threshold. The number of samples to collect is calculated so that if the inputs to the equation are true, the calculated number of samples will cause the null hypothesis to be rejected.

The formula used to calculate the number of samples is:

$$n = 1.16\left[\frac{\left(S^2_{sample} + \frac{S^2_{analytical}}{r}\right)}{\Delta^2}\left(Z_{1-\alpha} + Z_{1-\beta}\right)^2 + 0.5Z^2_{1-\alpha}\right]$$

where

n	is the number of samples,
S	is the estimated standard deviation of the measured values including analytical error,
Δ	is the width of the gray region,
α	is the acceptable probability of incorrectly concluding the site median(mean) is less than the threshold,
β	is the acceptable probability of incorrectly concluding the site median(mean) exceeds the threshold,
$Z_{1-\alpha}$	is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\alpha}$ is 1-α,
$Z_{1-\beta}$	is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\beta}$ is 1-β.

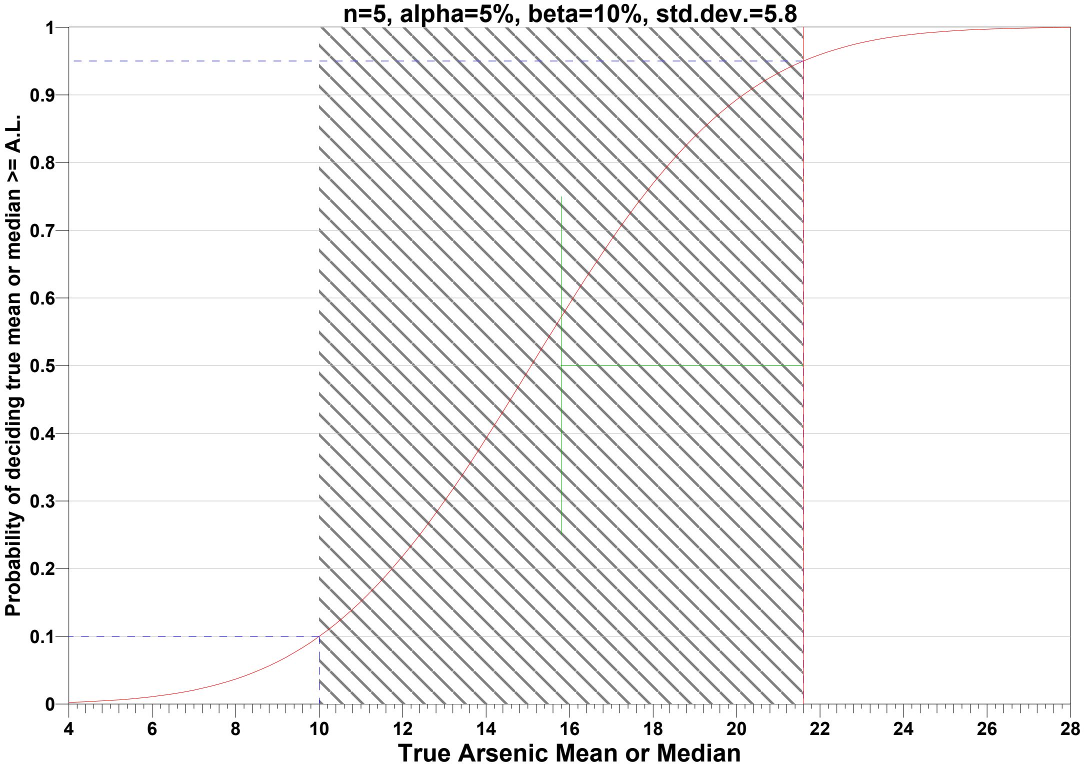
The values of these inputs that result in the calculated number of sampling locations are:

Analyte	**n**	**Parameter**					
		S	Δ	α	β	$Z_{1-\alpha}$ [a]	$Z_{1-\beta}$ [b]
Arsenic	5	5.8	11.6	0.05	0.1	1.64485	1.28155

[a] This value is automatically calculated by VSP based upon the user defined value of α.
[b] This value is automatically calculated by VSP based upon the user defined value of β.

The following figure is a performance goal diagram, described in EPA's QA/G-4 guidance (EPA, 2000). It shows the probability of concluding the sample area is dirty on the vertical axis versus a range of possible true median(mean) values for the site on the horizontal axis. This graph contains all of the inputs to the number of samples equation and pictorially represents the calculation.

The red vertical line is shown at the threshold (action limit) on the horizontal axis. The width of the gray shaded area is equal to Δ; the upper horizontal dashed blue line is positioned at 1-α on the vertical axis; the lower horizontal dashed blue line is positioned at β on the vertical axis. The vertical green line is positioned at one standard deviation below the threshold. The shape of the red curve corresponds to the estimates of variability. The calculated number of samples results in the curve that passes through the lower bound of Δ at β and the upper bound of Δ at 1-α. If any of the inputs change, the number of samples that result in the correct curve changes.



Wilcoxon Signed Rank (One-Sample) Test

n=5, alpha=5%, beta=10%, std.dev.=5.8

Statistical Assumptions
The assumptions associated with the formulas for computing the number of samples are:

1. the data originate from a symmetric (but not necessarily normal) population,
2. the variance estimate, S^2, is reasonable and representative of the population being sampled,
3. the population values are not spatially or temporally correlated, and
4. the sampling locations will be selected probabilistically.

The first three assumptions will be assessed in a post data collection analysis. The last assumption is valid because the gridded sample locations were selected based on a random start.

Sensitivity Analysis
The sensitivity of the calculation of number of samples was explored by varying the lower bound of gray region (% of action level), beta (%), probability of mistakenly concluding that μ > action level and alpha (%), probability of mistakenly concluding that μ < action level. The following table shows the results of this analysis.

Number of Samples				
AL=21.6		α=5	α=10	α=15
LBGR=90	β=5	93	73	61
	β=10	74	56	46
	β=15	62	46	37
LBGR=80	β=5	25	19	16
	β=10	20	15	12
	β=15	17	13	10
LBGR=70	β=5	12	9	8
	β=10	10	8	6
	β=15	9	6	5

LBGR = Lower Bound of Gray Region (% of Action Level)
β = Beta (%), Probability of mistakenly concluding that μ > action level
α = Alpha (%), Probability of mistakenly concluding that μ < action level
AL = Action Level (Threshold)

Cost of Sampling
The total cost of the completed sampling program depends on several cost inputs, some of which are fixed, and others that are based on the number of samples collected and measured. Based on the numbers of samples determined above, the estimated total cost of sampling and analysis at this site is $3,500.00, which averages out to a per sample cost of $700.00. The following table summarizes the inputs and resulting cost estimates.

COST INFORMATION			
Cost Details	**Per Analysis**	**Per Sample**	**5 Samples**
Field collection costs		$100.00	$500.00
Analytical costs	$400.00	$400.00	$2,000.00
Sum of Field & Analytical costs		**$500.00**	**$2,500.00**
Fixed planning and validation costs			$1,000.00
Total cost			**$3,500.00**

Data Analysis for Arsenic
The following data points were entered by the user for analysis.

Arsenic										
Rank	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0
40	0	0								

SUMMARY STATISTICS for Arsenic								
n	42							
Min	0							
Max	0							
Range	0							
Mean	0							
Median	0							
Variance	0							
StdDev	0							
Std Error	0							
Skewness	-1.#IND							
Interquartile Range	0							
Percentiles								
1%	**5%**	**10%**	**25%**	**50%**	**75%**	**90%**	**95%**	**99%**

Appendix F

Standard Operating Procedures

Standard Operating Procedure No. 001
for
Sample Labels

Prepared by

EA Engineering, Science, and Technology, Inc.
11019 McCormick Road
Hunt Valley, Maryland 21031

Revision 0
August 2007

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1. SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure is to delineate protocols for the use of sample labels. Every sample will have a sample label uniquely identifying the sampling point and analysis parameters. An example label is provided below. Other formats with similar levels of detail are acceptable.

PROJECT NAME _____________ PROJECT NUM. ___________
SAMPLE LOCATION/SITE ID ___________________________
DATE: ____/____/____ TIME: _____:_____
ANALYTES: METALS VOC EXPLOSIVES ORGANICS OTHER
FILTERED: [NO] [YES]
PRESERVATIVE: [NONE] [HNO_3] [OTHER ______]
SAMPLER: ____________________

2. MATERIALS

The following materials may be required: sample label and indelible laboratory marker.

3. PROCEDURE

The following sections describe how to use the sample labeling system.

3.1 LABEL INFORMATION

As each sample is collected/selected, fill out a sample label. Enter the following information on each label:

- Project name
- Project number
- Location/site identification—Enter the media type (i.e., well number, surface water, soil, etc.) sampling number, and other pertinent information concerning where the sample was taken
- Date of sample collection

- Time of sample collection

- Analyses to be performed (NOTE: Due to number of analytes, details of analysis should be arranged with laboratory *prior to start of work)*

- Whether filtered or unfiltered (water samples only)

- Preservatives (water samples only)

- Number of containers for the sample (e.g., 1 of 2, 2 of 2).

3.2 ROUTINE CHECK

Double-check the label information to make sure it is correct. Detach the label, remove the backing, and apply the label to the sample container. Cover the label with clear tape, ensuring that the tape completely encircles the container.

3.3 RECORD INFORMATION

Record the sample number and designated sampling point in the field logbook, along with the following sample information:

- Time of sample collection (each logbook page should be dated)

- Location of the sample

- Organic vapor meter or photoionization meter readings for the sample (when appropriate)

- Any unusual or pertinent observations (oily sheen on groundwater sample, incidental odors, soil color, grain size, plasticity, etc.)

- Number of containers required for each sample

- Whether the sample is a quality assurance sample (split, duplicate, or blank).

3.3.1 Logbook Entry

A typical logbook entry might look like this:

- 7:35 a.m. Sample No. MW-3. PID = 35 ppm
- Petroleum odor present. Sample designated MW-3-001.

NOTE: Duplicate samples will be given a unique sample designation rather than the actual sample number with an added prefix or suffix. This will prevent any indication to the laboratory that this is a duplicate sample. This fictitious sample number will be listed in the logbook along with the actual location of the sample.

3.4 SHIPMENT

Place the sample upright in the designated sample cooler. Make sure there is plenty of ice in the cooler at all times.

4. MAINTENANCE

Not applicable.

5. PRECAUTIONS

5.1 INCIDENTAL ODORS

Note that although incidental odors should be noted in the logbook, it is unwise from a safety and health standpoint to routinely "sniff test" samples for contaminants.

5.2 DUPLICATE SAMPLE

No indication of which samples are duplicates is to be provided to the laboratory.

6. REFERENCES

U.S. Environmental Protection Agency. 1980. Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans. QAMS-005/80.

Standard Operating Procedure No. 002
for
Chain-of-Custody Form

Prepared by

EA Engineering, Science, and Technology, Inc.
11019 McCormick Road
Hunt Valley, Maryland 21031

Revision 0
August 2007

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2. MATERIALS 1

3. PROCEDURE 1

4. MAINTENANCE 1

5. PRECAUTIONS 2

6. REFERENCES 2

1. SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure is to delineate protocols for use of the chain-of-custody form. An example is provided as Figure SOP002-1. Other formats with similar levels of detail are acceptable.

2. MATERIALS

The following materials may be required: chain-of-custody form and indelible ink pen.

3. PROCEDURE

- Give the site name and project name/number.
- Enter the sample identification code.
- Indicate the sampling dates for all samples.
- List the sampling times (military format) for all samples.
- Indicate “grab” or “composite” sample with an “X.”
- Specify the sample location.
- Enter the total number of containers per cooler.
- List the analyses/container volume.
- Obtain the signature of sample team leader.
- State the carrier service and airbill number, analytical laboratory, and custody seal numbers.
- Sign, date, and time the “relinquished by” section.
- Upon completion of the form, retain the shipper copy, and affix the other copies to the inside of the sample cooler, in a zip-seal bag to protect from moisture, to be sent to the designated laboratory.

4. MAINTENANCE

Not applicable.

5. PRECAUTIONS

None.

6. REFERENCES

U.S. Environmental Protection Agency (U.S. EPA). 1980. Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans, QAMS-005/80.

U.S. EPA. 1990. Sampler's Guide to the Contract Laboratory Program. EPA/540/P-90/006, Directive 9240.0-06, Office of Emergency and Remedial Response, Washington, D.C. December.

U.S. EPA. 1991. User's Guide to the Contract Laboratory Program. EPA/540/O-91/002, Directive 9240.0-01D, Office of Emergency and Remedial Response. January.

Company Name:

Project Manager or Contact:

Phone:

Project No.

Project Name:

Dept.: Task:

Sample Storage Location:

ATO Number:

Page of

Report #:

Parameters/Method Numbers for Analysis

Chain of Custody Record

EA Laboratories
19 Loveton Circle
Sparks, MD 21152
Telephone: (410) 771-4950
Fax: (410) 771-4077

Report Deliverables:
1 2 3 4 D E

EDD: Yes/No

DUE TO CLIENT: _________

Date	Time	Water	Soil	Sample Identification 19 Characters	**No. of Containers**														**EA Labs Accession Number**	Remarks
																				LPM:

Samples by: (Signature)	Date/Time	Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Date/Time
Relinquished by: (Signature)	Date/Time	Received by Laboratory: (Signature)	Date/Time	Airbill Number:	Sample Shipped by: (Circle) Fed Ex. Puro. UPS Hand Carried Other:

Cooler Temp. _______C pH: ___ Yes ___ No Comments: Custody Seals Intact ___ Yes ___ No

NOTE: Please indicate method number for analyses requested. This will help clarify any questions with laboratory techniques.

Standard Operating Procedure No. 003
for
Subsurface/Utility Clearance

Prepared by

EA Engineering, Science, and Technology, Inc.
11019 McCormick Road
Hunt Valley, Maryland 21031

Revision 0
August 2007

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APPENDIX A: SUBSURFACE CLEARANCE PROCEDURE CHECKLIST
APPENDIX B: UNIFORM COLOR CODES FOR MARKING OF UNDERGROUND FACILITIES

1. SCOPE AND APPLICATION

1.1 PURPOSE

The purpose of this Standard Operating Procedure is to prevent injury to workers and damage to subsurface structures (including tanks, pipe lines, water lines, gas lines, electrical service, etc.) during ground disturbance activities (including drilling, augering, sampling, use of direct-push technologies, excavation, trenching, concrete coring or removal, fence post installation, grading, or other similar operations).

1.2 LIMITATIONS

The procedures set forth in this document are the suggested procedures but may not be applicable to particular sites based on the site-specific considerations. The Project Manager is responsible for making a site-specific evaluation of each site to determine whether the Subsurface/Clearance Procedures should be utilized or require modification. If safety or other site-specific considerations require a modified or different procedure, the Project Manager should review the modified procedure with the Business Unit Director, Profit Center Manager, or Senior Technical Reviewer.

1.3 SCOPE

This procedure provides minimum guidance for subsurface clearance activities, which must be followed prior to and during ground disturbance activities at EA project sites. Even after completing the subsurface clearance activities required in this procedure, all ground disturbance activities should proceed with due caution.

Deviations from this procedure may be provided on an exception basis for specific situations, such as underground storage tank systems removals, verified aboveground/overhead services/lines, undeveloped land/idle facilities, shallow groundwater conditions, soil stability, or well construction quality assurance/quality control concerns, etc.

EA or its subcontractors are responsible for, and shall ensure that, all ground disturbance activities are completed safely, without incident, and in accordance with applicable federal, state, and local regulations.

This procedure shall not override any site-specific or consultant/contractor procedures that are more stringent or provide a greater degree of safety or protection of health or the environment.

2. PROCEDURES

The EA Project Manager or his designee must complete the Subsurface Clearance Procedure Checklist (Appendix A) in conjunction with the following procedures. The checklist must be completed before initiating any ground disturbance activities. The completed checklist must be submitted to the appropriate team individuals, subcontractors, and/or the client and included in the project files.

2.1 SAFETY

A Health and Safety Plan must be available onsite and followed by all contractors and subcontractors.

All work areas shall be defined and secured with safety cones, safety tape, construction fence, other barriers, or signs as appropriate.

Site work permits must be obtained as required by site procedures. Based on site conditions or classification, the use of intrinsically-safe equipment may be required.

To ensure the safety of all onsite personnel and subsurface structure integrity, consideration should be given to de-energizing and locking out selected site utilities or temporarily shutting down a portion of or the entire facility.

2.2 PREPARATION TASKS

Objective—To gather all relevant information about potential subsurface structures prior to the actual site visit.

2.2.1 Obtain Permits and Site Access

The consultant/contractor is responsible for following all applicable laws, guidance, and approved codes of practice; obtaining all necessary permits and utility clearances; and securing site access permission.

2.2.2 Historic Site Information

Obtain most recent as-built drawings and/or site plans (including underground storage tank, product, and vent lines) as available.

NOTE: As-built drawings may not accurately depict the locations and depths of improvements and subsurface structures and should, therefore, not be **solely** relied upon.

EA should obtain any other site information such as easements, right-of-ways, historical plot plans, fire insurance plans, tank (dip) charts, previous site investigations, soil surveys, boring logs, and aerial photographs, etc. as relevant to the planned ground disturbance activities.

Where applicable, EA should also contact contract personnel who may have historic site knowledge.

2.2.3 Mark-Outs

Objective—To identify location of subsurface structures on surface.

EA must ensure that a thorough mark-out at the site is completed to locate electrical, gas, telephone, water, sewer, low voltage electric lines, product delivery pipelines, fiber optic, and all other subsurface utilities/services.

- Where available, public utility companies must be contacted to identify underground utilities. (This can be accomplished through the One-Call system in most instances.)

- In addition, where available and warranted by site conditions, a private utility/pipeline mark-out company should be contracted to perform an electronic subsurface survey to identify the presence of suspected hazardous or critical underground utilities and subsurface structures. In some cases, this is necessary to confirm public utility mark-outs in the vicinity of planned ground disturbance activities.

EA will review all available site plan subsurface information with the private mark-out company to assist in locating utilities and other subsurface structures.

NOTE: Mark-outs may not accurately depict the exact locations of improvements and subsurface structures and should, therefore, not be **solely** relied upon.

Where possible, EA personnel are encouraged to be onsite at the time of subsurface mark-outs. This is to ensure accuracy and understanding of subsurface structures identified and provides an opportunity to exchange information with mark-out company personnel regarding planned work activities.

Subsurface structures should be marked throughout the entire work area(s) with adequate materials (e.g., site conditions may require paint and tape/flags). Ground disturbance activities must be started within 30 days of mark-out, unless local ordinances specify a shorter time period. If activities are not started within required time period or markings have faded, mark-outs must be redone.

EA personnel will record time and date of mark-out request and list all companies contacted by the service and confirmation number. This should be available for review onsite and checked off after visual confirmation of markings.

2.2.4 Initial Site Visit

Objective—To compare the site plan to actual conditions based on information gathered in Procedures 2 and 3 above, obtain additional site information needed, and prepare a vicinity map.

EA will document all findings and update the site plan with this information. On third party sites, close coordination with the site owner's representatives for mark-outs, review of as-builts, and other information reviews should be conducted prior to work. Project Managers are encouraged to provide updated as-built information to the client.

In some regions, it may be more effective and efficient to conduct the site visit at the same time the contractor and drill rig are mobilized to the site. The inspection should include the following activities and may include others as determined by the consultant/contractor and the Project Manager.

2.2.5 Utilities

EA shall perform a detailed site walk-through for the purpose of identifying all aboveground indicators of subsurface utilities/services that may be leading to or from buildings within the planned work area. The inspection shall include, but not be limited to, the following:

- Utility mark-outs
- Aboveground utilities
- Area lights/signs
- Phones
- Drains
- Junction boxes
- Natural gas meters or connections
- Other utilities including: fire hydrants, on/below grade electrical transformers, splice cages, sewer lines, pipeline markers, cable markers, valve box covers, clean-outs/traps, sprinkler systems, steam lines (including insulated tanks that may indicate steam lines), and cathodic protection on lines/tanks
- Observe paving scars (i.e., fresh asphalt/concrete patches, scored asphalt/concrete).

NOTE: In many cases, the onsite location of low-voltage electrical lines and individual property water and sewer line branches may be approximated by using the following technique:

- Locate the entry/connection location at the facility building

- Attempt to identify utility connections for the mains (water sewer, etc.) by locating clean-outs, valve manways, etc. The location path of the utility is likely with the area between the main connection and facility building connection. Subsurface electrical line locations from the facility building to signs, lamps, etc. can be estimated with the same process.

2.2.6 Other Subsurface Systems

Some other subsurface systems to be cognizant of during subsurface activities include product delivery systems (i.e., at gas stations) and existing remediation systems.

2.2.7 Selection of Ground Disturbance Locations

EA will utilize the information collected to this point in combination with regulatory requirements and project objectives to select ground disturbance locations. Ground disturbance locations should also consider the location of overhead obstructions (e.g., power lines). Work at active gasoline retail locations must consider several special considerations that should be outlined in the site-specific safety and health plan.

2.2.8 Review of Selected Locations with the Client

EA will review the selected ground disturbance locations with the client. EA will not proceed with the subsurface activities until the plan has been discussed with the client. During execution of the project, subsurface activities are required outside of the area previously approved by the client. EA will submit these changes to the client for approval prior to execution.

2.2.9 Ground Disturbance Activity Sequence

EA will plan ground disturbance activities starting at the point farthest from the location of suspected underground improvements. This is done to determine the natural subsurface conditions and to allow EA site personnel to recognize fill conditions.

Experience has shown that the following warning signs may indicate the presence of a subsurface structure:

- Warning tape (typically indicative of underground services).

- Pea gravel/sand/non-indigenous material (typically indicative of tanks or lines).

- Red concrete (typically indicative of electrical duct banks).

- The abrupt absence of soil recovery in a hand auger. This could indicate pea gravel or sand that has spilled out of the auger. This may not be indicative in areas where native soil conditions typically result in poor hand auger recoveries.

- Any unexpected departure from the native soil or backfill conditions as established by prior onsite digging.

If any of these conditions is encountered by EA site personnel, digging should stop and the client should be contacted.

3. SUBSURFACE CLEARANCE METHODS

The method used to delineate the subsurface should be compatible with the inherent associated risk given the type of facility/property, soil stratigraphy, and the location of the ground disturbance activity, such that required delineation is obtained. It should be noted that in areas where there is paving, sufficient paving should be removed to allow clear visibility of the subsurface conditions during clearance activities. The following is a list of potential clearance methods that may be used on a job site:

- Vacuum digging
- Probing
- Hand digging
- Hand augering
- Post-hole digging.

EA personnel will evaluate the potential for electrical shock or fire/explosion for each subsurface disturbance project and will evaluate as necessary the use of non-conductive or non-sparking tools (i.e., fiberglass hand shovels, and thick electrically insulating rubber grips on hand augers or probes). The potential need for the use of non-conductive materials, electrical safety insulated gloves, and footwear will also be evaluated on a case-by-case basis.

3.1 SUBSURFACE CLEARANCE PROCEDURES FOR DRILLING, DIRECT-PUSH TECHNOLGY, AUGERING, FENCE POST INSTALLATION, OR OTHER BOREHOLE INSTALLATION ACTIVITIES

The area to be delineated will exceed the diameter of the largest tool to be advanced and sufficiently allow for visual inspection of any obstructions encountered.

3.2 SUBSURFACE CLEARANCE PROCEDURES FOR TRENCHING/ EXCAVATION ACTIVITIES

Appropriate subsurface clearance methods should be conducted along the length and width of the excavation at a frequency sufficient to ensure adequate precautions have been applied to the entire work area. The frequency and density of investigations will be based on site knowledge, potential hazards, and risks of the work area to surrounding locations (e.g., proximity to a residential area or school).

Whenever subsurface structures are exposed, EA will cease work and mark the area (e.g., flags, stakes, cross bracing) to ensure the integrity of these exposed structures is maintained during subsequent trenching/excavation/backfilling.

Uniform color codes for marking of underground facilities are provided in Appendix B.

Appendix A

Subsurface Clearance Procedure Checklist

Subsurface Clearance Procedure Checklist

Site Identification: ______________________________

Project Consultant/Contractor: ______________________________

Section 1: Safety, Preparation Tasks, and Mark-Outs

Activity	Yes	No	N/A	Comments including Justification if Response Is No or Not Applicable
Health and Safety Plan is available and all contractors and subcontractors are familiar with it.				
All applicable local, state, and federal permits have been obtained.				
Site access/permission has been secured.				
Most recent as-built drawings and/or site plans (including underground storage tank, product, and vent lines) obtained.				
Reviewed site information to identify subsurface structures relevant to planned site activities (easements, rights-of-way, historical plot plans, fire insurance plans, tank dip charts, previous site investigations, soil surveys, boring logs, aerial photographs, etc.).				
Utility mark-outs have been performed by public utility company(s). Mark-outs clear/visible.				
Subsurface structure mark-outs performed by private mark-out company. Mark-outs clear/visible.				
Additional Activities: Were dig locations reviewed with site representative?				

Section 2: Initial Site Visit and Selecting Ground Disturbance Locations

Activity	Yes	No	N/A	Comments including Justification if Response Is No or Not Applicable
Location of all aboveground indicators of subsurface utilities/services that may be leading to or from buildings within the planned work area has been identified.				
Location of utility mark-outs by all utility companies previously contacted has been identified within required time period.				
Location of all subsurface structure mark-outs by private mark-out company has been identified within required time period.				
Location of area lights/signs and associated subsurface lines identified.				
Location of all phones and associated subsurface lines identified.				
Location of all drains and associated interconnecting lines identified.				
Location of all electrical junction boxes and associated interconnecting lines identified				
Location of all natural gas meters or connections and all interconnecting lines identified				

Completed by: ______________________________
Name

Signature: ______________________________ ______________
Company Date

Appendix B

Uniform Color Codes for Excavation

APWA UNIFORM COLOR CODE

WHITE - Proposed Excavation

PINK - Temporary Survey Markings

RED - Electric Power Lines, Cables, Conduit and Lighting Cables

YELLOW - Gas, Oil, Steam, Petroleum or Gaseous Materials

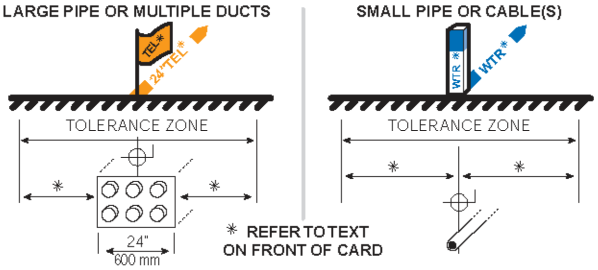
ORANGE - Communication, Alarm or Signal Lines, Cables or Conduit

BLUE - Potable Water

PURPLE - Reclaimed Water, Irrigation and Slurry Lines

GREEN - Sewers and Drain Lines

TYPICAL MARKING



* REFER TO TEXT ON FRONT OF CARD

Customize with your center's phone and address information

GUIDELINES FOR UNIFORM TEMPORARY MARKING OF UNDERGROUND FACILITIES

This marking guide provides for universal use and understanding of the temporary marking of subsurface facilities to prevent accidents and damage or service interruption by contractors, excavators, utility companies, municipalities or any others working on or near underground facilities.

ONE-CALL SYSTEMS

The One-Call damage prevention system shall be contacted prior to excavation.

PROPOSED EXCAVATION

Use white marks to show the location, route or boundary of proposed excavation. Surface marks on roadways do not exceed 1.5" by 18" (40 mm by 450 mm). The facility color and facility owner identity may be added to white flags or stakes.

USE OF TEMPORARY MARKING

Use color-coded surface marks (i.e., paint or chalk) to indicate the location or route of active and out-of-service buried lines. To increase visibility, color coded vertical markers (i.e., stakes or flags) should supplement surface marks. Marks and markers indicate the name, initials or logo of the company that owns or operates the line, and width of the facility if it is greater than 2" (50 mm). Marks placed by other than line owner/operator or its agent indicate the identity of the designating firm. Multiple lines in joint trench are marked in tandem. If the surface over the buried line is to be removed, supplementary offset markings are used. Offset markings are on a uniform alignment and clearly indicate the actual facility is a specific distance away.

TOLERANCE ZONE

Any excavation within the tolerance zone is performed with non-powered hand tools or non-invasive method until the marked facility is exposed. The width of the tolerance zone may be specified in law or code. If not, a tolerance zone including the width of the facility plus 18" (450 mm) measured horizontally from each side of the facility is recommended.

ADOPT UNIFORM COLOR CODE

The American Public Works Association encourages public agencies, utilities, contractors, other associations, manufacturers and all others involved in excavation to adopt the APWA Uniform Color Code, using ANSI standard Z535.1 Safety Colors for temporary marking and facility identification.

Rev. 4/99

Standard Operating Procedure No. 004
for
Sample Packing and Shipping

Prepared by

EA Engineering, Science, and Technology, Inc.
11019 McCormick Road
Hunt Valley, Maryland 21031

Revision 0
August 2007

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1. SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure (SOP) is to delineate protocols for the packing and shipping of samples to the laboratory for analysis.

2. MATERIALS

The following materials may be required:

Clear tape	Plastic garbage bags
Custody seals	Sample documentation
Ice	Waterproof coolers (hard plastic or metal)
Metal cans with friction-seal lids (e.g., paint cans)	Zip-seal plastic bags
Packing material[1]	

3. PROCEDURE

Check cap tightness and verify that clear tape covers label and encircles container. Wrap sample container in bubble wrap or closed cell foam sheets. Enclose each sample in a clear zip-seal plastic bag.

Place several layers of bubble wrap, or at least 1 in. of vermiculite on the bottom of the cooler. Line cooler with open garbage bag, place all the samples upright inside a garbage bag, and tie the bag.

Double bag and seal loose ice to prevent melting ice from soaking the packing material. Place the ice outside the garbage bags containing the samples.

Pack shipping containers with packing material (closed-cell foam, vermiculite, or bubble wrap). Place this packing material around the sample bottles or metal cans to avoid breakage during shipment.

Enclose all sample documentation (i.e., Field Parameter Forms, chain-of-custodies) in a waterproof plastic bag and tape the bag to the underside of the cooler lid. If more than one cooler is being used, each cooler will have its own documentation.

Seal the coolers with signed and dated custody seals so that if the cooler were opened, the custody seal would be broken. Place clear tape over the custody seal to prevent damage to the seal.

---

1. Permissible packing materials are: (a) (non-absorbent) bubble wrap or closed cell foam packing sheets, or (b) (absorbent) vermiculite. Organic materials such as paper, wood shavings (excelsior), and cornstarch packing "peanuts" will not be used.

Refer to SOP Nos. 001, 002, 016, and 039.

Tape the cooler shut with packing tape over the hinges and place tape over the cooler drain. Ship all samples via overnight delivery on the same day they are collected if possible.

4. MAINTENANCE

Not applicable.

5. PRECAUTIONS

Any samples suspected to be of medium/high contaminant concentration or containing dioxin must be enclosed in a metal can with a clipped or sealable lid (e.g., similar to a paint can). Label the outer metal container with the sample number of the sample inside.

6. REFERENCES

U.S. Environmental Protection Agency (U.S. EPA). 1980. Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans, QAMS-005/80.

U.S. EPA. 1990. Sampler's Guide to the Contract Laboratory Program. EPA/540/P-90/006, Directive 9240.0-06, Office of Emergency and Remedial Response, Washington, D.C. December.

U.S. EPA. 1991. User's Guide to the Contract Laboratory Program. EPA/540/O-91/002, Directive 9240.0-01D, Office of Emergency and Remedial Response. January.

Standard Operating Procedure No. 005
for
Field Decontamination

Prepared by

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1. SCOPE AND APPLICATION

All personnel or equipment involved in intrusive sampling, or which enter a hazardous waste site during intrusive sampling, must be thoroughly decontaminated prior to leaving the site to minimize the spread of contamination and prevent adverse health effects. This Standard Operating Procedure describes the normal decontamination of sampling equipment and site personnel.

2. MATERIALS

The following materials may be required:

0.01N HCl	Non-phosphate laboratory detergent (liquinox)
0.10N nitric acid	Plastic garbage bags
Aluminum foil or clean plastic sheeting	Plastic sheeting, buckets, etc. to collect wash water and rinsates
Approved water	Pressure sprayer, rinse bottles, brushes
High performance liquid chromatography (HPLC)-grade water[1]	Reagent grade alcohol[2]

3. PROCEDURE

3.1 SAMPLE BOTTLES

At the completion of each sampling activity, the exterior surfaces of the sample bottles must be decontaminated as follows:

- Ensure the bottle lids are on tight.
- Wipe the outside of the bottle with a paper towel to remove gross contamination.

3.2 PERSONNEL DECONTAMINATION

Review the project Health and Safety Plan for the appropriate decontamination procedures.

---

1. For the purposes of this Standard Operating Procedure, HPLC-grade water is considered equivalent to “deionized ultra filtered water,” “reagent-grade distilled water,” and “deionized organic-free water.” The end product being water which is pure with no spurious ions or organics to contaminate the sample. The method of generation is left to the individual contractor.
2. For the purposes of this Standard Operating Procedure, the term “reagent grade alcohol” refers to either pesticide grade isopropanol or reagent grade methanol.

3.3 EQUIPMENT DECONTAMINATION

3.3.1 Water Samplers

3.3.1.1 Bailers

After each use, polytetrafluoroethelyne (PTFE) double check valve bailers used for groundwater sampling will be decontaminated as follows:

- Discard all ropes used in sampling in properly marked sealable container, or as directed by the Health and Safety Plan. NOTE: No tubing is to be used in conjunction with a bailer in collecting samples.
- Scrub the bailer to remove gross (visible) contamination, using appropriate brush(es), approved water, and non-phosphate detergent.
- Rinse off detergent three times with approved water.
- Rinse bailer with reagent grade alcohol.
- Rinse bailer three times with HPLC-grade water.
- Rinse bailer with 0.10N nitric acid solution.
- Rinse bailer three times with HPLC-grade water.
- Allow bailer to air dry.[3]
- Wrap bailer in aluminum foil or clean plastic sheeting, or store in a clean, dedicated polyvinyl chloride or PTFE storage container.
- Dispose of used decontamination solutions with drummed purge water.
- Rinse bailer with HPLC-grade water immediately prior to re-use.

3.3.1.2 Pumps

Submersible pumps will be decontaminated as follows:

---

[3] If the bailer has just been used for purging and is being decontaminated prior to sampling, do not air dry. Double rinse with HPLC-grade water and proceed to collect samples.

- Scrub the exterior of the pump to remove gross (visible) contamination, using appropriate brush(es), approved water, and non-phosphate detergent. (Steam cleaning may be substituted for detergent scrub.)

- Calculate the volume of pump plus any tubing which is not disposable and not dedicated to a single well. Pump three volumes of non-phosphate laboratory detergent solution to purge and clean the interior of the pump.

- Rinse by pumping no less than nine volumes of approved water to rinse.

- Rinse pump exterior with reagent grade alcohol.

- Rinse pump exterior with HPLC-grade water.

- Allow pump to air dry.

- Wrap pump in aluminum foil or clean plastic sheeting, or store in a clean, dedicated polyvinyl chloride or PTFE storage container.

- Prior to reusing pump rinse exterior again with HPLC-grade water. (Double rinse in Bullet 5 above may be substituted for this step).

3.3.1.3 Dip Samplers

All dip samplers, whether bucket, long-handled, or short-handled, will be decontaminated in the same manner as provided in Section 3.3.1.1.

3.3.1.4 Labware

Labware, such as beakers, which are used to hold samples for field measurements, water chemistry, etc. will be decontaminated according to the procedures in Section 3.3.1.1.

3.3.1.5 Water Level Indicators

Electric water level indicators, weighted measuring tapes, or piezometers used in the determination of water levels, well depths, and/or non-aqueous phase liquid levels will be decontaminated in accordance with Section 3.3.1.1. Clean laboratory wipes may be substituted for brushes. Tapes, probes, and piezometers should be wiped dry with clean laboratory wipes, and coiled on spools or clean plastic sheeting rather than allowed to air dry.

3.3.2 Solid Materials Samplers

Solid materials samplers include soil sampling probes, augers, trowels, shovels, sludge samplers, and sediment samplers, which will be decontaminated as follows:

- Scrub the sampler to remove gross (visible) contamination, using appropriate brush(es), approved water, and non-phosphate laboratory detergent.

- Rinse off detergent with approved water.

- Rinse sampler with reagent grade alcohol.

- Rinse sampler with HPLC-grade water.

- For non-metallic samplers only, rinse sampler with 0.10N nitric acid solution.

- For non-metallic samplers only, rinse sampler with HPLC-grade water.

- Allow sampler to air dry.

- Wrap sampler in aluminum foil clean plastic sheeting, or store in a new zipseal bag (size permitting) or clean, dedicated polyvinyl chloride or PTFE storage container.

- Dispose used decontamination solutions properly according to the site-specific Health and Safety Plan.

- Rinse sampler with HPLC-grade water immediately prior to re-use.

3.3.3 Other Sampling and Measurement Probes

Soil gas sampling probes will be decontaminated as solids sampling devices.

Temperature, pH, conductivity, redox, and dissolved oxygen probes will be decontaminated according to manufacturer's specifications. If no such specifications exist, remove gross contaminant and triple rinse probe with HPLC-grade water. A summary of the decontamination procedures to be used must be included in the instrument-specific standard operating procedure.

Measuring tapes that become contaminated through contact with soil during field use will be decontaminated as follows:

- Wipe tape with a clean cloth or laboratory wipe that has been soaked with non-phosphate laboratory detergent solution to remove gross contamination. Rinse cloth in the solution and continue wiping until tape is clean.

- Wipe tape with a second clean, wet cloth (or laboratory wipe) to remove soap residues.

- Dry tape with a third cloth (or laboratory wipe) and rewind into case, or re-coil tape.

3.3.4 Drilling Rigs and Other Heavy Equipment

All drilling rigs and associated equipment such as augers, drill casing, rods, samplers, tools, recirculation tank, and water tank (inside and out) will be decontaminated prior to site entry after over-the-road mobilization and immediately upon departure from a site after drilling a hole. Supplementary cleaning will be performed prior to site entry when there is a likelihood that contamination has accumulated on tires and as spatter or dust enroute from one site to the next.

- Place contaminated equipment in an enclosure designed to contain all decontamination residues (water, sludge, etc.).

- Steam clean equipment until all dirt, mud, grease, asphaltic, bituminous, or other encrusting coating materials (with the exception of manufacturer-applied paint) have been removed.

- Water used will be taken from an approved source.

- Containerize in 55-gal drums; sample; characterize; and, based on sample results, dispose of all decontamination residues properly.

Other heavy equipment includes use of backhoes, excavators, skid steers, etc. If heavy equipment is utilized during field activities, i.e., a backhoe for test pitting, the bucket should not come in contact with soil to be sampled. If the bucket contacts the soil to be sampled, then it should be decontaminated between sample locations, following the same procedures as listed above for a drill rig.

3.3.5 High Performance Liquid Chromatography-Grade Water Storage

Dedicated glass storage containers will be used solely for dispensing HPLC-grade water. New HPLC-grade water containers will be decontaminated as follows:

- Clean with tap water from approved source and non-phosphate laboratory detergent while scrubbing the exterior and interior of the container with a stiff-bristled brush.

- Rinse thoroughly with approved water.

- Rinse with 0.01N nitric acid.

- Rinse with approved water.

- Rinse thoroughly with HPLC-grade water.

- Fill clean container with HPLC-grade water. Cap with one layer of PTFE-lined paper and one layer of aluminum foil. Secure cap with rubber band and date the container.

Used HPLC-grade water containers will be decontaminated as follows:

- Clean the exterior with tap water from an approved source, non-phosphate laboratory detergent, and a stiff-bristled brush.
- Rinse the exterior thoroughly with HPLC-grade water.
- Rinse the interior twice with pesticide-grade isopropanol.
- Rinse interior thoroughly with HPLC-grade water.
- Fill clean container with HPLC-grade water. Cap with one layer of PTFE-lined paper and one layer of aluminum foil. Secure cap with rubber band and date the container.

3.3.6 Ice Chests and Reusable Shipping Containers

- Scrub exterior/interior with approved brush and liquinox detergent.
- Rinse off detergent three times with approved water.
- Let air dry and properly store until re-use.

NOTE: If container/ice chest is severely contaminated, clean as thoroughly as possible, render unusable, and properly dispose.

4. MAINTENANCE

HPLC-grade water will be stored only in decontaminated glass containers with aluminum foil lids as stipulated above. The water may not be stored for more than nor used more than 3 days after manufacture.

HPLC-grade water will be manufactured onsite. An approved tap water source will be used as the influent to the system. Procedures for system setup, operation, and maintenance will conform to manufacturer's specifications.

5. PRECAUTIONS

Dispose of all wash water, rinse water, rinsates, and other sampling wastes (tubing, plastic sheeting, etc.) in properly marked, sealable containers, or as directed by the Health and Safety Plan.

Once a piece of equipment has been decontaminated, be careful to keep it in such condition until needed.

Do not eat, smoke, or drink onsite.

6. REFERENCES

Site-specific Health and Safety Plan.

Standard Operating Procedure No. 007
for
Surface Water Sampling Procedures

Prepared by

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1. SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure (SOP) is to delineate protocols for sampling surface water. This procedure can be applied to the collection of surface water samples from streams, rivers, ditches, lakes, ponds, and lagoons. Surface water samples provide an indication of the amount of contaminant in the surface water. It is, therefore, important to collect a representative sample.

2. MATERIALS

The following materials may be required:

0.45-µ disposable filters	Sample bottles
Cooler with ice	Short-handled dip sampler (PTFE) or stainless steel)
Long-handled dip sampler (polytetrafluoroethelyne [PTFE] or stainless steel)	Stainless steel or PTFE-lined bucket
Peristaltic pump with 0.45-µM filters and disposable tygon tubing	

3. PROCEDURE

For all surface water samples, mark the sampling locations on a site map. Photograph (if cameras are allowed onsite) and describe each location, and place a numbered stake above the visible high water mark on the bank closest to the sampling location, and/or mark adjacent trees with surveyor's flagging. The photographs and descriptions must be adequate to allow the sampling station to be relocated at some future date by someone other than the original sampling crew. Use the long handled dip sampler where access is poor or non-contact with water is suggested in the Health and Safety Plan.

Sampling should performed deliberately and methodically to minimize disturbance of bottom sediments, yet as quickly as possible to ensure a representative sample. To prevent contamination of the exterior of the sample container, and/or potential contamination of the surface water sample by laboratory contaminants on the exterior of the bottle, the sample container should never be dipped into the water, rather a decontaminated, long-handled or measuring cup-type PTFE or stainless steel sampler, or a sampling bucket should be used to collect unfiltered samples.

Sampling with the PTFE or stainless steel sampler (long-handled or measuring cup-type):

- Remove the cap from the sample bottle.

- Dip a sample of surface water using the sampler.

- Tilt sample bottle and gently pour sample from sampler into the bottle. Allow the sample to trickle down the side of the bottle. Avoid aerating the sample.

- Add preservative as required by SOP No. 039. Replace cap, and place in cooler immediately.

Sampling with stainless steel or PTFE-lined bucket:

- Remove cap from sample bottle.

- Gently dip collection bucket in the water. Fill bucket and carefully lift from water body.

- Tilt sample bottle and gently pour sample from sampler into the bottle. Allow the sample to trickle down the side of the bottle. Avoid aerating the sample.

- Add preservative as required by SOP No. 039. Replace cap, and place in cooler immediately.

– OR –

- Use smaller sampling cup to transfer sample from bucket to sample bottle as described above.

Both filtered and unfiltered samples will be taken for metals analyses. Bulk samples for filtration will be collected using the stainless steel or PTFE-lined bucket method described above. Sample filtration must be performed immediately upon retrieval of the bulk sample as follows.

Filtration will be performed immediately after collecting sample. Set up filtration equipment prior to collecting sample. Filtration may be accomplished by gravity, or if necessary, due to slow filtering, a peristaltic pump will be used to pressure filter the sample. Vacuum filtration will not be used due to the possibility of analyte volatilization.

Gravity filtration will be accomplished as follows:

- Using decontaminated forceps, place a 0.45-µM membrane in a decontaminated filter funnel.

- Slowly pour sample into the funnel and collect filtrate directly into appropriate sample container(s).

- Add preservative(s) as required by SOP No. 039. Immediately cap container and place in cooler.

- Dispose of filter membrane.

Pressure filtration will be accomplished as follows:

- Using previously assembled disposable tubing, 45-µ in-line filter, and peristaltic pump, filter sample from collection bucket into appropriate container.
- Adjust pump rate to avoid aeration of sample.
- Fill container, preserve as indicated in SOP No. 039, immediately cap container and place in cooler.
- Dispose of filter and tubing.

Refer to SOP Nos. 001, 002, 004, 005, 016, and 039.

4. MAINTENANCE

Refer to manufacturer's specifications for maintenance procedures on generators and pumps.

5. PRECAUTIONS

Avoid disturbing bottom sediments.

Consult the Health and Safety Plan prior to collecting any samples for personal protective equipment such as dermal and respiratory protection and personal flotation devices when sampling in or near deep water or from boats.

Always decontaminate the sampling and filtration equipment, and change gloves between sampling locations to minimize the risk of cross-contamination.

Always set up generators downwind of working area. Never service generators onsite.

6. REFERENCES

None.

Standard Operating Procedure No. 008
for
pH Measurement

Prepared by

EA Engineering, Science, and Technology, Inc.
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5. PRECAUTIONS 3

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1. SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure (SOP) is to delineate protocols for measuring the pH of all types of aqueous solutions, including drinking water, saline water, and industrial and domestic wastes. As a measure of the hydrogen ion content of a solution, pH gives a general indication of the acidity or alkalinity of a water sample.

Use of brand names in this SOP is not intended as endorsement or mandate that a given brand be used. Alternate equivalent brands of detectors, sensors, meters, etc. are acceptable. If alternate equipment is to be used, the contractor will provide applicable and comparable SOPs for the maintenance and calibration of same.

2. MATERIALS

The following materials may be required:

Φ ® 12 pH Meter
Automatic temperature compensator (ATC) probe
Beakers
Combination (pH) electrode
Commercial buffer solutions (standards) of pH 4.00, 7.00, and 10.00
HPLC-grade water
Laboratory wipes for blotting electrodes
Wash bottle

3. PROCEDURE

3.1 CALIBRATION CHECK

Calibration of the pH meter will be checked on a daily basis. A two-point calibration should be used as follows:

1. Prepare beakers of buffer solutions of pH 4.00, 7.00, and 10.00.

2. Calibration should closely bracket the expected pH range of the samples to be taken.

3. Turn on instrument, clear instrument.

4. Rinse the electrode with distilled water and blot excess.

5. Immerse probes in beaker of pH 4.00 or 7.00 standard, swirl gently.

6. Press pH key, then STD key.

7. Keep the probes in the sample until the reading stabilizes. The reading should be the pH of the standard.

8. Rinse the electrode with distilled water and blot excess.

9. Repeat the procedure with pH 7.00 and 10.00 standards.

10. Record the initial readings.

11. If the measured values vary from the expected value by greater than 0.2 pH units, recalibrate the instrument with fresh aliquots of buffer solution. If the discrepancy persists, alert the Field Operations Leader, who has the option of trying to fix the meter or obtaining a second pH meter.

12. Record all measurements in the field logbook.

13. Verify calibration by reading the pH of the third buffer solution.

14. Refer to SOP No. 016.

3.2 pH MEASUREMENTS

Measurements of pH will be taken using the two-point standardization method as follows:

1. Connect the ATC and pH electrodes to the appropriate inputs.

2. Turn on instrument, clear instrument.

3. Prepare two small beakers of standard buffer solutions. Ideally, the pH values of these standards will “bracket” the expected pH value of the sample and be as close as possible to the pH of the sample.

4. Rinse a small beaker with distilled water, then sample water. Fill the beaker with sample water.

5. Rinse the probes with distilled water. Blot excess.

6. Immerse electrode and ATC in first standard. Swirl gently. Press pH key and STD key. Wait for display to stop flashing.

7. Rinse the probes with distilled water. Blot excess.

8. Immerse electrode and ATC in second standard. Swirl gently. Press STD key. Wait for display to stop flashing.

9. Rinse the probes with distilled water. Blot excess.

10. Immerse the probes in the sample and swirl gently, keeping the probes in the sample until the display stops flashing.

11. Record the sample pH and temperature after stabilization. Note any problems such as meter drift.

12. Rinse the probes with distilled water. Blot excess.

13. Repeat Steps 9 through 12 for additional samples.

Decontaminate probe according to manufacturer's specifications.

Decontaminate beakers according to SOP No. 005, Section 3.3.1.4 (Labware).

4. MAINTENANCE

The following steps will be taken to maintain the pH meter:

1. Check the batteries each time the meter is used.

2. Keep the probe stored in a 0.1 M KCl solution adjusted to pH 4 when the meter is not in use. Alternatively, the electrode may be rinsed with deionized water and the protective cap put on, trapping any residual water inside it (do not blot the electrode dry prior to putting the cap on).

5. PRECAUTIONS

Remove coatings of oil material or particulate matter that can impair electrode response by gentle wiping or detergent washing, followed by distilled water rinsing.

As noted in Section 1, these procedures may not apply to alternate manufacturer's equipment.

Calibration is always performed using the pH 7.00 and one end point (pH4.00 or 11.00) standard. **Never** calibrate the instrument using two end points only.

6. REFERENCES

Beckman Instruments, Inc. Users Manual for Φ® 10 pH Meter, Φ® 11 pH meter, and Φ® 12 pH/ISE Meter.

Franston, M.H. et al. (eds). 1981. Standard Methods for the Examination of Water and Wastewater, 15th Edition. American Public Health Association, American Water Works Association and Water Pollution Control Federation.

U.S. Environmental Protection Agency. 1983. Methods for Chemical Analysis of Water and Wastes. March.

Standard Operating Procedure No. 009
for
Temperature Measurement

Prepared by

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1. SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure (SOP) is to delineate protocols for measuring the temperature of a solid or liquid sample, in particular, for measuring water temperature. Groundwater temperature does not vary dramatically over the course of a year. Therefore, groundwater temperature can be used to help identify an aquifer, identify stream reaches where groundwater inflow is occurring, identify thermal gradients in lakes or ponds, and also indicate when sufficient water has been removed from a well during purging.

2. MATERIALS

The following materials may be required: digital reading thermocouple thermometer in combination meter or in a stick. Accuracy = ±0.5°C.

3. PROCEDURE

Rinse the probe with distilled water. Insert the probe into the sample, and leave it in the sample until the temperature stabilizes. Record the temperature reading, being sure to indicate °C or °F. Decontaminate the probe according to Section 3.3 of SOP No. 005 (Field Decontamination).

Refer to SOP Nos. 005 and 016.

NOTE: °C = (°F - 32) (5/9)
°F = ([9/5]°C) + 32.

4. MAINTENANCE

Not applicable.

5. PRECAUTIONS

None.

6. REFERENCES

U.S. Environmental Protection Agency. 1983. Methods for Chemical Analysis of Water and Wastes. March.

Standard Operating Procedure No. 010
for
Water Level and
Well Depth Measurements

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1. SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure (SOP) is to delineate protocols for measuring water level and well depth. This procedure is applicable to the sampling of monitoring wells and must be performed prior to any activities which may disturb the water level, such as purging or aquifer testing.

2. MATERIALS

The following materials may be required:

Electric water level indicator (dipmeter) with cable measured at 0.01-ft increments OR weighted steel tape and chalk OR transducer and datalogger
Oil/water interface probe
Plastic sheeting
Photoionization detector or intrinsically safe flame ionization detector

3. PROCEDURE

3.1 PRELIMINARY STEPS

Locate the well and verify its position on the site map. Record whether positive identification was obtained, including the well number and any identifying marks or codes contained on the well casing or protective casing. Gain access to the top of the well casing.

Locate the permanent reference mark at the top of the casing. This reference point will be scribed, notched, or otherwise noted on the top of the casing. If no such marks are present, measure to the top of the highest point of the well casing and so note this fact in the field logbook. Determine from the records and record in the notebook the elevation of this point.

Record any observations and remarks regarding the completion characteristics and well condition, such as evidence of cracked casing or surface seals, security of the well (locked cap), and evidence of tampering.

Keep all equipment and supplies protected from gross contamination; use clean plastic sheeting. Keep the water level indicator probe in its protective case when not in use.

3.2 OPERATION

Sample the air in the well head for gross organic vapors by lifting the well cap only high enough for an organic vapor meter (photoionization detector or flame ionization detector) probe to be entered into the well casing. This will indicate the presence of gross volatile contaminants as well as indicating potential sampler exposure.

Remove cap. Allow well to vent for 60-90 seconds. Resample headspace. Record both readings. If the second reading is lower than the first, use the second reading to determining whether respiratory protection will be required during subsequent water level and well depth determinations, and sampling.

Note that all headspace sampling must be performed at arm's length and from the upwind side of the well if possible.

Refer to SOP Nos. 011, 023, or 024 as appropriate.

If non-aqueous phase liquid (NAPL) contamination is suspected[1], use an interface probe to determine the existence and thickness of NAPLs.

Open the probe housing, turn the probe on, and test the alarm. Slowly lower the probe into the well until the alarm sounds. A continuous alarm indicates a NAPL while an intermittent alarm indicates water. If a NAPL is detected, record the initial level (first alarm). Mark the spot by grasping the cable with the thumb and forefingers at the top of the casing. If a mark is present on the casing, use the mark as the reference point. If no mark is present, use the highest point on the casing as the reference point. Withdraw the cable sufficiently to record the depth.

Continue to slowly lower the probe until it passes into the water phase. Slowly retract the probe until the NAPL alarm sounds and record that level in the manner as described above.

Record the thickness of the light NAPL[2] (Section 3.3).

Continue to slowly lower the interface probe through the water column to check for the presence of dense NAPL.

Measure and record the thickness of the dense NAPL layer (if any) as described above.

Slowly raise the interface probe, recording the depth to each interface as the probe is withdrawn. If there is a discrepancy in depths, clean the probe sensors and re-check the depths.

NOTE: Air/liquid interface depth is more reliable if probe is lowered into liquid. NAPL/water depths are more accurate if probe is moved from water into NAPL.

Always lower and raise interface probe slowly to prevent undue mixing of media.

---

1. Interface probes will be used in all wells for first round sampling, regardless of site history. If no NAPLs are detected during the first round of sampling, this step may be omitted during subsequent sampling events **unless** conditions such as site history or headspace vapors would indicate otherwise.
2. If NAPL is viscous, such as coal tar or weather bunker oil, several confirmation measurements should be made after decontamination of the probe to verify that the NAPL is not sticking to the probe and causing erroneous readings. One way to accomplish this would be to partially fill a 5-gal bucket with water and dip the probe to ensure that decontamination has effectively removed the NAPL.

Always perform NAPL check in wells installed in areas with suspected NAPL contamination. Always perform NAPL check if headspace test reveals presence of volatiles. Always perform NAPL check the first time a well is sampled. **If** a well has been sampled previously **and** no NAPLs were present **and** none of the preceding conditions are met, the NAPL check may be omitted.

If no NAPL is present, use an electronic water level detector as follows:

- Remove the water level indicator probe from the case, turn on the sounder, and test check the battery and sensitivity scale by pushing the red button. Adjust the sensitivity scale until you can hear the buzzer.

- Slowly lower the probe and cable into the well, allowing the cable reel to unwind. Continue lowering until the meter buzzes. Very slowly, raise and lower the probe until the point is reached where the meter **just** buzzes. Marking the spot by grasping the cable with the thumb and forefingers at the top of the casing. If a mark is present on the casing, use the mark as the reference point. If no mark is present, use the highest point on the casing as the reference point. Withdraw the cable and record the depth.

Alternatively use a steel tape with an attached weight if aquifer gradients are lower than 0.05 ft/ft. Due to the possibility of adding unknown contaminants from chalk colorants, only white chalk is permitted.

Rub chalk onto the first 1 ft of the steel tape and slowly lower the chalked end into the well until the weighted end is below the water surface. (A small splash can be heard when the weighted end hits the water surface.)

Using the method described above read and record the length from the steel tape.

Remove the steel tape. The chalk will be wet or absent where the tape was below the water surface. Locate, read, and record this length. Subtract wetted length from total length and record the difference. This is the depth to water table.

Transducers and dataloggers will be used where water level fluctuations over time are to be measured, such as tidal fluctuation studies (SOP No. 045) and aquifer (hydraulic) tests (SOP No. 033). Note that transducers are inappropriate for measuring well depth.

Slowly lower the transducer into the well until it is below the lowest possible piezometric level (typically 2-3 ft below the water table).

Tape the umbilical to the protective casing to prevent the transducer from falling further.

Attach the umbilical leads to the datalogger.

Turn datalogger on.

To measure the well depth, lower electric water level indicator probe or tape until slack is noted. Very slowly raise and lower the cable until the exact bottom of the well is "felt." Measure (cable) or read the length (tape) and record the depth.

Note that if the electric water level indicator is used to determine depth of well, the offset distance between the tip of the probe and the electrode must be added to the reading to determine actual depth.

Withdraw the probe or tape. Decontaminate the probe(s) and cable(s).

3.3 DATA RECORDING AND MANIPULATION

Record the following computations:

- Date and time
- Weather
- Method of measurement
- Casing elevation
- NAPL surface elevation = casing elevation – depth to NAPL
- NAPL thickness = depth to bottom of NAPL – depth to top of NAPL
- Water level elevation = casing elevation – depth to water
- Well bottom elevation = casing elevation – depth to bottom (or read directly from tape).

Refer to SOP Nos. 005 and 016.

4. CALIBRATION

No calibration is needed.

5. PRECAUTIONS

Depending upon the device used, correction factors may be required for some measurements. Check instrument batteries prior to each use. Exercise care not to break the seals at the top of the electric water level indicator probe.

6. REFERENCES

McAlary, T.A. and J.F. Barker. 1987. Volatilization Losses of Organics during Groundwater Sampling from Low Permeability Materials in Groundwater Monitoring Review. Fall.

Thornhill, J.T. 1989. Accuracy of Depth to Groundwater Measurements in U.S. Environmental Protection Agency Superfund Groundwater Issue EPA/540/4-89/002.

Standard Operating Procedure No. 012
for
Specific Conductance Measurements

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1. SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure (SOP) is to delineate protocols for measuring the specific conductance of any aqueous solution, including drinking water, saline water, and industrial and domestic wastes. Conductivity is the ability of an aqueous solution to pass an electrical current. The current is primarily carried by dissolved inorganic ions such as chlorides, nitrates, sulfates, along with cations such as sodium, calcium, magnesium and others. Organic compounds do not carry current and, therefore, have almost no conductivity.

2. MATERIALS

The following materials may be required:

Conductivity meter with integral temperature compensation; accuracy = ±2 percent at 25°C (77°F)
Conductivity cell
Appropriate conductivity reference solution
High performance liquid chromatography (HPLC)-grade water (see SOP No. 005, Footnote 2)
Thermometer (optional, Section 5)

3. PROCEDURE

3.1 CALIBRATION

The specific conductivity meter should be calibrated at the beginning of each day[1] as follows:

1. Thoroughly rinse the probe with appropriate conductivity reference solution.

2. Zero meter if appropriate.

3. Measure the specific conductance of fresh appropriate conductivity reference solution record it in the field notebook, and adjust the calibration knob until the meter reads properly.

4. Rinse probe with HPLC-grade water.

5. Measure the specific conductance of HPLC-grade water and record in the field logbook. If specific conductivity of HPLC-grade water is not 0 (±2 percent) recalibrate instrument.

---

[1] The meter should be recalibrated any time the readings are suspect (e.g., out of expected range).

3.2 OPERATION

The specific conductivity meter will be operated as follows:

1. Thoroughly rinse the probe and sample beaker with sample water.

2. Measure the temperature of the sample water. Convert Fahrenheit temperature readings to Celsius using C = 5/9(F - 32) if Celsius temperature is not obtained directly.

3. Place the probe in the sample beaker with sufficient sample to completely submerge the probe. Swirl the probe to remove any air bubbles trapped in the probe.

4. Select the highest multiplier scale on the meter and turn the instrument on. Progressively use lower multiplier scales until a mid-scale deflection is obtained.

5. If appropriate, check probe accuracy by pressing cell test button. If value change is >10 percent check probe.

6. Record the temperature and conductivity values.

7. Specific conductivity values are corrected for temperature using:

   K^25^oC = {*K measured*} over {1+ 0.0191 (t-25)}

   where

   K = Conductivity in µmhos
   t = Temperature, °C

8. Decontaminate the probe (see SOP No. 005, Section 3.3.3).

Refer to SOP Nos. 005 and 016.

4. MAINTENANCE

The following steps will be taken to properly maintain the conductivity meter:

1. Check the batteries each time the instrument is used.

2. Inspect the probe on a daily basis for damage or loss of platinum black plating from the electrode. If the platinum is damaged, alert the Field Team Leader and arrange to get a new cell.

3. Follow manufacturer's specifications regarding storage of probe between uses.

5. PRECAUTIONS

Be certain there is no air in the cell before taking a reading. If conductivity meter does not have integral temperature compensation, use a thermometer to determine temperature of the sample.

6. REFERENCES

Manufacturer's Manual.

U.S. Environmental Protection Agency. 1983. Methods for Chemical Analysis of Water and Wastes. March.

Standard Operating Procedure No. 013
for
Collection of Monitoring Well Samples

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1. SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure is to delineate protocols for the collection of groundwater samples from monitoring wells.

2. MATERIALS

The following materials may be required:

0.45 μM filters	Polyvinyl chloride bailer (for purging only)
Bladder pump (dedicated to one well only)	Sample bottles and labels
Conductivity meter	Stainless steel bailer (for purging and sampling)
Dissolved oxygen meter	Submersible pump and hose (for purging only)
Generator	Thermometer (optional)[1]
Logbook or book of field parameter forms	Transparent bailer with a double check valve
Peristaltic pump with tubing for filtering samples	Turbidity meter
pH meter with oxidation-reduction potential probe	Tygon tubing
Photoionization detector organic vapor analyzer.	Variable speed, low flow submersible pump (e.g., Grundfos MP1 groundwater sampling pump) (for purging and sampling)
Plastic sheeting	Water level indicator
Polypropylene rope	
Polytetrafluoroethelyne (PTFE) bailer with PTFE-coated stainless steel cable, double check valve top, and controlled flow bottom discharge attachment[2] for volatile organic compound (VOC) sampling (40-mL vials), and top discharge attachment for collecting larger samples (1-L bottles) (for purging and sampling)	

3. PROCEDURE

3.1 GENERAL

Groundwater sampling will follow these general steps:

- Arrive onsite
- Set up apparatus (generators, pumps, etc.)
- Glove
- Organic vapor check, water level, and well depth measurements

---

1. Temperature compensation and measurement capabilities are generally available as integral functions of pH meters and conductivity meters. If this is the case, a separate thermometer is not required.
2. Although use of a controlled flow bottom discharge valve is historically preferred, use of such a device can cause aeration of the sample.

- Sample non-aqueous phase liquids (NAPLs) (as required)

- Begin purge procedure

  — If using bailer to purge and sample, see Section 3.6
  — If using pump to purge and bailer to sample, see Section 3.7
  — If using bladder or low-flow pump to purge and sample, see Section 3.8

- Decontaminate/reglove

- Take samples

  — If with bailer, see Section 3.6
  — If with bladder or low flow pumps, see Section 3.8

- Decontaminate/dispose of wastes, move equipment to next site.

3.2 GENERAL RULES FOR GROUNDWATER FIELD PARAMETER LOGBOOK

Only one site or installation per logbook, and only one sampling location per page or form (if using pre-printed forms). The same book may be used for more than one sampling event. First five pages will be reserved for index, general notes, etc. Sign and date each entry. Last five pages will be reserved for recording calibration data for the pH, temperature, turbidity, oxidation-reduction potential, dissolved oxygen, and conductivity meters. Use the page number or a separately recorded "Cal Reference Number" to refer to each calibration. As appropriate, insert the cardboard flap under the form being filled out, so that writing does not go through to the pages below. As appropriate, fill in the forms from front to back of the logbook, tearing out the white copy for each sample when the sample has been collected. This copy goes in the cooler with the sample, directly to the laboratory. The original copy must be torn out before you write on the back of the duplicate form. As appropriate, duplicate copies, index pages, and calibration sheets remain intact.

3.3 GROUNDWATER SAMPLING GENERAL RULES

Groundwater samples will be collected from the least contaminated wells first, progressing to the most contaminated[3]. Upon arrival at the well site, immediately set up and organize the purging, sampling, and filtration equipment. If needed, due to muddy or contaminated ground, remoteness from sampling vehicle, and\or for placement of hose(s) and\or power cord if a pump is used, place clean plastic sheeting at, or around the well, to serve as a clean staging area for purging and sampling equipment, as conditions warrant. Care must be exercised not to step on plastic sheeting. If the well is remote from the sampling vehicle, set up the filtration equipment

---

[3] First round samples are to be collected from upgradient wells first, moving to downgradient wells under the assumption that upgradient wells will be less contaminated than downgradient wells. Results of first round analysis may mandate a change in sampling sequence.

and place rope, wrapped bailer, and pre-labeled sample containers on the plastic sheet, from the well. When a pump is to be used, situate the portable generator on level ground approximately 15 ft away from and downwind from the well. All generator maintenance (oil and fueling) is to be performed offsite. If the hose(s) and/or power cord of the pump are not on a reel, place the pump with its hose and power cord on the plastic sheeting downhill from the well.

Check well headspace for organic vapor which may pose a health and safety hazard and indicate the presence of NAPL. Measure depth(s) to and thickness(es) of NAPL(s) as appropriate. Measure the depth to water and depth of well. From the water depth, well diameter, sand pack length, etc., calculate the equivalent volume (1 EV) of water in the well.

1 EV = volume in casing + volume in saturated sand pack. Therefore, if the water table lies below the top of the sandpack, use the following equation:

$$1 \text{ EV} = (\pi R_w^2 h_w) + (0.30\pi(R_s^2 - R_w^2)h_w) * (0.0043)$$

If the water table lies above the top of the sandpack use this equation:

$$1 \text{ EV} = [(\pi R_w^2 h_w) + (0.30\pi(R_s^2 - R_w^2)h_s)] * (0.0043)$$

where

R_s = Radius of sandpack in inches
R_w = Radius of well casing in inches
h_s = Height of sandpack in inches
h_w = Water depth in inches

0.0043 gal/in.^{3}
Assumed filter pack porosity = 30 percent.

Samples will always be collected in order of decreasing volatility (i.e., the samples to be analyzed for the volatile constituents should be collected first). Deliver the VOC sample to the vial by allowing the water to trickle down the inside wall of the vial at a rate no greater than approximately 100 ml/min. Other samples may be delivered at a faster rate. Sampling rates will at no time exceed 1 L/min. Procedures for each class of samples are contained in the site-specific Quality Assurance Project Plan.

When collecting samples for volatile analysis, care should be taken to prevent analyte loss by volatilization. The following procedures should be adhered to when collecting these samples:

- Avoid excessive aeration and agitation of sample.

- Fill vial so that a reverse meniscus is present by adjusting the flow rate from the sampling device.

- Place septum on vial so that the PTFE side is in contact with the sample. After the cap is on the bottle, check for air bubbles in the sample. If air bubbles are present, properly dispose of that sample and recollect the sample in the same vial.

- Make sure vial is labeled and immediately transfer the vial to the cooler with ice.

Filtered and unfiltered samples will be taken for inorganics (metals) analyses. The samples will be filtered through an in-line 0.45-µM filter (preferred method), or by gravity through a 0.45-µM membrane placed in a filter funnel. Use forceps to place the membrane into the funnel and pour sample through funnel until appropriate volumes have been filtered.

If necessary, due to slow filtering, a peristaltic pump may be used to filter the sample through an in-line filter. Connect the pump to the generator, attach tygon tubing to the bottom discharge valve on the bailer. Start pump and collect sample from the end of the in-line filter directly into the proper container, preserved, and placed in the cooler. Filtered samples will be preserved in the field with acid to a pH of less than 2. Make sure sample bottle is labeled and the cap is on tightly. Then place in cooler with ice immediately.

— OR —

If a low flow pump is used collect the samples, filtered samples will be taken by installing a 0.45-µM filter in-line and pumping the water through the filter. Collect sample from the end of the in-line filter directly into the proper container, preserved, and placed in the cooler. Filtered samples will be preserved in the field with acid to a pH of less than 2. Make sure sample bottle is labeled and the cap is on tightly. Then place in cooler with ice immediately.

Unfiltered samples will be collected by slowly pouring the sample water into the appropriate sample container, being careful not to agitate or cause bubbles to form. Do not overfill bottles. Make sure sample bottle is labeled and the cap is on tightly, then place the sample in cooler with ice immediately.

All samples will be delivered to the laboratory as soon as possible. If possible, samples will be shipped on the same day as they are collected. If samples must be retained due to weekend sampling (Friday through Sunday), the laboratory will be notified as to the time sensitive nature of the samples.

3.4 SAMPLING OF NON-AQUEOUS PHASE LIQUIDS

If NAPLs are detected in the well, a sample from all layers must be collected prior to any purging activities. NAPLs may be indicated by the presence of volatiles in the well headspace, and confirmed by the oil/water interface probe.

Collecting light non-aqueous phase liquid (LNAPL) will be accomplished using a transparent bailer with a double check valve. This bailer will be slowly lowered until the bottom of the bailer is 1-2 in. below the LNAPL-water interface, then slowly withdrawn. Verify that the interface was sampled by visual inspection of the bailer contents through the side of the bailer. Measure the thickness of the LNAPL in the bailer and note in the Field Logbook. Sample for laboratory analysis. An additional field verification may be performed by decanting the remainder of the contents of the bailer into a glass jar, adding a hydrophobic dye such as Sudan IV, or Redoil, shaking the sample and looking for coloration of NAPL. Alternate field tests are: examine the sample under ultraviolet light (many fluoresce), or allow the sample to stand overnight, and examine for interface and/or volatiles in the headspace the following day. Refer to following sections on purging and sample collection for setup and general operation.

Collecting dense non-aqueous phase liquids (DNAPLs) will be accomplished using a transparent bailer with a double check valve. The bailer must be lowered very slowly to the bottom of the well and raised slowly out of the well in a controlled fashion. Sample for analysis as above. The same field check described above may be employed for DNAPL. Refer to following sections on purging and sample collection for set up and general operation.

If NAPLs are present in the well, **and** a low-flow pump is to be used for purging and sampling, the well will be allowed to re-equilibrate prior to purging and sampling. This will be accomplished by allowing the well to stand undisturbed for at least 8 hours prior to purging and sample collection.

3.5 WELL PURGING GENERAL RULES

Water within the casing of a well will stagnate, degas, lose volatiles, possibly precipitate metals due to changes in redox potential, and may react with the screen and/or casing material. It is, therefore, necessary to purge a sufficient volume of this stagnant water from the well and/or casing to ensure that a representative sample of formation water can be obtained. Traditionally, the volume of water to be purged was arbitrarily set at 3-5 equivalent volumes. Recent advances in sampling technologies have caused a re-thinking of such arbitrary purge volumes. It is for this reason that monitoring of select chemical and physical properties of the sample medium will be used instead of strict volumes to determine when a representative sample may be taken from a well.

Acceptable purge/sampling devices include: bailers, high-discharge submersible pumps (purge only), and variable speed, low-flow pumps which include both submersible pumps (purge and sample) and dedicated bladder pumps (purge and sampling). It is recommended to purge and sample at similar rates with one type device per well. An acceptable exception to this general rule is to use a high-discharge submersible pump to purge a deep, fast-recharging well, and a bailer to sample the same well.

Peristaltic, gas-lift, and centrifugal pumps can cause volatilization, produce high pressure differentials, and can result in variability in the analysis of some analytes of interest. These types of pumps will not be used to purge or sample wells.

To prevent groundwater from cascading down the sides of the screen into an open hole, thereby aerating the sample, purge rates will closely match recharge rates. If the static water level is within the casing, the initial purge rates may be set high enough to lower the water level to the top of the screen, then reduced to maintain that level.

Purging will be accomplished with either a submersible pump, a low-flow (submersible or bladder) pump, or bailer. The choice of bailer or pump will be based on depth to water table, volume to be purged, and permeability of the aquifer. If the well recharges rapidly and/or has greater than 20 gal (estimated EV) to be purged, water may be removed with a submersible pump or a low-flow pump. If the well recharges slowly and/or has less than 20 gal to be purged, water will be removed with a bailer or a low-flow pump.

Purging will be accomplished with as minimal disturbance to the surrounding formation as possible.

Purge water will be containerized onsite until analysis of samples is completed. Based on sample results, accumulated purge water will be properly disposed.

If the water level is within the screened interval and the well recharge rate is less than 0.1 L/min, purge the well using a low-flow pump as follows:

1. Draw the water down to within 1 ft of the top of the pump.

2. Allow the well to recover.

3. Check and record field parameters.

4. Repeat Steps 1 through 3 then collect samples for metals analysis only[4].

5. Note the event in the Field Logbook, and report the problem to the Project Manager. If this extremely low recharge problem consistently occurs in a given well, the well may be considered for re-development and/or replacement.

6. If adjacent wells have elevated VOC levels, additional soil gas surveys will be considered in the vicinity of the low recharge well to help determine the need for replacement.

3.6 PURGING AND SAMPLING WITH BAILERS

Bailers may be used for both purging and sampling wells if: (a) the well recharge rate is less than 4 L/min, (b) depth to the water table is less than 50 ft, and (c) less than 20 gal are to be purged (5 EV < 20 gal)[5].

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4. Analyte losses due to volatilization in a drained well are too high for valid VOC sampling (M^{c}Alary and Barker 1987).

When purging with a bailer, either a polyvinyl chloride, PTFE, or stainless steel bailer may be used. The bailer will be attached to either a spool of PTFE-coated stainless steel cable or polypropylene rope. If using cable, attach it to the bailer using stainless steel cable clamps. Thoroughly decontaminate the cable after each use, prior to rewinding cable onto spool. Cable clamps and raw cable ends may serve to trap contamination. Exercise particular caution in decontaminating these areas. If using rope, attach the rope to the bailer using a bowline knot, dispense the needed length (a few feet more than the well depth) and cut the remainder away; then, at the end opposite the bailer, make a slip knot and place it around the well casing or protective posts to prevent losing the bailer and rope down the well. The polypropylene rope will be not reused; it will be properly disposed of. Either type of bailer will be repeatedly lowered gently into the well until it fills with water, removed, and the water will be discharged into an appropriate container until purging is complete. Care must be taken not to unduly agitate the water, as this tends to aerate the sample, increase turbidity, makes stabilization of required parameters difficult to achieve, and generally prolongs purging.

After purging 2 EV, obtain a sample of groundwater and measure the following stabilization parameters: temperature, conductivity, pH, turbidity, redox potential (Eh), and dissolved oxygen level at each successive half-well volume. When three of these stabilization parameters are in agreement within approximately 10 percent in three consecutive half-well volume samples, sufficient water has been purged from the well. The results of these tests should be recorded in the sampling logbook. Should these parameters not reach agreement, no more than five well volumes will be purged.

Immediately upon completion of purging, collect samples for laboratory analysis using a PTFE bailer on a PTFE-coated stainless steel cable. The bailer will be equipped with double check valve top and controlled flow bottom discharge attachments for VOC sampling (40-mL vials), and top discharge attachment for collecting larger samples (1-L bottles).

Slowly, so as not to agitate the water, lower the bailer into the well, using a spool of PTFE-coated cable. Allow bailer to fill, withdraw smoothly. Refill bailer as needed.

If the controlled flow bottom discharge attachment is used for VOC sampling, attach it to the bottom of the bailer. Using the stopcock valve on the bailer to control the flow, fill sample vials as described above in Section 3.3.

Remove check valve top and pour unfiltered sample into inorganics sample bottles.

Collect filtered samples as described in Section 3.3. Decontaminate bailer and cable.

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5. These numbers are based on the following assumptions: (1) In purging, it is preferable to remove water at approximately the recharge rate; (2) 4 L/min is estimated as the approximate maximum rate at which water can be removed with a bailer from depths of 20-50 ft; and (3) 20 gal is estimated to be at the limit of the sampler's endurance, at which point fatigue and sloppiness of technique begin.

3.7 PURGING WITH PUMP, SAMPLING WITH BAILER

If the recharge rate of the well is greater than 30 L/min, or the water level is deeper than 50 ft, or more than 20 gal of purge water will be generated (5 EV > 20 gal), then purging and sampling may be accomplished using a submersible pump/bailer combination.

When purging with a pump, gradually lower the intake until it is submerged within the screened interval. Lower an electronic water level probe to the top of the screen (as determined from completion records) to the monitor water level, start pump, and slowly lower the pump as the water level continues to fall. Care should be exercised to lower the water column to the top of the screened interval (water level probe will stop beeping) but not below the top of the screen if possible. This will ensure that the stagnant layer has been removed, but should minimize the detrimental effects of over pumping the well. Secure hose(s) and/or power cord to casing and place discharge hose into the proper container, downhill and as far away from the well as possible. Determine and record the discharge rate.

Discharge rate = volume of container/time to fill container

The discharge rate will be established at approximately equal to or just greater than the well’s recharge rate (determined from well development). If well development records are incomplete, recharge rate can be determined by monitoring the rise/fall of the water level within the casing as one purges the well. If the water level is static at a given pumping rate, but fluctuates up or down as pumping rate is decreased or increased, the pumping rate at which the water level is static is the recharge rate.

After purging 2 EV, obtain a sample of groundwater and measure the following stabilization parameters: temperature, conductivity, pH, turbidity, redox potential (Eh), and dissolved oxygen level at each successive half-well volume. When three of these stabilization parameters are in agreement within approximately 10 percent in three consecutive half-well volume samples, sufficient water has been purged from the well. The results of these tests should be recorded in the sampling logbook. Should these parameters not reach agreement, no more than five well volumes will be purged.

Immediately upon completion of purging, collect samples for laboratory analysis using a PTFE bailer on a PTFE-coated stainless steel cable. The bailer will be equipped with double check valve top and controlled flow bottom discharge attachments for VOC sampling (40-mL vials), and top discharge attachment for collecting larger samples (1-L bottles). Filtration of metals samples will be accomplished using either an in-line filter attached to the bottom of the bailer, or a funnel and appropriate filter (Section 3.3).

Slowly, so as not to agitate the water, lower the bailer into the well, using a spool of PTFE-coated cable. Allow bailer to fill, withdraw smoothly, fill sample containers as described in Section 3.6. Decontaminate bailer and cable in and decontaminate pump.

3.8 PURGING AND SAMPLING WITH LOW-FLOW PUMP

To obtain representative samples, subsurface disturbances should be kept to a minimum, thereby preventing sample alteration due to sampling actions. The reasoning behind the use of low-flow pumps to purge and sample monitoring wells is that these pumps minimize physical disturbance (turbulence) at the sampling point and chemical changes (aeration) in the medium. For these reasons, the low-flow pump is the preferred method for both purging and sampling in most cases. For the purposes of this SOP, "low-flow pumps" are defined as either dedicated bladder pumps or variable speed submersible pumps. Practical operational flow rates for these sampling devices range from 0.1 L/min to 30 L/min.

Low-flow pumps may be used for purging and sampling any well having recharge greater than 0.1 L/min, which is the practical lower limit of pump performance. Below that pumping rate, pump inefficiencies and/or overheating may alter the physical and chemical properties of the sample. If the pump is continuously operated at sampling rates higher than the well recharge rate, the water level will be lowered in the well, possibly allowing aeration of the sample which is unacceptable sampling procedure. Low-flow pumps are suitable for sampling wells with recharge rates lower than 0.1 L/min if precautions are taken to avoid aeration of the sample.

Low flow submersible pumps will be used as follows:

- Lower the pump into the well, slowly so as not to agitate the water, until the pump is at the mid-point of the screened interval or the mid-point of the water column if the static water table lies below the top of the screen[6]

- Attach the pump's umbilical cord (which will consist of power cord and sampling tubing) to the protective casing, or lock the cord spool so that the pump cannot move vertically in the well during sampling.

- Lower the water level probe into the well behind the pump until it just touches water. This will allow the sampler to monitor the water level while purging and sampling, and prevent the inadvertent drying of the well.

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6. This assumes a 10-ft screened interval. If the screened interval is greater than 10 ft, multiple samples should be taken as follows:
   - If the screen is 10-12 ft, sample the canter of the water column, as outlined above.
   - If the screen is longer than 12 ft, and the water column is 10 ft or less, sample the center of the water column.
   - If the screen is longer than 12 ft, and the water column fills the screen, or extends above the screen, sample at 1/3 and 2/3 the height of the water column, or about every 6 ft.

- Begin purging at the pump's lowest setting, then gradually increase rate[7] until the pumping rate matches the aquifer recharge rate. **If the water level is above the top of the screen**, the pumping rate may be allowed to slightly exceed recharge rate, lowering the water level to no less than 1 ft above the screen, then reduced until it matches recharge rate and purging continued. **If the water level is below the top of the screen**, always keep the purge rate lower than well's recharge rate.

- Monitor stabilization parameters listed in Section 3.6 beginning immediately, using an in-line monitoring system. Record parameters regularly, at a rate of one set of parameters per each 1-3 liters of water removed from the well. When these parameters stabilize to within 10 percent over three consecutive readings, reduce[8] flow rate to 0.1 L/min (if needed) and begin collecting VOC samples directly from the discharge line.

- If the well recharges at a rate less than 0.1 L/min, purge until the water level is even with the top of the screen, allow the well to recover, and sample immediately.

- Remove and decontaminate water level probe and pump.

4. MAINTENANCE

Refer to manufacturer's requirements for maintenance of pumps and generators.

5. PRECAUTIONS

Refer to the site-specific Health and Safety Plan for appropriate personal protective equipment.

6. REFERENCES

Garske, E.E. and M.R. Schock. 1986. An Inexpensive Flow-Through Cell and Measurement System for Monitoring Selected Chemical Parameters in Groundwater.

Gass, T.E., J.F. Barker, R. Dickhout, and J.S. Fyfe. 1991. Test Results of the Grundfos Groundwater Sampling Pump, in Proceedings of the Fifth National Symposium on Aquifer Restoration and Groundwater Monitoring.

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[7] Some sources indicate that the pumping rate should not exceed 1 L/min, with 0.5 L/min being preferable. The optimal purge rate is highly aquifer dependent, and may range from less than 0.5 L/min to greater than 10 L/min. The purge rate for a given well will, therefore, be a field decision, based on well development, purge, and sampling records rather than SOP mandate.

[8] Sampling should occur at the same rate as purging as long as aeration of sample does not occur.

McAlary, T. A. and J.F. Barker. 1987. Volatilization Losses of Organics During Groundwater Sampling From Low Permeability Materials, in Groundwater Monitoring Review. Fall.

Puls, R.W. and R.M. Powell. 1992. Acquisition of Representative Groundwater Quality Samples for Metals, in Groundwater Monitoring Review. Summer.

Puls, R.W., J.H. Eychaner, and R.M. Powell. 1990. Colloidal-Facilitated Transport of Organic Contaminants in Groundwater: Part I. Sampling Considerations, in EPA Environmental Research Brief. EPA/600/M-90/023. December.

Puls, R.W., R.M. Powell, D.A. Clark, and C.J. Paul. 1991. Facilitated Transport of Inorganic Contaminants in Groundwater: Part II Colloidal Transport, in EPA Environmental Research Brief. EPA/600/M-91/040. July.

Puls, R.W., R.M. Powell, B. Bledsoe, D.A. Clark, and C.J. Paul. 1992. Metals in Groundwater: Sampling Artifacts and Reproducibility, in Hazardous Waste & Hazardous Materials. Volume 9, No. 2.

Standard Operating Procedure No. 014
for
Collection of Production Well Samples

Prepared by

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Revision 0
August 2007

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1. SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure (SOP) is to delineate protocols for the collection of groundwater samples from production wells. This protocol will allow for collection of samples from both active production wells and inactive production wells (Section 3).

2. MATERIALS

The following equipment may be required:

Conductivity meter	pH meter
Dissolved oxygen meter	Sample bottles and labels
Logbook or field parameter form	Temperature meter
Oxidation-reduction potential probe	Turbidity meter

3. PROCEDURE

Upon arrival at the well site, immediately set up and organize the sampling and ancillary equipment. If needed, due to muddy or contaminated ground and/or remoteness from sampling vehicle, place plastic sheeting at or around the sampling location as conditions warrant. Exercise caution not to step on and contaminate the sheeting.

If the well is remote from the sampling vehicle, set up the filtration equipment and place sample containers on the plastic sheet, uphill of the sampling location.

If a pump is to be used for filtration, situate the portable generator on level ground approximately 15 ft away from and downwind from the sampling location. All generator maintenance (oil and fueling) is to be preformed offsite.

If the well is currently in use, as close as possible to the well, open a tap to a high flow rate and allow the well to purge.

Obtain a sample of groundwater for temperature, conductivity, oxidation-reduction potential, dissolved oxygen, turbidity, and pH measurements. Record values in sampling logbook.

Take samples for physical stabilization (water quality) parameters every 5 minutes during the well purging process.

Allow the well to purge until the water quality parameters of pH, temperature, conductivity, turbidity, oxidation-reduction potential, and dissolved oxygen measurements stabilize within 10 percent in three consecutive 5-minute sampling periods, purging will be considered complete and sampling may proceed. Slow water flow rate to a trickle.

For procedures for collecting samples, with the exception of the sample source being a bailer, refer to SOP No. 013.

If the well is not currently in use, use a pump and bailer, or low-flow pump for sampling. Refer to SOP No. 013 for purging and sampling protocol. Decontaminate equipment. Refer to SOP Nos. 001, 002, 004, 005, 013, and 016.

4. MAINTENANCE

Not applicable.

5. PRECAUTIONS

Not applicable.

6. REFERENCES

U.S. Army Toxic and Hazardous Materials Agency. 1990. Installation Restoration Quality Assurance Program, December 1985, 1st Edition, March 1987, 2nd Edition.

Standard Operating Procedure No. 016
for
Surface Water, Groundwater, and Soil/Sediment Field Logbooks

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1. SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure (SOP) is to delineate protocols for recording surface water, groundwater, soil/sediment sampling information, instrument calibration data, and data from hydrologic testing in the field logbooks. Acceptable field logbooks are: bound, unprinted books such as a surveyor's field book, or a federal supply service No. 7530-00-222-3525 record book (or equivalent); or they may be company-proprietary, pre-printed forms bound into a field logbook. Example forms are provided herein. Alternate, equivalent forms are acceptable.

2. MATERIALS

The following material may be required: applicable field logbook and indelible ink pen.

3. PROCEDURE

Information pertinent to soil/sediment, groundwater, or surface water sampling will be recorded in the appropriate logbook. Each page/form of the logbook will be consecutively numbered. Entries will be made in indelible ink. Corrections will consist of line-out deletions that are initialed and dated. If using carbon paper or self-duplicating forms, before entering data in logbook, insert a sheet protector between form sets to isolate first blank form from remaining forms.

3.1 SOIL/SEDIMENT LOGBOOK (Requires Figures SOP016-1 and SOP016-3)

3.1.1 Field Parameter Form (Items on Figures SOP016-1 and SOP016-2)

1. HIGH CONCENTRATION EXPECTED?: Answer "Yes" or "No."

2. HIGH HAZARD?: Answer "Yes" or "No."

3. SITE: Record the complete name of the site.

4. AREA: Record the area designation of the sample site.

5. INST CODE: Record the 2-letter installation code appropriate for the installation or site. Correct abbreviations can be found on Pages 3-6 of the IRDMS User's Guide for chemical data entry.

6. FILE NAME: Record "CSO" for a soil sample or "CSE" for a sediment sample.

7. SITE TYPE: Record the abbreviation appropriate for where the sample was taken. Correct abbreviations can be found on Pages 18-21 of the IRDMS User's Guide for chemical data entry. This entry must match the Site Type on the map file form.

8. SITE ID: Record a code up to 10 characters or numbers which is unique to the site.

9. FIELD SAMPLE NUMBER: Record a code specific for the sample.

10. DATE: Enter the date the sample was taken.

11. TIME: Enter the time (12-hour or 24-hour clock acceptable as long as internally consistent) the sample was taken.

12. AM PM: Circle "AM" or "PM" to designate morning or afternoon (12-hour clock).

13. SAMPLE PROG: Record "GQA" (Groundwater Quality Assessment) or other appropriate sample program.

14. DEPTH (TOP): Record the total depth sampled.

15. DEPTH INTERVAL: Record the intervals at which the plug will be sampled.

16. UNITS: Record the units of depth (feet, meters)

17. SAMPLE MEASUREMENTS: Check the appropriate sampling method.

18. CHK: Check off each container released to a laboratory.

19. ANALYSIS: Record the type of analysis to be performed on each sample container.

20. SAMPLE CONTAINER: Record the sample container type and size.

21. NO.: Record the number of containers.

22. REMARKS: Record any remarks about the sample

23. TOTAL NUMBER OF CONTAINERS FOR SAMPLE: Record the total number of containers.

24. SITE DESCRIPTION: Describe the location where the sample was collected.

25. SAMPLE FORM: Record the form of the sample (i.e., clay, loam, etc.) using The Unified Soil Classification System.

26. COLOR: Record the color of the sample as determined from standard Munsell Color Charts.

27. ODOR: Record the odor of the sample or "none." See SOP No. 001 Section 5.

28. PID (HNu): Record the measured PID (HNu) values.

29. UNUSUAL FEATURES: Record anything unusual about the site or sample.

30. WEATHER/TEMPERATURE: Record the weather and temperature.

31. SAMPLER: Record your name.

3.1.2 Map File Form (Figure SOP016-3)

1. The map file logbook form will be located on the reverse of the field parameter logbook form, or on an adjoining page of the field logbook (if level book is used).

2. SITE ID: Record the Site ID from the field parameter form.

3. POINTER: Record the field sample number for the sample being pointed to.

4. DESCRIPTION/MEASUREMENTS: Describe the location where the sample was taken, along with distances to landmarks.

5. SKETCH/DIMENSIONS: Diagram the surroundings and record the distances to landmarks.

6. MAP REFERENCE: Record which U.S. Geological Survey Quad Map references the site.

7. COORDINATE DEFINITION: Write the compass directions the X- and Y-Coordinates of the map run.

8. COORDINATE SYSTEM: Write “UTM” (Universal Transverse Mercator).

9. SOURCE: Record the 1-digit code representing the Map Reference.

10. ACCURACY: Give units (e.g., write “1-M” for 1 meter).

11. X-COORDINATE: Record the X-Coordinate of the sample site location.

12. Y-COORDINATE: Record the Y-Coordinate of the sample site location.

13. UNITS: Record the units map sections are measured in.

14. ELEVATION REFERENCE: Record whether topography was determined from a map or a topographical survey.

15. ELEVATION SOURCE: Record the 1-digit code representing the elevation reference.

16. ACCURACY: Record the accuracy of the map or survey providing the topographical information.

17. ELEVATION: Record the elevation of the sampling site.

18. UNITS: Write the units in which the elevation is recorded.

19. SAMPLER: Write your name.

3.2 SURFACE WATER LOGBOOK (Requires Figures SOP016-2 and SOP016-3)

3.2.1 Field Parameter Form (Items Unique to Figure SOP016-3)

1. CAL REF: Record the calibration reference for the pH meter.

2. pH: Record the pH of the sample.

3. TEMP: Record the temperature of the sample in degrees Celsius.

4. COND: Record the conductivity of the water.

5. For all other sections, see Section 3.2.1.

3.3 GROUNDWATER SAMPLING LOGBOOK (Requires Figures SOP016-2, SOP016-3, and SOP016-4)

3.3.1 Field Parameter Form (Items on Figure SOP016-4)

1. WELL NO. OR ID: Record the abbreviation appropriate for where the sample was taken. Correct abbreviations can be found on Pages 18-21 of the IRDMS User's Guide for chemical data entry.

2. SAMPLE NO.: Record the reference number of the sample.

3. WELL/SITE DESCRIPTION: Describe the location where the sample was taken, along with distances to landmarks.

4. X-COORD and Y-COORD: Record the survey coordinates for the sampling site.

5. ELEV: Record the elevation where the sample was taken.

6. UNITS: Record the units the elevation was recorded in.

7. DATE: Record the date in the form MM/DD/YY.

8. TIME: Record the time, including a designation of AM or PM.

9. AIR TEMP.: Record the air temperature, including a designation of C or F (Celsius or Fahrenheit).

10. WELL DEPTH: Record the depth of the well in feet and inches.

11. CASING HT.: Record the height of the casing in feet and inches.

12. WATER DEPTH: Record the depth (underground) of the water in feet and inches.

13. WELL DIAMETER: Record the diameter of the well in inches.

14. WATER COLUMN HEIGHT: Record the height of the water column in feet and inches.

15. SANDPACK DIAM.: Record the diameter of the sandpack. Generally, this will be the same as the bore diameter.

16. EQUIVALENT VOLUME OF STANDING WATER: Use one of the following equations, to determine one equivalent volume (EV):

    1 EV = Volume in casing + volume in saturated sand pack. Or to restate:

    $$1\ \text{EV} = (BR_w^2h_w + 0.30B(R_s^2 - R_w^2)h_s) * (0.0043)$$

    where

    R_s = Radius of sandpack in inches
    R_w = Radius of well casing in inches
    h_s = Height of sandpack in inches
    h_w = Water depth in inches

    $0.0043 = \text{gal/in.}^3$
    and filter pack porosity is assumed as 30 percent

    — OR —

    $$\text{Volume in casing} = (0.0043\ \text{gal/in.}^3)(B)(12\ \text{in./ft})(R_c^2)(W_h)$$

    where

    R_c = Radius of casing in inches
    W_h = Water column height in feet

    $$\text{Vol. in sandpack} = (0.0043\ \text{gal/in.}^3)(B)(12\ \text{in./ft})(R_b^2 - R_c^2)(W_h)(0.30)$$

    (if W_h is less than the length of the sandpack),

— PLUS —

Vol. in sandpack = $(0.0043 \text{ gal/in.}^3)(B)(12 \text{ in./ft})(R_b^2 - R_c^2)(S_h)(0.30)$

(if W_h is greater than the length of the sandpack).

where
R_b = Radius of the borehole
S_h = Length of the sandpack.

Show this calculation in the comments section.

17. VOLUME OF BAILER OR PUMP RATE: Record bailer volume or pump rate.

18. TOTAL NUMBER OF BAILERS OR PUMP TIME: Record the number of bailers required to remove 3 equivalent volumes (EV) of water from the well or the total purge time and volume as applicable.

19. WELL WENT DRY? Write "YES" OR "NO."

20. NUMBER OF BAILERS OR PUMP TIME: Record the number of bailers or pump time which made the well go dry.

21. VOLUME REMOVED: Record the volume of water (gal) removed before the well went dry.

22. RECOVERY TIME: Record the time required for the well to refill.

23. PURGE AGAIN?: Answer "YES" or "NO."

24. TOTAL VOL. REMOVED: Record the total volume of water (in gal) removed from the well.

25. CAL REF.: Record the calibration reference for the pH meter.

26. TIME: Record time started (INITIAL T[0]), 2 times DURING the sampling and the time sampling ended (FINAL).

27. pH: Record the pH at start of sampling (INITIAL), twice DURING the sampling and at the end of sampling (FINAL).

28. TEMP: Record the water temperature (Celsius) at the start of sampling, twice DURING the sampling and at the end of sampling (FINAL).

29. COND: Record the conductivity of the water at the start of sampling, twice DURING the sampling and at the end of sampling (FINAL).

30. D.O.: Record the dissolved oxygen level in the water at the start of sampling, twice DURING the sampling and at the end of sampling (FINAL).

31. TURBIDITY: Record the readings from the turbidity meter (nephelometer) and units at the start of sampling, twice DURING the sampling and at the end of sampling (FINAL).

32. ORD: Record the oxidation/reduction (RedOx) potential of the water sample at the start of sampling, twice DURING the sampling and at the end of sampling (FINAL).

33. HEAD SPACE: Record any positive readings from organic vapor meter reading taken in well headspace prior to sampling.

34. NAPL: Record the presence and thickness of any non-aqueous phase liquids (light or dense)

35. COMMENTS: Record any pertinent information not already covered in the form.

36. SIGNATURE: Sign the form.

3.4 FIELD CALIBRATION FORMS (Maintained as a separate logbook, or incorporated into sampling logbooks)

3.4.1 Items on Figure SOP016-5

1. Record time and date of calibration. Note whether 12- or 24-hour clock was used.

2. Record calibration standard reference number.

3. Record meter I.D. number

4. Record initial instrument reading, recalibration reading (if necessary), and final calibration reading on appropriate line.

5. Record value of reference standard (as required).

6. COMMENTS: Record any pertinent information not already covered on form.

7. SIGNATURE: Sign form.

3.5 GROUNDWATER HYDROLOGY TESTS LOGBOOK (Must include Figures SOP016-6 and SOP016-7 and/or SOP016-8, OR SOP016-9 or SOP016-10)

3.5.1 Field Permeability Test Data Sheet (Items on Figures SOP016-6)

1. CONTRACTOR: Organization performing the test.

2. SEQ. #: Enter page number of this set of forms (page # of #).

3. PROJECT NAME: Record the name assigned by the contractor's organization to the project.

4. PROJECT NO.: Record the contractor assigned project number or the contract number.

5. LOCATION: Specific location

6. CLIENT: Agency or company with the contract under which the work is being performed.

7. FIELD PARTY CHIEF: Printed name of the person responsible for this particular field test.

8. WELL #: Record the well number as it appears on the well completion tag, affixed to the protector casing or well completion records.

9. TEST TYPE: Short description of the type of test to be performed.

10. RISING/FALLING HEAD WITH SLUG: Check if the test involved the insertion/removal of and inert object.

11. RISING/FALLING HEAD WITHOUT SLUG: Check if the test involved the addition/removal of a quantity of water.

12. START DATE: Date on which the test was begun.

13. CLOCK TIME: Time each datum (depth to groundwater level) is collected. Note whether 12- or 24-hour clock was used.

14. ELAPSED TIME: Time since the last datum was collected.

15. DEPTH TO GWL (ft): Depth to the top of the groundwater table (Groundwater Level) as measured by manual methods.

16. REC. (ft): Water level as reported by transducer/datalogger (this is the depth of water above the transducer.

17. TIME: Time the discharge rate check was begun (addition or removal of water method). Note whether 12- or 24-hour clock was used.

18. FLOW METER (Addition or removal of water method): The amount of water added or removed as registered by the flowmeter, in gal of liters.

19. DISCHARGE RATE: Flowmeter reading divided by time interval (gal/min or liters/min).

20. SIGNATURE: The person completing this form must sign the form at the end of the test.

21. DATE: Date the form was signed.

3.5.2 Groundwater Levels – Single Well (Items on Figure SOP016-7)

1. CONTRACTOR: Organization performing the test.

2. SEQ. #: Enter page number of this set of forms (page # of #).

3. PROJECT NO.: Record the contractor assigned project number or the contract number.

4. WELL #: Record the well number as it appears on the well completion tag, affixed to the protector casing or well completion records.

5. PROJECT NAME: Record the name assigned by the contractor’s organization to the project.

6. LOCATION: Specific location.

7. FIELD PARTY CHIEF: Printed name of the person responsible for this particular field test.

8. CLIENT: Agency with the contract under which the work is being performed.

Well Data

9. STICKUP: Enter the length of well casing extending above the average ground surface at the base of the protective casing.

10. MEASURED UP(+)/DOWN(-) FROM: Describe the starting point for the previous measurement.

11. MP ELEVATION: Enter the elevation of the measuring point here. NOTE: This datum may require reference to tables and/or maps and may be added after completing the day’s field work.

12. DATUM = MSL OR: Is the datum for the previous elevation Mean Sea Level? If not, what? Also tell whether it was derived from a map elevation (write “MAP”) or survey data (write “SURVEY”).

13. MEASURING POINT DESCRIPTION: Describe the point used as the origin for all down-hole (water table) measurements. NOTE: Remedial investigation wells are required to have a permanently marked reference (measuring) point (refer to SOP No. 019).

14. REMARKS: Record any pertinent observations about the site/well conditions not specifically required in the preceding.

15. DATE: Date of each water level reading

16. TIME: Time of each water level reading. Note whether 12- or 24-hour clock was used.

17. ELAPSED TIME: Time since test was begun.

18. DEPTH TO WATER: Measured depth to the groundwater table.

19. WATER ELEVATION: Elevation of the top of the groundwater table (use datum listed above).

20. MEAS. METH.: Method used to measure the water level in the well (see abbreviation key at the bottom of the data sheet).

21. TAPE NO.: The unique identification number of the traceable standard tape used to calibrate the measuring device.

22. WELL STATUS: Condition of the well at the time of measuring (see abbreviation key at the bottom of the data sheet).

23. REMARKS: Any additional pertinent comments not specifically required above.

24. INITIALS: Initials of person completing this data entry.

25. ABBREVIATION KEYS: Self explanatory.

26. SIGNATURE: The person completing this form must sign the form at the end of the test.

27. DATE: Date the form was signed.

3.5.3 Groundwater Levels – Single Well (Items on Figure SOP016-8)

1. CONTRACTOR: Organization performing the test.

2. SEQ. #: Enter page number of this set of forms (page # of #).

3. PROJECT NO.: Record the contractor assigned project number or the contract number.

4. WELL #: Record the well number as it appears on the well completion tag, affixed to the protector casing or well completion records.

5. PROJECT NAME: Record the name assigned by the contractor's organization to the project.

6. LOCATION: Specific location.

7. FIELD PARTY CHIEF: Printed name of the person responsible for this particular field test.

8. CLIENT: Agency with the contract under which the work is being performed.

WELL DATA

9. STICKUP: Enter the length of well casing extending above the average ground surface at the base of the protective casing.

10. MEASURED UP(+)/DOWN(-) FROM: Describe the starting point for the previous measurement.

11. MP ELEVATION: Enter the elevation of the measuring point here. NOTE: This datum may require reference to tables and/or maps and may be added after completing the day's field work.

12. DATUM = MSL OR: Is the datum for the previous elevation Mean Sea Level? If not, what? Also tell whether it was derived from a map elevation (write "MAP") or survey data (write "SURVEY").

13. MEASURING POINT DESCRIPTION: Describe the point used as the origin for all down-hole (water table) measurements. NOTE: All Rhode Island wells are required to have a permanently marked reference (measuring) point (refer to SOP No. 019).

14. REMARKS: Record any pertinent observations about the site/well conditions not specifically required in the preceding.

15. DATALOGGER: This section is record of pertinent datalogger information.

16. MANUFACTURER: Record the manufacturer/brand name as stated on the datalogger.

17. MODEL: Enter the model number of the datalogger.

18. S/N: Enter the serial number of this datalogger.

19. TAG PROGRAMMED IN LOGGER: What is the identifier used in the datalogger's program to indicate that this unit was used to record a given data set?

20. TRANSDUCER: This section is a listing of pertinent information about the transducer used.

21. MANUFACTURER: Record the manufacturer/brand name as stated on the transducer.

22. MODEL: Enter the model number of the transducer.

23. S/N: Enter the serial number of this transducer.

24. INPUT/UNITS: What are the units this transducer uses?

25. RANGE: Record the pressure or depth range over which this transducer is certified.

CALIBRATION

26. PRESSURE RATING: This is taken from the manufacturer’s specifications for a given transducer. (Usually in psi, or kpa).

27. “SUBMERGENCE = ___ (V) / (MV)”: Record the voltage returned by the transducer at a given depth of submergence. Indicate whether the reading is in volts (v), or millivolts (mv).

28. VOLUME WATER ADDED/REMOVED: (Applicable if inert object insertion/removal method was not employed.) Record the volume of water added to or removed from the well.

29. DISCHARGE RATE: If z (above) is filled, enter the rate at which this water was added or removed.

30. INITIAL WATER LEVEL (ft): Enter the water level in the well at the beginning of the test.

31. PRESSURE TRANSDUCER SUBMERGENCE: Record the depth to which the transducer is submerged at the beginning of the test and the depth to the transducer at the end if the test. All depths will be recorded to the nearest 0.01 ft.

32. TIME: Record the time the test is begun and ended. Note whether 12- or 24-hour clock was used.

33. OBSERVED CHANGES IN ADJACENT WELLS: Note any changes in water levels in nearby wells.

34. RESULTS RECORDED ON DISKETTE #: Tracking number of the diskette on which these data are archived.

35. DISKETTE FILE NAME: Name of the file(s).

36. SIGNATURE: The person completing this form must sign the form at the end of the test

37. DATE: Date the form was signed.

3.6 GROUNDWATER LEVELS – MULTIPLE WELLS (Items on Figure SOP016-9)

1. CONTRACTOR: Organization performing the test.

2. SEQ. #: Enter page number of this set of forms (page # of #).

3. PROJECT NO.: Record the contractor assigned project number or the contract number.

4. PROJECT NAME: Record the name assigned by the contractor's organization to the project.

5. LOCATION: Specific location.

6. FIELD PARTY CHIEF: Printed name of the person responsible for this particular field test.

7. CLIENT: Agency with the contract under which the work is being performed.

8. REMARKS: Any pertinent observations not specifically required above.

9. WELL: Record the well number as it appears on the well completion tag, affixed to the protector casing or well completion records.

10. DATE: Date this measurement was made.

11. TIME: Time this measurement was made. Note whether 12- or 24-hour clock was used.

12. DEPTH TO WATER: Depth from MP to top of groundwater table.

13. STICKUP: Enter the length of well casing extending above the average ground surface at the base of the protective casing.

14. MP ELEV.: Enter the elevation of the measuring point here. NOTE: This datum may require reference to tables and/or maps and may be added after completing the day's field work.

15. MEAS. METH.: Method used to measure the water level in the well (see abbreviation key at the bottom of the data sheet).

16. REMARKS/MP: Describe the location and nature of the measuring point.

17. INITIALS: Initials of the person completing this form.

18. ABBREVIATION KEYS: Self explanatory.

19. SIGNATURE: The person completing this form must sign the form at the end of the test.

20. DATE: Date the form was signed.

3.7 GROUNDWATER LEVELS – DATALOGGERS (Items on Figure SOP016-10)

1. CONTRACTOR: Organization performing the test.

2. SEQ. #: Enter page number of this set of forms (page # of #).

3. PROJECT NO.: Record the contractor assigned project number or the contract number.

4. WELL #: Record the well number as it appears on the well completion tag, affixed to the protector casing or well completion records.

5. PROJECT NAME: Record the name assigned by the contractor's organization to the project.

6. LOCATION: Specific location.

7. FIELD PARTY CHIEF: Printed name of the person responsible for this particular field test.

8. CLIENT: Agency with the contract under which the work is being performed.

WELL DATA

9. STICKUP: Enter the length of well casing extending above the average ground surface at the base of the protective casing.

10. MEASURED UP(+)/DOWN(-) FROM: Describe the starting point for the previous measurement.

11. MP ELEVATION: Enter the elevation of the measuring point here. NOTE: This datum may require reference to tables and/or maps and may be added after completing the day's field work.

12. DATUM = MSL OR: Is the datum for the previous elevation Mean Sea Level? If not, what? Also tell whether it was derived from a map elevation (write "MAP") or survey data (write "SURVEY").

13. MEASURING POINT DESCRIPTION: Describe the point used as the origin for all down-hole (water table) measurements. NOTE: All Rhode Island wells are required to have a permanently marked reference (measuring) point (refer to SOP No. 019, Section 3.4).

14. REMARKS: Record any pertinent observations about the site/well conditions not specifically required in the preceding.

DATALOGGER (This section is a record of pertinent datalogger information)

15. MANUFACTURER: Record the manufacturer/brand name as stated on the datalogger.

16. MODEL: Enter the model number of the datalogger.

17. S/N: Enter the serial number of this datalogger.

18. TAG PROGRAMMED IN LOGGER: What is the identifier used in the datalogger's program to indicate that this unit was used to record a given data set?

TRANSDUCER (This section is a listing of pertinent information about the transducer used)

19. MANUFACTURER: Record the manufacturer/brand name as stated on the transducer.

20. MODEL: Enter the model number of the transducer.

21. S/N: Enter the serial number of this transducer.

22. INPUT/UNITS: What are the units this transducer uses?

23. RANGE: Record the pressure or depth range over which this transducer is certified.

CALIBRATION

24. PRESSURE RATING: This is taken from the manufacturer's specifications for a given transducer (usually in psi, or kpa).

25. "SUBMERGENCE = ___ (V) / (MV)": Record the voltage returned by the transducer at a given depth of submergence. Indicate whether the reading is in volts (v), or millivolts (mv).

26. DATE: Date of each water level reading

27. TIME: Time of each water level reading. Note whether 12- or 24-hour clock was used.

28. LOGGING TIME INTERVAL: Time since test was begun.

29. WL FEET BELOW MP: Measured depth to the groundwater table from measuring point.

30. SUBMERGENCE: Depth of water above the transducer.

31. MEAS.METHOD: What device/method was used to measure the water level.

32. TAPE NO.: Record the tape identification number.

33. TRANSDUCER MOVED?: Was the transducer moved since the last water level reading?

34. REMARKS: Any pertinent remarks not otherwise specified.

35. INITIALS:

DATA TRANSFER TO DISKETTE:

36. DATE: Date data were archived onto diskette.

37. TIME: Time stamp the computer assigns the data file.

38. FILE NAME: Name assigned the data file.

39. SOFTWARE USED FOR TRANSFER: Any special software, or computer operating system used to write the files to diskette. NOTE: If a “shareware” archiver which compresses files was used, and the archived file is not self-extracting, a copy of the unarchive program should be copied onto the diskette also.

40. OUTPUT FORMAT: What is the format of the output file? (DOS, UNIX, Binary, Compressed?)

41. INITIALS: Initials of the person who copied the data to diskette.

42. ABBREVIATION KEY: Self-explanatory.

4. MAINTENANCE

Not applicable.

5. PRECAUTIONS

None.

6. REFERENCES

U.S. Environmental Protection Agency. 1984. User’s Guide to the Contract Laboratory Program. July.

FIGURE SOP016-1
FIELD PARAMETER LOGBOOK
SOIL AND SEDIMENT SAMPLES

HIGH CONCENTRATION EXPECTED? HIGH HAZARD?

INSTALLATION/SITE ________________________________ AREA ___________________

INST CODE FILE NAME ____

SITE TYPE SITE ID
FIELD SAMPLE NUMBER

DATE (MM/DD/YY) / / TIME AM PM SAMPLE PROG.

DEPTH (TOP) DEPTH INTERVAL UNIT _____________

SAMPLING METHOD:

SPLIT SPOON AUGER SHELBY TUBE SCOOP OTHER

CHK ANALYSIS SAMPLE CONTAINER NO. REMARKS

TOTAL NUMBER OF CONTAINERS FOR SAMPLE

DESCRIPTION OF SITE AND SAMPLE CONDITIONS
SITE DESCRIPTION:____
SAMPLE FORM ______________________ COLOR _____________ ODOR _____________
PID (HNu) _______________________ UNUSUAL FEATURES _______________________
____
WEATHER/TEMPERATURE
SAMPLER

HIGH CONCENTRATION EXPECTED? HIGH HAZARD?

FIGURE SOP016-2
FIELD PARAMETER LOGBOOK
GROUNDWATER AND SURFACE WATER SAMPLES

INSTALLATION/SITE AREA
INST CODE FILE NAME SITE TYPE
SITE ID FIELD SAMPLE NUMBER
DATE (MM/DD/YY) / / TIME AM PM SAMPLE PROG.
DEPTH (TOP) DEPTH INTERVAL UNITS

SAMPLING MEASUREMENTS

CAL REF.	pH	TEMPERATURE C	CONDUCTIVITY	OTHER

CHK	ANALYSIS	SAMPLE CONTAINER	NO.	REMARKS

TOTAL NUMBER OF CONTAINERS FOR SAMPLE

DESCRIPTION OF SITE AND SAMPLE CONDITIONS

SITE DESCRIPTION
SAMPLING METHOD
SAMPLE FORM COLOR ODOR
PID (HNu)
UNUSUAL FEATURES
WEATHER/TEMPERATURE _________________________ SAMPLER _________________

FIGURE SOP016-3
MAP FILE LOGBOOK

SITE ID POINTER ____________________
DESCRIPTION/MEASUREMENTS
SKETCH/DIMENSIONS:

MAP REFERENCE
COORDINATE DEFINITION (X is Y is)
COORDINATE SYSTEM SOURCE ACCURACY
X-COORDINATE Y-COORDINATE UNITS
ELEVATION REFERENCE
ELEVATION SOURCE ACCURACY ELEVATION
UNITS

SAMPLER

FIGURE SOP016-4
MAP FILE AND PURGING LOGBOOK
GROUNDWATER SAMPLES

WELL COORD. OR ID SAMPLE NO.______________
WELL/SITE
DESCRIPTION____
____
X-COORD. Y-COORD. _______________ ELEV. UNITS
DATE ____/____/____ TIME AIR TEMP.

WELL DEPTH _________ ft _________ in. CASING HT. _________ ft _______ in.
WATER DEPTH __________ ft _________ in. WELL DIAMETER __________ in.
WATER COLUMN HEIGHT _________ ft _________ in. SANDPACK DIAM. ________ in.
EQUIVALENT VOLUME OF STANDING WATER ____________ (gal) (L)
VOLUME OF BAILER ___________ (gal) (L) or PUMP RATE ___________ (gpm) (lpm)
TOTAL NO. OF BAILERS (5 EV)___________ or PUMP TIME ___________ MIN.
WELL WENT DRY? [Yes] [No] NUM. OF BAILERS ________ or PUMP TIME______MIN
VOL. REMOVED __________ (gal) (L) RECOVERY TIME __________ MIN
PURGE AGAIN? [Yes] [No] TOTAL VOL. REMOVED __________ (gal) (L)

Date and Time	Quantity Removed	Time Required	pH	Cond	Temp	ORD	Turb	DO	Character of water (color/ clarity/odor/partic.)
(before)									
(during)									
(during)									
(during									
(after)									

COMMENTS:____
____
____
____

____
SIGNATURE

FIGURE SOP016-5
FIELD CALIBRATION: pH, CONDUCTIVITY, TEMPERATURE, TURBIDITY, OXIDATION-REDUCTION POTENTIAL, AND DISSOLVED OXYGEN METERS

INITIAL CALIBRATION	FINAL CALIBRATION
DATE:	DATE:
TIME:	TIME:

pH METER CALIBRATION

CALIBRATION STANDARD REFERENCE NO: _______________

METER ID ______________________________

pH STANDARD	INITIAL READING	RECALIB. READING	FINAL READING
7.0			
10.0			
4.0			

CONDUCTIVITY METER CALIBRATION

CALIBRATION STANDARD REFERENCE NO: _______________

METER ID _________________

COND. STANDARD	INITIAL READING	RECALIB. READING	FINAL READING

TEMPERATURE METER CALIBRATION

METER ID ________________

TEMP. STANDARD	INITIAL READING	RECALIB. READING	FINAL READING
ICE WATER			
BOILING WATER			
OTHER			

FIGURE SOP016-5 *(continued)*

TURBIDITY METER CALIBRATION

CALIBRATION STANDARD REFERENCE NO: _______________

METER ID ________________

STANDARD	INITIAL READING	RECALIB. READING	FINAL READING

ORD METER CALIBRATION

CALIBRATION STANDARD REFERENCE NO: _______________

METER ID ________________

STANDARD	INITIAL READING	RECALIB. READING	FINAL READING

DISSOLVED OXYGEN METER CALIBRATION

CALIBRATION STANDARD REFERENCE NO: _______________

METER ID ____________________________

STANDARD	INITIAL READING	RECALIB. READING	FINAL READING

COMMENTS:____
____
____
____

____
SIGNATURE

FIGURE SOP016-6
FIELD PERMEABILITY TEST DATA SHEET

Contractor: **Seq. #** /

Project Name:	Project #:
Location:	Client:
Party Chief:	Contractor:
Observation Well:	
Test Type: Rising/Falling Head w/Slug	Rising/Falling Head w/out Slug
Start Date:	

								Discharge Rate		
Clock Time	Elapsed Time (min)	Depth to GWL (ft)	Rec (ft)	Clock Time	Elapsed Time	Depth to GWL (ft)	Rec (ft)	Time	Flow Meter	Discharge Rate

Signature: ____ **Date:** ______________________

FIGURE SOP016-7
GROUNDWATER LEVELS – SINGLE WELL

Contractor: **Seq. #** /

Project No.:
Project Name:
Field Party Chief:

WELL DATA:

Stickup: (ft)
MP Elevation:
Area:

Datum = MSL or:

Measuring Point Description:

Datalogger:
Manufacturer: Model: S/N:
Tag No. Programmed in Logger:

Transducer: Manufacturer: Model: S/N:
Input/Units: Range:

Calibration:
Pressure Rating:
0 ft submergence = (v) / (mv) ft submergence = (v) / (mv)

Volume Water Added/Removed:
Discharge Rate:
Initial Water Level (ft):

Pressure Transducer Submergence
Initial (ft): Final(ft): Time:Start: End:
Observed Changes in Adjacent Wells:

Results Recorded on Diskette #:
Diskette File Name:

Signature: ______________________________________ **Date:** _____________________

FIGURE SOP016-8
GROUNDWATER LEVELS – MULTIPLE WELLS

Contractor: **Seq. #** /

Project No.:
Project Name:
Field Party Chief:

WELL DATA:

Stickup: (ft)
MP Elevation:

Measuring Point Description:
Remarks:
Well No.:
up (+)/down (-) from:
Datum = MSL or:

Date	Time	Elapsed Time	Depth to Water	Water Elevation	Meas. Meth.	Tape No.	Well Status	Remarks	Initials

Measurement Method:
A = Airline
C = Chalk and tape
E = Electric tape
T = Tape with popper
X = Other (describe in remarks)

Well Status:
D = Dry
F = Flowing
P = Pumping
RP = Recently pumped
NP = Nearby well pumping
NRP = Nearby well recently
X = Obstructed

Signature: ____ **Date:** ______________________

FIGURE SOP016-8 *(continued)*

Contractor: **Seq. #** /

Project No.:
Project Name: Location:
Field Party Chief: Client:

Well	Date	Time	Depth to Water	Stickup	MP Elev.	Meas. Meth.	Tape No.	Remarks/MP	Initials

Measurement Method:
A = Airline
C = Chalk and tape
E = Electric tape
T = Tape with popper
X = Other (describe in remarks)

Well Status:
D = Dry
F = Flowing
P = Pumping
RP = Recently pumped
NP = Nearby well pumping
NRP = Nearby well recently
X = Obstructed

FIGURE SOP016-9
GROUNDWATER LEVELS DATALOGGERS

Contractor
Project No.: **Well No.:**
Project Name: **Site:**
Field Party Chief: **Area:**

WELL DATA: Stickup: **(ft)** **up (+)/down (-) from:**

Measuring Point Description:
Remarks:

Datalogger:
Manufacturer: Model: S/N:
Tag No. Programmed in Logger:
Transducer: Manufacturer: Model: S/N:
Input/Units: Range:
Calibration: Pressure Rating:
0 ft submergence = (v) / (mv) ft submergence = (v)

Logging	Date	Time	Logging Time Interval	WL, ft Below MP	Submergence (logger reading)	Meas. Method	Tape No.	Well Status	Transducer Moved	Remarks	Initials
Start											
Stop											
Start											
Stop											

Data Transfer to Disk

Date	Time	File Name	Software Used for Transfer	Output Format	Initials

Measurement Method:
A = Airline
C = Chalk and tape
E = Electric tape
T = Tape with popper
X = Other (describe in remarks)

Well Status:
D = Dry
F = Flowing
P = Pumping
RP = Recently
NP = Nearby well pumping
NRP = Nearby well recently pumped
X = Obstructed

Signature **Date**

Standard Operating Procedure No. 019
for
Monitoring Well Installation

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Revision 0
August 2007

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APPENDIX A: FIELD RECORD OF WELL DEVELOPMENT FORM

1. SCOPE AND APPLICATION

The installation of monitoring wells is contingent upon the existing conditions at the project site. The purpose of this Standard Operating Procedure is to delineate the quality control measures required to ensure the accurate installation of monitoring wells. The applicable Work Plan should be consulted for specific installation instructions. The term “monitoring wells,” as used herein, is defined to denote any environmental sampling well. An example well log form is provided in Appendix A. Alternate, equivalent forms are acceptable.

2. MATERIALS

2.1 DRILLING EQUIPMENT

The following drilling equipment may be required:

- Appropriately sized drill adequately equipped with augers, bits, drill stem, etc.
- Steam cleaner and water obtained from approved source for decontaminating drilling equipment.
- Photoionization Detector: Microtip HL-200 (or equivalent)
- Water level indicator
- Weighted steel tape measure
- Lower explosive limit – oxygen monitor
- Steel drums for intrusion derived wastes (drill cuttings, contaminated personal protective equipment, decontamination solutions, etc.)
- Source of approved water
- Heavy plastic sheeting
- Sorbent pads and/or log.

2.2 WELL INSTALLATION MATERIALS[1]

The following well installation materials may be required:

- Well screen:[2]
  - Polyvinyl chloride (PVC): JOHNSON (or equivalent); PVC 0.010 slot; Schedule 40; flush-threaded (leak-proof) joints; PVC complies with American Society for Testing and Materials (ASTM) D2665, ASTM D1784, and ASTM F480; free of ink markings; cleaned and prepackaged by manufacturer.
  - Stainless steel: JOHNSON (or equivalent); stainless steel 0.010 slot; 304 stainless steel[3]; ASTM F480 flush threads; cleaned, wrapped, and heat sealed by manufacturer.
- Riser pipe:
  - PVC: JOHNSON (or equivalent); STD; PVC; Schedule 40; flush-threaded (leak-proof) joints; PVC complies with ASTM D2665, ASTM D1784, and ASTM F480; free of ink markings; cleaned and prepackaged by manufacturer.
  - Stainless steel: JOHNSON (or equivalent); Schedule 5; 304 stainless steel; ASTM Type A312 material; 4-in. diameter; cleaned, wrapped, and heat sealed by manufacturer.
- Plugs/caps: JOHNSON (or equivalent); standard PVC or stainless steel.
- Filter pack: MORIE, 100 well gravel (or equivalent). NOTE: Final gradation may vary as a function of the gradation of the formation.[2]
- Fine Ottawa sand.
- Bentonite seal: BAROID, bentonite pellets (3/8-in. diameter)
- Cement: Type II Portland Cement (table below).

---

1. Technical information on all installed materials (screens, riser pipe, filter pack, bentonite, cement, etc.) and representative samples of the proposed filter pack, bentonite powder, and bentonite pellets will be supplied to the Project Manager.
2. Well screen slot size and filter pack gradation will be determined from sieve analysis of aquifer materials. Screen and casing material type will be determined based on field tests of groundwater chemistry and contaminants.
3. Unless the sum of Cl-, F-, and Br- is >1,000 ppm, in which case Type 316 should be used.

Cement Type	Special Characteristics	Recommended Usage
I	No special properties	General use as grout mix or cement plug (if sulfates <250 ppm), surface pad.
IA	Air-entraining Type I (Note that air entrainment properties can be achieved by chemical admixtures)	Air entrainment gives cement greater freeze-thaw resistance. Recommended for surface pads.
II	Moderate sulfate resistance, low heat of hydration	General use as grout mix or cement plug where groundwater sulfate >250 ppm and <1,500 ppm, surface pad.
IIA	Air-entraining Type II	See Type IA.
III	High early strength, high heat of hydration	Elevated temperature can damage well casing and fracture grout/cement plugs. NOT RECOMMENDED.
IIIA	Air-entraining Type III	NOT RECOMMENDED.
IV	Low heat of hydration	General use as grout mix or cement plug preferred type for well abandonment to ensure intact grout/cement plug.
V	High Sulfate resistance	Use when groundwater sulfate levels >1,500 ppm.

- Bentonite powder: BAROID, Aquagel Gold Seal.
- Steel protective casing: BRAINARD-KILMAN (or equivalent) zinc-plated steel, lockable, painted.[4]
- Geotextile: MIRAFI (or equivalent); GTF 130; non-woven; 4 oz.
- Coarse (blanket) gravel: Crushed stone aggregate.
- Containers for purged water, as required.
- Submersible pump or bailer of appropriate capacity, and surge block sized to fit well.
- Hach DREL 2000 portable laboratory (or equivalent).
- Conductivity, pH, oxidation-reduction potential (ORP), turbidity, dissolved oxygen, and temperature meters.
- Electric well sounder and measuring tape.
- Portland Type II cement (see previous table).
- Steel Posts (pickets), painted (see footnote).

---

4. All painted components (protector casing, steel pickets) will be painted high-visibility orange and allowed to dry completely prior to being brought onsite.

2.3 DOCUMENTATION

The following document may be provided:

- Copy of appropriate Work Plan
- Copy of approved Health and Safety Plan
- Copies of well and excavation permits
- Boring log forms
- Well completion diagram form
- Well development form.

2.4 GEOLOGIST'S PERSONAL EQUIPMENT

The following equipment may be required for the geologist:

- 10X handlens
- Unified Soil classification System chart
- Munsell color chart
- Sieve set (Keck model SS-81 or equivalent)
- Personal protective equipment as required by the Health and Safety Plan.

3. PROCEDURE

3.1 MATERIALS APPROVAL

Water sources for drilling, grouting, sealing, filter placement, well installation, and equipment decontamination must be approved by the Project Manager prior to arrival of the drilling equipment. Information required for the water source includes: water source, manufacturer/ owner, address and telephone number, type of treatment and filtration prior to tap, time of access, cost per gallon (if applicable), dates and results associated with all available chemical analyses over the past 2 years, and the name and address of the analytical laboratory (if applicable).

Pure sodium bentonite with no additives (bentonite) will be the only drilling fluid additive allowed, and its use must be approved by the Project Manager prior to the arrival of the drilling equipment. The information required for evaluation includes: brand name, manufacturer, manufacturer's address and telephone number, product description, and intended use for the product.

Granular Filter Pack material must be approved by the Project Manager prior to drilling. A 1-pint representative sample must be supplied to the Project Manager. Information required includes: lithology, grain size distribution, brand name, source, processing method, and slot size of intended screen.

Portland Type II cement will be used for grout (see previous table).

3.2 DRILLING

The objective of the selected drilling technique is to ensure that the drilling method provides representative data while minimizing subsurface contamination, cross-contamination of aquifers, and drilling costs. The preferred drilling method is with a hollow-stem auger. Other drilling methods[5] are approved as conditions warrant, and will not require variances be issued by the U.S. Environmental Protection Agency. The method used at a specific site will be proposed in the work plan and evaluated by the Project Manager. Any drilling method not listed herein will require approval on a case by case basis by the U.S. Environmental Protection Agency.

A Site Geologist will be present during all well drilling and installation activities and will fully characterize all tasks performed in support of these activities into the monitoring well logbook. The Site Geologist will be responsible at only one operating rig for the logging of samples, monitoring of drilling operations, recording of water losses/gains and groundwater data, preparing the boring logs and well diagrams, and recording the well installation procedures of the rig. The Site Geologist will have onsite sufficient equipment in operable condition to perform efficiently his/her duties as outlined in the contractual documents. Items in the possession of each Site Geologist will include the approved Health and Safety Plan, this Standard Operating Procedure, a hand lens (10X), a standard color chart, grain-size chart, and a weighted (with steel or iron) steel tape long enough to measure the deepest well, heavy enough to reach that depth, and small enough to fit readily within the annulus between the well and drill casing. The Site Geologist will also have onsite, a water level measuring device, preferably electrical.

Only solid vegetable shortening (e.g., Crisco®) without flavoring or additives may be used on downhole drilling equipment. Additives containing either lead or copper will not be allowed. In addition, polychlorinated biphenyls will not be permitted in hydraulic fluids or other fluids used in the drilling rig, pumps, and field equipment/vehicles.

---

5. If the design depth of the well is <100 ft, open, hollow-stem augers will be used to drill the well unless “running sands” preclude the use of open augers. In that case, an inert “knockout” plug may be used in the bottom of the auger string. This plug will be driven out of the augers and left at the bottom of the hole when the well is installed.

   If the design depth of the well is >100 ft, rotary drilling methods may be used to install wells. The following drill fluids and methods are approved in the order listed: (1) rotary drilling with water from an approved source as drilling fluid (clays from the formations will tend thicken the fluid and coat the walls of the borehole and this is acceptable); (2) rotary drilling with water as a fluid, advancing a temporary casing with the bit to maintain an open hole; and (3) mud rotary using water with additives as drill fluid. Due to the potential for aquifer contamination and plugging, mud rotary drilling is not recommended for monitoring wells. If, however, “running sands” are encountered and the aquifer is expected to have a relatively high flow rate, then mud rotary is considered an approved method. Pure sodium bentonite is the only approved additive. Mud rotary drilling must be halted at the last aquitard above the target aquifer. Casing must be set, all bentonite-bearing fluids flushed from the hole and drill rig, and drilling may be resumed using water only as the drill fluid until the target depth is reached.

Surface runoff or other fluids will not be allowed to enter any boring or well during or after drilling/construction.

Antifreeze used to keep equipment from freezing will not contain rust inhibitors and sealants. Antifreeze is prohibited in areas in contact with drilling fluid. The ground surface at the well site will be protected from possible coolant, fuel, and hydraulic fluid spills and/or leakage by placement of plastic sheeting with raised edges, draining into a lined catch basin large enough to contain spills and/or leakage from motors, radiators, or vehicle tanks. Sorbent pillows will be placed to catch obvious leaks from the drill rig. Sorbent logs may be used instead of, or in conjunction with, a lined catch basin to contain spills.

An accurate measurement of the water level will be made upon encountering water in the borehole and later upon stabilization. Levels will be periodically checked throughout the course of drilling. Any unusual change in the water level in the hole, such as a sudden rise of a few inches may indicate artesian pressure in a confined aquifer, will be the basis for cessation of drilling. The geologist will immediately contact the Project Manager[6]. Particular attention for such water level changes will be given after penetrating any clay or silt bed, regardless of thickness, which has the potential to act as a confining layer.

Anticipated depths of wells are given in well specific work plans. In case the previously defined criteria have not been met before the depth range for a given hole is reached, the geologist will stop the drilling and confer with the Project Manager. The current boring conditions (depth, nature of the stratigraphic unit, and water table depth) will be compared to those of other wells nearby to decide to continue drilling or to terminate and complete the well.

If the well is to be installed in the surficial aquifer, drilling will be terminated before penetrating the basal aquitard. The basal aquitard is defined as the first 2 ft-thick clay below the water table, or below 5 ft in the case of a shallow aquifer.

If the well is to be installed in a lower, confined aquifer:

- Penetrations of aquifers located lower than the water table aquifer will be limited to avoid cross-contamination.

- Placement of new upper confined aquifer wells will be initially limited to those areas where contamination has been confirmed.

- The location of upper confined aquifer wells will be based upon the findings of the water table aquifer investigation. Areas of known contamination will be targeted for installing upper confined aquifer wells for the purposes of delineating vertical contamination.

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[6] The contract technical oversight will also be contacted for guidance.

- Where possible, upper-confined aquifer wells will be located such that they afford triangulation with other wells within the same aquifer to allow for a determination of groundwater flow direction.

- Some upper-confined aquifer wells will be installed approximately 10-15 ft from water table wells to enable the accurate assessment of vertical hydraulic gradients. If the direction of groundwater flow is known, wells within a group will be located sidegradient of each other.

- The boring will be advanced until the base of the surficial aquifer is reached (Section 3.2).

- An outer, surface casing will be set 2-5 ft into the confining layer to minimize the potential for cross-contamination from the unconfined aquifer during drilling activities.

- The surface casing will be driven into the confining bed and grouted into place. Grout will be tremied into the annulus around the outside of the casing to within 5 ft of the ground surface. A grout plug at least 2 ft thick will be tremied into the bottom of the surface casing. The grout will be permitted to cure for 24 hours. All drilling fluids within the surface calling will then be removed, and the casing will be flushed with clean potable water.

- The drilling equipment will be decontaminated, a smaller bit or auger selected, and the hole will be continued through the grout plug into the confined aquifer.

- If deeper aquifers are to be screened, repeat preceding steps until total depth is reached.

If dense non-aqueous phase liquid (DNAPL) contamination is detected during drilling, the well will be terminated and completed at the base of the aquifer. Drilling will not continue through the confining unit.

Stainless steel screens will be used in DNAPL wells. Screen size selection will be according to criteria set forth in Section 3.4. The formation grain size will be multiplied by the higher factor (6) to determine filter pack grain size. This will ensure that the filter pack is sufficiently coarse to permit DNAPL to pass freely from the formation into the coarser filter pack, then into the open well (Cohen and Mercer 1993).

DNAPL sampling cups are prohibited. The well screen will be capped, and set 0.3 ft (0.5 ft max.) into the top of the confining bed and rest on the bottom of the hole or bentonite backfill (if used). No sand will be placed below the screen. The remainder of the well installation and completion will be accomplished according to Section 3.4.

3.3 LOGGING

All borings for monitoring wells will be logged by a geologist. Logs will be recorded in a field logbook and/or a boring log. If the information is recorded in a logbook, it will be transferred to Boring Log Forms on a daily basis. Field notes are to include, as a minimum:

- Boring number
- Material description (as discussed below)
- Weather conditions
- Evidence of contamination
- Water conditions (including measured water levels)
- Daily drilling footage and quantities (for billing purposes)
- Notations on man-placed materials
- Drilling method and borehole diameter
- Any deviations from established field plans
- Blow counts for standard penetration tests
- Core and split-spoon recoveries.

Material description for soil samples must include:

- Classification
- Unified Soil Classification symbol
- Secondary components and estimated percentages
- Color
- Plasticity
- Consistency
- Density
- Moisture content
- Texture/fabric/bedding and orientation
- Grain angularity
- Depositional environment and formation
- Incidental odors
- Photoionization detector reading(s)
- Staining.

Material description for rock samples must include:

- Classification
- Lithologic characteristics
- Bedding/banding characteristics
- Color
- Hardness
- Degree of cementation
- Texture
- Structure and orientation

- Degree of weathering
- Solution or void conditions
- Primary and secondary permeability
- Sample recovery
- Incidental odors
- Photoionization detector reading(s)
- Staining.

3.4 WELL CONSTRUCTION AND INSTALLATION

After the hole is drilled and logged, backfill hole as required for proper screen placement. The integrity of the aquitard will be restored by placing a bentonite plug of an appropriate thickness, either to the top of the aquitard (normal well installation) or to within 0.3 ft of the top of the aquitard (DNAPL well). Aquifer fill will be clean filter pack.

Normal screen placement for the water table (surficial) aquifer will be within 2 ft of the screen extending above the static water level. The bottom of the screen will rest no more than 6 in. from the bottom of the hole or backfill material, whichever is applicable.

NOTE: The end cap in DNAPL wells will rest on the bottom of the bottom of the hole, or bentonite backfill if applicable (Section 3.2).

Screen placement for a confined aquifer well will normally be at the top of the confined aquifer.

Screen lengths will not normally exceed 10 ft. If it appears advantageous in a given situation (e.g., to screen an entire aquifer which is thicker than 10 ft), approval must be sought on a case-by-case basis from the appropriate regulatory agency. Otherwise, wells will be screened as follows:

Thickness of Aquifer	Action
<10 ft	Screen entire aquifer
>10 ft <30 ft	Screen top 10 ft consider vertically nested well cluster
>30 ft	Install vertically nested well cluster

The installation of monitoring wells in uncased or partially cased holes will begin within 12 hours of completion of drilling, or if the hole is to be logged, within 12 hours of well logging, and within 48 hours for holes fully cased with temporary drill casings. Once installation has begun, work will continue until the well has been grouted and the drill casing has been removed.

Well screens, casings, and fittings will conform to National Sanitation Foundation Standard 14 or ASTM equivalent for potable water usage. These materials will bear the appropriate rating logo. If the logos are not present, a written statement from the manufacturer/supplier stating that the materials contain the appropriate rating must be obtained. Material used will be new and essentially chemically inert to the site environment.

Well screen and casing should be inert with respect to the groundwater; therefore, the selection of screen and casing material will be based on select field tests of aquifer chemistry and potential contaminants. The screen will be capped without sediment trap or DNAPL sampling cup, and lowered into the hole. The well casing will be pre-cut to extend 2-2.5 ft above ground surface. Prior to placement of the last piece of well casing, a notch or other permanent reference point will be cut, filed, or scribed into the top edge of the casing.

Screen slot size will be appropriately sized to retain 90-100 percent of the filter pack material, the size of which will be determined by sieve analysis of formational material (Section 3.4).

The tops of all well casing will be capped with covers composed of materials compatible with the products used in the well installation. Caps may either be vented, or a telescopic fit, constructed to preclude binding to the well casing caused by tightness of fit, unclean surfaces, or weather conditions. In either case, it should be secure enough to preclude the introduction of foreign material into the well, yet allow pressure equalization between the well and the atmosphere.

Filter pack material will be placed, lightly tamped, and leveled. Filter pack will extend from the bottom of the hole to a height of 1-2 ft above the top of the screen. The filter pack will be capped with a minimum of 1 ft of fine (Ottawa) sand to prevent the bentonite seal from infiltrating the filter pack. If the bentonite seal is placed as a slurry, a minimum of 2 ft of fine sand will be required.

If the hole is less than 20-ft deep, the filter pack may be poured into the annulus directly. If the hole is deeper than 20 ft, the filter pack must be tremied into place.

Granular filter packs will be chemically and texturally clean, inert, and siliceous.

Filter pack grain size will be based on formation grain-size analysis. The D30 (70 percent retained) sieve size multiplied by a factor of not less than 3 nor greater than 6 will be used to determine the appropriate grain size.

Calculations regarding filter pack volumes will be entered into the Field Logbook along with any discrepancies between calculated and actual volumes used. If a discrepancy of greater than 10 percent exists between calculated and actual volumes exists, an explanation for the discrepancy will also be entered in the Field Logbook.

Bentonite seals will be no less than 2-ft thick nor more than 5-ft thick as measured immediately after placement. The normal installation will include a 5-ft seal. Thinner seals may be used in special cases. The final depth to the top of the bentonite seal will be measured and recorded.

3.4.1 Grout

Grout used in construction will be composed by weight of:

- 20 parts cement (Portland cement, type II) (see previous table)
- 0.4-1 part (maximum) (2-5 percent) bentonite
- 8-gal (maximum) approved water per 94-lb bag of cement.

Neither additives nor borehole cuttings will be mixed with the grout. Bentonite will be added after the required amount of cement is mixed with the water.

All grout material will be combined in an aboveground container and mechanically blended to produce a thick, lump-free mixture. The mixed grout will be recirculated through the grout pump prior to placement. Grout placement will be performed using a commercially available grout pump and a rigid, side discharge tremie pipe.

The following will be noted in the Field Logbook: (1) calculations of predicted grout volumes; (2) exact amounts of cement, bentonite, and water used in mixing grout; (3) actual volume of grout placed in the hole; and (4) any discrepancies between calculated and actual volumes used. If a discrepancy of greater than 10 percent exists between calculated and actual volumes exists, an explanation for the discrepancy will also be entered in the Field Logbook.

Well protective casings will be installed around all monitoring wells on the following day as the initial grout placement around the well. Any annulus formed between the outside of the protective casing and the borehole will be filled to ground surface with cement.

The construction of each well will be depicted as built in a well construction diagram. The diagram will be attached to the boring log and will graphically denote:

- Screen location, length
- Joint location
- Granular filter pack
- Seal
- Grout
- Cave-in
- Centralizers
- Height of riser
- Protective casing detail.

3.5 MONITORING WELL COMPLETION

Assemble appropriate decontaminated lengths of pipe and screen. Make sure these are clean and free of grease, soil, and residue. Lower each section of pipe and screen into the borehole, one at a time, screwing each section securely into the section below it. No grease, lubricant, polytetrafluoroethelyne tape, or glue may be used in joining the pipe and screen sections.

If a well extends below 50 ft, centralizers will be installed at 50 ft and every 50 ft thereafter except within screened interval and bentonite seal. Centralizer material will be PVC, polytetrafluoroethelyne, or stainless steel. Determination of centralizer material will be based on the same criteria as screen and calling selection.

Cut the riser with a pipe cutter approximately 2-2.5 ft above grade. All pipe cuts MUST be square to ensure that the elevation between the highest and lowest point of the well casing is less than or equal to 0.02 ft Notch, file, or otherwise permanently scribe a permanent reference point on the top of the casing.

Torches and saws may not be used to cut the riser. Care must be taken that all filings or trimmings cut from the reference point fall outside the riser rather than into the well. **Under no circumstances will a permanent marker or paint pencil be used to mark the reference point**.

In some locations, safety requirements may mandate that a well be flush-mounted with no stick-up. If a flush-mounted well is required at a given location, an internal pressure cap must be used instead of a vented cap to ensure that rainwater cannot pool around the wellhead and enter the well through the cap.

When the well is set to the bottom of the hole, temporarily place a cap on top of the pipe to keep the well interior clean.

Place the appropriate filter pack (Section 3.4). Monitor the rise annulus with a weighted tape to assure that bridging is not occurring.

After the pack is in place, wait 3-5 minutes for the material to settle, tamp and level a capped PVC pipe, and check its depth weighted steel tape.

Add a 1-2 ft cap of fine-grained (Ottawa) sand to prevent infiltration of the filter pack by overlying bentonite seal. See Section 3.4 for guidance on appropriate thickness of fine sand layer.

Install the bentonite seal (2- to 5-ft thick) by dropping bentonite pellets into the hole gradually. If the well is deeper than 30 ft, a tremie pipe will be used to place either bentonite pellets or slurry. Tamp and level pellets. If the well is 30 ft, tamp with a capped PVC pipe, if >30 ft, tamping bay be accomplished with the weighted end of the tape. In either case, check the depth to the top of the seal with a weighted tape as above.

If the bentonite pellets are of poor quality, they may have a tendency to hydrate and swell inside the tremie pipe and bridge. This situation may be solved by the following procedure:

1. Use a different brand of pellets. Different brands may have longer hydration times.

2. Freeze the pellets[7]. Note that this will require a longer wait time to allow proper hydration after the pellets thaw.

3. Place the bentonite seal as a slurry using a side-discharge tremie pipe as though installing grout. Note (Section 3.4) this will require that a minimum of 2 ft of fine sand be placed as a cap on top of the filter pack material.

Wait for the pellets to hydrate and swell. Hydration times will be determined by field test or by manufacturer's instructions. Normally this will be 30-60 minutes. Document the hydration time in the field notebook. If the pellets are above the water level in the hole, add several buckets of clean water to the boring. Document the amount of water added to the hole.

Mix an appropriate cement-bentonite slurry (Section 3.4). Be sure the mixture is thoroughly mixed and as thick as is practicable.

Lower a side discharge tremie pipe into the annulus to the level of the pellet seal.

Pump the grout slurry into the annulus while withdrawing the tremie pipe and temporary casing.

Stop the grout fill at 5 ft below the ground surface. Allow to cure for not less than 12 hours. If grout settles more than 6 in., add grout to bring level back up to within 5 ft of ground surface. Place approximately 2 ft of bentonite pellets (minimum 0.5 ft) in annulus. Seat the protective casing in the bentonite seal, allowing no more than 0.2 ft between the top of the well casing and the bottom of the protective casing cap. Fill inner annulus (between well casing and protective casing) with bentonite pellets to the level of the ground surface. Cover bentonite pellets with 1 ft of clean granular material (coarse sand or pea gravel filter pack). Fill the outer annulus (between the protective casing and the borehole) with neat cement. Allow the cement to mound above ground level and finish to slope away from the casing. Lock the cap.

— OR —

Continue the grout fill to the ground surface. Seat the protective casing in the grout, allowing no more than 0.2 ft between the top of the well casing and the bottom of the protective casing cap. Lock the cap.

— AND —

Allow the grout slurry to set overnight.

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7. Bentonite pellets may be "flash-frozen" by brief immersion in liquid nitrogen (LN2). This can be accomplished by pouring LN2 over a small quantity (0.25-0.5 bucket) of pellets, allowing the LN2 to boil off, then pouring the pellets into the tremie pipe. **NOTE:** Use of LN2 is an additional jobsite hazard and must be addressed in the contractor's Health and Safety Plan. This contingency must be covered before drilling starts in order to avoid delays in well installation.

Fill the outer annulus (between the casing and the borehole) with neat cement. Allow the cement to mound above ground level and finish to slope away from the casing.

Slope the ground surface away from the casing for a distance of 2 ft, at a rate of no less than 1 in. in 2 ft. Surface this sloping pad with a geotextile mat covered by 3 in. of coarse gravel.

— OR —

Frame and pour a 4-ft square × 6-in. thick (4 ft × 4 ft × 6 in.) concrete pad centered around the protective casing.

— AND —

Set pre-painted protective steel pickets (3 or 4) evenly around and 4 ft out from well. These pickets will be set into 2 ft deep holes, the holes will then be filled with concrete; and if the pickets are not capped, they will also be filled with concrete.

3.6 WELL DEVELOPMENT

Well development is the process by which drilling fluids, solids, and other mobile particulates within the vicinity of the newly installed monitoring well have been removed while restoring the aquifer hydraulic conductivity. Development corrects any damage to or clogging of the aquifer caused by drilling, increases the porosity of the aquifer in the vicinity of the well, and stabilizes the formation and filter pack sands around the well screen.

Well development will be initiated after 48 consecutive hours but no longer than 7 calendar days following grouting and/or placement of surface protection.

Two well development techniques, over pumping and surging, will be employed in tandem. Over pumping is simply pumping the well at a rate higher than recharge. Surging is the operation of a plunger up and down within the well casing similar to a piston in a cylinder.

3.6.1 Materials Required

The following materials will be required for well development:

- Well Development Form
- Boring Log and Well Completion Diagram for the well
- Submersible pump or bailer of appropriate capacity, and surge block
- Conductivity, pH, ORP, turbidity, dissolved oxygen, and temperature meters
- Electric well sounder and measuring tape
- Containers for purged water, if required.

3.6.2 Summary of Procedures and Data Requirements

Pump or bail the well to ensure that water flows into it, and to remove some of the fine materials from the well. Removal of a minimum of one equivalent volume is recommended at this point. The rate of removal should be high enough to stress the well by lowering the water level to approximately half its original level. If well recharge exceeds 15 gpm, the requirement to lower the head will be waived.

Slowly lower a close-fitting surge block into the well until it rests below the static water level, but above the screened interval. (NOTE: This latter is not required in the case of a light non-aqueous phase liquid well.)

Begin a gentle surging motion which will allow any material blocking the screen to break up, go into suspension, and move into the well. Continue surging for 5-10 minutes, remove surge block, and pump or bail the well, rapidly removing at least one equivalent volume.

Repeat previous step at successively lower levels within the well screen until the bottom of the well is reached. Note that development should always begin above, or at the top of, the screen and move progressively downward to prevent the surge block from becoming sand locked in the well casing. As development progresses, successive surging can be more vigorous and of longer duration as long as the amount of sediment in the screen is kept to a minimum.

Development is expected to take at least 2 hours in a small well installed in a clean sand, and may last several days in large wells, or in wells set in silts with low permeabilities.

Development will continue until little or no sediment can be pulled into the well, and target values for parameters listed below are met.

At a minimum, development will remove 3-5 well volumes of water. One development volume (DV) is defined as (1) equivalent volume, plus (1) the amount of fluid lost during drilling, plus (1) the volume of water used in filter pack placement.

1. Monitor water quality parameters before beginning development procedures, and after removing 2, 2.5, and 3 well volumes of water.

2. If these parameters have stabilized over the three readings, the well will be considered developed.

3. If the parameters have not stabilized after these three readings, continue pumping the well to develop, but stop surging. Monitor the stabilization parameters every half DV.

4. When the parameters have stabilized over three consecutive readings at half DV intervals, the well will be considered developed.

All water removed must be disposed of as directed by the Work Plan.

Record all data as required on a Well Development Record Form (Appendix A), which is made a part of the complete Well Record. These data include:

- Depths and dimensions of the well, casing, and screen obtained from the well diagram.
- Water losses and uses during drilling, obtained from the boring log for the well.
- Measurements of the following indicator parameters: turbidity, pH, conductivity, ORP potential, dissolved oxygen, and temperature.
- Target values for the indicator parameters listed above are as follows: pH – stabilize, conductivity – stabilize, ORP – stabilize, dissolved oxygen –- stabilize, temperature – stabilize, turbidity – 5 nephelometric turbidity units or stabilize. A value is considered to have stabilized when three consecutive readings taken at half DV intervals are within 10 percent of each other.
- Notes on characteristics of the development water.
- Data on the equipment and technique used for development.
- Estimated recharge rate and rate/quantity of water removal during development.

4. MAINTENANCE

Not applicable.

5. PRECAUTIONS

Refer to the site-specific Health and Safety Plan for discussion of hazards and preventive measures during well development activities.

6. REFERENCES

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Appendix A

Field Record of Well Development Form

EA Engineering, P.C.
EA Science and Technology

FIELD RECORD OF WELL DEVELOPMENT

Project Name:	Project No:	Date:
EA Personnel:	Development Method:	
Weather/Temperature/Barometric Pressure:		Time:

Well No.:	Well Condition:
Well Diameter:	Measurement Reference:
Well Volume Calculations	
A. Depth To Water (ft):	D. Well Volume/ft:
B. Total Well Depth (ft):	E. Total Well Volume (gal)[C*D]:
C. Water Column Height (ft):	F. Five Well Volumes (gal):

Parameter	Beginning	1 Volume	2 Volumes	3 Volumes	4 Volumes	5 Volumes
Time (min)						
Depth to Water (ft)						
Purge Rate (gpm)						
Volume Purged (gal)						
pH						
Temperature (°F)						
Conductivity (µmhos/cm)						
Dissolved Oxygen						
Turbidity (NTU)						
ORP (mV)						

Parameter	6 Volumes	7 Volumes	8 Volumes	9 Volumes	10 Volumes	End
Time (min)						
Depth to Water (ft)						
Purge Rate (gpm)						
Volume Purged (gal)						
pH						
Temperature (°F)						
Conductivity (µmhos/cm)						
Dissolved Oxygen						
Turbidity (NTU)						
ORP (mV)						

NOTE: NTU = Nephelometric turbidity unit.
ORP = Oxidation-reduction potential.

COMMENTS AND OBSERVATIONS: ____________________

FIELD RECORD OF WELL DEVELOPMENT

Project Name:	Project No:	Date:
EA Personnel:	Development Method:	
Weather/Temperature/Barometric Pressure:		Time:

Well No.:	Well Condition:
Well Diameter:	Measurement Reference:

Parameter	Beginning	1 Volume	2 Volumes	3 Volumes	4 Volumes	5 Volumes
Time (min)						
Depth to Water (ft)						
Purge Rate (gpm)						
Volume Purged (gal)						
pH						
Temperature (°F)						
Conductivity (µmhos/cm)						
Dissolved Oxygen						
Turbidity (NTU)						
ORP (mV)						

Parameter	6 Volumes	7 Volumes	8 Volumes	9 Volumes	10 Volumes	End
Time (min)						
Depth to Water (ft)						
Purge Rate (gpm)						
Volume Purged (gal)						
pH						
Temperature (°F)						
Conductivity (µmhos/cm)						
Dissolved Oxygen						
Turbidity (NTU)						
ORP (mV)						

Standard Operating Procedure No. 021
for
Sediment Sampling

Prepared by

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Revision 0
August 2007

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1. SCOPE AND APPLICATION

This Standard Operating Procedure delineates protocols for sampling sediments from streams, rivers, ditches, lakes, ponds, and lagoons.

EA recognizes that other protocols have been developed that meet the criteria of quality and reproductivity. Clients may have their own sediment sampling protocols which may contain methodologies and procedures that address unique or unusual site-specific conditions or may be in response to local regulatory agency requirements. In such cases, EA will compare its and the client’s protocols. The goal is to provide the client with the most quality; therefore, if the client’s protocols provide as much or more quality assurance than EA’s protocols for the particular site or project, EA will adopt those particular protocols and this Standard Operating Procedure will be superseded in those respects. If EA is required to implement the client’s protocols in lieu of EA’s protocols, EA will make the client formally aware of any concerns regarding differences in protocols that might affect data quality and will document such concerns in the project file.

2. PROCEDURES

The water content of sediment varies. Sediments range from soft to dense and fine to rocky. A variety of equipment may be necessary to obtain representative samples, even at a single site. Factors to consider in selecting the appropriate sample equipment include sample location (edge or middle of the waterbody), depth of water and sediment, grain size, water velocity, and analytes of interest.

3. GENERAL PROCEDURES

1. Surface water and sediment samples are to be collected at the same location.

2. Collect the surface water sample first. Sediment sampling usually results in disturbance of the sediments, which may influence the analytical results of the surface water samples.

3. Wear gloves when collecting samples. Consult the Health and Safety Plan for proper personal protective equipment.

4. If sampling from a boat or near waterbodies with depths of 4 ft or more, the sampling team will wear life jackets.

5. Wading into a waterbody disturbs the sediment. Move slowly and cautiously, approach the sample location from downstream. If flow is not strong enough to move entrained particles away from the sample location, wait for the sediment to resettle before sampling.

6. Collect samples first from areas suspected of being the least contaminated, thus minimizing the risk of cross-contamination.

7. Collecting samples directly into sample containers is not recommended. Sediment samples should be placed in Teflon®, stainless steel, or glass trays, pans, or bowls for sample preparation.

8. Use the proper equipment and material construction for the analytes of interest. For example, for volatile organic compound analysis, the sampling material in direct contact with the sediment or surface water must consist of Teflon, polyethylene, or stainless steel.

9. Use proper decontamination methods before and after sampling and between samples.

10. Collect samples for volatile organic compound analysis first. Do not mix such samples before placing them in the sample containers. For composite volatile organic compound samples, place equal aliquots of each subsample in the sample container.

11. Sediment that will be analyzed for other than volatile organic compounds should be prepared as follows:

    - Place the sediment in a mixing container.
    - Divide the sediment into quarters.
    - Mix each quarter separately and thoroughly.
    - Combine the quarters and mix thoroughly.
    - For composite samples, mix each subsample as described above. Place equal aliquots of each subsample in a mixing container and follow the procedure described above.

12. Mark the sampling location on a site map. Photograph (optional, recommended) and describe each location, and place a numbered stake above the visible high water mark on the bank closest to the sampling location. The photographs and description must be adequate to allow the sampling station to be relocated at a future date.

13. Dispose of investigation-derived wastes according to applicable rules and regulations.

4. CORERS

A corer provides a vertical profile of the sediment, which may be useful in tracing historical contaminant trends. Because displacement is minimal, a corer is particularly useful when sampling for trace metals and organics. Corers can be constructed out of a variety of materials.

For example, a 2-in. diameter polyvinyl chloride pipe with a Teflon or polyethylene liner can be lowered into the sediment; a 2-in. diameter well cap can be used to form an airtight seal and negative pressure as the pipe is withdrawn.

- Ensure that the corer and (optional) liner are properly cleaned.
- Stand downstream of the sample location.
- Force the corer into the sediment with a smooth continuous motion. Rotate (not rock) the corer if necessary to penetrate the sediment.
- Twist the corer to detach the sample; then withdraw the corer in a single smooth motion. If the corer does not have a nosepiece, place a cap on the bottom to keep the sediment in place.
- Remove the top of the corer and decant the water (into appropriate sample containers for surface water analysis, if required).
- Remove the nosepiece or cap and deposit the sample into a stainless steel, Teflon, or glass tray.
- Transfer the sample into sample containers using a stainless steel spoon (or equivalent device).

5. SCOOPS AND SPOONS

When sampling at the margins of a waterbody or in shallow water, scoops and spoons may be the most appropriate sampling equipment. For collecting samples several feet from shore or in deeper water, the scoop or spoon may be attached to a pole or conduit.

- Stand downstream of the sample location.
- Collect the sample slowly and gradually to minimize disturbing the fine particles.
- Decant the water slowly to minimize loss of fine particles.
- Transfer the sediment to sample containers or mixing trays, as appropriate.

6. DREDGES

Three types of dredges are most frequently used: Peterson, Ponar, and Eckman. Many other dredge types are available; their applicability will depend on site-specific factors.

6.1 PETERSON AND PONAR DREDGES

- These dredges are suitable for hard, rocky substrates, deep waterbodies, and streams with fast currents. Ponars have top screens and side plates to prevent sample loss during retrieval.
- Open the jaws and place the cross bar into the proper notch.
- Lower the dredge to the bottom, making sure it settles flat.
- When tension is removed from the line, the cross bar will drop, enabling the dredge to close as the line is pulled upward during retrieval.
- Pull the dredge to the surface. Make sure the jaws are closed and that no sample was lost during retrieval.
- Open the jaws and transfer the sediment to sample containers or to a mixing tray.

6.2 ECKMAN DREDGE

- The Eckman dredge works best in soft substrates in waterbodies with slow or no flow.
- Open the spring-loaded jaws and attach the chains to the pegs at the top of the sampler.
- Lower the dredge to the bottom, making sure it settles flat.
- Holding the line taut, send down the message to close the jaws.
- Pull the dredge to the surface. Make sure the jaws are closed and that no sample was lost during retrieval.
- Open the jaws and transfer the sediment to sample containers or to a mixing tray.

Standard Operating Procedure No. 022
for
Sediment and Benthic Macroinvertebrate Sampling with Eckman Grab

Prepared by

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1. SCOPE AND APPLICATION

This Standard Operating Procedure covers the protocol for obtaining qualitative or quantitative samples of soft sediments and macroinvertebrates inhabiting soft sediments in lakes, reservoirs, and other waterbodies. The Eckman grab sampler is well suited to collecting samples in deeper (up to 100 ft) waterbodies.

Use of brand names in this Standard Operating Procedure is not intended as endorsement or mandate that a given brand be used. Alternate equivalent brands of detectors, sensors, meters, etc. are acceptable. If alternate equipment is to be used, the contractor will provide applicable and comparable standard operating procedures for the maintenance and calibration of same.

2. MATERIAL

The following materials may be required:

Eckman grab sampler: a box-shaped device with two scoop-like jaws	Sample containers
Boat	Sieve – 500 µ (U.S. Standard No. 30)
Personal protective equipment	Stainless steel spoon or trowel
Personal flotation devices	

3. PROCEDURES

The following is a summary of procedures on use of the Eckman grab sampler:

- Cock the sampler by raising each jaw upward into the cocked position using the attached able and secure the cable to the catch pin located at the top of the sampler.
- Once cocked, lift the sampler overboard and lower slowly but steadily to the bottom.
- Once on the bottom, indicated by a slack line, the weighted messenger is sent down the line tripping the catch mechanism, causing the spring loaded jaws to close the bottom of the sampler, containing the sediment.
- Raise the sample at a slow but steady rate to prevent sample loss or washout.
- Once the sample is on board, empty the sample into a stainless steel, polytetrafluoroethelyne, or polytetrafluoroethelyne-lined bowl or tray for processing.
    - — If the sediment will be analyzed for volatile organic compounds, transfer the sample into the appropriate sample containers immediately.

- If the sediment will not be analyzed for volatile organic compounds, use Stainless steel spoon to thoroughly homogenize sample, then transfer sample into appropriate containers. Add preservative (if required) and place in ice-filled chest.

  — If benthic macroinvertebrates are to be collected, sieve sample and transfer macroinvertebrates into appropriate container.

- Thoroughly decontaminate the device.

4. MAINTENANCE

Maintain according to manufacturer's suggestions.

5. PRECAUTIONS

The following precautions should be taken while using an Eckman grab sampler:

- Inspect the device for mechanical deficiencies prior to its use.

- This sampler is inefficient in waters deeper than approximately 75-100 ft, under adverse weather conditions, and in waters of moderate to strong currents or wave action.

- Exercise caution at all times once the grab is loaded or cocked because a safety lock is not part of the standard design.

- Operate the sampler from a boat with a winch and cable.

- Wear gloves when collecting sediment samples. Be sure to consult the health and safety plan for the proper dermal and respiratory protection prior to collecting any samples.

- Higher levels of personal protective equipment may be required by the Health and Safety Plan.

- While sampling from a boat in waterbodies with a depth of 5 ft or more, the sampling team will wear personal flotation devices (life jackets).

- Collect samples first from those areas that are suspected of being the least contaminated, thus minimizing the risk of cross-contamination.

6. REFERENCES

American Society for Testing and Materials. Standard 2.1. D4387 Guide for Selecting Grab Sampling Devices for Collecting Benthic Macroinvertebrates.

U.S. Environmental Protection Agency. 1990. Macroinvertebrate Field and Laboratory Methods for Evaluating the Biological Integrity of Surface Waters. Office of Research and Development. EPA/600/4-90/030. November.

Standard Operating Procedure No. 025
for
Soil Sampling

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1. SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure is to delineate protocols for sampling surface and subsurface soils. Soil samples give an indication of the area and depth of site contamination, so a representative sample is very important.

2. MATERIALS

The following materials may be required:

Bucket auger or push tube sampler	Split-spoon, Shelby tube, or core barrel sampler
Drill rig and associated equipment	Stainless steel bowl
Personal protective equipment as required by the Health and Safety Plan	Stainless steel spoon, trowel, knife, spatula (as needed)

3. PROCEDURE

3.1 SUBSURFACE SAMPLES

Don personal protective equipment. Collect split-spoon, core barrel, or Shelby Tube samples during drilling. Upon opening sampler, or extruding sample, immediately screen soil for volatile organic compounds using either a photoionization detector or flame ionization detector. If sampling for volatile organic compounds, determining the area of highest concentration, use a stainless steel knife, trowel, or laboratory spatula to peel and sample this area. Log the sample in the Field Logbook while it is still in the sampler. Peel and transfer the remaining sample in a decontaminated stainless steel bowl. Mix thoroughly with a decontaminated stainless steel spoon or trowel. Place the sample into the required number of sample jars. Preserve samples as required. Discard any remaining sample into the drums being used for collection of cuttings. Decon sampling implements. All borings will be abandoned.

NOTE: If sample recoveries are poor, it may be necessary to composite samples before placing them in jars. In this case, the procedure will be the same, except that two split-spoon samples will be mixed together. The Field Logbook should clearly state that the samples have been composited, which samples were composited, and why the compositing was done.

Samples taken for geotechnical analysis will be undisturbed samples, collected using a thin-walled (Shelby tube) sampler.

3.2 SURFICIAL SOIL SAMPLES

Don personal protective equipment. Remove vegetative mat. Collect a sample from under the vegetative mat with a stainless steel trowel, push tube sampler, or bucket auger. If a representative sample is desired over the depth of a shallow hole or if several shallow samples are to be taken to represent an area, composite as follows:

- As each sample is collected, place a standard volume in a stainless steel bowl.

- After all samples from each hole or area are in the bucket, homogenize the sample thoroughly with a decontaminated stainless steel spoon or spatula.

If no compositing is to occur, place sample directly into the sample jars. Place the leftover soil in the auger borings and holes left by sampling. If necessary, add clean sand to bring the subsampling areas back to original grade. Replace the vegetative mat over the disturbed areas. Samples for volatile organic compounds will not be composited. A separate sample will be taken from a central location of the area being composited and transferred directly from the sampler to the sample container. Preserve samples as required. Decon sampling implements.

4. MAINTENANCE

Not applicable.

5. PRECAUTIONS

Refer to the Health and Safety Plan.

Soil samples will not include vegetative matter, rocks, or pebbles, unless the latter are part of the overall soil matrix.

6. REFERENCES

American Society for Testing and Materials (ASTM). Method D1586-84, Penetration Test and Split-Barrel Sampling of Soils.

ASTM. Method D1587-83, Thin Walled Sampling of Soils.

Department of the Army, Office of the Chief of Engineers. 1972. Engineer Manual 1110-2-1907 Soil Sampling. 31 March.

Standard Operating Procedure No. 028
for
Well and Boring Abandonment

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1. SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure is to establish the protocols by which all wells and borings will be safely abandoned. The primary objective of well abandonment is to ensure that the abandoned well or boring does not provide a conduit for the vertical migration of contamination between aquifers.

2. MATERIALS

The following materials may be required:

Drill rig	Bentonite pellets (seal)
Filter pack material	Cement (Portland Type II)
Pure sodium bentonite with no additives (bentonite) powder (grout)	Approved water

3. PROCEDURE

The procedures used in boring abandonment will ideally accomplish two objectives: (1) protect aquifers from cross-contamination by sealing the borehole, and (2) restore the strata in the borehole to nearly original conditions by selective placement of fill material.

Any casing will be pulled, drilled out, or thoroughly pierced. Using tremie pipe, grout will be placed from the bottom of the hole to within 3 ft of the ground surface, and allowed to settle for 24 hours. The remainder of the hole will be filled with concrete. The surface of the concrete will be mounded, smoothed, and inscribed with “ABD,” for abandoned, any assigned well or boring designation, and the date the hole was abandoned. All boring logs, samples, completion records, and abandonment procedures will be included in the records of work on the site or cluster.

If the hole is within 10 ft of a monitoring well in the same aquifer, or a replacement well is to be installed within 10 ft of the well, any temporary casing will be pulled, drilled out, or thoroughly pierced. Using tremie pipe, the hole will then be backfilled with filter pack material opposite sand strata and bentonite or grout opposite substantial (2 ft or thicker) clay and silt strata. Where sand as backfill approaches the ground surface, 2 ft of bentonite will be placed above the sand and a 3-ft concrete plug will be placed at the surface. Otherwise, backfill materials will be placed from the bottom of the hole to within 3 ft of the ground surface. These materials will be allowed to settle for 24 hours. The remainder of the hole will be filled with concrete. The surface of the concrete will be mounded, smoothed, and inscribed with “ABD,” for abandoned, any assigned well or boring designation, and the date the hole was abandoned. All boring logs, samples, completion records, and abandonment procedures will be included in the records of work on the site cluster.

If the well is not within 10 ft of another monitoring well, or if there are no substantial, continuous sand bodies, and no replacement well is planned within 10 ft of the original well location, then the hole may be grouted from the bottom to the top.

3.1 GROUT

Grout used in construction will be composed by weight of:

- 20 parts cement (Portland cement, Type II or V)
- 0.4-1 part (maximum) (2-5 percent) bentonite
- 8 gal (maximum) approved water per 94-lb bag of cement.

Neither additives nor borehole cuttings will be mixed with the grout. Bentonite will be added after the required amount of cement is mixed with the water.

All grout material will be combined in an aboveground container and mechanically blended to produce a thick, lump-free mixture. The mixed grout will be recirculated through the grout pump prior to placement.

Grout placement will be performed using a commercially available grout pump and a rigid tremie pipe removal and grouting will be accomplished in stages, aquifer by aquifer, sealing the boring from the bottom to ground surface. This will be accomplished by placing a grout pipe to the bottom and pumping grout through the pipe until undiluted grout reaches the bottom of the next higher section of casing or, for the top-most section, until grout flows from the boring at ground surface. Efforts will be made to grout incrementally as the temporary casing is removed.

After 24 hours, the abandoned drilling site will be checked for grout settlement. On that day, any settlement depression will be filled with grout and rechecked 24 hours later. This process will be repeated until firm grout remains at the ground surface.

3.2 BORINGS

The term “Borings” as used in this Standard Operating Procedure applies to any drilled hole made during the course of a remedial investigation which is not completed as a well. This includes soil test borings, soil sampling borings, and deep stratigraphic borings. Whether completed to the planned depth or aborted for any reason prior to reaching that depth, borings will be grouted and normally closed within 4 hours, or within 4 hours or completion of logging of completion of logging.

3.2.1 Shallow Borings not Penetrating Water Table

Shallow borings made for the collection of subsurface soil samples will be abandoned by backfilling the hole with cuttings from the hole, **if and only if the boring does not penetrate the water table.** Clean sand will be used to make up any volume not filled by the cuttings.

3.2.2 Borings Penetrating the Water Table

Shallow borings made for the collection of subsurface soil samples **which penetrate the water table** will be abandoned by grouting the hole from the bottom to the top.

3.2.3 Deep Stratigraphic Borings

Deep stratigraphic borings will normally be located in areas which, by virtue of the historical record, are presumed relatively uncontaminated. Therefore, these borings are usually over 100 ft from any sampling well locations. Any boring located within 10 ft of a proposed well location, or located directly upgradient or downgradient (on anticipated flow line) of a proposed well location, will be abandoned by placing clean sand in the aquifer intervals and bentonite or grout in aquitard intervals as described above. If the boring is over 10 ft from and/or not upgradient of a proposed well location, the boring will be completely filled with grout.

3.3 WELLS

The following procedure applies to wells aborted prior to completion and existing wells determined to be ineffective or otherwise in need of closure.

Prior to abandoning any developed well, the proper well licensing body will be provided written notification along with an abandonment plan for that well.

If the well is within 10 ft of another monitoring well in the same aquifer, or a replacement well is to be installed within 10 ft of the well, casing will be pulled, drilled out, or thoroughly pierced. Using tremie pipe, the hole will then be backfilled with filter pack material opposite sand strata and bentonite or grout opposite substantial (2 ft or thicker) clay and silt strata. Where sand as backfill approaches the ground surface, 2 ft of bentonite will be placed above the sand and below the concrete plug near the surface. Backfill materials will be placed from the bottom of the hole to within 3 ft of the ground surface. These materials will be allowed to settle for 24 hours. The remainder of the hole will be filled with concrete. The surface of the concrete will be mounded, smoothed, and inscribed with "ABD," for abandoned, any assigned well or boring designation, and the date the hole was abandoned. All boring logs, samples, completion records, and abandonment procedures will be included in the records of work on the site cluster.

If the well is not within 10 ft of another monitoring well, and is not to be replaced by another well within 10 ft of the original location, casing will be pulled, drilled out, or thoroughly pierced. Using tremie pipe, grout will be placed from the bottom of the hole to within 3 ft of the ground surface, and allowed to settle for 24 hours. The remainder of the hole will be filled with concrete. The surface of the concrete will be mounded, smoothed, and inscribed with "ABD," for abandoned, any assigned well or boring designation, and the date the hole was abandoned. All boring logs, samples, completion records, and abandonment procedures will be included in the records of work on the site cluster.

4. REPLACEMENT WELLS

Replacement wells (if any) will normally be offset at least 10 ft from any abandoned well in a presumed upgradient or crossgradient groundwater direction. Site-specific conditions may necessitate variation to this placement.

5. PRECAUTIONS

None.

Standard Operating Procedure No. 030
for
Radioactive Surveys

Prepared by

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1. SCOPE AND APPLICATION

This Standard Operating Procedure (SOP) is developed to serve as guidance to personnel performing radiological environmental surveys of surface soil, water bodies, or other environmental media which may be potentially contaminated with alpha, beta, and beta-gamma radioisotopes.

Use of brand names in this SOP is not intended as endorsement or mandate that a given brand be used. Alternate equivalent brands of detectors, sensors, meters, etc. are acceptable. If alternate equipment is to be used, the contractor will provide applicable and comparable SOPs for the maintenance and calibration of same.

The following assumptions will be made:

- Radiological contamination is present at the site.
- All radioisotopes are present, unless historical documentation is available to help identify the specific radioisotope(s) present.
- A potential health hazard exists from external and internal radiation exposure until instrumentation survey data and appropriate environmental samples indicate otherwise.

2. MATERIALS

The following materials may be required:

Eberline Model PAC-1SAG survey meter mated with an alpha scintillation detector (or equivalent)
Eberline Model E-520 survey meter (or equivalent), mated with a HP-210 handheld detector (or equivalent)
Eberline Smart Portable (ESP-2) survey meter (or equivalent) mated with a SPA-3 low energy gamma scintillation detector (or equivalent)

3. SURVEY PROCEDURES

3.1 SURVEY SITE PREPARATION

Survey instrumentation and sampling equipment will remain outside the potentially contaminated area until the boundaries of the contaminated site can be established. Upon establishing the contaminated boundaries, entry and exit routes will be designated for ingress and egress into the area. Cold and hot lines should be established to control the spread of potential radiological contamination from hot to cold areas.

A cartesian grid (X-Y) of the survey site will be developed. The Project Officer in charge of the survey will develop a specific methodology to accomplish this framework. The grid pattern should also be usable in locating sampling points for cleanup and in reproducing the sampling data. The grid of the survey site should be used in planning for the collection of other environmental samples from the site. Universal Transverse Mercator coordinates are preferred but not mandated.

The Project Officer in charge should note the following observations:

- Any standing water on the survey site.
- Water run-off areas and where the run-off water is leading to, i.e., streams, lakes, marshes, etc. These areas must be considered during the pathway analysis.
- A pathway analysis will be performed to assist in determining the number and type of environmental samples needed to assess the potential health hazard.

3.2 INSTRUMENTATION SURVEY

3.2.1 Calibration and Operational Checks

All portable survey meters will be calibrated at quarterly intervals. All instruments will be properly labeled with the calibration date posted on the label.

All portable survey meters will be checked for operability prior to packing and shipping the instruments to the survey site. The operability check will consist of checking the operation of the survey meter with an appropriate radiation check source at a known distance from the instrument detector. The reading will be documented on the quality control form for each instrument and will be included in the instrumentation shipping kit.

The operability check will be repeated at the survey site prior to starting the instrumentation survey, and periodically during the survey. The instrument readings will be recorded on the quality control form for each instrument.

Background radiation levels will be determined prior to entering the survey site.

An alpha instrumentation survey will be performed with an Eberline Model PAC-1SAG survey meter mated with an alpha scintillation detector (or equivalent). All alpha instrumentation readings will be taken at approximately 1 cm from the surface of the test media. All results will be recorded in disintegrations per minute.

A beta instrumentation survey will be performed with an Eberline Model E-520 survey meter (or equivalent), mated with a HP-210 handheld detector (or equivalent). All results will be recorded in millirad per hour. Readings will be taken approximately 1 cm from the surface of the test media.

A beta-gamma instrumentation survey will be performed with an ESP-2 survey meter (or equivalent) mated with a SPA-3 low energy gamma scintillation detector (or equivalent). All beta-gamma measurements will be taken at approximately 1 m from the surface of the test media. The results will be recorded in microrads per hour and the distance at which the measurement was taken will be documented.

3.3 SURFACE SOIL SAMPLE SURVEY

The Project Officer will evaluate the need to collect soil samples. Soil samples may be needed to assess projected airborne contamination during remedial cleanup or when vehicles and personnel transverse the contaminated site. The Project Officer will design a soil sampling plan to adequately assess potential health risks from low level contamination in soil. The grid developed for the instrumentation survey could be used to assist in determining the soil sample collection points.

Background soil samples should be collected from areas outside of the potentially contaminated area. Background sample data could be used to compare natural occurring radioisotopes in the natural surroundings versus what is present in the contaminated site.

Soil samples will be collected, labeled, and preserved as detailed in SOP No. 025 (Soil Sampling). Soil sample numbers will incorporate grid coordinates so that each can be readily identified and tracked back to the collection point.

3.4 WATER SAMPLES SURVEYS

The Project Officer will evaluate the need to assess the potential contamination in the waterbodies surrounding the contaminated survey site.

A water sampling plan will be designed to accomplish this task. Sampling will be accomplished according to protocols established in SOP No. 007 (Surface Water Sampling Procedures).

Background water samples should be collected from tap water sources in the nearby areas, and any other waterbodies that could provide background data comparison to the potentially contaminated water site.

Water samples may be treated with nitric acid to prevent the plating of radiological materials to walls of the sample containers. Use of preservative is dictated specifically by the method and/or laboratory used for analysis (refer to Work Plan or Quality Assurance Project Plan).

Sample containers should be labeled and packaged to assist in tracking management and to prevent leaking and spills.

3.5 OTHER ENVIRONMENTAL SURVEYS

The Project Officer will evaluate the need to assess the potential contamination in other environmental media such as air samples, vegetation samples, animal samples, etc.

A sampling plan and assessment methodologies will be developed for site-specific environmental assessment.

Refer to SOP Nos. 003 and 016.

4. MAINTENANCE

Refer to manufacturer's manuals for calibration and maintenance of instruments.

5. PRECAUTIONS

NOTE: For purpose of this protocol, the soil surface is defined as the top 1-15 cm of soil.

6. REFERENCES

Krey, P.W. (Acting Director) and H.L. Beck (Acting Deputy Director). 1990. EML Procedures Manual 27th Edition, Volume 1 (HASL-300). Chieco, N.A. et al. (eds.), Environmental Measurements Laboratory, U.S. Department of Energy.

Standard Operating Procedure No. 036
for
Turbidity Measurements (DRT 100)

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1. SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure (SOP) is to delineate protocols for measuring the turbidity of all types of aqueous solutions, including drinking water, saline water, and industrial and domestic wastes. Turbidity is an indication of the optical properties that cause light to be scattered or absorbed through an aqueous sample. Turbidity is largely a function of the refractive index and the size and shape of the particles suspended or dissolved in the solution. Turbidity meters do not produce an “absolute” measurement, but one that is “relative” to the optical nature of the solids in solution.

Use of brand names in this SOP is not intended as endorsement or mandate that a given brand be used. Alternate equivalent brands of detectors, sensors, meters, etc. are acceptable. If alternate equipment is to be used, the contractor will provide applicable and comparable SOPs for the maintenance and calibration of same.

2. MATERIALS

The following materials may be required:

Turbidity meter (DRT 100 or equivalent)
Lint free laboratory wipes (Kimwipes or equivalent)
Formazin standards (from manufacturer)
Sample bottle
Cuvettes

3. PROCEDURE

Calibration of the turbidity meter will be checked on a daily basis as follows:

- Set the range switch to 1000 range before turning the turbidity meter on and whenever the light shield is not in place over the sample well.

- Allow the turbidity meter 15-60 minutes to warmup.

- Clean the reference standard with kimwipes.

- Place the formazin suspension or reference standard in the turbidity meter sample well.

- Place the light shield over the reference standard.

- Rotate the front panel range switch counterclockwise to the appropriate nephelometric turbidity unit range.

- Adjust the reference adjust knob counterclockwise to read the same value as the reference standard value. This value is stamped on top of the reference standard.
- The turbidity meter is now standardized on all ranges to the factory formazin calibration and unknown samples may be read directly in nephelometric turbidity unit, feeder terminal unit, or Jackson turbidity unit.
- Rotate the range switch clockwise to the 1000 range before removing the reference standard.
- Record reading in field logbook (Refer to SOP Nos. 003 and 016).
- Do not leave the reference standard in the sample well for long periods.

Turbidity will be measured as follows:

- Pour aqueous sample into a new cuvette assuring no air bubbles.
- Place the cuvette into the sample well.
- Place the light shield over the sample.
- Rotate the range switch counterclockwise to the range which provides best readability and sensitivity for the sample being measured.
- Allow the turbidity meter to stabilize before recording the nephelometric turbidity unit value.
- Turn the range switch clockwise to the 1000 range and then remove the sample.
- Do not leave the filled cuvette in the sample well for long periods.
- Repeat above steps for additional samples.

Cuvette cleaning procedure is as follows:

- Cuvette must be clean and free of rubs or scratches.
- Wash the cuvette in a detergent solution.
- Rinse thoroughly 8-10 times, preferably with distilled water to remove all streaks.
- Polish with kimwipes.
- Cuvettes must be stored in a clean dust-free environment.

4. MAINTENANCE

Source lamp may be replaced as follows:

- Remove the instrument case per manufacturer instruction.
- Remove the bulb by loosening a screw and removing the electrical leads.
- Insert the new bulb and reconnect the electrical leads.
- Before tightening the screw, be sure to position the filament so that it will be parallel to the axis of the sample well.
- Insert the lamp alignment tool in the sample well to focus the new bulb.
- Move the lamp bracket assembly in or out until a focused image of the filament is within the rectangular box on the lamp alignment tool.
- Once the filament image has been aligned and focused within the rectangular box on the lamp adjustment tool, tighten all screws snugly.
- Replace the instrument case.

5. PRECAUTIONS

Handle the reference standard or sample cuvettes by the top to prevent surface scratches or finger smudges which will cause analysis errors.

Check the mechanical meter zero when the instrument is in a vertical position and the power switch is off. Adjust to zero only if necessary by means of the black screw on the meter face.

The turbidity meter should be left on for the entire work shift to minimize warm-up and recalibration delays.

Do not leave the reference standard or filled curvette in the sample well for long periods.

Leave the light shield in place on the instrument when it is not in use in order to protect the sample well for long periods.

Always set the range switch to 1000 range before turning the instrument on and whenever the light shield is not in place over the well.

6. REFERENCES

Manufacturer’s Manual.

Standard Operating Procedure No. 037
for
Dissolved Oxygen Measurements
(YSI Model 57)

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1. SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure (SOP) is to delineate protocols for measuring the dissolved oxygen (DO) of all types of aqueous solutions, including drinking water, saline water, and industrial and domestic wastes. DO is a measurement of the amount of soluble oxygen in an aqueous solution. It is a general indication of an aerobic/anaerobic condition of a water sample.

Use of brand names in this SOP is not intended as endorsement or mandate that a given brand be used. Alternate equivalent brands of detectors, sensors, meters, etc. are acceptable. If alternate equipment is to be used, the contractor will provide applicable and comparable SOPs for the maintenance and calibration of same.

2. MATERIALS

The following materials may be required:

DO meter (YSI Model 57 or equivalent)
Self-stirring biological oxygen demand bottle probe
Membrane standards
Biological oxygen demand bottle

3. PROCEDURE

3.1 SETUP

It is important that before the meter is prepared for use and calibrated, it should be placed in the intended operating position, i.e., vertical, tilted, or horizontal. The instrument may need readjustment if the operating position is altered. The setup procedures should be as follows:

- With the switch set to **OFF**, adjust the meter pointer to zero with the screw in the center of the meter panel.

- Switch to **RED LINE** and adjust the **RED LINE** knob until the meter needle aligns with the red mark if necessary.

- Switch to **ZERO** and adjust to 0 mg/L scale with the **ZERO** control knob.

- Attach the prepared probe to the **PROBE** connector of the instrument and adjust the retaining ring finger tight.

- Before calibrating, allow 15 minutes for optimum probe stabilization. Repolarize whenever the instrument has been **OFF** or the probe has been disconnected.

3.2 CALIBRATION

Calibration is accomplished by exposing the probe to a known oxygen concentration, such as water-saturated air (%), or water of a known oxygen content (mg/L), and then adjusting the calibration controls so the display shows a reading matching the oxygen concentration of the known sample. Calibration can be disturbed by physical shock, touching the membrane, and fouling of the membrane or drying out of the electrolyte. Calibration will be checked after each series of measurements. Calibration of the DO meter will be performed on a daily basis as follows:

1. Place the probe in moist air. Biological oxygen demand probes can be placed in partially filled (50 ml) biological oxygen demand bottles. Wait 10 minutes for temperature to stabilize ± 2°C.

2. Switch to **TEMPERATURE** and read. Refer to Table SOP037-1 for solubility of oxygen in fresh water (calibration value).

3. Determine altitude or atmospheric correction factor from Table SOP037-2.

4. Multiply the calibration value from Table SOP037-1 by the correction factor from Table SOP037-2 to obtain the correct calibration value.

   EXAMPLE: Assume a temperature of 20°C and an altitude of 1,100 ft. From Table SOP037-1, the calibration value of 20°C is 9.09 mg/L. From Table SOP037-2, the correction factor for 1,100 ft is 0.96. Therefore, the corrected calibration value is 9.09 mg/L × 0.96 = 8.73 mg/L.

5. Switch to the appropriate mg/L range, set the **SALINITY** knob to zero and adjust the **CALIBRATE** knob until the meter reads the calibration value from Step 4. Wait 2 minutes to verify calibration stability. Readjust if necessary.

3.3 DISSOLVED OXYGEN MEASUREMENT

- With the instrument prepared for use and the probe calibrated, place the probe in the sample.

- Turn the **STIRRER** knob **ON**.

- Adjust the **SALINITY** knob to the salinity of the sample if appropriate.

- Allow sufficient time for the probe to equilibrate to the sample temperature and DO.

- Read DO on appropriate scale.

- Before measuring the DO of the next sample, rinse probe and sample bottle with distilled water and then with next water sample.

Follow steps above for the next sample(s).

The DO meter should normally be left on during the working day to avoid the delay of waiting for probe repolarization.

4. MAINTENANCE

The following steps will be taken to maintain the DO meter:

- Replace the batteries when the **RED LINE** knob is at its extreme adjustment or at least annually.

- In the **BATT CHECK** position on the **STIRRER** knob, the voltage of the stirrer batteries is displayed on the red **0-10** scale. Do not permit them to discharge below 6 volts.

- Replace membrane every 2 weeks depending on application. Probes will be stored in a humid environment to prevent drying out.

5. PRECAUTIONS

The DO meter case is water resistant when properly closed. As a precaution against damaged gaskets or loose fittings, the instrument case will be opened and inspected for moisture whenever the instrument has been subjected to immersion or heavy spray. The case is opened by removing the screws on the rear cover an lifting the cover off.

6. REFERENCES

Manufacturer’s handbook.

TABLE SOP037-1 SOLUBILITY OF OXYGEN IN WATER EXPOSED TO WATER SATURATED AIR AT 760 mm Hg PRESSURE

Temperature (°C)	Solubility (mg/L)	Temperature (°C)	Solubility (mg/L)	Temperature (°C)	Solubility (mg/L)
0	14.62	17	9.67	34	7.07
1	14.22	18	9.47	35	7.95
2	13.83	19	9.28	36	7.84
3	13.46	20	9.09	37	6.73
4	13.11	21	8.92	38	6.62
5	12.77	22	8.74	39	6.52
6	12.45	23	8.58	40	6.41
7	12.14	24	8.42	41	6.31
8	11.84	25	8.26	42	6.21
9	11.56	26	8.11	43	6.12
10	11.29	27	7.97	44	6.02
11	11.03	28	7.83	45	5.95
12	10.78	29	7.69	46	5.84
13	10.54	30	7.56	47	5.74
14	10.31	31	7.43	48	5.65
15	10.08	32	7.31	49	5.56
16	9.87	33	7.18	50	5.47

NOTE: Derived from 17th Edition, Standard Methods for the Examination of Water and Wastewater.

TABLE SOP037-2 CALIBRATION VALUES FOR VARIOUS ATMOSPHERIC PRESSURES AND ALTITUDES

Pressure			Altitude in		Calibration Value(%)
in. Hg	mm Hg	kPa	feet	meter	
30.23	768	102.3	-276	-84	101
29.92	760	101.3	0	0	100
29.61	752	100.3	278	85	99
29.33	745	99.3	558	170	98
29.02	737	98.3	841	256	97
28.74	730	97.3	1126	343	96
28.43	722	96.3	1413	431	95
28.11	714	95.3	1703	519	94
27.83	707	94.2	1995	608	93
27.52	699	93.2	2290	698	92
27.24	692	92.2	2587	789	91
26.93	684	91.2	2887	880	90
26.61	676	90.2	3190	972	89
26.34	669	89.2	3496	1066	88
26.02	661	88.2	3804	1160	87
25.75	654	87.1	4115	1254	86
25.43	646	86.1	4430	1350	85
25.12	638	85.1	4747	1447	84
24.84	631	84.1	5067	1544	83
24.53	623	83.1	5391	1643	82
24.25	616	82.1	5717	1743	81
23.94	608	81.1	6047	1843	80
23.62	600	80.0	6381	1945	79
23.35	593	79.0	6717	2047	78
23.03	585	78.0	7058	2151	77
22.76	578	77.0	7401	2256	76
22.44	570	76.0	7749	2362	75
22.13	562	75.0	8100	2469	74
21.85	555	74.0	8455	2577	73
21.54	547	73.0	8815	2687	72
21.26	540	71.9	9178	2797	71
20.94	532	70.9	9545	2909	70
20.63	524	69.9	9917	3023	69
20.35	517	68.9	10293	3137	68
20.04	509	67.9	10673	3253	67
19.76	502	66.9	11058	3371	66

NOTE: Derived from 17th Edition, Standard Methods for the Examination of Water and Wastewater.

Standard Operating Procedure No. 038
for
Redox Potential Measurements

Prepared by

EA Engineering, Science, and Technology, Inc.
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1. SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure is to delineate protocols for measuring the redox of flooded sediment and soil. Redox is an indication of the reduction of oxidation intensity of an anaerobic system. Redox will be expressed in mV. A complete anaerobic system redox potential is -150 Mv. A positive value indicates an aerobic system.

Redox measurement in a natural system is difficult to obtain due to the absence of true equilibria, heterogeneity of media, and pH effects deprived redox measurements in natural media of precise thermodynamic significance (Ponnamperuma 1972). Despite the difficulties involved in the redox measurements in natural media, it is widely accepted that redox readings in natural anaerobic systems can provide valuable environmental information. Whitfield found redox useful as a semi-quantitative indicator of the degree of stagnation of a particular aquatic environment as did Ponnamperuma for flooded soils and sediments. The redox measurements of natural waters are not representative of that median, since natural waters are in a highly dynamic state rather than in or near equilibrium, according to Stumm and Morgan 1970. It is generally recognized that redox measurements in oxygenated natural waters are invalid.

2. MATERIALS

The following materials may be required:

pH meter	Sample bottle
Combination pH electrode	Standard solution (pH 4 and 7 buffers saturated with quinhydrone)
Lint-free laboratory wipes (Kimwipes, or equivalent)	Wash bottle
Distilled water	

3. PROCEDURE

Calibration of the pH meter will be calibrated on a daily basis as follows.

- Prepare beaker of standard solution with known voltage(s)
- Connect electrodes to instrument
- Turn on and clear
- Rinse electrode with distilled water blot excess with laboratory wipes
- Immerse probe in beaker of standard solution
- Press mV key
- After the reading stabilizes, the absolute mV of solution is displayed.
- Rinse electrode and blot excess.

Redox will be measured after calibration as follows:

- Prepare sample in a beaker
- Rinse electrode and blot excess water
- Immerse electrode in sample and stir briefly
- Press mV switch
- Record the reading after it stabilizes
- For next sample(s), follow above steps.

4. MAINTENANCE

Check the batteries each time the meter is used.

Keep the probe stored in a 0.1 M KCL solution when not in use. Alternatively, the electrode may be rinsed with deionized water and trapping any residual water inside the protective cap.

5. PRECAUTION

Remove coatings of oil material or particulate matter that can impair electrode response by gentle wiping or detergent washing, followed by distilled water rinsing.

6. REFERENCES

Beckman Instruments, Inc. User Manual for 10, 11, and 12 pH/ISE meter.

Ponnamperuma, F.N. 1972. The Chemistry of Submerged Soils, Advances in Agronomy. Vol. 24.

Stumm, W. and J.J. Morgan. 1970. Aquatic Chemistry, Wiley, New York.

Whitfield, M. 1969. Eh as an Operational Parameter in Estuarine Studies. *Limnol. Oceanogr.*, Vol. 14.

Standard Operating Procedure No. 039
for
Sample Preservation and Container Requirements

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1. PURPOSE AND SCOPE

The purpose of this Standard Operating Procedure (SOP) is to define the preservatives and techniques to be employed in preserving environmental samples between collection and analysis.

2. MATERIALS

The following materials may be required:

Containers (see Section 3 for description)	NaOH
HNO_3	Ice chests
H_2SO_4	Ice

3. DEFINITION OF CONTAINER TYPES

Type A **Container**: 80 oz amber glass, ring handle bottle/jug, 38-mm neck finish.
Closure: White polypropylene or black phenolic, baked polyethylene cap, 38-430 size, 0.015-mm polytetrafluoroethelyne (PTFE) liner.

Type B **Container**: 40-mL glass vial, 24-mm neck finish
Closure: White polypropylene or black phenolic, open top, screw cap, 15-mm opening, 24-400 size.
Septum: 24-mm disc of 0.005-in PTFE bonded to 0.120-in. silicon for total thickness of 0.125-in.

Type C **Container**: 1-L high density polyethylene, cylinder-round bottle, 28-mm neck finish.
Closure: White polyethylene cap, white ribbed, 28-410 size; F217 polyethylene liner.

Type D **Container**: 120-mL wide mouth glass vial, 48-mm neck finish.
Closure: White polyethylene cap, 40-480 size; 0.015-mm PTFE liner.

Type E **Container**: 250-mL boston round glass bottle
Closure: White polypropylene or black phenolic, open top, screw cap.
Septum: Disc of 0.005-in PTFE bonded to 0.120-in silicon for total thickness of 0.125-in.

Type F	**Container**: 8-oz short, wide mouth, straight-sided, flint glass jar, 70-mm neck finish. **Closure**: White polypropylene or black phenolic, baked polyethylene cap, 48-400 size; 0.030-mm PTFE liner.
Type G	**Container**: 4-oz tall, wide mouth, straight -sided, flint glass jar, 48-mm neck finish. **Closure**: White polypropylene or black phenolic, baked polyethylene cap, 48-400 size; 0.015-mm PTFE liner.
Type H	**Container**: 1-L amber, Boston round, glass bottle, 33-mm pour-out neck finish. **Closure**: White polypropylene or black phenolic, baked polyethylene cap, 33-430 size; 0.015-mm PTFE liner.
Type K	**Container**: 4-L amber glass ring handle bottle/jug, 38-mm neck finish. **Closure**: White polypropylene or black phenolic, baked polyethylene cap, 38-430 size; 0.015-mm PTFE liner.
Type L	**Container**: 500-mL high-density polyethylene, cylinder bottle, 28-mm neck finish. **Closure**: White polypropylene, white ribbed, 28-410 size; F217 polyethylene liner.

4. PROCEDURE

All containers must be certified clean, with copies of laboratory certification furnished upon request.

Water samples will be collected into pre-preserved containers appropriate to the intended analyte as given in Quality Assurance Project Plan. Samples taken for volatile organic compounds will be collected in accordance with SOP No. 003, Section 3.3.8. Samples taken for metals analysis will be verified in the field to a pH <2. The container should be tightly capped, then swirled to thoroughly mix the sample. The cap will then be loosened to release any excess pressure this operation may have generated. Samples taken for total phosphorous content will be verified in the field to a pH <2. The container should be tightly capped and swirled to thoroughly mix the sample. The cap will then be loosened to release any excess pressure this operation may have generated. Samples taken for cyanide will be verified for a pH >12. No preservatives will be added to any other water samples. These samples will be immediately placed on ice and cooled to 4°C.

Soil and sediment samples will be collected into containers appropriate to the intended analyte as given in the Quality Assurance Project Plan. Samples taken for volatile organic compound analysis will collected in accordance with the site-specific SOP. Samples taken for metals analysis will be tightly capped, placed on ice, and maintained at a temperature of 4°C. Samples taken for total phosphorous content will be tightly capped, placed on ice, and maintained at a temperature of 4°C. Samples taken for cyanide will be alkalized to a pH > 12 by the addition of NaOH. No preservatives will be added to any other soil samples. These samples will be immediately placed on ice and cooled to 4°C.

5. MAINTENANCE

Not applicable.

6. PRECAUTIONS

Note that acidifying a sample containing cyanide may liberate HCN gas.

- Avoid breathing any fumes emanating from acidified samples.
- Acidify samples only in the open, rather than in closed spaces such as a vehicle.
- Hold suspected HCN-generating sample away from body and downwind while manipulating it.
- See the Health and Safety Plan for other safety measures

7. REFERENCES

U.S. Environmental Protection Agency (U.S. EPA). 1986. Test Methods for Evaluating Solid Waste, SW-845.

U.S. EPA. 1987. A Compendium of Superfund Field Operations Methods, EPA 540-P87-001.

U.S. EPA. 1991. A Compendium of ERT Soil Sampling and Surface Geophysics Procedures.

Standard Operating Procedure No. 042
for
Disposal of
Investigation-Derived Material

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1. SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure is to define the required steps for disposing of investigation-derived material (IDM) generated during field activities.

IDM, as used herein, includes soil cuttings, drilling muds, purged groundwater, decontamination fluids, and disposable personal protective equipment. For the sake of clarity and ease in use, this Standard Operating Procedure is subdivided into procedures for disposal of liquid IDM and solid IDM as follows:

- Liquid IDM (Section 3.2) includes the following materials:
  - Water from initial development of new wells and the redevelopment of existing wells.
  - Purge water from groundwater sampling.
  - Decontamination fluids (Section 3.4)
- Solid IDM (Section 3.3) consists of the following materials:
  - Drill cuttings from monitoring well installation
  - Grout, a mixture of cement and bentonite, generated during installation of monitoring wells
  - Disposable personal protective equipment (Section 3.4).

2. MATERIALS

The following materials may be required:

Any additional equipment that may be dictated by project or site-specific plans	Hazardous waste labels
Bar codes	Permanent marker
Chain-of-custody forms	Field Logbook (bound)
Department of Transportation 17C spec. metal containers	Waste identification labels

3. PROCEDURE

3.1 GENERAL

No container will be labeled as a “Hazardous Waste” unless the contents are in fact known to be hazardous as defined by 40 CFR 261.

IDM may be disposed onsite if it is: (1) initially screened, or evaluated to determine whether it is contaminated; (2) not abandoned in an environmentally unsound manner; and (3) not inherently waste-like.

IDM are to be considered contaminated if they: (1) are visually or grossly contaminated, (2) have activated any field monitoring device which indicates that the level exceeds standard Level 1, (3) have previously been found to exhibit levels of contamination above environmental quality standards, and (4) the responsible party and/or appropriate regulator deem(s) that records of historical uses indicate that additional testing of the IDM is needed, or additional caution is warranted handling IDM from a given site.

3.2 PROCEDURES FOR LIQUID INVESTIGATION-DERIVED MATERIAL DISPOSAL

1. All water from initial development of new wells, and purge water generated during the first round of groundwater sampling will be containerized in Department of Transportation approved 55-gal drums. Decontamination fluids may be bulk-containerized until completion of field task.

2. Label all containers as to type of media, the date the container was sealed, the point-of-generation, and the points-of-contact. The well number and container number will be identified on the container.

3. The contractor/support personnel will log all media generated onsite into a bound Field Logbook. Media information should include the following: the date of generation, contents of containers, the number of containers with the same contents (if applicable), location of containers, the well number the media is associated with, personnel sampling the media, sampling dates, and sampling results.

4. Containers of well development water and purge water may be stored at the well site pending first round analytical results.

5. Laboratory turnaround time must be no greater than 30 days. Upon receipt of the analytical results, a copy will be furnished to the client within 3 working days. Both the client and contractor will evaluate the data to determine disposal requirements, per state and local regulations. A disposal decision is required within 10 days of receipt of sampling results. Appropriate disposal must be performed no later than 50 days from the decision date unless prevented by inclement weather (e.g., rain and muddy conditions may preclude site access, freezing weather may freeze media).

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1. This value is defined as two times background, where “background” values are to be determined as follows: (1) regional background values will be used where they are available; and (2) if regional values are not available, background may be empirically determined at uncontaminated sampling sites using onsite sensors such as organic vapor analyzers (photoionization detector or flame ionization detector), scintillometers, etc.

Dispose of non-hazardous media in accordance with Step 6 et seq. through 8 et seq. of this procedure.

Dispose of hazardous waste in accordance with Step 9 et seq. of this procedure.

6. If the first round analytical data of the liquid media is below the Maximum Contaminant Levels established by the Federal Safe Drinking Water Act, the water may be gradually infiltrated into the ground at least 50 ft downgradient of the well.

   If the well location has no downgradient area, the water will be infiltrated into the ground in an area deemed appropriate by the client and the contractor/support personnel.

   Disposal locations must allow percolation of the water and prohibit "ponding."

   Upon completion of water discharge to ground, enter type of media, amount of media, date of disposal, and discharge point(s) in a bound Field Logbook and provide this information to the client.

   Empty containers are to be properly decontaminated, stored, and reused by the appropriate personnel.

   If the liquid media sampling results do not meet the required Maximum Contaminant Levels and cannot be discharged to the ground, then determine if the waste meets the sanitary sewer discharge criteria (National Pollutant Discharge Elimination System standards).

7. If at any time visual contamination of purge/development water is observed, or if organic vapor monitor readings (HNu, photoionization detector) register more than 5 ppm above background and/or rad meters register more than twice the background mrems, then the liquid will be drummed and a composite sample will be taken that day. A disposal decision will be based on the analytical results of this sample rather than the first round of analytical results.

3.3 PROCEDURE FOR SOLID INVESTIGATION-DERIVED MATERIAL DISPOSAL

1. If the conditions outlined in Section 3.1 are met, proceed to Section 3.3, Step 2; otherwise, go to Section 3.3, Step 7.

2. During drilling operations, the resulting cuttings and mud will be discharged onto the ground near the well if the following conditions are met: (1) no visual contamination is observed, (2) organic vapors are less than 5 ppm above background, (3) rad meter readings (if applicable) are under two times background, and (4) if the potential for metals contamination exists, the medium has been screened and found to be less than two times background.

Proper sediment and erosion control measures will be implemented as follows:

- Drill cuttings will be uniformly spread and contoured to blend with the surroundings of the site.

- If amount of solid IDM exceeds 5,000 ft^2 or 100 yd^3 of material, a Sediment and Erosion Control Plan is required.

- If the amount of solid IDM is under 5,000 ft^2 or 100 yd^3, the site will be stabilized as soon as possible. Stabilization includes mulch, seed, and tack.

- Critical areas require stabilization within 7 days from the date of well completion. Critical areas include swales, water sources, drainage ditches, etc.

- All other disturbed areas require stabilization within 14 days from the date of well completion.

3. If the well location is in or near a wetland, the drill cuttings will be drummed and transported away from the site for spreading.

4. Label all IDM containers that will not be spread on the day of generation. Each container should be labeled with the type of media, the date the container was sealed, the point-of-generation, and the name of the contact person. The well number and container number should be identified on the container.

5. The contractor/support personnel will log all media generated onsite into a bound Field Logbook. Media information should include: the date of generation, contents in containers, the number of containers with the same contents, location of containers, and the well number the media is associated with.

6. Containers will be staged at the well site until contractor/support personnel spread the cuttings in the appropriate locations, using proper sediment and erosion control measures per Section 3.3 et seq.

7. If drilling mud and cuttings show visible contamination, or organic vapor readings are more than 5 ppm above background levels, or rad meter readings (if applicable) show greater than two times background levels, media will immediately be containerized, labeled appropriately (Section 3.2), and sampled on the same day.

8. The solid IDM should be sampled and appropriate Toxicity Characteristic Leaching Procedure analyses conducted prior to determining disposition. Laboratory turn-around time must be no greater than 30 days. Upon receipt of analytical results, a copy will be furnished to the client within 3 working days. The contractor will evaluate the data to determine disposal requirements within 10 days. Appropriate disposal must be performed no later than 50 days after the decision date if weather permits (Section 3.2).

- If the solid IDM are determined to be non-hazardous and uncontaminated, go to Section 3.3.

- If the solid IDM are determined to be non-hazardous but contaminated , go to Section 3.3.

- If the solid IDM are found to be hazardous wastes, go to Section 3.3.

9. If the solid IDM are not a hazardous waste **and** analytical data shows contaminant concentrations below the U.S. Environmental Protection Agency Region 3 (or applicable Region where work is being performed) Risk-Based Concentrations, contact the appropriate federal, state, or local agency for approval to discharge onto the ground near the site of generation.

    - Follow steps detailed in Section 3.3, Step 2 et seq. (above) pertaining to sediment and erosion control.

    - Upon completion of the solid IDM discharge to the ground, enter type of media, amount of media, date of disposal, and discharge point(s) in a bound Field Logbook. This information must be provided to the client.

    - Empty containers are to be properly decontaminated, stored and reused by appropriate personnel.

10. If the intrusive media is not a hazardous waste but analytical data shows concentrations above the screening criteria, dispose of the IDM according to state and local regulations.

    - Ensure that the waste containers are properly labeled as applicable in accordance with Section 3.3, Step 4.

    - Inform the client of the type and amount of waste, and the location of the waste.

    - When the waste is removed, enter the type of waste, amount of waste, date of pickup, and the destination of the waste in a bound Field Logbook. This information must be provided to the client.

3.4 PROCEDURES FOR DECONTAMINATION SOLUTION AND PERSONAL PROTECTIVE EQUIPMENT DISPOSAL

Decontamination solutions include catch water from steam-cleaning operations performed on large sampling equipment, drill rigs, and drums, as well as smaller quantities of soapy water and rinse solutions used in decontaminating field sampling equipment. At the completion of the field event, a composite sample of the decontamination solution will be taken. The decontamination solution will be treated as liquid IDM pending results (Section 3.2 et seq.).

Personal protective equipment will be containerized onsite, appropriately labeled, and disposed of in a designated trash receptacle.

4. MAINTENANCE

Not applicable.

5. REFERENCES

Environment Article Section 7-201(t).

U.S. Environmental Protection Agency. 1991. Management of Investigation-Derived Wastes during Site Inspections PB91-921331, OERR Directive 9345.3-02. Office of Emergency and Remedial Response U.S. Environmental Protection Agency, Washington, D.C. May.

Standard Operating Procedure No. 047
Direct-Push Technology Sampling

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1. SCOPE AND APPLICATION

This Standard Operating Procedure (SOP) establishes the protocol for using direct-push technology (DPT) in media sampling and performing subsurface characterization. This SOP includes the following DPT methods: Geoprobe®, Hydropunch®, Cone Penetrometer Testing (CPT), and Site Characterization and Analysis Penetrometer System (SCAPS).

2. MATERIALS

The following materials may be required:

Appropriately sized, all-terrain vehicle-skid-or track-mounted; DPT equipment; and supplies (i.e., hydraulic derrick and hammer assembly)	Personal protective equipment
Bentonite grout and clean sand for DPT hole abandonment	Phosphate-free, laboratory-grade detergent (e.g., Liquinox, Alconox, etc.)
DPT stainless steel rods	Source of approved water
Heavy plastic sheeting	Steam cleaner/sprayer and water obtained from approved source for decontaminating DPT equipment
Logbook	Steel drums for intrusion derived wastes (e.g., contaminated personal protective equipment, decon solutions, etc.)
Long-handled bristle brushes	Wash and rinse tubs
Mini-bailer or tubing and peristaltic pump (groundwater sampling only)	

3. GEOPROBE® AND HYDROPUNCH®

3.1 MATERIALS

Water sources for Geoprobe® and Hydropunch® activities, grouting, sealing, filter placement, well installation, and equipment decontamination must be approved by the Project Manager prior to arrival of the Geoprobe® and Hydropunch® equipment. Information required for the water source includes: water source, manufacturer/owner, address and telephone number, type of treatment and filtration prior to tap, time of access, cost per gallon (if applicable), dates and results associated with all available chemical analysis over the past 2 years, and the name and address of the analytical laboratory (if applicable).

Pure sodium bentonite with no additives will be the only additive allowed, and its use must be approved by the Project Manager prior to the arrival of the Geoprobe® and Hydropunch® equipment. The information required for evaluation includes: brand name, manufacturer, manufacturer's address and telephone number, product number, product description, and intended use for the product.

Portland Type II cement will be used for grout (refer to SOP No. 019).

3.2 GROUNDWATER – HYDRAULIC PUSHING AND SAMPLING

The objective of the selected DPT sampling technique is to allow grab samples to be taken at a selected site to facilitate aquifer characterization and analysis of potential contaminants. The analytical results from sampling can also be used to determine the placement of monitoring wells.

A site geologist will be present during all sampling and installation procedures, and will fully document all procedures and soil characteristics in the Field Logbook. Refer to SOP No. 003 (Field Logbook).

The site geologist will have on hand, at a minimum, a copy of the approved Health and Safety Plan, this SOP, the Field Investigation Work Plan, a hand lens (10X), a standard color chart, and a grain size chart.

Only solid vegetable shortening (e.g., Crisco®) without flavoring or additives may be used on downhole Geoprobe® and Hydropunch® equipment.

Surface runoff or other fluids will not be allowed to enter any DPT location or well during or after DPT activities.

The subcontractor will use the equipment specific guidelines for installation of the Geoprobe® DPT equipment. Probe rods will be forced into the ground by hydraulic means.

- Drive the sampler to the desired groundwater sampling interval. At the desired depth, insert extension rods down the inside diameter of the probe rods until the extension reaches the bottom of the screen. Remove the probe rods and sampler sheath while holding the screen in place.

- Collect the groundwater sample in the screen interval with a mini-bailer, peristaltic or vacuum pump, or other acceptable small diameter sampling device.

- The head of the rod may be equipped with a sensing device for characterization of soil properties or the contaminant content.

The subcontractor will use the equipment-specific guidelines for installation of the Hydropunch® equipment. Rods will be forced into the ground by hydraulic means.

- The Hydropunch® tool is a double cylinder, designed to be sealed until the desired sampling depth is reached. Upon reaching the desired sampling depth, the outer cylinder is pulled back, exposing a perforated, stainless steel sampling barrel covered with filter material.

- The water sample enters the barrel and the sample is retrieved by pulling the probe rods from the hole with the hydraulic derrick and hammer assembly. Groundwater is the only media that is sampled by Hydropunch® equipment.

- The head of the rod may be equipped with a sensing device for characterization of the soil properties or the contaminant content.

- The sample volume collected with this technique is approximately 500-1,000 ml. Larger sample volumes can be collected by inserting tubing attached to a peristaltic pump into the rods to obtain water samples.

If desired, a small diameter monitoring well may be installed at this point. Refer to SOP No. 019 (Monitoring Well Installation).

If a well will not be installed, the rods will be removed as the borehole is simultaneously filled with a bentonite/grout mixture. A polyvinyl chloride (PVC) tube fed into the rod casing will allow the addition of grout.

3.3 SUBSURFACE SOIL – HYDRAULIC PUSHING AND SAMPLING

The objective of the selected DPT sampling technique is to allow grab samples to be taken at a selected site for characterization of the stratigraphy and for analysis of potential contaminants. The analytical results from sampling can also be used to determine the placement of monitoring wells.

A site geologist will be present during all DPT sampling and soil characterization. All procedures and soil characteristics will be fully documented in the Field Logbook (refer to SOP No. 003 [Field Logbook]).

The site geologist will have on hand, at a minimum, a copy of the approved Health and Safety Plan, this SOP, the Field Investigation Plan, a hand lens (10X), a standard color chart, and a grain-size chart.

Only solid vegetable shortening (e.g., Crisco®) without flavoring or additives may be used on downhole Geoprobe® equipment.

Surface runoff or other fluids will not be allowed to enter any DPT location or well during or after DPT activities.

The subcontractor will use the equipment specific guidelines for installation of the Geoprobe® DPT equipment. Probe rods will be forced into the ground by hydraulic means. Additional rods will be added in 3- to 4-ft increments until the leading edge of the sampler reaches the top of the desired sampling interval.

Once the desired sampling depth has been reached, insert extension rods down the inside diameter of the probe rods until it reaches the top of the sampler assembly. Attach the extension rod handle to the top extension rod. Turn the handle clockwise until the stop-pin detaches from the drive head. Remove the extension rods and the stop-pin. Attach a drive cap to the probe and drive the sampler approximately 2 ft using hydraulic derrick.

The DPT sampler can be retrieved by pulling the probe rods from the hole with the hydraulic derrick and hammer assembly.

The liner will be capped with Teflon® tape and vinyl end caps. The liners can be split open to remove samples for composition analysis or for transfer to other containers for shipment to the laboratory for analysis.

The head of the rod may be equipped with a sensing device for characterization of the soil properties or the contaminant content.

3.4 DECONTAMINATION

All Geoprobe® and Hydropunch® DPT equipment must be thoroughly cleaned before and after each use to allow retrieval of representative groundwater samples. Geoprobe® soil sample liners are disposed of after each use. Scrub all metal parts with a stiff, long bristle brush and a non-phosphate soap solution. Steam cleaning may be substituted where available. Rinse with distilled water and allow to air-dry before assembly.

After decontamination, a new clean liner will be installed and all parts will be inspected for wear or damage.

Refer to SOP No. 005 (Decontamination).

3.5 ABANDONMENT

Pure bentonite or a bentonite/grout mixture (20:1) will be used to fill the resulting borehole if the water table is penetrated. Boreholes that do not penetrate the water table will be backfilled with cuttings from the hole and topped with a bentonite seal. Clean sand will be used to fill any remaining volume in the borehole.

Abandonment of Geoprobe® and Hydropunch® generated DPT boreholes will meet the standards established under SOP No. 028 (Well and Boring Abandonment).

4. CONE PENETROMETER TESTING

4.1 MATERIALS

A CPT rig typically consists of an enclosed 20- to 40-ton truck equipped with vertical hydraulic rams that are used to force a sensor probe into the ground. The weight of the CPT rig is dependent upon the thrust required at the site. The majority of CPT rigs are mounted in heavy-duty trucks that are ballasted to a total dead weight of approximately 15 tons. Screw anchors are utilized to develop the extra reaction to reach the maximum thrust of 20 tons. The rig is separated into two separate workspaces: data acquisition and hydraulic push areas.

Water sources for CPT activities and decontamination must be approved by the Project Manager prior to arrival of the CPT equipment. Information required for the water source includes: water source, manufacturer/owner, address and telephone number, type of treatment and filtration prior to tap, time of access, cost per gallon (if applicable), dates and results associated with all available chemical analysis over the past 2 years, and the name and address of the analytical laboratory (if applicable).

Pure sodium bentonite with no additives will be the only additive allowed, and its use must be approved by the Project Manager prior to the arrival of the DPT equipment. The information required for evaluation includes: brand name, manufacturer, manufacturer’s address and telephone number, product number, product description, and intended use for the product.

Portland Type II cement will be used for grout (refer to SOP No. 019).

4.2 SUBSURFACE CHARACTERIZATION

The objective of this technology is to collect stratigraphic information using CPT equipment to determine subsurface stratigraphy and geotechnical properties at a particular site. CPT activities will be in accordance with American Society for Testing and Materials D 3441-86 and American Society for Testing and Materials D 5778-95. The stratigraphic information gathered can be used to facilitate the selection of DPT sampling screen intervals. At the same time, it is possible to install a 0.25-in. diameter pre-packed PVC monitoring well.

CPT rods are used to hydraulically push the CPT probe into the subsurface. Probes cannot be pushed into hard rock, and significant gravel or cobble content in the formation may impede or preclude penetration of the probe. The depth of penetration achievable depends on the type of formation, type of sampling probe, and size of the hydraulic equipment used.

The CPT probe includes the following components:

- A conical tip to measure vertical resistance beneath the tip.
- A friction sleeve to measure frictional resistance on the side of the probe, as a function of depth.

- Two internal strain gauge-type load cells, which independently measure the vertical resistance and side friction.

- A cone pressure gauge to measure the water pressure as the probe is pushed into the ground.

- Inclinometer to determine potential drifting of the probe (optional).

- Seismic transducers to perform downhole seismic surveys (optional). Therefore, stratigraphic data collected with the CPT include: tip resistance, local friction, friction ratio, pore pressure, and resistivity.

Data will be transferred from the probe to the data acquisition system or logger through an electrical cable. The hole will be advanced continuously at a rate of 0.6-1.0 in. per second. The data will be logged at every 0.4-0.8 in. of penetration. Monitor the probe's stratigraphic position will be monitored as it advances downward. Perform pore water pressure dissipation tests in representative hydrostratigraphic intervals. Record dissipated pore water pressures to represent hydraulic head values.

Once the confining unit underlying the surficial aquifer or the required depth has been reached, the CPT is pulled from the ground. Target interval samples can be collected during CPT hole advancement using direct push sampling techniques, i.e., Geoprobe® or Hydropunch® (Section 3).

4.3 DECONTAMINATION

All CPT equipment must be thoroughly cleaned before arrival at the work site, between test holes, and prior to being moved out of a work area. Scrub all metal parts with a stiff, long bristle brush and a non-phosphate soap solution. Steam cleaning may be substituted where available. Rinse with distilled water and allow to air-dry before assembly.

Refer to SOP No. 005 (Decontamination).

4 .4 ABANDONMENT

If the push hole was developed for the stratigraphic test only, once the testing is completed, grout the hole from bottom to top. If the hole has not collapsed after removing the CPT, PVC piping will be used to grout the hole. If the hole has collapsed after removing the CPT, then hollow CPT rods and a sacrificial tip will be used to grout the hole. The PVC pipe or CPT rods will be pushed to the bottom of the hole. Grout will then be pumped to the bottom of the hole as the PVC pipe or CPT rods are withdrawn.

Refer to SOP No. 028 (Well and Boring Abandonment).

5. SITE CHARACTERIZATION AND ANALYSIS PENETROMETER SYSTEM

5.1 MATERIALS

SCAPS cone penetrometer and laser induced fluorescence (LIF) technology requires the use of a specialized 20-ton truck. The truck has two separate enclosed compartments. Each compartment is temperature controlled and monitored for air quality. The two rooms are the data acquisition and processing room, and the hydraulic ram/rod handling room. Approximately 20 ft of overhead clearance is required to fully extend the hydraulic ram and allow for leveling jack movement.

All materials required to complete SCAPS analysis are provided by the subcontractor to include cone penetrometer equipment. All hydraulic equipment, SCAPS rods, nitrogen lasers, etc. are included within the vehicle. A decontamination water source and a source of water for mixing the grout are required.

Water sources for equipment decontamination must be approved by the Project Manager prior to arrival of the SCAPS equipment. Information required for the water source includes: water source, manufacturer/owner, address and telephone number, type of treatment and filtration prior to tap, time of access, cost per gallon (if applicable), dates and results associated with all available chemical analysis over the past 2 years, and the name and address of the analytical laboratory (if applicable).

Pure sodium bentonite with no additives will be the only additive allowed, and its use must be approved by the Project Manager prior to the arrival of the SCAPS equipment. The information required for evaluation includes: brand name, manufacturer, manufacturer’s address and telephone number, product number, product description, and intended use for the product.

Portland Type II cement will be used for grout (refer to SOP No. 019).

5.2 HYDRAULIC PUSHING AND SAMPLING

The objective of the SCAPS technique is to allow grab samples and stratigraphic information to be collected at a selected site to facilitate subsurface characterization and for analysis of potential contaminants. The analytical results obtained can also be used to determine the placement of monitoring wells. At the same time, it is possible to install a small diameter well for sampling purposes. Refer to SOP No. 019 (Monitoring Well Installation). If a well will not be installed, the borehole can be grouted as the equipment is removed.

A site geologist will be present during all installation and sampling procedures and will fully document all procedures and soil characteristics in the Field Logbook (refer to SOP No. 003 [Field Logbook]).

The site geologist will have on hand, at a minimum, a copy of the approved Health and Safety Plan, this SOP, the Field Investigation Work Plan, a hand lens (10X), a standard color chart, and a grain-size chart.

Only solid vegetable shortening (e.g., Crisco®) without flavoring or additives may be used on downhole SCAPS equipment.

Surface runoff or other fluids will not be allowed to enter any DPT location or well during or after direct-push activities.

The subcontractor will use the equipment specific guidelines for installation of the SCAPS DPT equipment. Prior to SCAPS field activities, calibration soil samples will be collected and analyzed in order to determine the LIF sensor fluorescence threshold and detection limits for the site.

SCAPS LIF technology uses a pulsed nitrogen laser coupled with an optical detector to make fluorescence measurements via optical fibers. The LIF sensor is mounted on a cone penetrometer probe so that soil classification data and fluorescence data are collected simultaneously. The laser consumes nitrogen gas, which is supplied from cylinders stored on the accompanying trailer.

The SCAPS CPT sensors are used to gather stratigraphic information. See Section 4 for CPT operating procedures.

Target interval samples can be collected during SCAPS hole advancement using direct push sampling techniques such as Geoprobe® or Hydropunch® (Section 3).

5.3 DECONTAMINATION

Decontamination of SCAPS equipment is automated after initialization by a field team member. A pressurized hot water system is used to decontaminate the push rods as they are retracted from the ground. The SCAPS vehicle is equipped with a decontamination collar mounted to the bottom that cleans the rods. The decontamination water is removed by vacuum and transferred to a storage drum prior to disposal or treatment. A trailer attached to the back of the vehicle contains the water pump, heater for decontamination, and decontamination water containment drum.

Worker exposure is reduced by minimizing contact with contaminated media.

Refer to SOP No. 005 (Decontamination).

5.4 ABANDONMENT

SCAPS automatically grouts the penetrometer cavity as the rods are removed. The grout is pumped at high pressure through a 0.25-in. diameter tube in the center of the penetrometer rods. The tip is sacrificed at the bottom of the cavity to allow release of the grout.

A trailer attached to the back of the vehicle contains the 300-gal grout mixing bin and pump.

If the automatic grout feed does not work, the cavity will be manually filled with grout.

Abandonment of SCAPS generated borehole will meet the standards established under SOP No. 028 (Well and Boring Abandonment).

6. MAINTENANCE

Not applicable.

7. PRECAUTIONS

Refer to the site-specific Health and Safety Plan for discussion of hazards and preventive measures during intrusive activities.

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Standard Operating Procedure No. 048
for
Low-Flow Sampling

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1. GROUNDWATER SAMPLING BY LOW-FLOW PURGE AND SAMPLING METHOD USING DEDICATED PUMPS

1.1 SCOPE OF APPLICATION

The purpose of this Standard Operating Procedure (SOP) is to establish the protocol for collecting groundwater samples using dedicated pump systems. The procedure is designed to permit the collection of groundwater samples with minimum turbidity.

1.2 EQUIPMENT/MATERIALS

- Work Plan.
- Well construction data, location map, and field data from last sampling event.
- Field logbook and Field Record of Well Gauging, Purging, and Sampling forms (Figure SOP048-1).
- Electric water level measuring device, 0.01 ft accuracy for monitoring water level during pumping operations.
- Pumps: adjustable rate, submersible pumps constructed of stainless steel and Teflon®.
- Tubing: Teflon or Teflon-lined polyethylene must be used to collect samples for organic analysis. For samples collected for inorganics analysis, Teflon or Teflon-lined polyethylene tubing will be used.
- Flow measurement supplies (e.g., graduated cylinder and stop watch).
- Power source (generator, etc.).
- Water quality indicator parameter monitoring instruments—pH, turbidity, specific conductance, and temperature. Optional indicators—Eh and dissolved oxygen.
- Flow-through cell (preferred) or clean container for water quality probes.
- Decontamination supplies (for monitoring instrumentation).
- Sample bottles and sample preservation supplies (as required by the analytical methods).
- Sample tags or labels.
- Cooler with bagged ice for sample bottles.
- Drum for purge water containment.

1.3 PRELIMINARY SITE ACTIVITIES

The following site activities are required prior to performing well purging and groundwater sampling. Field logbooks and sampling forms should be filled out as the procedure is being performed, as noted:

- Enter the following information in the field logbook and sampling form, as appropriate: site name, project number, field personnel, well identification, weather conditions, date and time, equipment used, and quality assurance/quality control data for field instrumentation.

- Check well for damage or evidence of tampering, record pertinent observations in field logbook and sampling form.

- Lay out sheet of polyethylene for monitoring and sampling equipment.

- Unlock well and remove well cap (if applicable).

- Measure VOCs with an ionization detector (flame or photo) instrument at the rim of the well and in the breathing zone, and record the readings in the field logbook and the sampling form.

- Measure and record the height of protective casing above the concrete pad or ground surface, as appropriate. This reading is compared to that recorded during well installation as an indication of possible well damage or settling that may have occurred.

- Dedicated sampling pumps should be positioned with the pump intake mid-point in the screened interval. If non-dedicated equipment is used, care will be taken to position pump or sampling hose intake at the screen mid-point.

- Measure and record the depth to water (to 0.01 ft) in the well to be sampled before purging begins. If the well casing does not have a reference point (usually a v-cut or indelible mark in the well casing), make one. If a reference point is made, it will be noted in the field logbook. Care should be taken to minimize disturbance of any particulate attached to the sides or at the bottom of the well. The depth to well bottom will be measured following the completion of sampling because of the potential to stir up sediment at the bottom of the well.

- Prepare the pump by checking electrical connections, discharge tubing, and motor (Grundfos Redi-Flo2). Locate the generator (if applicable) downwind of the well; connect the power converter to the generator and to the pump.

1.4 WELL PURGING AND SAMPLING PROCEDURE

The following general procedure should be followed to obtain representative groundwater samples. Field logbooks and sampling forms should be filled out as the procedure is being performed, as noted:

- Enter the following information in the field logbook and sampling form, as appropriate, prior to purging: purge date and time, purge method, and total well depth.

- Connect the flow-through cell or clean container containing the instrumentation header to the pump discharge and begin purging the well at 0.2-0.5 L/min, unless a different purge rate has been previously established for that well. Fill the flow cell completely. Care should be taken not to cause entrapment of air in the system. Record the purge start time and purge rate.

- Establish that the water level has not dropped significantly such that the pump is dry (bubbles in discharge) or water is heard cascading down the inside of the well. Ideally, the pump rate should cause little or no water level drawdown in the well (>0.5 ft and the water level should stabilize). The water level should be monitored every 3-5 minutes (or as appropriate) during pumping. Record pumping rate adjustments and depths to water. Pumping rates should, if needed, be reduced to the minimum capabilities of the pump (e.g., 0.1-0.2 L/min) to avoid pumping the well dry and/or to ensure stabilization of indicator parameters. If water levels continue to drop with the pump on the lowest flow rate, the pump will be shut off and the well will be allowed to recharge to prevent the well from going dry. **The well will not be purged to dryness prior to sampling to prevent erroneous field parameters and groundwater samples.** Sampling will commence as soon as the well has recharged to a sufficient level to collected the appropriate volume of samples with the pump.

- During purging of the well, monitor the water quality indicator parameters (turbidity, temperature, specific conductance, pH, etc.) every 3-5 minutes (or as appropriate). Record purge rate, volume purged, depth to water, water quality indicator parameters values, and clock time at 3- to 5-minute intervals in field logbook and sampling record. Purging of the standing well water is considered complete when three consecutive readings of the water quality indicator parameters agree within approximately 10 percent. Turbidity readings consistently below 10 nephelometric turbidity units (NTU) are considered to represent stabilization of discharge water for this parameter. If the parameters have stabilized, but the turbidity is not in the range of the 10 NTU goal, the pump flow rate should be decreased and measurement of the parameters should continue every 3-5 minutes.

- Purge water at a well will be containerized if a well has exceeded the MEG or MCL in previous sampling events. Any purge water that is collected will be treated at the groundwater treatment plant.

- Prior to sampling, disconnect the discharge tubing from the flow-through cell. If the water discharged by the pump is silty, wait for the water to clear before sampling. Ensure that bubbles are not observed in the discharge tubing. Record pertinent observations in field logbook and sampling records.

- Begin filling sample containers by allowing the pump discharge to flow gently down the inside of the container with as little agitation or aeration as possible. Collect the samples in the order below, as applicable:

  — VOCs
  — Inorganics.

- VOC samples requiring pH adjustment will have their pH checked to assure that the proper pH has been obtained. This will require that a test sample be collected to determine the amount of preservative that needs to be added to the sample containers prior to sampling. Details on sample preservation are discussed in Section 1.5.

- Label each sample as collected. Those samples (VOCs, etc.) requiring cooling will be placed into an ice cooler for delivery to the laboratory. Inorganic samples, after preservation, do not need to be cooled.

- After collection of the samples, restore the dedicated pumping assembly to the well by hanging the tube, electric line, and support cable inside the well by the specially-designed PVC well cap assembly. Lock well.

- Complete remaining portions of Field Record of Well Gauging, Purging, and Sampling form (Figure SOP048-1) after each well is sampled, including sample date and time, total quantity of water removed, well sampling sequence, types of sample bottles used, sample identification numbers, preservatives used, parameters requested for analysis, and field observations of sampling event.

1.5 SAMPLE PRESERVATION

The following preservation procedures are examples of typical preservation protocols specific to the indicated analyses. Pre-preserved bottles will be used if possible. Minimum sample preservation requirements for each parameter group are summarized below:

- **VOCs—**Aqueous VOC samples must be collected as specified below. Each VOC sample is taken in duplicate:

  — Uncap the sample bottle, taking care not to touch the Teflon-faced septum. If the septum is contaminated in any way, it should be replaced.

  — Fill a sample bottle, preserve with HC1, and check the pH. Adjust the volume of HC1 to assure pH<2.

- Add the amount of HC1 determined in the above step, and fill the sample vial slowly from the tubing, minimizing air entrainment, until the vial slightly overflows.

- Place the Teflon-faced silicon rubber septum on the convex meniscus, Teflon side (shiny side) down and screw cap on.

- Invert the bottle, tap lightly, and check for air bubbles.

- If air bubbles are present, open the bottle, add sample to eliminate air bubbles, and reseal. Repeat this procedure until the bottle is filled and no air bubbles are detected.

- Place samples on ice until shipment.

- **Inorganics—**Fill the sample bottle, preserve the sample to pH<2 with nitric acid (HNO_3), seal container, and place sample on ice for shipment.

Disposable pipettes should be used to introduce chemicals into the samples if necessary. Chemicals used for preserving should be poured into a 150-ml beaker. They should not be drawn directly from the preservative bottles because the bottle may become contaminated. Measurements for pH and temperature should not be taken from the sample containers. When preserving samples to a required pH, pH paper should be used to check the resultant pH. The sample should be poured across the pH paper. Never place pH paper directly into sample.

NOTE: Shipping regulations limit the amount of preservative which can be added. For a 1-L sample, this is generally 1.5 ml of acid preservative.

1.6 FIELD QUALITY CONTROL

Quality control samples are required to verify that the sample collection and handling process has not affected the quality of the groundwater samples. All field quality control samples must be prepared exactly as regular investigation samples with regard to sample volume, containers, and preservation. The following quality control samples will be collected for each sample delivery group (SDG) (an SDG may not exceed 20 samples) at the frequency noted:

- Field Duplicate—Required at a frequency of 10 percent per SDG.

- Matrix Spike/Matrix Spike Duplicate—Required at a frequency of 5 percent.

- Equipment Rinsate Blank—Required once prior to installation of dedicated pump systems.

- Source Water Blank—Required at a frequency of once per source per sampling event when equipment (rinsate) blank is required.

- Trip Blank—Required for VOC samples at a frequency of one per sample shipment.

1.7 DECONTAMINATION

Non-dedicated sampling equipment and field monitoring equipment will be decontaminated prior to use and following sampling of each well. This equipment will be decontaminated by the procedure listed below. Alternative procedures must be approved by the Project Manager prior to sampling event. Decontamination fluids will be collected in a 5-gal bucket and treated at the groundwater treatment plant.

The following decontamination procedure will be used:

- Flush the equipment with potable water
- Flush with non-phosphate detergent solution
- Flush with tap water to remove all of the detergent solution
- Flush with distilled/deionized water
- Flush with isopropyl alcohol
- Flush with distilled/deionized water.

It is recommended that the detergent and isopropyl alcohol used in the above sequence be used sparingly.

2. GROUNDWATER SAMPLING BY LOW-FLOW PURGE AND SAMPLING METHOD USING PERISTALTIC PUMPS

2.1 SCOPE OF APPLICATION

The purpose of this SOP is to establish the protocol for collecting groundwater samples using peristaltic pump systems. The procedure is designed to permit the collection of groundwater samples with minimum turbidity, and is intended to be used in conjunction with the analyses for the most common types of groundwater contaminants (VOCs and inorganic compounds).

2.2 EQUIPMENT/MATERIALS

- Work Plan.

- Well construction data, location map, field data from last sampling event.

- Field logbook and Field Record of Well Gauging, Purging, and Sampling forms (Figure SOP048-1).

- Water level measuring device, 0.01 ft accuracy (electronic preferred) for monitoring water level drawdown during pumping operations.

- Peristaltic pump.

- In-well tubing: Teflon or Teflon-lined polyethylene must be used to collect samples for organic analysis. For samples collected for inorganics analysis, Teflon or Teflon-lined polyethylene, PVC, Tygon, or polyethylene tubing may be used.

- Pump head tubing: Silicon tubing must be used to in the pump head assembly.

- Flow measurement supplies (e.g., graduated cylinder and stop watch).

- Power source (battery, etc.).

- Water quality indicator parameter monitoring instruments – pH, turbidity, specific conductance, and temperature. Optional indicators – Eh and dissolved oxygen.

- Flow-through cell (preferred) or clean container for water quality probe.

- Decontamination supplies (for monitoring instrumentation).

- Sample bottles and sample preservation supplies (as required by the analytical methods).

- Sample tags or labels.

- Cooler with bagged ice for sample bottles.

- Drum for purge water containment.

2.3 PRELIMINARY SITE ACTIVITIES

The following site activities are required prior to performing well purging and groundwater sampling. Field logbooks and sampling forms should be filled out as the procedure is being performed, as noted:

- Enter the following information in the field logbook and sampling form, as appropriate: site name, project number, field personnel, well identification, weather conditions, date and time, equipment used, and quality assurance/quality control data for field instrumentation.

- Check well for damage or evidence of tampering, record pertinent observations in field logbook and sampling form.

- Unlock well and remove well cap (if applicable).

- Measure VOCs with an ionization detector (photo or flame) instrument at the rim of the well and in the breathing zone and record the readings in the field logbook and the sampling form.

- Measure and record the height of protective casing above the concrete pad, or ground surface, as appropriate. This reading is compared to that recorded during well installation as an indication of possible well damage or settling that may have occurred.

- Measure and record the depth to water (to 0.01 ft) in the well to be sampled before purging begins. If the well casing does not have a reference point (usually a v-cut or indelible mark in the well casing), make one. If a reference point is made, it will be noted in the field logbook. Care should be taken to minimize disturbance of any particulate attached to the sides or at the bottom of the well. The depth to well bottom will not be measured following the completion of sampling because of the potential to stir up sediment at the bottom of the well.

- Position the intake of the sampling hose at the mid-point of the screened interval.

- Prepare the pump by checking electrical connections and discharge tubing. Locate the battery downwind of the well; connect the peristaltic pump to the battery.

2.4 WELL PURGING AND SAMPLING PROCEDURES

The following general procedure should be followed to obtain representative groundwater samples. Field logbooks and sampling forms should be filled out as the procedure is being performed, as noted:

- Enter the following information in the field logbook and sampling form, as appropriate, prior to purging: purge date and time, purge method, and total well depth.

- Measure the water level with the pump in well before starting the pump. Begin purging the well at 0.3-0.5 L/min, unless a different purge rate has been previously established for that well.

- If well diameter permits, establish that the water level has not dropped significantly such that the pump is dry (air in discharge) or tubing suction is broken. Ideally, the pump rate should cause little or no water level drawdown in the well (>0.5 ft and the water level should stabilize). The water level should be monitored every 3-5 minutes (or as appropriate) during pumping. Care should be taken not to cause pump suction to be broken, or entrainment of air in the pump system. Record pumping rate adjustments and depths to water. Pumping rates should, if needed, be reduced to the minimum capabilities of the pump (e.g., 0.3 L/min) to avoid pumping the well dry and/or to ensure stabilization of indicator parameters. If water levels continue to drop with the pump on the lowest flow rate, the pump will be shut off and the well will be allowed to recharge to prevent the well from going dry. **The well will not be purged to dryness prior to sampling to prevent erroneous field parameters and groundwater samples.** Sampling will commence as soon as the well has recharged to a sufficient level to collected the appropriate volume of samples with the pump.

- During purging of the well, monitor the field indicator parameters (turbidity, temperature, specific conductance, pH, etc.) every 3-5 minutes (or as appropriate). Purging of the standing well water is considered complete when three consecutive readings of the water quality indicator parameters agree within approximately 10 percent. Turbidity readings consistently below 10 NTU are considered to represent stabilization of discharge water for this parameter. If the parameters have stabilized, but the turbidity is not in the range of the 10 NTU goal, the pump flow rate should be decreased and measurement of the parameters should continue every 3-5 minutes.

- Purge water at a well will be containerized if a well has exceeded the MEG or MCL in previous sampling events. Any purge water that is collected will be treated at the groundwater treatment plant.

- Prior to sampling, disconnect the sample discharge tubing from the flow-through cell. If the water discharged by the pump is silty, wait for the water to clear before sampling. Ensure that bubbles are not observed in the discharge tubing.

- Collect groundwater samples directly from the silicon tubing into preserved (when appropriate) sample containers. Begin filling sample containers from the pump discharge, allowing the water to fill the containers by allowing the pump discharge to flow gently down the inside of the container with as little agitation or aeration as possible. Collect the samples in the order below, as applicable:

  — VOCs
  — Inorganics.

- VOC samples requiring pH adjustment will have their pH checked to assure that the proper pH has been obtained. This will require that a test sample be collected to determine the amount of preservative that needs to be added to the sample containers prior to sampling. Detail on sample preservation are discussed in Section 2.5.

- Label each sample as collected. Those samples (VOCs, etc.) requiring cooling will be placed into an ice cooler for delivery to the laboratory. Inorganic samples, after preservation, do not need to be cooled.

- After collection of the samples, restore the dedicated tubing assembly to the well by hanging the tube inside the well by the specially-designed PVC well cap assembly. Lock well.

- Complete remaining portions of Field Record of Well Gauging, Purging, and Sampling form (Figure SOP048-1) after each well is sampled, including: sample date and time, total quantity of water removed, well sampling sequence, types of sample bottles used, sample identification numbers, preservatives used, parameters requested for analysis, and field observations of sampling event.

- The silicon tubing used in the peristaltic pump will be changed after use at each well.

2.5 SAMPLE PRESERVATION

The following preservation procedures are examples of typical preservation protocols specific to the indicated analyses. Pre-preserved bottles will be used if possible. Minimum sample preservation requirements for each parameter group are summarized below:

- **VOCs—**Aqueous VOC samples must be collected as specified below. Each VOC sample is taken in duplicate:

  — Uncap the sample bottle, taking care not to touch the Teflon-faced septum. If the septum is contaminated in any way, it should be replaced.

  — Fill a sample bottle, preserve with HCL, and check the pH. Adjust the volume of HCL to assure pH<2.

  — Add the amount of HCL determined in the above step, and fill the sample vial slowly from the tubing, minimizing air entrainment, until the vial slightly overflows.

  — Place the Teflon-faced silicon rubber septum on the convex meniscus, Teflon side (shiny side) down, and screw cap on.

  — Invert the bottle, tap lightly, and check for air bubbles.

  — If air bubbles are present, open the bottle, add sample to eliminate air bubbles, and reseal. Repeat this procedure until the bottle is filled and no air bubbles are detected.

  — Place samples on ice until shipment.

- **Inorganics—**Fill the sample bottle, preserve the sample to pH<2 with nitric acid (HNO_3), seal container, and place sample on ice for shipment.

Disposable pipettes should be used to introduce chemicals into the samples if necessary. Chemicals used for preserving should be poured into a 150-ml beaker. They should not be drawn directly from the preservative bottles because the bottle may become contaminated. Measurements for pH and temperature should not be taken from the sample containers. When preserving samples to a required pH, pH paper should be used to check the resultant pH. The sample should be poured across the pH paper. Never place pH paper directly into sample.

NOTE: Shipping regulations limit the amount of preservative which can be added. For a 1-L sample, this is generally 1.5 ml of acid preservative.

2.6 FIELD QUALITY CONTROL

Quality control samples are required to verify that the sample collection and handling process has not affected the quality of the groundwater samples. All field quality control samples must be prepared exactly as regular investigation samples with regard to sample volume, containers, and preservation. The following quality control samples will be collected for each SDG (an SDG may not exceed 20 samples) at the frequency noted:

- Field Duplicate—Required at a frequency of 10 percent per SDG

- Matrix Spike/Matrix Spike Duplicate—Required at a frequency of 5 percent

- Equipment (Rinsate) Blank—Required once prior to installation of dedicated sample tubing

- Source Water Blank—Required at a frequency of one per source per sampling event

- Trip Blank—Required for VOC samples at a frequency of one per sample shipment.

- Temperature Blank—Required at a frequency of once per sample shipment container.

2.7 DECONTAMINATION

Non-dedicated sampling and field monitoring equipment will be decontaminated prior to use and following sampling of each well. This equipment will be decontaminated by the procedure listed below. Alternate procedures must be approved by the Project Manager prior to the sampling event. Decontamination fluids will be collected in a 5-gal bucket and treated at the groundwater treatment plant.

The following decontamination procedure will be used:

- Flush the equipment with potable water
- Flush with non-phosphate detergent solution
- Flush with tap water to remove all of the detergent solution
- Flush with distilled/deionized water
- Flush with isopropyl alcohol
- Flush with distilled/deionized water.

It is recommended that the detergent and isopropyl alcohol used in the above sequence be used sparingly.

3. SURFACE WATER AND LEACHATE SEEP SAMPLING PROCEDURE

3.1 SCOPE OF APPLICATION

The purpose of this SOP is to establish the protocol for collecting surface water and leachate seep samples. The procedure is designed to permit the collection of representative surface water and leachate seep samples, and has been adapted from the procedure outlined in the Work Plan. This SOP is suitable for collecting surface water and seep samples requiring analyses for the most common types of surface water contaminants (VOCs and inorganic compounds).

3.2 EQUIPMENT/MATERIALS

- Work Plan.
- Location map, field data from last sampling event.
- Field logbook and Field Record of Surface Water and Sediment Sampling forms (Figure SOP048-2).
- Water quality indicator parameter monitoring instruments – pH, turbidity, specific conductance, and temperature. Optional indicators – Eh and dissolved oxygen.
- Decontamination supplies (for monitoring instrumentation).
- Dedicated, pre-cleaned 1-L wide-mouth or volatile organic analyte sample container (for sample collection).
- Sample bottles and sample preservation supplies (as required by the analytical methods).
- Sample tags or labels.
- Cooler with bagged ice for sample bottles.

3.3 PRELIMINARY SITE ACTIVITIES

The following site activities are required prior to performing surface water or leachate seep sampling. Field logbooks and sampling forms should be filled out as the procedure is being performed, as noted:

- Enter the following information in the field logbook and sampling form, as appropriate: site name, project number, field personnel, sample station identification, weather conditions, date and time, equipment used, and quality assurance/quality control data for field instrumentation.

- Visually inspect sample station for evidence of changes in physical condition; record pertinent observations in field logbook and sampling form.

- Measure VOCs with a flame ionization detector instrument in the breathing zone and record the reading in the field logbook and sampling form.

3.4 SAMPLING PROCEDURE

The technique for surface water and leachate seep sampling must be selected after addressing such items as:

- Depth of waterbody
- Depth of sample
- Stratification
- Seasonal variations
- Analytical parameters of interest.

The following general procedure should be used to obtain representative surface water and leachate seep samples. Field logbooks and sampling forms should be filled out as the procedure is being performed, as noted:

- Enter the following information in the field logbook and sampling form, as appropriate, prior to sampling: date and time, sample method, and sample depth.

- Collect the sample from the surface water, within several tenths of a foot of the streambed, by immersing a new, dedicated 1-L glass or volatile organic analyte sample container into the waterbody. If a stream is being sampled, collect the sample upstream of the sampler with the opening of the sampling device oriented upstream but avoiding floating debris.

- Directly fill the appropriate sample containers from the 1-L or volatile organic analyte sampling device.

- Collect the samples in the order below, as applicable:

  — VOCs
  — Inorganics.

- Water sample containers are generally filled directly from the source or sampler without special considerations. The exception is the collection of aqueous VOC samples requiring pH adjustment. VOC samples will have their pH checked to assure that the proper pH has been obtained. This will require that a test sample be collected to determine the amount of preservative that needs to be added to the sample containers prior to sampling. Details on sample preservation methods are discussed in Section 3.6.

- Label each sample as collected. Those samples (VOCs, etc.) requiring cooling will be placed into an ice cooler for delivery to the laboratory. Inorganic samples, after preservation, do not need to be cooled.

- Measure water quality indicator parameters, if possible, by direct immersion of instrument probes into the waterbody immediately following sample collection. If direct measurement is not possible, measure these parameters from water remaining in the sampling device or another sample bottle. Record this information in the field logbook and sample data record.

- Complete remaining portions of the Field Record of Surface Water and Sediment Sampling form (Figure SOP048-2) after each station is sampled, including: time of sample collection, types of sample bottles used, sample identification numbers, preservatives used, parameters requested for analysis, and field observations of sampling event.

3.5 SAMPLE PRESERVATION

The following preservation procedures are examples of typical preservation protocols specific to the indicated analyses. Minimum sample preservation requirements for each parameter group are summarized below:

- **VOCs—**Aqueous VOC samples must be collected as specified below. Each sample is taken in duplicate:

    - Uncap the sample bottle, taking care not to touch the Teflon-faced septum. If the septum is contaminated in any way, it should be replaced.

    - Fill a sample bottle, preserve with HC1, and check the pH. Adjust the volume of HC1 to assure pH<2.

    - Add the amount of HC1 determined in the above step, and fill the sample vial slowly from the 1-L container, minimizing air entrainment, until the vial slightly overflows.

    - Place the Teflon-faced silicon rubber septum on the convex meniscus, Teflon side (shiny side) down and screw cap on.

    - Invert the bottle, tap lightly, and check for air bubbles.

    - If air bubbles are present, open the bottle, add sample to eliminate air bubbles, and reseal. Repeat this procedure until the bottle is filled and no air bubbles are detected.

    - Place samples on ice until shipment.

- **Inorganics—**Fill the sample bottle, preserve the sample to pH<2 with nitric acid (HNO_3), seal container, and place sample on ice for shipment.

Disposable pipettes should be used to introduce chemicals into the samples. Chemicals used for preserving should be poured into a 150-ml beaker. They should not be drawn directly from the preservative bottles because the bottle may become contaminated. Measurements for pH and temperature should not be taken from the sample containers. When preserving samples to a required pH, pH paper should be used to check the resultant pH. The sample should be poured across the pH paper. Never place pH paper directly into sample.

NOTE: Shipping regulations limit the amount of preservative which can be added. For a 1-L sample, this is generally 1.5 ml of acid preservative.

3.6 FIELD QUALITY CONTROL

Quality control samples are required to verify that the sample collection and handling process has not affected the quality of the surface water and leachate seep samples. All field quality control samples must be prepared exactly as regular investigation samples with regard to sample volume, containers, and preservation. The following quality control samples will be collected for each SDG (an SDG may not exceed 20 samples) at the frequency noted:

- Field Duplicate—Required at a frequency of 10 percent per SDG.

- Matrix Spike/Matrix Spike Duplicate—Required at a frequency of 5 percent.

- Equipment (Rinsate) Blank—Required at a frequency of once per day per media sampled.

- Source Water Blank—Required at a frequency of once per source per sampling event when equipment (rinsate) blank is required.

- Trip Blank—Required for VOC samples at a frequency of one per sample shipment.

3.7 DECONTAMINATION

Field monitoring equipment will be decontaminated prior to use and following sampling of each station by the procedure listed below. Laboratory pre-cleaned, dedicated 1-L glass sample collection containers are used once and discarded and, therefore, do not undergo any decontamination. Decontamination fluids will be collected in a 5-gal bucket and treated at the groundwater treatment plant.

The following decontamination procedure will be used:

- Flush the equipment with potable water
- Flush with non-phosphate detergent solution
- Flush with tap water to remove all of the detergent solution
- Flush with distilled/deionized water
- Flush with isopropyl alcohol
- Flush with distilled/deionized water.

It is recommended that the detergent and isopropyl alcohol used in the above sequence be used sparingly.

4. REFERENCES

U.S. Environmental Protection Agency. 1996. Groundwater Issue-Low Flow Sampling (Minimal Drawdown) Groundwater Sampling Procedures. April.

FIELD RECORD OF WELL GAUGING, PURGING, AND SAMPLING

Site Name: ____________ Project Number: ____________
Well ID: ____________ Well Lock Status: ____________
Well Condition: ____________ Weather: ____________

Gauge Date: ____________ Gauge Time: ____________
Sounding Method: ____________ Measurement Ref: ____________
Stick Up/Down (ft): ____________ Well Diameter (in.): ____________

Purge Date: ____________ Purge Time: ____________
Purge Method: ____________ Field Personnel: ____________
Ambient Air VOCs (ppm): ____________ Well Mouth VOCs (ppm): ____________

WELL VOLUME

A. Well Depth (ft): ____________ D. Well Volume/ft (L): ____________
B. Depth to Water (ft): ____________ E. Well Volume (L) (C*D): ____________
C. Liquid Depth (ft) (A-B) ____________ F. Three Well Volumes (L) (E*3) ____________
G. Measurable LNAPL? Yes ________ /ft No ________

Parameter	Beginning	1	2	3	4	5
Time (min.)						
Depth to Water (ft)						
Purge Rate (L/min)						
Volume Purged (L)						
pH						
Temperature (°C)						
Conductivity (µmhos/cm)						
Dissolved Oxygen (mg/L)						
Turbidity (NTU)						
eH (mV)						

Total Quantity of Water Removed (L): ____________
Samplers: ____________ Sampling Time (Start/End): ____________
Sampling Date: ____________ Decontamination Fluids Used: ____________
Sample Type: ____________ Sample Preservatives: ____________
Sample Bottle IDs: ____________
Sample Parameters: ____________

Figure SOP048-1.

FIELD RECORD OF WELL GAUGING, PURGING, AND SAMPLING

Site Name: ______________________ Project Number: ______________________ Date: ______________________

Well ID: Field Personnel:

Parameter	6	7	8	9	10	11
Time (min.)						
Depth to Water (ft)						
Purge Rate (L/min)						
Volume Purged (L)						
pH						
Temperature (°C)						
Conductivity (µmhos/cm)						
Dissolved Oxygen (mg/L)						
Turbidity (NTU)						
eH (mV)						

Parameter	12	13	14	15	16	17
Time (min.)						
Depth to Water (ft)						
Purge Rate (L/min)						
Volume Purged (L)						
pH						
Temperature (°C)						
Conductivity (µmhos/cm)						
Dissolved Oxygen (mg/L)						
Turbidity (NTU)						
eH (mV)						

Comments and Observations:

Figure SOP048-1.

FIELD RECORD OF SURFACE WATER AND SEDIMENT SAMPLING

Site Name:			Project Number:
Sample Location ID:			Date:
Time:	Start:	End:	Sample Team Members:

SURFACE WATER INFORMATION

Type of Surface Water:
( ) Stream ( ) River
( ) Pond/Lake ( ) Seep

Water Depth and Sample Location _________ (ft)

Depth of Sample from Top of Water ________ (ft)

Equipment Used for Collection:
( ) None, Grab into Bottle
( ) Bomb Sampler
( ) Pump _____________

Decontamination Fluids Used:
( ) Isopropyl Alcohol
( ) ASTM Type II Water
( ) Deionized Water
( ) Liquinox Solution
( ) Hexane
( ) HNO_3 Solution
( ) Potable Water
( ) None

Water Quality Parameters
( ) Temperature ____
( ) Conductivity ___ µmhs/cm
( ) pH ____ units
( ) Dissolved oxygen ____ mg/L
( ) Turbidity ____ NTU
( ) Eh ____ mv

Velocity Measurements Obtained? ( ) No ( ) Yes, See Flow Measurement Data Record

Field QC Data: ( ) Field Duplicate Collected Sample Location Sketch: Method
Used:
Duplicate ID ____________ ( ) Yes ( ) Winkler
( ) MS/MSD ( ) No ( ) Probe

SEDIMENT INFORMATION

Type of Sample Collected:
( ) Discrete
( ) Composite

Sediment Type:
( ) Clay
( ) Sand
( ) Organic
( ) Gravel

Equipment Used for Collection:
( ) Gravity Corer
( ) Stainless Steel Split Spoon
( ) Dredge
( ) Hand Spoon/Trowel
( ) Aluminum Pans
( ) Stainless Steel Bucket
( ) ____________________________

Decontamination Fluids Used:
( ) Isopropyl Alcohol
( ) ASTM Type II Water
( ) Deionized Water
( ) Liquinox Solution
( ) Hexane
( ) HNO_3 Solution
( ) Potable Water
( ) None

Sample Observations:
( ) Odor ____
( ) Color

Field QC Data: ( ) Field Duplicate Collected ( ) MS/MSD
Duplicate ID ___________________________

SAMPLES COLLECTED

Check if Required at this Location	Matrix		Check if Preserved with Acid/Base	Volume Required	Check if Sample Collected	Sample Bottle IDs			
	Surface Water	Sediment							

NOTES/SKETCH

Figure SOP048-2.

Standard Operating Procedure No. 051
for
Low Flow Purge and Sampling with Dedicated Pumps

Prepared by

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Revision: 0
August 2007

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1. SCOPE OF APPLICATION

The purpose of this Standard Operating Procedure is to establish the protocol for collecting groundwater samples using dedicated pump systems. The procedure is designed to permit the collection of groundwater samples with minimum turbidity, and is intended to be used in conjunction with the analyses for the most common types of groundwater contaminants (volatile organic compounds and semivolatile organic compounds, pesticides, polychlorinated biphenyls, metals, and inorganic compounds). This Standard Operating Procedure was prepared based on draft guidance prepared by U.S. Environmental Protection Agency Region 1 and conforms with the procedures described in the Long-Term Monitoring Plan.

2. EQUIPMENT/MATERIALS

- Long-Term Monitoring Plan.
- Well construction data, location map, and field data from last sampling event.
- Field logbook, Field Record of Well Gauging Form (Figure SOP051-1), and Field Record of Well Gauging, Purging, and Sampling Form (Figure SOP051-2).
- Electronic water level measuring device, 0.01 ft accuracy for monitoring water level during pumping operations.
- Pumps: adjustable rate, submersible pumps constructed of stainless steel and Teflon.
- Tubing: Teflon or Teflon-lined polyethylene must be used to collect samples for organic and inorganic analyses.
- Flow measurement supplies (e.g., graduated cylinder and stop watch).
- Power source (generator, etc.).
- Water quality indicator parameter monitoring instruments—pH, turbidity, specific conductances, and temperature. Optional indicators—Eh and dissolved oxygen. Water quality indicator parameters will be measured in the field in accordance with EPA-600/4-79-020 (1983) using the following methods: temperature (Method 170.1), pH (Method 150.1), turbidity (Method 180.1), specific conductance (Method 120.1), and dissolved oxygen (Method 360.1).

- Flow-through cell for water quality parameters.

- Decontamination supplies (for monitoring instrumentation).

- Sample bottles and sample preservation supplies (as required by the analytical methods).

- Sample tags or labels.

- Cooler with bagged ice for sample bottles.

3. PRELIMINARY SITE ACTIVITIES

The following site activities are required prior to performing well purging and groundwater sampling. Field logbooks and sampling forms should be filled out as the procedure is being performed, as noted:

- Enter the following information in the field logbook and sampling form, as appropriate: site name, project number, field personnel, well identification, weather conditions, date and time, equipment used, and quality assurance/quality control data for field instrumentation.

- Check well for damage or evidence of tampering, record pertinent observations in field logbook and sampling form.

- Lay out sheet of polyethylene for monitoring and sampling equipment.

- Unlock well and remove well cap (if applicable).

- Measure volatile organic compounds with a photoionization detector instrument at the rim of the well and in the breathing zone, and record the readings in the field logbook and the sampling form.

- Measure and record the height of protective casing above the concrete pad or ground surface, as appropriate. This reading is compared to that recorded during well installation as an indication of possible well damage or settling that may have occurred.

- Measure and record the depth to water (to 0.01 ft) in the well to be sampled before purging begins. If the well casing does not have a reference point (usually a v-cut or indelible mark in the well casing), make one. Care should be taken to minimize disturbance of any particulate attached to the sides or at the bottom of the well. The depth to well bottom will be measured following completion of the sampling because of the potential to stir up sediment at the bottom of the well.

- Prepare the pump by checking electrical connections, discharge tubing, and motor (Grundfos Redi-Flo2). Locate the generator (if applicable) downwind of the well; connect the power converter to the generator and the pump.

4. SAMPLING PROCEDURE

The following general procedure should be followed to obtain representative groundwater samples. Field logbooks and sampling forms should be filled out as the procedure is being performed, as noted:

- Enter the following information in the field logbook and sampling form, as appropriate, prior to purging: purge date and time, purge method, and total well depth.

- Connect the flow-through cell containing the instrumentation header to the pump discharge and begin purging the well at 0.2-0.5 L/min, unless a different purge rate has been previously established for that well. Fill the flow-through cell completely. Care should be taken not to cause entrapment of air in the system. Record the purge start time and purge rate.

- Establish that the water level has not dropped significantly such that the pump is dry (bubbles in discharge) or water is heard cascading down the inside of the well. Ideally, the pump rate should cause little or no water level drawdown in the well (<0.5 ft and the water level should stabilize). The water level should be monitored every 3-5 minutes (or as appropriate) during pumping. Record pumping rate adjustments and depths to water. Pumping rates should, if needed, be reduced to the minimum capabilities of the pump (e.g., 0.1-0.2 L/min) to avoid pumping the well dry and/or to ensure stabilization of indicator parameters. If the water level continues to drop with the pump on the lowest flow rate, the pump will be shut off and the well allowed to recharge to prevent it from going dry. **The well will not be purged to dryness prior to sampling to prevent erroneous field parameters and groundwater samples.** Sampling will commence as soon as the well has recharged to a sufficient level to collect the appropriate volume of samples with the pump.

- During purging of the well, monitor the water quality indicator parameters (turbidity, temperature, specific conductance, pH, etc.) every 3-5 minutes (or as appropriate). Record purge rate, volume purged, depth to water, water quality indicator parameters values, and clock time at 3- to 5-minute intervals in field logbook and sampling record. Purging of the standing well water is considered complete when three consecutive readings of the water quality indicator parameters agree within approximately 10 percent. Turbidity readings consistently below 10 nephelometric turbidity units (NTUs) are considered to represent stabilization of discharge water for this parameter. If the parameters have stabilized, but the turbidity is not in the range of the 10 NTU goal, the pump flow rate should be decreased and measurement of the parameters should continue every 3-5 minutes.

- Prior to sampling, disconnect the discharge tubing from the flow-through cell. If the water discharged by the pump is silty, wait for the water to clear before sampling. Ensure that bubbles are not observed in the discharge tubing. Record pertinent observations in field logbook and sampling records.

- The purging rate will be controlled so that the well is not purged dry before sampling. If necessary, purging will be temporarily halted to permit recharge rather than allowing the well to be purged dry.

- Begin filling sample containers from the pump discharge, allowing the water to fill the containers by allowing the pump discharge to flow gently down the inside of the container with as little agitation or aeration as possible.

- Label each sample as collected. Those samples requiring cooling will be placed into an ice cooler for delivery to the laboratory.

- After collection of the samples, restore the dedicated pumping assembly to the well by hanging the tube, electric line, and support cable inside the well by the specially-designed PVC well cap assembly. Lock well.

- Complete remaining portions of Field Record of Well Gauging, Purging, and Sampling form (Figure SOP051-2) after each well is sampled, including sample date and time, total quantity of water removed, well sampling sequence, types of sample bottles used, sample identification numbers, preservatives used, parameters requested for analysis, and field observations of sampling event.

5. SAMPLE PRESERVATION

The following preservation procedures are examples of typical preservation protocols specific to the indicated analyses. Minimum sample preservation requirements for each parameter group are summarized below and in Table 3-1 of the Quality Assurance Project Plan:

- **Pesticides and Herbicides**—Fill the sample bottle, seal with a Teflon-lined cap, and place on ice for shipment.

6. FIELD QUALITY CONTROL

Quality control samples are required to verify that the sample collection and handling process has not affected the quality of the groundwater samples. All field quality control samples must be prepared exactly as regular investigation samples with regard to sample volume, containers, and preservation. The following quality control samples will be collected for each sample delivery group (a sample delivery group may not exceed 20 samples) at the frequency noted:

- **Field Duplicate**—Required at a frequency of 10 percent per sample delivery group

- **Matrix Spike/Matrix Spike Duplicate**—Required at a frequency of 5 percent

- **Equipment Rinsate Blank—**Required once prior to installation of dedicated pump systems

- **Source Water Blank**—Required at a frequency of once per sampling event when equipment rinsate blank is required.

- **Trip Blank—**Required for volatile organic compound samples at a frequency of one per sample shipment.

NOTE: The dedicated pumps remain in the wells between sampling events.

7. DECONTAMINATION

Non-dedicated sampling equipment and field monitoring equipment will be decontaminated prior to use and following sampling of each well. This equipment will be decontaminated by the procedure listed below. Alternative procedures must be approved by the Project Manager prior to sampling event. Decontamination fluids will be collected in a 5-gal bucket and treated at the groundwater treatment plant.

The following decontamination procedure will be used:

- Flush the equipment with potable water
- Flush with non-phosphate detergent solution
- Flush with tap water to remove all of the detergent solution
- Flush with distilled/deionized water
- Flush with isopropyl alcohol
- Flush with distilled/deionized water.

It is recommended that the detergent and isopropyl alcohol used in the above sequence be used sparingly.

FIELD RECORD OF WELL GAUGING

Project Name:
Project No:
Date:
Weather/Temperature:
EA Personnel:
Equipment:

Well Number	Well Elevation	Depth to Water	Depth to LNAPL	LNAPL Thickness	Corrected Water Table Elevation[(a)]

(a) Based on an assumed specific gravity of 0.80 for LNAPL.

NOTE: All measurements in feet.
LNAPL = Light, non-aqueous phase liquid.

FIELD RECORD OF WELL GAUGING, PURGING, AND SAMPLING

Site Name:		Project Number:	
Well ID:		Well Lock Status:	
Well Condition:		Weather:	

Gauge Date:		Gauge Time:	
Sounding Method:		Measurement Ref:	
Stick Up/Down (ft):		Well Diameter (in.):	

Purge Date:		Purge Time:	
Purge Method:		Field Personnel:	
Ambient Air VOCs (ppm):		Well Mouth VOCs (ppm):	

WELL VOLUME

A. Well Depth (ft):		D. Well Volume/ft (L):	
B. Depth to Water (ft):		E. Well Volume (L) (C*D):	
C. Liquid Depth (ft) (A-B)		F. Three Well Volumes (L) (E*3):	

G. Measurable LNAPL? Yes ________ /ft No ________

Parameter	Beginning	1	2	3	4	5
Time (min.)						
Depth to Water (ft)						
Purge Rate (L/min)						
Volume Purged (L)						
pH						
Temperature (°C)						
Conductivity (µmhos/cm)						
Dissolved Oxygen (mg/L)						
Turbidity (NTU)						
eH (mV)						

Total Quantity of Water Removed (L): ____________

Samplers:		Sampling Time (Start/End):	
Sampling Date:		Decontamination Fluids Used:	
Sample Type:		Sample Preservatives:	

Sample Bottle IDs: ____________
Sample Parameters: ____________

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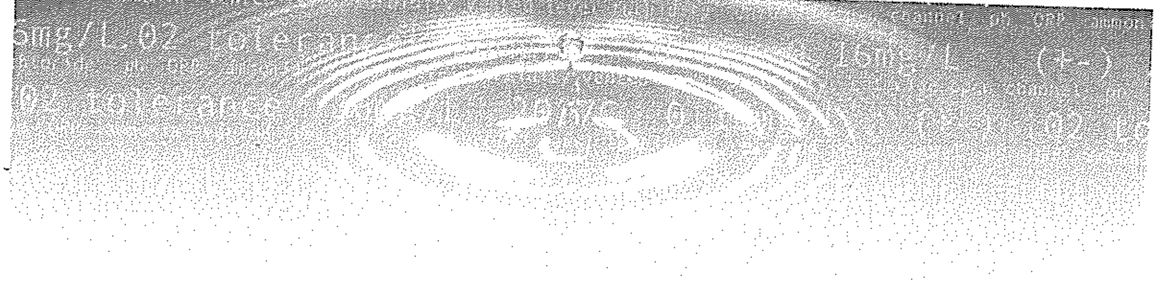


YSI 556 MPS
Multi Probe System

Operations Manual

6. Calibrate

All of the sensors, except temperature, require periodic calibration to assure high performance. You will find specific calibration procedures for all sensors that require calibration in the following sections. If a sensor listed is not installed in your probe module, skip that section and proceed to the next sensor until the calibration is complete.

⚠ **CAUTION:** Reagents that are used to calibrate and check this instrument may be hazardous to your health. Take a moment to review *Appendix D Health and Safety*. Some calibration standard solutions may require special handling.

6.1 Getting Ready to Calibrate

6.1.1 Containers Needed to Calibrate the Probe Module

The transport/calibration cup that comes with your probe module serves as a calibration chamber for all calibrations and minimizes the volume of calibration reagents required.

Instead of the transport/calibration cup, you may use laboratory glassware to perform calibrations. If you do not use the transport/calibration cup that is designed for the probe module, you are cautioned to do the following:

- Perform all calibrations with the Probe Sensor Guard installed. This protects the sensors from possible physical damage.
- Use a ring stand and clamp to secure the probe module body to prevent the module from falling over. Most laboratory glassware has convex bottoms.
- Ensure that all sensors are immersed in calibration solutions. Many of the calibrations factor in readings from other sensors (e.g., temperature sensor). The top vent hole of the conductivity sensor must also be immersed during some calibrations.

6.1.3 Recommended Volumes

Follow these instructions to use the transport/calibration cup for calibration procedures.

- Ensure that an o-ring is installed in the o-ring groove of the transport/calibration cup bottom cap, and that the bottom cap is securely tightened.

  NOTE: Do not over-tighten as this could cause damage to the threaded portions.
- Remove the probe sensor guard, if it is installed.
- Remove the o-ring, if installed, from the probe module and inspect the installed o-ring on the probe module for obvious defects and, if necessary, replace it with the extra o-ring supplied.
- Some calibrations can be accomplished with the probe module upright or upside down. A separate clamp and stand, such as a ring stand, is required to support the probe module in the inverted position.
- To calibrate, follow the procedures in the next section, Calibration Procedures. The approximate volumes of the reagents are specified below for both the upright and upside down orientations.
- When using the Transport/Calibration Cup for dissolved oxygen % saturation calibration, make certain that the vessel is vented to the atmosphere by loosening the bottom cap or cup assembly and that approximately 1/8" of water is present in the cup.

Sensor to Calibrate	**Upright**	**Upside Down**
Conductivity	55ml	55ml
pH/ORP	30ml	60ml

Table 6.1 Calibration Volumes

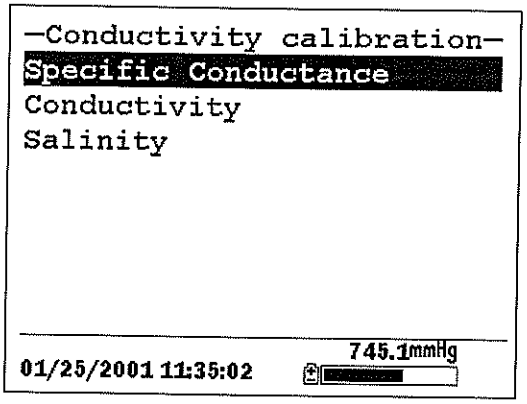
6.2.2 Conductivity Calibration

This procedure calibrates specific conductance (recommended), conductivity and salinity. Calibrating any one option automatically calibrates the other two.

1. Go to the calibrate screen as described in Section 6.2.1 Accessing the Calibrate Screen.

2. Use the arrow keys to highlight the **Conductivity** selection. See Figure 6.2 Calibrate Screen.

3. Press **Enter.** The Conductivity Calibration Selection Screen is displayed.



—Conductivity calibration—
Specific Conductance
Conductivity
Salinity

745.1mmHg
01/25/2001 11:35:02

Figure 6.3 Conductivity Calibration Selection Screen

4. Use the arrow keys to highlight the Specific Conductance selection.

5. Press **Enter.** The Conductivity Calibration Entry Screen is displayed.

7. Carefully immerse the sensor end of the probe module into the solution.

8. Gently rotate and/or move the probe module up and down to remove any bubbles from the conductivity cell.

   NOTE: The sensor must be completely immersed past its vent hole. Using the recommended volumes from Table 6.1 Calibration Volumes, should ensure that the vent hole is covered.

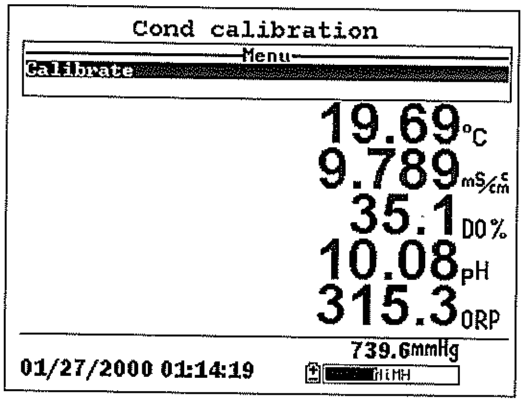
9. Screw the transport/calibration cup on the threaded end of the probe module and securely tighten.

   NOTE: Do not overtighten as this could cause damage to the threaded portions.

10. Use the keypad to enter the calibration value of the standard you are using.

    NOTE: Be sure to enter the value in **mS/cm at 25°C**.

11. Press **Enter**. The Conductivity Calibration Screen is displayed.



Cond calibration

19.69°C
9.789mS/cm
35.1DO%
10.08pH
315.3ORP
739.6mmHg
01/27/2000 01:14:19

Figure 6.5 Conductivity Calibration Screen

12. Allow at least one minute for temperature equilibration before proceeding. The current values of all enabled sensors

NOTE: The instrument must be on for at least 20 minutes to polarize the DO sensor before calibrating.

2. Use the arrow keys to highlight the **Dissolved Oxygen** selection. See Figure 6.2 Calibrate Screen.
3. Press **Enter**. The dissolved oxygen calibration screen is displayed.

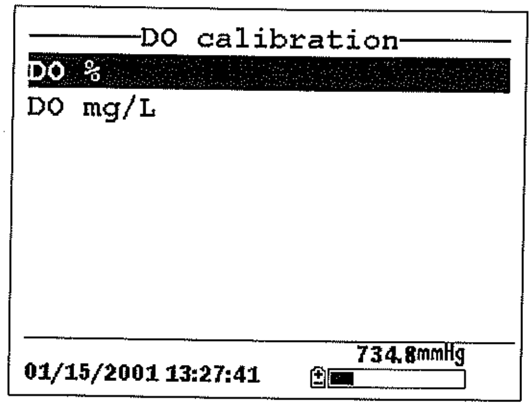


Figure 6.7 DO Calibration Screen

DO Calibration in % Saturation

1. Use the arrow keys to highlight the DO% selection.
2. Press **Enter**. The DO Barometric Pressure Entry Screen is displayed.

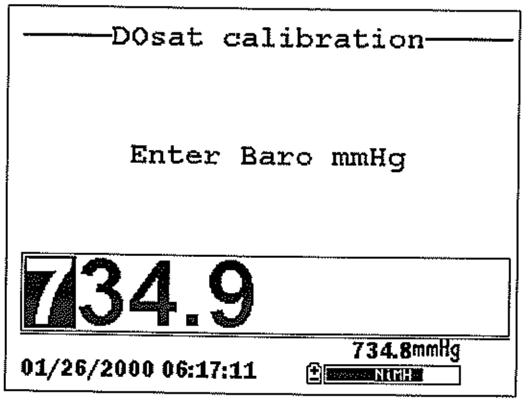


Figure 6.8 DO Barometric Pressure Entry Screen

the temperature to equilibrate before proceeding. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize.

9. Observe the reading under DO %. When the reading shows no significant change for approximately 30 seconds, press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to Continue. See Figure 6.6 Calibrated.

10. Press **Enter**. This returns you to the DO calibration screen, See Figure 6.7 DO Calibration Screen.

11. Press **Escape** to return to the calibrate menu. See Figure 6.2 Calibrate Screen.

12. Rinse the probe module and sensors in tap or purified water and dry.

DO Calibration in mg/L

DO calibration in mg/L is carried out in a water sample which has a known concentration of dissolved oxygen (usually determined by a Winkler titration).

1. Go to the DO calibrate screen as described in Section *6.2.3 Dissolved Oxygen Calibration*, steps 1 through 3.

2. Use the arrow keys to highlight the **DO mg/L** selection.

3. Press **Enter**. The DO mg/L Entry Screen is displayed.

7. Stir the water with a stir bar, or by rapidly moving the probe module, to provide fresh sample to the DO sensor.

8. Allow at least one minute for temperature equilibration before proceeding. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize.

9. Observe the DO mg/L reading, when the reading is stable (shows no significant change for approximately 30 seconds), press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to Continue.

10. Press **Enter**. This returns you to the DO calibration screen. See Figure 6.7 DO Calibration Screen.

11. Press **Escape** to return to the calibrate menu. See Figure 6.2 Calibrate Screen.

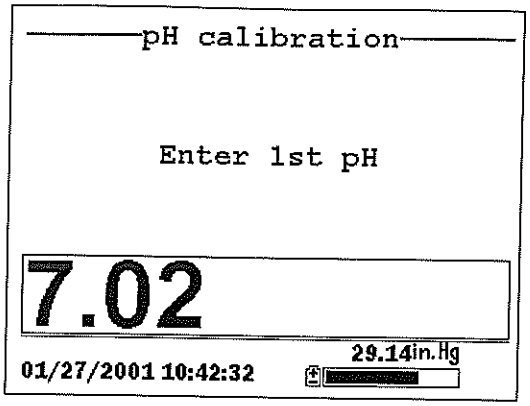
12. Rinse the probe module and sensors in tap or purified water and dry.

6.2.4 pH Calibration

1. Go to the calibrate screen as described in *Section 6.2.1 Accessing the Calibrate Screen.*

2. Use the arrow keys to highlight the **pH** selection. See Figure 6.2 Calibrate Screen.

3. Press **Enter**. The pH calibration screen is displayed.



pH calibration

Enter 1st pH

7.02

29.14in.Hg

01/27/2001 10:42:32

Figure 6.13 pH Entry Screen

6. Place the correct amount (see Table 6.1 Calibration Volumes) of pH buffer into a clean, dry or pre-rinsed transport/calibration cup.

⚠ **WARNING**: Calibration reagents may be hazardous to your health. See *Appendix D Health and Safety* for more information.

NOTE: For maximum accuracy, the pH buffers you choose should be within the same pH range as the water you are preparing to sample.

NOTE: Before proceeding, ensure that the sensor is as dry as possible. Ideally, rinse the pH sensor with a small amount of buffer that can be discarded. Be certain that you avoid cross-contamination of buffers with other solutions.

7. Carefully immerse the sensor end of the probe module into the solution.

8. Gently rotate and/or move the probe module up and down to remove any bubbles from the pH sensor.

NOTE: The sensor must be completely immersed. Using the recommended volumes from Table 6.1 Calibration Volumes, should ensure that the sensor is covered.

15. Rinse the probe module, transport/calibration cup and sensors in tap or purified water and dry.

16. Repeat steps 6 through 13 above using a second pH buffer.

17. Press **Enter**. This returns you to the pH Calibration Screen, See Figure 6.12 pH Calibration Screen.

18. Press **Escape** to return to the calibrate menu. See Figure 6.2 Calibrate Screen.

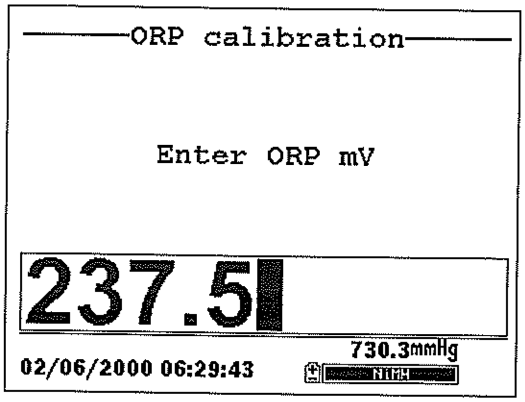
19. Rinse the probe module and sensors in tap or purified water and dry.

6.2.5 ORP Calibration

1. Go to the calibrate screen as described in Section *6.2.1 Accessing the Calibrate Screen.*

2. Use the arrow keys to highlight the **ORP** selection. See Figure 6.2 Calibrate Screen.

3. Press **Enter**. The ORP calibration screen is displayed.



ORP calibration

Enter ORP mV

237.5

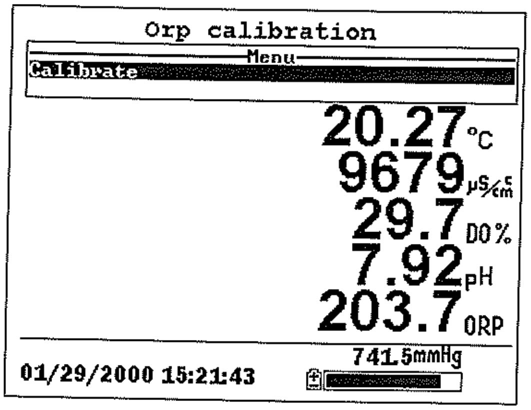
730.3mmHg

02/06/2000 06:29:43

Figure 6.15 Specified ORP Calibration Screen

4. Place the correct amount (see Table 6.1 Calibration Volumes) of a known ORP solution (we recommend Zobell solution) into a clean, dry or pre-rinsed transport/calibration cup.

9. Press **Enter**. The ORP calibration screen is displayed.



Orp calibration

Menu

Calibrate

20.27°C
9679µS/cm
29.7DO%
7.92pH
203.7ORP

741.5mmHg

01/29/2000 15:21:43

Figure 6.16 ORP Calibration Screen

10. Allow at least one minute for temperature equilibration before proceeding. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize.

    NOTE: Verify that the temperature reading matches the value you used in Table 6.2 Zobel Solution Values.

11. Observe the reading under ORP, when the reading shows no significant change for approximately 30 seconds, press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to Continue.

12. Press **Enter**. This returns you to the Calibrate Screen. See Figure 6.2 Calibrate Screen.

13. Rinse the probe module and sensors in tap or purified water and dry.

CAUTION: This returns a sensor to the factory settings. For example, in selecting to return specific conductance to the factory setting, salinity and conductivity will automatically return to their factory settings.

8. Press **Enter**. This returns you to the Conductivity Calibrate Selection Screen, See Figure 6.3 Conductivity Calibration Selection Screen.

9. Press **Escape** to return to the calibrate menu. See Figure 6.2 Calibrate Screen.

Thermo Fisher NITON XRF
(XLt, XLI, XLp)
Operator Training

General Instrument Description :

The instrument consists of the main body and a battery pack. The nose of the instrument contains either a miniaturized X-ray tube or one to three radioactive isotope sources. This is completely shielded. There is a 1 1/2 cm window on the end where the incident radiation exits the instrument and the elemental X-rays from the sample enter the instrument to reach the detector. The orange button under the window is the proximity button. In some countries it is necessary for this button to be in contact with the sample to be analyzed for the shutter to open and start the analysis. This button does not have to be activated in the United States for alloy analysis but it does need to be depressed in the lead paint mode. There is another button at the back of the instrument. In some countries the operator is required to be touching this button with a second hand for the shutter to open and start the analysis. This button does not have to be activated in the United States. There are several orange lights around the edge of the instrument. These will go on and off when X-rays are generated from an X-ray tube and during analysis. They also go on and off when the shutter is opened on an instrument with isotope sources. These are lights to warn people in the area that X-rays are being generated. The lights flash at one (1) second intervals and can be counted for you time spent making the analysis. This is helpful if you cannot see the screen when making a measurement. The battery pack contains two input/output ports. The top one is used to connect to a PC for remote operations or downloading analysis data to the PC. The bottom port is for battery charging. There is a wrist safety strap at the rear of the instrument. Use this as a precaution to keep from dropping the instrument.

Safety Note: The instrument must be pointed away from the user or anyone else in the area during any part of the analysis process to avoid radiation exposure. No part of the operator's body should be in the path of the X-rays. With proper operation, if one were to use the instrument eight hours a day, five days a week, and fifty weeks per year, one would receive less than one-tenth of the allowable radiation dosage for a pregnant woman. Instruments that have a radioactive source have a regulatory requirement that a Leak Test be performed every 6 months. A test kit is obtained which contains something like a Q-tip that is used to wipe around all seams and screw heads. This tip is sent to a laboratory to determine if any radioactive material has leaked out of the instrument. For Tube instruments, each State has different requirements. Normally the States require the operator to wear a dosimeter devise. Please check you State for Registration and Safety requirements.

Instrument Control Panel

The Left button is the On/Off/Escape button. Press and hold (about 3 seconds) until a beep is heard to turn instrument on or off. Release at beep. Any other time it is pressed it acts like an escape button returning to the Main Menu. The Right button is the Enter

button to go to or activate the icon on the screen that is highlighted as well as to take a barcode reading. An activity may start at this point or go to a sub-menu. The Center button is a 4-way touch pad that works like a joystick. This is used to move the highlighted icon around on the screen: left, right, up down. The viewing window is a LCD Touch Screen. An icon on the screen can be selected by touching the icon with a finger tip or stylus. If one is not able to select the desired icon with a finger or stylus, move the highlight to desired icon with 4-way touch pad and press Enter (right button).

Instrument Startup :

Attach a charged battery to the main body of the instrument. Press and hold the left button. Release the button when the instrument beeps. After a few seconds, a Logon screen appears. Touch anywhere on the screen to progress to the next screen, a numeric keypad. From the Serial Output icon, one can toggle between on and off for Download Region, Download Spectra, Printer, and Live Serial Output. If the icon has a backslash through it, that function is off. The printer is a small portable printer that can be attached to the instrument with the serial cable.

The Utilities icon takes one to another menu. Here, Current Baud Rate icon is used to toggle between 115K and 38K Baud. This is used to set proper baud rate for communication between personal computer and XRF analyzer. This is usually 115K with newer computers. The Rotate Screen 180 icon toggles between having the screen right side up or upside down to make viewing the screen easier in certain situations. The Specs icon displays the instrument's specifications, such as the serial number, software and firmware versions, library, temperature, bias, data coprocessors, and battery life. This information would be helpful to NITON personnel when trouble shooting problems. The Date & Time icon is used to set the current date and time. The date and time are stored with each analysis for record documentation. When the instrument has isotope sources such as Cd-109 and Fe-55, the correct date and time is particularly important for accurate analysis since the amount of decay of the isotope is used in calculating results.

The correct date and time are not critical for the analysis with the Am-241 isotope because of its long half-life or the X-ray tube, but it is good to have the correct date and time for the documented records. The Calibrate icon takes one to another screen to calibrate the touch screen or detector. The Calibrate Touch Screen icon is to be used to

insure that the stylus actually selects what it is pointed to. Use the stylus to tap exactly on the four small crosses that appear. The Calibrate Detector icon is used to automatically calibrate the detector. The instrument's detector should be calibrated after the instrument is turned on and before any analysis is performed. X-rays from the X-ray tube or isotope hit the shutter which is tungsten with a silver coating, and the resulting sample X-rays go to the detector for calibration.

While this is happening, a spectrum is seen on the screen along with a running time and the progress of calibration in percent completed. Adjustments are made automatically so that the W and Ag X-ray energy spectra are at the proper energy level.

The Data icon in the main menu takes one to another menu to view sample data and libraries. View Data allows one to scroll back and forth through previous sample analyses by using the left and right sides of the 4-way touch pad. The most prominent elements are displayed on the screen and additional elements can be seen by using the bottom portion of the 4-way touch pad. Erase is used to delete various readings from the instrument. Individual analyses cannot be erased, but only all of a certain type. The Erase icon brings up Erase All Data, Erase Readings, Erase Signatures, Erase Super Chem, and Erase Super Prec. To prevent the accidental loss of important data, when one of these erase icons is selected, one will be asked if you are sure you want to erase that data. Erase All Data removes sample readings, signatures, and super Chem data. Erase Readings will erase just the sample analysis data. Erase Signatures will erase just the signature spectra data. Erase Super Chem will erase just the Super Chem spectra and composition data. Erase Super Prec will erase the super precious metal spectra and composition data.

View Libraries icon take one to another screen to be able to View Grade Library, View Additional Library, and View Super Stds. This allows one to see the alloy specification stored on the instrument. The 4-way touchpad is used to scroll through the standard alloy compositions. View Signatures lets you see what Signature ID data is stored, and More takes one to View Super Chem and View Super Prec if anything has been stored in these modes.

The Mode icon is for selecting the calibration for the type of samples that are to be analyzed. The Thin Sample Mode icon takes you to another menu to choose the type of samples to be tested. This will allow the analysis of dust wipes and air filters, and coatings for elemental analysis. The thin samples that can be analyzed are Dust Wipes, 37 mm Filter, 25 mm Filter, Standard Filter Mode, and TSP Filter Mode. TSP is Total Suspended Particulate. The Bulk Sample Mode icon takes you to another menu for the analysis of soil, mining, and other thick samples for metallic composition and/or contamination. The Bulk Sample Mode allows for the analysis with Standard Soil Mode, Industrial Bulk Cu/Zn/Pb, Industrial Bulk Ta/Hf/Re, and Plastics Analysis Mode. The Pb Paint icon takes one to another screen for further selection. Standard Mode is used to determine if the Pb level is above or below the action level. The analysis is automatically stopped when it is determined with confidence that the lead level is above or below the action level. The result will come back as Positive or Negative. A depth index value is given to indicate if the lead is on the surface or buried. The larger the depth index, the deeper the lead. Analysis under the K + L Mode can be continued as long as the operator wants to get a more precise determination. A value for lead based on the K-shell X-m rays and the L-shell X-rays is given, along with what the XRF has determined to be the best Pb concentration. The standard deviation is included for the analysis. The depth index is given in this mode and the X-ray energy spectra are available. Set Action Level icon allows one to set the action level that is appropriate for the region where the analysis is being done. The most common action level is 1.0 mg/cm2.

The Alloy icon takes you to another menu to access one of the alloy testing modes. The Threshold Mode is not currently used. The Precious Metals icon allows you to analyze and identify precious metal alloys such as gold, silver, and platinum group metals. This will analyze for Fe, Co, Ni, Cu, Zn, Ru, Rh, Pd, Ag, Ir, Pt, and Au. The Signature ID Mode icon allows you to obtain and store a spectral signature of a reference sample, and to identify unknown alloy samples by direct comparison to this stored spectral signature. Store Signature Mode is used to input the ID name and Teach the intensity data with a count of at least 60 seconds. When Signature ID Mode is selected after any number of signatures are entered into the instrument, it is possible to run the Signature Match mode. If a match is found, the ID will be given but no chemistry is given. No Match is given if nothing in the Signature ID library matches this spectrum. The SuperChem Mode icon allows you to create a custom library of alloys, specifically matched to your needs and your XRF analyzer. This is similar to Signature ID except an alloy ID is entered along with its certified chemical analysis. The ID must be different from any ID in the standard library. The standard is counted for at least 60 seconds and stored. The chemical analysis for this standard is entered and stored. A sample can then be analyzed in the Super Chem Test mode. The unknown sample in this case must be very similar in concentration for all elements to the stored standard. Super Chem can also be used for precious metals analysis. Since the precious metals analysis looks at different elements there is a separate Super Chem mode. In this case one would use Super Chem Store, Super Chem Teach, Precious Super Chem Store, and Precious Super Chem Test in the same manner as used in the regular Super Chem.

The Chemistry Mode icon allows you to choose the most appropriate subtype of chemistry mode for the alloy samples you are testing. All Alloys icon is used for most any alloy sample when you don't know anything in advance about the composition of the sample. The Alloys with Cu/Zn/Pb icon is used when you know, without a doubt, that the sample alloy contains Cu, Zn. and/or Pb and NOT Ta, Hf, or Re. The analysis will not measure concentrations of Hf, Ta, or Re in a sample. The Alloys with Ta/Hf/Re icon is used when you know, without a doubt, that the sample alloy contains Ta, Hf, and/or Re

and NOT Cu, Zn, and/or Pb. The analysis will not measure concentrations of Cu, Zn, or Pb in a sample. Two alloy libraries may be stored in the instrument at a time. Switch Libraries icon allows one to switch to the second library. The library being used will be indicated when the analysis is started. User Definable Mode is for Empirical Calibrations. on the main menu is selected for data entry if desired and to start the analysis once the mode has been selected.

The Data Entry icon allows you to enter data about the sample to be tested. A number of identifying entries can be made to identify the sample being analyzed. These data field names can be customized. These entries can be made with the built-in barcode scanner. Press the Enter button (right button) to scan a barcode when the item number is highlighted for an identifying entry. Touch ~ to get to the Virtual Keyboard and enter the ID for the field with the stylus. This information is saved along with the reading. When preparing customized data fields for analysis, it is possible to also prepare sub-menus for those fields. If sub-menus have been prepared just click on the field name and a drop-down menu appears. Make a selection from that menu.

Examples of data fields for Data Entry:

- Alloy Analysis: Sample #, Vendor, Lot, Batch, Operator, Note

- Dust Wipe and Filters: Sample #, Location, Operator, Condition, Type, Note
- Industrial Bulk: Sample #, Location, Operator, Note
- Std. Soil: Sample #, Location, Operator, Note
- Plastics: Sample #, Operator, Note
- Pb Paint: Side, Floor, Room, Structure, Color, Condition, Substrate, Inspector, Site, Misc

Results Screen :

The results screen contains the following information. The Reading Number is how the results are identified on the instrument. The instrument assigns the number and this is one higher that last reading. The Test duration is the number of nominal seconds since the initiation of the reading. This takes into account dead time and isotope decay life (if an isotope source is used). The analysis Mode is given to show what test mode was used for the analysis. The next item is a Match/No Match. This gives name(s) of any matching alloys in the instrument's library. No Match is given if it doesn't match any alloy in the library. A Match Number is then given. This is the chi square deviation, which is a rating of confidence in the identification of the alloy. It is an indication of how close all of the elements for a specific alloy are to the midpoint of the range. These numbers range from 0.0 to 10.0. A perfect match is 0.0, which indicates that the analysis for all elements indicate that it falls near the midpoint for the specification in the library for the identified alloy grade. A number greater than 4.0 indicates No Match. A number of less than 2.0 indicate a Good Match, but longer testing may decrease this number. A value of 2.0-3.0 is a Probable Match, and a value of 3.0-4.0 is a Possible Match. If alloy grade identification is made and an asterisk (*) appears next to the Match Number, this means one or more elements are out of specification for that alloy grade. An asterisk (*) will appear next to the element symbol to indicate which element is out of specification. The Element/Concentration/Confidence is given. This portion of the screen has the elements that have been detected with confidence as being present, the concentration in percent, and the 2 sigma (95%) confidence interval. Complete Analysis can be seen by using the down portion of the 4-way touch pad to scroll to all elements. Use the left and right portion of the 4-way touch pad to see Other sample results stored on the instrument.

SpectraView: - Tapping SPECTRA brings up the energy spectrum.

- E - Key for position of cursor
- R - Resolution in electron volts
- Nearby peaks - K (alpha), K (beta), L (alpha), L (beta), and/or L (gamma) peaks of the three elements closest to the cursor
- Reading number
- Nominal seconds of measurement
- Total counts per second

Once the spectrum is brought up, some of the peaks can be identified. Push the left button on the XRF (Escape Key) allows one to manipulate the spectra. The top portion of the 4-way touch pad expands the energy scale to spread out the spectrum. The bottom portion of the 4-way touch pad will contract the spectrum. The left and right portion of the 4-way touch pad moves the cursor across the screen. When the cursor is on one of the peaks, the nearby element peaks are identified. It is also possible to use the stylus to place the cursor on the peak. This can be used to qualitatively identify some of the elements in the sample.

NITON NDT Software NDT - niton data transfer

The NITON NDT software on the CD can be loaded onto a computer. This installation provides the necessary icons to get to manuals for PC interaction and the actual icons for certain functions. The manuals are in .pdf format. The following manuals are on the CD:

- Online NDT Manual - downloading data and report generation
- Online NDTl Manual - working with the alloy library
- Online NDTr Manual - operating XRF Analyzer remotely
- Online NDTc Manual - uploading a file provided by NITON to the XRF Analyzer
- Online NDTp Manual - installing upgrade to XRF Analyzer

There are also icons for each task associated with the above manuals. At this point a password must be entered. At this time, the user password is 1234. Touch 1234 and then E for enter with a finger or stylus. If the corresponding number is not highlighted at the touch it will be necessary to enter the password using the 4-way touch pad and the enter key. Uses the 4-way touch pad to highlight the #1 and press the right button for enter. Continue using the 4-way touch pad for #'s 2, 3, 4, and E to get to the main menu.

Menu System

The instrument is operated with a series of menus and sub-menus. If the icon on the screen is shaded, that feature is not available on that particular instrument. An icon with a diagonal line through them means that item is currently turned off. The main menu consists of Common Setup, Utilities, Data, Mode, and Test.

The Common Setup icon takes one to another menu. This brings up another menu with Hardware Setup, Set Protocol, Set Cal Factor (Ind. Bulk), and Serial Output.

From the Hardware Setup icon, Backlight allows for the backlight for the touch screen to be toggled on or off. This will allow for easy reading in light or dark areas. A backslash through the icon means the backlight is off. The battery life is shortened if the backlight is on. The Scan Engine icon is used to toggle between having the built in barcode scanner on or off.

A backslash through icon means the barcode scanner is off. If the barcode reader is not used, it does not matter if the scan engine is on or off. The Welding Mask icon will be shaded unless this option was included at the factory. The welding mask allows for the analysis of a narrower window. A factory installed calibration is required because of the different configuration. If the welding mask option is available on the instrument, the standard calibration will be used if there is a backslash for this icon. The weld mask calibration will be used if there is not a backslash for this icon. Touching this icon toggles between on and off. The Rear Interlock Start icon can toggle between on and off. If it is "On", pressing the rear interlock button can start the analysis instead of pulling the trigger. The Proximity Button Start icon can toggle between on and off. If this button is "On", the analysis can be started by pressing the proximity button against the sample instead of pulling the trigger.

From the Set Protocol icon, Enable Sources allows one to select what source or sources, is used for the analysis if the instrument is set up with more than one source. Source Switch on Time Only, Source Auto-Switch Match Time, Source Auto-Switch Match Num allows for source switching to be on or off, switch sources based on a match time, or switch sources based on a selected match number. Set Maximum Measurement Time allows one to set the maximum time for a measurement. This time is in seconds. Enter the maximum number of seconds for an analysis from the numeric keypad. The default maximum measurement time is 36,000 seconds.

If it is established that the values obtained from the standard analysis in the industrial bulk mode are off by a constant factor, it is possible to get a correct reading by using calibration factors. The Set Cal Factors (Ind Bulk) icon allows one to enter these factors. The Set Cal Factors (md Bulk) field is only active if the Industrial Bulk mode had been selected. Several sets of calibration factors can be installed for material containing Cu/Zn/Pb and for material containing Ta/Hf/Re. Industrial Bulk (Cu/Zn/Pb) can be used to enter up to for sets of factors for Sn, Pd, Ag, Bal, Mo, Nb, Zr, Bi, Pb, W, Zn, Cu, Ni, Co, Fe, Mn, Cr, V, and Ti. The Cal Factors Factory values are all set at 1.0. Industrial. Bulk (Ta/Hf/Re) can be used to enter up to four sets of factors for Sn, Pd, Ag, Bal, Mo, Nb, Zr, Bi, Re, W, Ta, Hf, Co, Fe, Mn, Cr, V, and Ti. The Cal Factors Factory values are all set at 1.0. The Plastics Analysis Mode is selected when analyzing for heavy metals in plastic material.

the stylus to place the cursor on the peak. This can be used to qualitatively identify some of the elements in the sample.

NITON NDT Software

The NITON NDT software on the CD can be loaded onto a computer. This installation provides the necessary icons to get to manuals for PC interaction and the actual icons for certain functions. The manuals are in .pdf format. The following manuals are on the CD:

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- Online NDTc Manual - uploading a file provided by NITON to the XRF Analyzer
- Online NDTp Manual - installing upgrade to XRF Analyzer

There are also icons for each task associated with the above manuals. At this point a password must be entered. At this time, the user password is 1234. Touch 1234 and then E for enter with a finger or stylus. If the corresponding number is not highlighted at the touch it will be necessary to enter the password using the 4-way touch pad and the enter key. Uses the 4-way touch pad to highlight the #1 and press the right button for enter. Continue using the 4-way touch pad for #'s 2, 3, 4, and E to get to the main menu.

Menu System

The instrument is operated with a series of menus and sub-menus. If the icon on the screen is shaded, that feature is not available on that particular instrument. An icon with a diagonal line through them means that item is currently turned off. The main menu consists of Common Setup, Utilities, Data, Mode, and Test.

The Common Setup icon takes one to another menu. This brings up another menu with Hardware Setup, Set Protocol, Set Cal Factor (Ind. Bulk), and Serial Output.

From the Hardware Setup icon, Backlight allows for the backlight for the touch screen to be toggled on or off. This will allow for easy reading in light or dark areas. A backslash through the icon means the backlight is off. The battery life is shortened if the backlight is on. The Scan Engine icon is used to toggle between having the built in barcode scanner on or off.

A backslash through icon means the barcode scanner is off. If the barcode reader is not used, it does not matter if the scan engine is on or off. The Welding Mask icon will be shaded unless this option was included at the factory. The welding mask allows for the analysis of a narrower window. A factory installed calibration is required because of the different configuration. If the welding mask option is available on the instrument, the standard calibration will be used if there is a backslash for this icon. The weld mask calibration will be used if there is not a backslash for this icon. Touching this icon toggles between on and off. The Rear Interlock Start icon can toggle between on and off. If it is "On", pressing the rear interlock button can start the analysis instead of pulling the trigger. The Proximity Button Start icon can toggle between on and off. If this button is "On", the analysis can be started by pressing the proximity button against the sample instead of pulling the trigger.

From the Set Protocol icon, Enable Sources allows one to select what source or sources, is used for the analysis if the instrument is set up with more than one source. Source Switch on Time Only, Source Auto-Switch Match Time, Source Auto-Switch Match Num allows for source switching to be on or off, switch sources based on a match time, or switch sources based on a selected match number. Set Maximum Measurement Time allows one to set the maximum time for a measurement. This time is in seconds. Enter the maximum number of seconds for an analysis from the numeric keypad. The default maximum measurement time is 36,000 seconds.

If it is established that the values obtained from the standard analysis in the industrial bulk mode are off by a constant factor, it is possible to get a correct reading by using calibration factors. The Set Cal Factors (Ind Bulk) icon allows one to enter these factors. The Set Cal Factors (md Bulk) field is only active if the Industrial Bulk mode had been selected. Several sets of calibration factors can be installed for material containing Cu/Zn/Pb and for material containing Ta/Hf/Re. Industrial Bulk (Cu/Zn/Pb) can be used to enter up to for sets of factors for Sn, Pd, Ag, Bal, Mo, Nb, Zr, Bi, Pb, W, Zn, Cu, Ni, Co, Fe, Mn, Cr, V, and Ti. The Cal Factors Factory values are all set at 1.0. Industrial. Bulk (Ta/Hf/Re) can be used to enter up to four sets of factors for Sn, Pd, Ag, Bal, Mo, Nb, Zr, Bi, Re, W, Ta, Hf, Co, Fe, Mn, Cr, V, and Ti. The Cal Factors Factory values are all set at 1.0. The Plastics Analysis Mode is selected when analyzing for heavy metals in plastic material.

Dear Ms. Shannon Edson,

I am submitting a request on behalf of COMPANY NAME for a safety device exemption for a Niton portable XRF analyzer Model XLt XXX in accordance with Rule 289.228(d)(1)(B). According to the instrument vendor, this device was designed specifically for the capability to directly analyze objects (i.e., samples) over a wide range of sizes, types, and geometries in a field portable manner. This design objective prohibits the use of a "Safety Device" which would prevent access by individuals to the primary beam. Although many safety features are incorporated into the device design, Thermo Niton LLC does not supply the instrument with a "safety device" as defined by the Texas Department of Health, nor are there any available accessories or instrument modifications meeting the definition of a safety device.

As an alternative to operating this instrument with an incorporated safety device, COMPANY NAME will adopt and implement the following two policies:

1) Training - Only authorized individuals will be given access to the device and allowed to use it. Authorization will be contingent upon each individuals completion of training on operational use and basic radiation safety awareness. At a minimum, this training will consist of a requirement to read the Instrument User's Guide with particular attention to the section on Radiation Safety. At least one person in the company will be trained directly by the manufacturer and this person will supplement the User's Guide review with additional training that may be necessary. Records of training will be maintained on file for each person authorized to use the device, along with a list of authorized individuals.
2) Dosimetry – Authorized individuals will be issued dosimetry obtained from a NVLAP accredited dosimetry service provider. They will be required to wear this dosimetry at all times while using the device.

Please let me know if you need any other information as part of your consideration to grant this exemption.

TEXAS
Department of
State Health Services

BUSINESS INFORMATION FORM

INSTRUCTIONS - Complete the box that is applicable to your business. Mail or fax original(s) to the Texas Department of State Health Services, Radiation Safety Licensing Branch (RSLB), 1100 West 49th Street, Austin, Texas 78756-3189. Fax number (512)834-6716. If there are any questions, contact RSLB-Machine Source Group at (512) 834-6688.

COMPLETE THIS BOX IF THE APPLICANT IS A CORPORATION

REGISTRATION/CERTIFICATION NUMBER ______________________
(Applicants applying for New Registration will not have a registration/certification number)

NAME OF CORPORATION: ______________________

DOING BUSINESS AS: ______________________

TYPE OF CORPORATION: ______________________

BUSINESS ADDRESS: ______________________

____

TELEPHONE NUMBER: ______________________

REGISTERED AGENT: ______________________

REGISTERED AGENT ADDRESS: ______________________
(if different than facility address above)

REGISTERED AGENT TELEPHONE NUMBER: ______________________

TEXAS SECRETARY OF STATE CHARTER NUMBER: ______________________
Charter Number – Taxpayer Identification Number, Filing Number or Federal Identification Number
For more information concerning Texas Secretary of State Charter Number call 800-252-1381

I certify that the information provided above is true and correct:

______________________ ______________________
Signature of an Officer of the Applicant Typed or Printed Name

______________________ ______________________
Position with Applicant Date

PRIVACY NOTIFICATION: If you are applying as an individual, with few exceptions, you have the right to request and be informed about information that the State of Texas collects about you. You are entitled to receive and review the information upon request. You also have the right to ask the state agency to correct any information that is determined to be incorrect. See http://www.dshs.state.tx.us for more information on Privacy Notification. (Reference: Government Code, Section 552.021, 552.023, 559.003 and 559.004).

SEE BACK FOR ADDITIONAL OPTIONS

COMPLETE THIS BOX IF APPLICANT IS ANOTHER TYPE OF BUSINESS ORGANIZATION OTHER THAN A CORPORATION

REGISTRATION/CERTIFICATION NUMBER ____________________
(Applicants applying for New Registration will not have a registration/certification number)

NAME OF BUSINESS: ____________________

DOING BUSINESS AS: ____________________

TYPE OF BUSINESS ORGANIZATION: ____________________
(i.e., partnership, professional association, etc.)

BUSINESS ADDRESS: ____________________

____

TELEPHONE NUMBER: ____________________

TEXAS SECRETARY OF STATE CHARTER NUMBER: ____________________
Charter Number – Taxpayer Identification Number, Filing Number or Federal Identification Number
For more information concerning Texas Secretary of State Charter Number call 800-252-1381

I certify that the information provided above is true and correct:

____________________ Signature of an Officer of the Applicant

____________________ Typed or Printed Name

____________________ Position with Applicant

____________________ Date

COMPLETE THIS BOX IF APPLICANT IS AN INDIVIDUAL

REGISTRATION/CERTIFICATION NUMBER ____________________

NAME: ____________________

DOING BUSINESS AS: ____________________

BUSINESS ADDRESS: ____________________

____

TELEPHONE NUMBER: ____________________

I certify that the information provided above is true and correct:

____________________ Signature of Individual Owner

____________________ Typed or Printed Name

____________________ Date

PRIVACY NOTIFICATION: If you are applying as an individual, with few exceptions, you have the right to request and be informed about information that the State of Texas collects about you. You are entitled to receive and review the information upon request. You also have the right to ask the state agency to correct any information that is determined to be incorrect. See http://www.dshs.state.tx.us for more information on Privacy Notification. (Reference: Government Code, Section 552.021, 552.023, 559.003 and 559.004).

TEXAS DEPARTMENT OF STATE HEALTH SERVICES RADIATION SAFETY LICENSING BRANCH

ZZ113-120

REGISTRATION APPLICATION FOR INDUSTRIAL RADIATION MACHINE AND SERVICES

INSTRUCTIONS - Complete ALL ITEMS on the application. Mail original(s) to the Texas Department of State Health Services, Radiation Safety Licensing Branch (RSLB), 1100 West 49th Street, Austin, Texas 78756-3189. Upon approval of the application, the applicant will receive a Certificate of Registration. For new registrations, include the appropriate fee. If there are any questions, contact the RSLB at (512)834-6688.

1. a. Legal name of business, facility or individual:*

b. Business mailing address:

2. Physical address where radiation machines will be used or records stored, or dispatched from: (Submit separate application forms for each additional use location under this registration.)

3. Type of action: (Check all that apply)

_____ New Registration (Attach appropriate fee)

_____ Technical Renewal of Registration No.__________ *

_____ Amendment to Registration No. __________

_____ Name Change* _____ Address Change

_____ RSO Change* _____ Additional Service

_____ Additional Use Location _____ Equipment Change*

4. Telephone No.:

5. Fax No:

6. Temporary Job Sites: ☐ Yes or ☐ No

7. Radiation Safety Officer (RSO): (attach qualifications*)

8. E-mail Address:

9. Machine / X-Ray Service Provider Data (See table on back of this form.)

Use Category*

Add: Please indicate the number and type of units used in each category	Delete: Please indicate the number and type of units to delete in each category
___ 572 – Minimal Threat - Type____________________(see table on reverse)	___ 572 – Minimal Threat - Type____________________(see table on reverse)
___ 573- Other Industrial - Type____________________(see table on reverse)	___ 573- Other Industrial - Type____________________(see table on reverse)
___ 575- Services (Indicate type(s) of services provided in item 10.)	___ 575- Services
___ 880- Industrial Radiography (Fixed Site)	___ 880- Industrial Radiography (Fixed Site)
___ 562- Industrial Radiography (Temporary Site)	___ 562- Industrial Radiography (Temporary Site)
___ 576-Radiagraphic Machines Only*	

10. Services: To be completed by applicants who PROVIDE x-ray machine servicing and/or services.

Indicate type of x-ray machine servicing and/or services provided:

_____ Assembler, X-Ray (Assemble, Install, Repair)

_____ Dose/Dose Rate Measurement*

_____ Demonstration and Sales*

_____ Calibration of Measuring Instruments

_____ Consultant, X-Ray*

_____ Agency Accepted Training Course

_____ Provider of Equipment*

_____ Equipment Performance Evaluation*

11. I hereby accept the responsibilities of Radiation Safety Officer*.

Signature of Radiation Safety Officer Date Typed or printed name

12. Certification: I certify that the information is true and correct to the best of my knowledge.

Signature of Applicant Date Typed or printed name

Signature of Owner or Partner* Date Typed or printed name

13. As a licensed practitioner, I do hereby affirm that I am associated with this applicant and provide supervision to non-practitioners administering radiation to human beings or animals. *

Signature of Licensed Practitioner Date Typed or Printed Name Licensing Board No.

* SEE REVERSE FOR INSTRUCTIONS

INSTRUCTIONS

The following is an explanation for the specific items identified by an asterisk (*), from the front page.

Item1a and 3: Legal name of business, facility or individual

A Business Information Form (BRC Form 226-1) must be submitted for all new applications, for any name or ownership change, and for technical renewals.

Item 3, 7 and 11: Radiation Safety Officer (RSO)
The individual named as RSO must meet the requirements specified in 25 Texas Administrative Code TAC § 289.226(t)(1). A resume or written documentation for the individual designated as the RSO, describing experience and qualifications to serve in that capacity, must be submitted with the application.

Item 9:

572 – Minimal Threat
Fluorescence X-Ray (Closed Beam)
Gauges X-Ray
Cabinet X-Ray
Package X-Ray
Electron Beam Welding
Particle Size Analyzer
Ion-Implant
Cathodoluminescence
Minimal Threat - Other

562- Industrial Radiography (Temp Sites)

880- Industrial Radiography (Fixed Site)

573 - Other Industrial
Portable/Handheld Fluorescence X-Ray (Open Beam)*
Diffraction X-Ray
Fluoroscopy Hand Held Intensified
Fluoroscopy X-Ray
Industrial Accelerator
Spectrography X-Ray
Flash X-Ray
Educational Facility (X-Ray For Non-Human Use)
Morgues
Other - Industrial

*Safety device exemption required according to §289.228(d)(1) for Portable/Handheld Fluorescence X-Ray (Open Beam).

575 - Services
Assembler X-Ray
Calibration (Survey Instrumentation)
Monitoring Services
Demonstration/Sales
Dose/Dose Rate Measure (X-Ray Equipment)
Provider of Equipment
Consultant
X-Ray Equipment Performance Evaluations
Training Course

576 – Radiographic Machines Only
Signature and Texas License Board Number required in item 13.

Item 10: Services:

Dose/Dose Rate Measurement: Performance of radiation dose or dose rate measurements shall be performed under the supervision of a Licensed Medical Physicist.

Demonstration and Sales: Involves an individual who energizes or causes a radiation machine to be energized in order to demonstrate or sell the equipment.

Consultant: An individual who provides radiation protection or health physics consultations or surveys that require the consultant to operate or cause a radiation machine to be operated in order to make measurements or gather data.

Provider of Equipment (POE): Is an entity that furnishes a radiation machine on a routine basis to a facility for limited time periods. If providing personnel, submit operating and safety procedures.

Equipment Performance Evaluation (EPE): Performance of tests to assure proper function of dental x-ray equipment. EPE for medical, chiropractic, or podiatric x-ray machines must be performed under the supervision of a Licensed Medical Physicist.

Item 12: Signature of Owner or Partner: This line does not need to be completed if the business is a corporation.

Item 13: Signature of Licensed Practitioner: This line does not need to be completed if radiation is not administered to live human beings or animals.

PRIVACY NOTIFICATION: If you are applying as an individual, with few exceptions, you have the right to request and be informed about information that the State of Texas collects about you. You are entitled to receive and review the information upon request. You also have the right to ask the state agency to correct any information that is determined to be incorrect. See http://www.dshs.state.tx.us for more information on Privacy Notification. (Reference: Government Code, Section 552.021, 552.023, 559.003 and 559.004).

ULTRAMETER II™

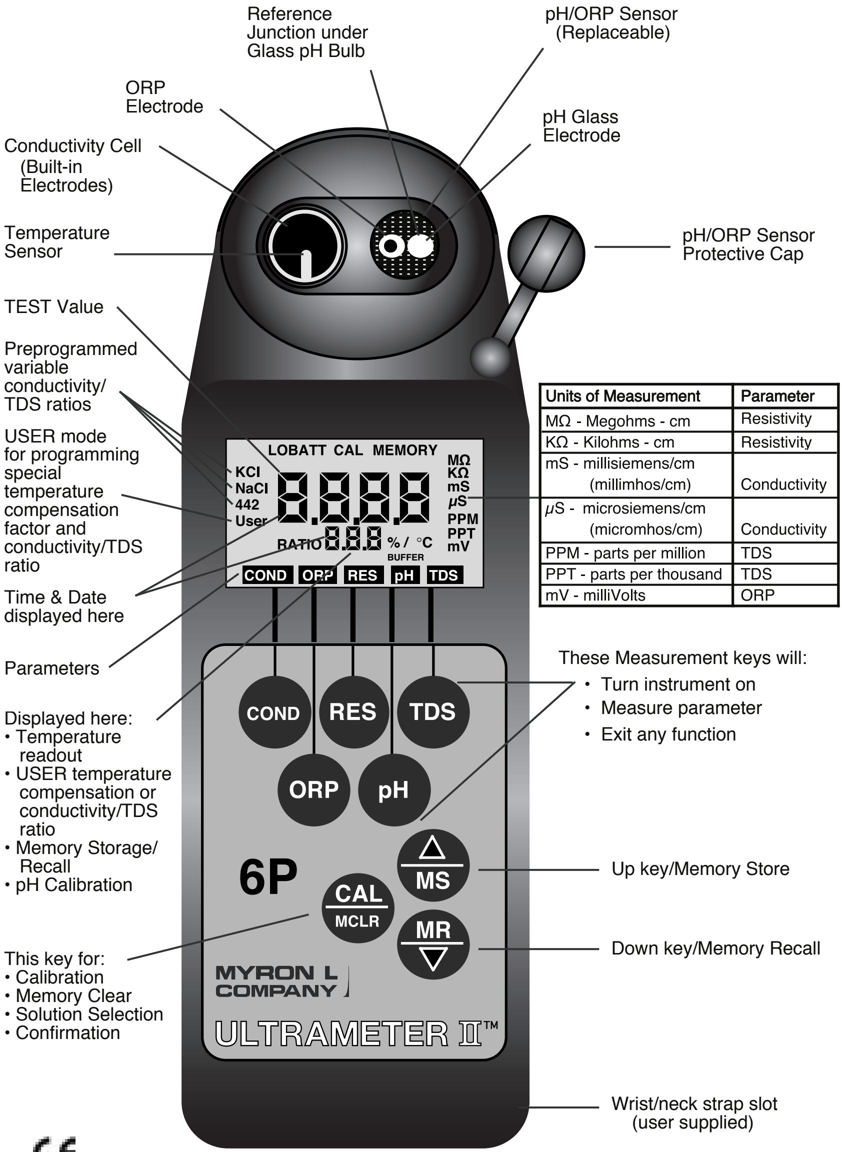
Operation Manual

MODELS 6P & 4P

MYRON L COMPANY
Water Quality Instrumentation
Accuracy • Reliability • Simplicity

12 may 05

Instrument Illustration



Units of Measurement	Parameter
MΩ - Megohms - cm	Resistivity
KΩ - Kilohms - cm	Resistivity
mS - millisiemens/cm (millimhos/cm)	Conductivity
μS - microsiemens/cm (micromhos/cm)	Conductivity
PPM - parts per million	TDS
PPT - parts per thousand	TDS
mV - milliVolts	ORP

MODEL 6P Shown

For detailed explanations see Table of Contents

27apr05

I. INTRODUCTION

Thank you for selecting the feature-packed Ultrameter II™, one of the Myron L Company's latest in an increasing line of instruments utilizing advanced microprocessor-based circuitry and SMT manufacturing processes. This circuitry makes the instrument extremely accurate, reliable and very easy to use.

The Ultrameter II incorporates several new features including a clock with time and date, an increased memory of up to 100 locations with time and date stamp, the ability of the user to adjust the timeout "Auto OFF", and enhanced performance (see pages 2 & 3 for the list of Features and Specifications).

The most exciting new feature is data logging with the ability to download the memory or stored test data with its corresponding time and date. This feature allows the user to create spreadsheets and graphs with ease, and quickly and accurately manipulate data more effectively. The optional uDock™ and software is compatible with most computers using either Microsoft Windows XP or 2000™, or Macintosh OS9.2 or OSX™. The data may be imported into a variety of spreadsheet formats like Microsoft Excel CSV™.
Please Note: Although the Myron L Company has performed extensive testing, we can not guarantee compatibility of all applications and formats. We suggest testing your application and format for compatibility before relying on it.

For your convenience, on the bottom side of your Ultrameter II is a brief set of instructions. A waterproof pocket sized card with abbreviated instructions is also included with the instrument.

Special note ...... Conductivity, resistivity, and TDS require mathematical correction to 25°C values (ref. Temperature Compensation, pg. 38). On the left of the Ultrameter II's liquid crystal display is shown an indicator of the salt solution characteristic used to model temperature compensation of conductivity and its TDS conversion. The indicator may be KCl, NaCl, 442™ or USER. Selection affects the temperature correction of conductivity, and the calculation of TDS from compensated conductivity (ref. Conductivity Conversion to Total Dissolved Solids (TDS), pg. 41). The selection can affect the reported conductivity of hot or cold solutions, and will change the reported TDS of a solution. Generally, using KCl for conductivity, NaCl for resistivity, and 442™ (Natural Water characteristic) for TDS will reflect present industry practice for standardization. This is how your instrument, as shipped from the factory, is set to operate. For use in sea water desalination for example, both the conductivity and TDS may easily be changed to NaCl.

II. FEATURES and SPECIFICATIONS

A. Features

- Superior resolution 4 digit LCD displays full 9999 μS/ppm.
- Accuracy of BETTER than ±1% of reading in a handheld instrument.
- All electrodes are internal for maximum protection.
- Improved 4 electrode sensor technology.
- Waterproof to 1 meter/3 feet.
- Autoranging conductivity/TDS/resistivity.
- Prompts for easy pH calibration (6P).
- Factory calibrations stored in microprocessor.
- 3 conductivity/TDS solution conversions preprogrammed into microprocessor.
- USER mode feature allows:
  - Programming your own cond/TDS conversion factor.
  - Programming your own temperature compensation factor.
  - Disabling temperature compensation.
- Real Time Clock with Time and Date.
- Data Logging with TIME and DATE in memory.
- Memory stores 100 readings.
- Download capability with optional uDock™.
- User adjustable timeout “Auto OFF”.

B. General Specifications

Display	4 Digit LCD
Dimensions (LxWxH)	196 x 68 x 64 mm 7.7 x 2.7 x 2.5 in.
Weight	352 g/12.4 oz.
Case Material	VALOX*
Cond/Res/TDS Cell Material	VALOX*
Cond/TDS Electrodes (4)	316 Stainless Steel
Cond/Res/TDS Cell Capacity	5 ml/0.2 oz.
pH/ORP Sensor Well Capacity	1.2 ml (6P)/0.04 oz.
Power	9V Alkaline Battery
Battery Life	>100 Hours/5000 Readings
Operating/Storage Temperature	0-55°C/32-132°F
Protection Ratings	IP67/NEMA 6 (waterproof to 1 meter/3 feet)

* ™ GE Corp.

Additional information available on our website at:
www.myronl.com

C. Specification Chart

	pH (6P)	**ORP (6P)**	**Conductivity**	**TDS**	**Resistivity**	**Temperature**
Ranges	0-14 pH	±999 mV	0-9999 µS/cm 10-200 mS/cm in 5 autoranges	0-9999 ppm 10-200 ppt in 5 autoranges	10KΩ - 30MΩ	0-71 °C 32 - 160 °F
Resolution	±.01 pH	±1 mV	0.01 (<100 µS) 0.1 (<1000 µS) 1.0 (<10 mS) 0.01 (<100 mS) 0.1 (<200 mS)	0.01 (<100 ppm) 0.1 (<1000 ppm) 1.0 (<10 ppt) 0.01 (<100 ppt) 0.1 (<200 ppt)	0.01 (<100 KΩ) 0.1 (<1000 KΩ) 0.1 (>1 MΩ)	0.1 °C/F
Accuracy	±.01 pH	±1 mV	±1% of reading	±1% of reading	±1% of reading	±0.1 °C
Auto Temperature Compensation	0-71 °C 32 - 160 °F		0-71 °C 32 - 160 °F	0-71 °C 32 - 160 °F	0-71 °C 32 - 160 °F	
Adjustable Temperature Compensation			0 - 9.99%/ °C	0 - 9.99%/ °C	0 - 9.99%/ °C	
Cond/TDS Ratios Preprogrammed			KCl, NaCl, 442™			
Adjustable Cond/TDS Ratio Factor			0.20 - 7.99			

D. Warranty/Service

The Myron L Ultrameter II, excluding the pH/ORP sensor (6P), has a TWO (2) year limited warranty. The pH/ORP sensor (6P) has a six (6) month limited warranty for materials and workmanship. If an instrument fails to operate properly, see Troubleshooting Chart, pg. 35. The battery and pH/ORP sensor are user-replaceable. For other service, return the instrument prepaid to the Myron L Company.

MYRON L COMPANY
2450 Impala Drive
Carlsbad, CA 92010-7226 USA
760-438-2021
www.myronl.com

If, in the opinion of the factory, failure was due to materials or workmanship, repair or replacement will be made without charge. A reasonable service charge will be made for diagnosis or repairs due to normal wear, abuse or tampering. This warranty is limited to the repair or replacement of the Ultrameter II only. The Myron L Company assumes no other responsibility or liability.

E. Ultrameter II Models

ULTRAMETER II MODELS	4P	6P
PARAMETERS	Conductivity/TDS Resistivity/Temp.	Conductivity/TDS/pH Resistivity/ORP/Temp.

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III. RULES of OPERATION

A. Operation

Using the instrument is simple:

- Individual or multiple parameter readings may be obtained by filling individual sensors or entire cell cup area.
- Rinse the conductivity cell or pH/ORP sensor (6P) well with test solution 3 times and refill. Temperature and/or measurement extremes will require additional rinses for maximum accuracy.
- Press the desired measurement key to start measurement. Pressing the key again does no harm and restarts the 15 second "off" timer.
- Note the value displayed or press the MS key to store the reading (ref. Memory Storage, pg. 21). It's that simple!

B. Characteristics of the Keys

- Though your Ultrameter II has a variety of sophisticated options, it is designed to provide quick, easy, accurate measurements by simply pressing one key.
- All functions are performed one key at a time.
- There is no "off" key. After 15 seconds of inactivity the instrument turns itself off (60 seconds in CAL mode). User adjustable up to 75 seconds.
- Rarely will a key be required to be held down (as in Procedure to Select a Solution, pg. 11; or Cond. or TDS Calibration, pg. 15).

C. Operation of the Keys (See Instrument Illustration on pg. i)

1. Measurement Keys in General

Any of the 5 measurement keys in the upper part of the keypad turns on the instrument in the mode selected. The mode is shown at the bottom of the display, and the measurement units appear at the right. Pressing a measurement key does this even if you are in a calibration sequence and also serves to abandon a change (ref. Leaving Calibration, pg. 14).

2. COND, RES and TDS keys

These 3 keys are used with solution in the Conductivity Cell.

Precautions:

- While filling cell cup ensure no air bubbles cling on the cell wall.
- If the proper solution is not selected (KCl, NaCl, 442 or USER), refer to Why Solution Selection is Available, pg. 11 and Procedure to Select a Solution, pg. 11.

a. COND Key

Solution to be tested is introduced into the conductivity cell and a press of (COND) displays conductivity with units on the right. On the left is shown the solution type selected for conductivity.

b. RES Key

A press of (RES) displays resistivity with units on the right. On the left is shown solution type selected for resistivity (ref. Solution Selection, pg. 11). The range of display of resistivity is limited to between 10 kilohms (KΩ) and 30 megohms (MΩ). A solution outside that range will only show [- - - -] in the display.

c. TDS key

A press of (TDS) displays Total Dissolved Solids with units on the right. This is a display of the concentration of material calculated from compensated conductivity using the characteristics of a known material. On the left is shown solution type selected for TDS (ref. Solution Selection, pg. 11).

3. pH and ORP keys

Measurements are made on solution held in the pH/ORP sensor well (ref. pH and ORP, pg. 44). The protective cap is removed and the sensor well is filled and rinsed with sample enough times to completely replace the storage solution.

After use, the pH/ORP sensor well must be refilled with Myron L Storage Solution, and the protective cap reinstalled securely (ref. Maintenance of the pH/ORP Sensor, pg. 9 and Cleaning pH/ORP Sensors, pg. 33).

a. pH key (6P)

A press of (pH) displays pH readings. No units are displayed on the right.

b. ORP key (6P)

A press of (ORP) displays Oxidation-Reduction Potential/REDOX reading in millivolts, “mV” is displayed.

4. CAL/MCLR key

A press of (CAL/MCLR) allows you to enter the calibration mode while measuring conductivity, TDS or pH. Once in CAL mode, a press of this key accepts the new value. If no more calibration options follow, the instrument returns to measuring (ref. Leaving Calibration, pg. 14).

If (CAL/MCLR) is held down for about 3 seconds, CAL mode is not entered, but “**SEL**” appears to allow Solution Selection (ref. pg. 11) with the Up or Down keys. As in calibration, the CAL key is now an “accept” key.

While reviewing stored records, the MCLR side of the key is active to allow clearing records (ref. Clearing a Record/Memory Clear, pg. 21).

5. UP or DOWN keys

While measuring in any parameter, the ▲ MS or MR ▼ keys activate the Memory Store and Memory Recall functions.
While in CAL mode, the keys step or scroll the displayed value up or down. A single press steps the display and holding either key scrolls the value rapidly.
While in Memory Recall, the keys move the display up and down the stack of records (ref. Memory Recall, pg. 21).

IV. AFTER USING the ULTRAMETER II

A. Maintenance of the Conductivity Cell

Rinse out the cell cup with clean water. Do not scrub the cell. For oily films, squirt in a foaming non-abrasive cleaner and rinse. Even if a very active chemical discolors the electrodes, this does not affect the accuracy; leave it alone (ref. Cleaning Sensors, pg. 32).

B. Maintenance of the pH/ORP Sensor (6P)

The sensor well must be kept wet with a solution. Before replacing the rubber cap, rinse and fill the sensor well with Myron L pH Storage Solution. If unavailable, use an almost saturated KCl solution, pH 4 buffer or at least a strong table salt solution. NEVER USE DISTILLED WATER. (ref. pH and ORP Practices, pg. 20)

V. SPECIFIC RECOMMENDED MEASURING PROCEDURES

If the proper solution is not selected (KCl, NaCl, 442 or USER), see Solution Selection, pg. 11.

NOTE: *After sampling high concentration solutions or temperature extremes, more rinsing may be required. When sampling low conductivity solutions, be sure the pH cap is well seated so no solution washes into the conductivity cell from around the pH cap.*

A. Measuring Conductivity & Total Dissolved Solids (TDS)

1. Rinse cell cup 3 times with sample to be measured. (This conditions the temperature compensation network and prepares the cell.)

2. Refill cell cup with sample.

3. Press COND or TDS.

4. Take reading. A display of [- - - -] indicates an overrange condition.

B. Measuring Resistivity

Resistivity is for low conductivity solutions. In a cell cup the value may drift from trace contaminants or absorption from atmospheric gasses, so measuring a flowing sample is recommended.

1. Ensure pH protective cap is secure to avoid contamination.

2. Hold instrument at 30° angle (cup sloping downward).

3. Let sample flow continuously into conductivity cell with no aeration.

4. Press RES key; use best reading.

NOTE: *If reading is lower than 10 kilohms display will be dashes: [- - - -]. Use Conductivity.*

C. Measuring pH (6P)

1. Remove protective cap by squeezing its sides and pulling up.

2. Rinse sensor well 3 times with sample to be measured. Shake out each sample to remove any residual liquid.

3. Refill both sensor wells with sample.

4. Press pH .

5. Take reading.

6. **IMPORTANT:** After use, fill pH/ORP sensor well with Myron L pH Sensor Storage Solution and replace protective cap.
   If Myron L pH Sensor Storage Solution is unavailable, use a strong KCl solution, pH 4 buffer, or a saturated solution of table salt and tap water (ref. Cleaning pH/ORP Sensors, pg. 33). Do not allow pH/ORP sensor to dry out.

D. Measuring ORP (6P)

1. Remove protective cap by squeezing its sides and pulling up.

2. Rinse sensor well 3 times with sample to be measured. Shake out each sample to remove any residual liquid.

3. Refill both sensor wells with sample.

4. Press ORP.

5. Take reading.

6. **IMPORTANT:** After use, fill pH/ORP sensor well with Myron L pH Sensor Storage Solution and replace protective cap.
If Myron L pH Sensor Storage Solution is unavailable, use a strong KCl solution, pH 4 buffer, or a saturated solution of table salt and tap water (ref. Cleaning pH/ORP Sensors, pg. 33). Do not allow pH/ORP sensor to dry out.

VI. SOLUTION SELECTION

A. Why Solution Selection is Available

Conductivity, resistivity, and TDS require temperature correction to 25°C values (ref. Standardized to 25°C, pg. 38). Selection determines the temperature correction of conductivity and calculation of TDS from compensated conductivity (ref. Cond. Conversion to TDS, pg. 41).

B. The 4 Solution Types

On the left side of the display is the salt solution characteristic used to model temperature compensation of conductivity and its TDS conversion. Generally, using KCl for conductivity, NaCl for resistivity, and 442 (Natural Water characteristic) for TDS will reflect present industry practice for standardization. This is the setup as shipped from the factory (ref. Solution Characteristics, pg. 41).

The USER selection allows a custom value to be entered for the temperature compensation of conductivity and also the conversion ratio if measuring TDS.

C. Calibration of Each Solution Type

There is a separate calibration for each of the 4 solution types. Note that calibration of a 442 solution does not affect the calibration of a NaCl solution. For example: Calibration (ref. Conductivity or TDS Calibration, pg. 15) is performed separately for each type of solution one wishes to measure (ref. Conductivity/TDS Standard Solutions, pg. 37).

D. Procedure to Select a Solution

NOTE: Check display to see if solution displayed (KCl, NaCl, 442 or USER) is already the type desired. If not:

1. Press COND, RES or TDS to select the parameter on which

you wish to change the solution type.

2. Press and hold CAL/MCLR key about 3 seconds to make "**SEL**" appear (see Figure 1). For demonstration purposes, all 4 solution types are shown simultaneously.

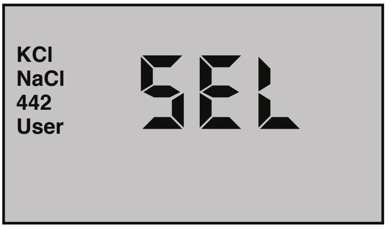


Figure 1

3. Use ▲/MS or MR/▼ key to obtain type of solution desired (ref. Solution Characteristics, pg. 41). The selected solution type will be displayed: KCl, NaCl, 442 or User.

4. Press CAL/MCLR to accept new solution type.

E. Application of USER Solution Type

1. User Programmable Temperature Compensation (Tempco)

This feature allows you to change your Ultrameter II's temperature compensating factor to another factor between 0-9.99%/°C (ref. Temperature Compensation, pg. 38). This feature does not apply to pH or ORP.

a. As in Procedure to Select a Solution, pg. 11, select "USER" mode.

b. With "USER" mode now selected, press CAL/MCLR. You may now adjust a temperature compensation from .00%/°C to 9.99%/°C, by pressing ▲/MS or MR/▼. See example in Figure 2.

c. Press CAL/MCLR twice to skip calibration adjustment and accept the new tempco (3 times if in TDS mode). You are now ready to measure samples with your new temperature compensation factor.

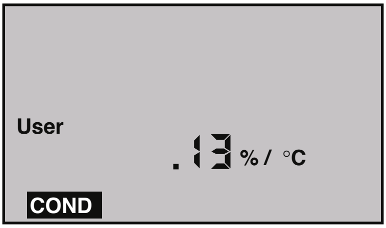


Figure 2

2. Disabling Temperature Compensation

a. Select USER mode, see Procedure to Select a Solution, pg. 11.

b. With "USER" selected, press CAL/MCLR. If the display does not show .00%/°C, hold MR ▼ long enough to bring the tempco to .00%/°C (see Figure 3).

c. Press CAL/MCLR twice (3 times if in TDS mode). Temperature compensation is now disabled (=0) for measurements in USER mode.

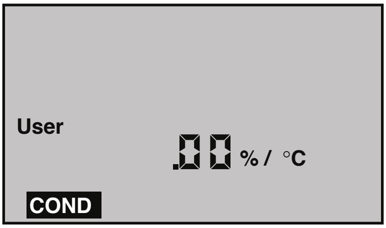


Figure 3

3. User Programmable Conductivity to TDS Ratio

This feature allows you to select a custom conductivity to TDS conversion ratio for USER mode measurements.

For example: The conversion ratio range is 0.20-7.99 (i.e., if conductivity is 100 μS and TDS is 75 ppm, you would adjust to 0.75) (ref. Conductivity Conversion to TDS, pg. 41).

a. While in "USER" mode, press TDS.

b. Press CAL/MCLR twice (to skip over tempco adjustment) and "**RATIO**" will appear (see Figure 4).

c. Adjust with ▲ MS or MR ▼ key until new conversion ratio is displayed.

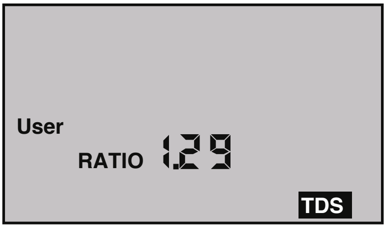


Figure 4

d. Press CAL/MCLR twice (to skip over calibration adjustment) to accept new conversion ratio. You are now ready to measure samples with the new conductivity/TDS ratio.

In these first six sections, you have learned all you need to make accurate measurements. The following sections contain calibration, advanced operations and technical information.

VII. CALIBRATION

A. Calibration Intervals

Generally, calibration is recommended about once per month with Conductivity or TDS solutions. Calibration with pH solutions should be checked twice a month. Calibration of ORP is not necessary (ref. CALIBRATION INTERVALS, pg. 19).

B. Rules for Calibration of the Ultrameter II

1. Calibration Steps

a. Starting Calibration

Calibration is begun by pressing (CAL/MCLR) while measuring Conductivity, TDS or pH. Measuring continues, but the CAL icon is on, indicating calibration is now changeable.

The reading is changed with the (▲/MS) and (MR/▼) to match the known value. The calibration for each of the 4 solution types may be performed from either conductivity or TDS mode.

Depending on what is being calibrated, there may be 1, 2 or 3 steps to the calibration procedures.

	KCl, NaCl or 442	User
Cond	Gain only	Tempco, then Gain
Res	Done in conductivity	Done in conductivity or TDS
TDS	Gain only	Tempco, Ratio, then Gain
pH	7, acid and/or base (6P)	
ORP	Zero set with pH 7 automatically (6P)	

The (CAL/MCLR) becomes an "ACCEPT" key. At each point, pressing (CAL/MCLR) accepts the new calibration value and steps you to the next adjustment (or out of CAL mode if there are no more steps).

To bypass a calibration step, just press (CAL/MCLR) to accept the present value as is.

b. Leaving Calibration

You know you are finished when the "**CAL**" icon goes out. Pressing any

measurement key abandons changes not yet accepted and exits calibration mode.
Leaving pH after the 2nd buffer results in the same gain being entered in place of the 3rd buffer.

2. Calibration Limits

There are calibration limits. A nominal "FAC" value is an ideal value stored by the factory. Attempts to calibrate too far, up or down, from there will cause the displayed value to be replaced with "FAC". If you accept it (press the "Cal" key), you will have the original default factory calibration for this measurement. The need to calibrate so far out that "FAC" appears indicates a procedural problem, wrong standard solution, a very dirty cell cup or an aging pH/ORP sensor (ref. Troubleshooting Chart, pg. 35).

C. Calibration Procedures

1. Conductivity or TDS Calibration

a. Rinse conductivity cell three times with proper standard (KCl, NaCl, or 442) (ref. Cond/TDS Standard Solutions, pg. 37). For user calibration see User Calibration Conductivity/TDS below.

b. Refill conductivity cell with same standard. KCl-7000 shown.

c. Press COND or TDS, then press CAL/MCLR, "**CAL**" icon will appear on the display (see Figure 5).

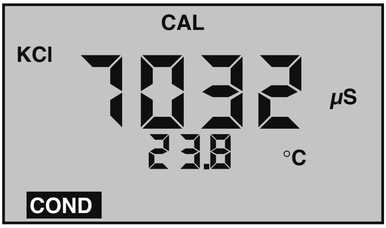


Figure 5

d. Press ▲/MS or MR/▼ to step the displayed value toward the standard's value (7032 > 7000) or hold a key down to cause rapid scrolling of the reading.

e. Press CAL/MCLR once to confirm new value and end the calibration sequence for this particular solution type. If another solution type is also to be measured, change solution type now and repeat this procedure.

2. User Calibration Conductivity/TDS

Instrument must be in **USER** mode, see Solution Selection, pg. 11.

a. Rinse conductivity cell three times with <u>your</u> standard.

b. Refill conductivity cell with same standard.

c. Press COND or TDS, then press CAL/MCLR twice in COND/three times in TDS. The “**CAL**” icon will appear on the display.

d. Press ▲/MS or MR/▼ to step the displayed value toward the standard’s value or hold a key down to cause rapid scrolling of the reading.

e. Press CAL/MCLR once to confirm new value and end the calibration sequence for this particular solution type.

3. <u>Resistivity Calibration</u>

Resistivity is the reciprocal of Conductivity. Resistivity is calibrated only if conductivity is calibrated for the same solution type.

4. <u>Reloading Factory Calibration (Cond or TDS)</u>

If calibration is suspect or known to be wrong, and no standard solution is available, the calibration value can be replaced with the original factory value for that solution. This “FAC” value is the same for all Ultrameter IIs, and returns you to a known state without solution in the cell. The “FAC” internal electronics calibration (which bypasses the electrodes and cell) is not intended to replace calibration with conductivity standard solutions. If another solution type requires resetting, change solution type and repeat this procedure.

a. Press COND or TDS.

b. Press CAL/MCLR. (If in USER solution mode, press CAL key twice if in Conductivity, and three times if in TDS to skip over tempco and ratio adjustments.)

c. Press ▲/MS key until “**FAC**” appears and release.

d. Press CAL/MCLR to accept the factory calibration setting.

5. pH Calibration (6P)

Important: Always “zero” your Ultrameter II with a pH 7 buffer solution before adjusting the gain with acid or base buffers, i.e., 4 and/or 10, etc.

a. pH Zero Calibration (6P)

1. Rinse sensor well 3 times with 7 buffer solution.

2. Refill both sensor wells with 7 buffer solution.

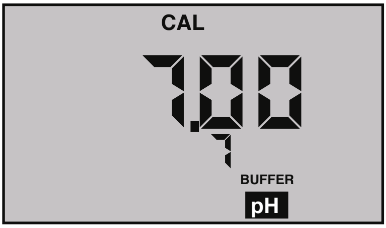


Figure 6

3. Press (pH) to verify the pH calibration. If the display shows 7.00, skip the pH Zero Calibration and proceed to section b. pH Gain Calibration.

4. Press (CAL/MCLR) to enter calibration mode. The “**CAL**”, “**BUFFER**” and “**7**” annunciators will appear (see Figure 6). Displayed value will be the uncalibrated sensor.

NOTES: *If a wrong buffer is added (outside of 6-8 pH),“**7**” and **BUFFER**” will flash, and the Ultrameter II will not adjust.*
The uncalibrated pH value displayed in step 4 will assist in determining the accuracy of the pH sensor. If the pH reading is above 8 with pH 7 buffer solution, the sensor well needs additional rinsing or the pH sensor is defective and needs to be replaced.

5. Press (▲/MS) or (MR/▼) until the display reads 7.00.

NOTE: *Attempted calibration of >1 pH point from factory calibration will cause “**FAC**” to appear. This indicates the need for sensor replacement (ref. Troubleshooting pg. 35) or fresh buffer solution. The “FAC” internal electronic calibration is not intended to replace calibration with pH buffers. It assumes an ideal pH sensor. Each “FAC” indicates a factory setting for that calibration step (i.e., 7, acid, base).*

You may press (CAL/MCLR) *to accept the preset factory value, or you may* *reduce your variation from factory setting by pressing* ▲/MS *or* MR/▼*.*

6. Press CAL/MCLR to accept the new value. The pH Zero Calibration is now complete. You may continue with pH Gain Calibration or exit by pressing any measurement key.

b. <u>pH Gain Calibration (6P)</u>

Important: Always calibrate or verify your Ultrameter II with a pH 7 buffer solution before adjusting the gain with acid or base buffers, i.e., 4 and/or 10, etc. Either acid or base solution can be used for the 2nd point "Gain" calibration and then the opposite for the 3rd point. The display will verify that a buffer is in the sensor well by displaying either "Acd" or "bAS".

1. The pH calibration mode is initiated by either completion of the pH Zero Calibration, or verifying 7 buffer and pressing the CAL/MCLR key twice while in pH measurement mode.
2. At this point the "**CAL**", "**BUFFER**" and "**Acd**" or "**bAS**" annunciators will be displayed (see Figures 7 and 8).

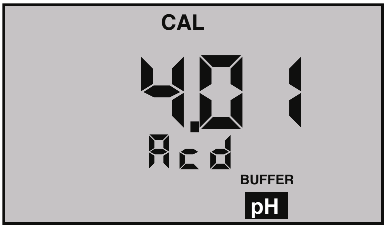


Figure 7

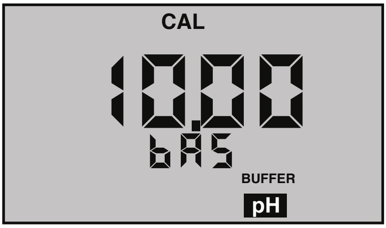


Figure 8

NOTE: *If the "**Acd**" and "**bAS**" indicators are blinking, the unit is indicating an error and needs either an acid or base solution present in the sensor well.*

3. Rinse sensor well 3 times with acid or base buffer solution.
4. Refill sensor well again with same buffer solution.
5. Press ▲/MS or MR/▼ until display agrees with buffer value.

6. Press CAL/MCLR to accept 2nd point of calibration. Now the display shows the next type of buffer to be used.

Single point Gain Calibration is complete. You may continue for the 3rd point of Calibration (2nd Gain) or exit by pressing any measurement key. Exiting causes the value accepted for the buffer to be used for both acid and base measurements.
To continue with 3rd point calibration, use basic buffer if acidic buffer was used in the 2nd point, or vice-versa. Again, match the display to the known buffer value as in step 2 and continue with the following steps.

7. Repeat steps 3 through 6 using opposite buffer solution.
8. Press CAL/MCLR to accept 3rd point of calibration which ends Calibration procedure. Fill sensor well with Myron L Storage Solution and replace protective cap.

6. ORP Calibration (6P)

ORP electrodes rarely give false readings without problems in the reference electrode. For this reason, and because calibration solutions for ORP are highly reactive and potentially hazardous, your Ultrameter II has an electronic ORP calibration. This causes the zero point on the reference electrode to be set whenever pH 7 calibration is done.

7. Temperature Calibration

Temperature calibration is not necessary in the Ultrameter II.

VIII. CALIBRATION INTERVALS

There is no simple answer as to how often one should calibrate an instrument. The Ultrameter II is designed to not require frequent recalibration. The most common sources of error were eliminated in the design, and there are no mechanical adjustments. Still, to ensure specified accuracy, any instrument has to be checked against chemical standards occasionally.

A. Suggested Intervals

On the average, we expect calibration need only be checked monthly for the Conductivity, RES or TDS functions. The pH (6P) function should be checked every 2 weeks to ensure accuracy. Measuring some solutions will require more frequent intervals.

B. Calibration Tracking Records

To minimize your calibration effort, keep records. If adjustments you are making are minimal for your application, you can check less often. Changes in conductivity calibration should be recorded in percent. Changes in pH calibration (6P) are best recorded in pH units.

Calibration is purposely limited in the Ultrameter II to ±10% for the conductivity cell because more than that indicates damage, not drift. Likewise, calibration changes are limited to ±1 pH unit (6P) because more than that indicates the end of the sensor lifetime, and it should be replaced.

C. Conductivity, RES, TDS Practices to Maintain Calibration

1. Clean oily films or organic material from the cell electrodes with foaming cleaner or mild acid. Do not scrub inside the cell.

2. Calibrate with solutions close to the measurements you make. Readings are compensated for temperature based on the type of solution. If you choose to measure tap water with a KCl compensation, which is often done (ref. An Example, pg. 39), and you calibrate with 442 solution because it is handy, the further away from 25°C you are, the more error you have. Your records of calibration changes will reflect temperature changes more than the instrument's accuracy.

3. Rinse out the cell with pure water after making measurements. Allowing slow dissolving crystals to form in the cell contaminates future samples.

4. For maximum accuracy, keep the pH sensor cap on tight so no fluid washes into the conductivity cell.

D. pH and ORP Practices to Maintain Calibration (6P)

1. Keep the sensor wet with Myron L Storage Solution.

2. Rinse away caustic solutions immediately after use.

ORP calibration solutions are caustic, and ±5% is considered very accurate. By using the pH zero setting (0 mV = 7 pH) for ORP and precision electronics for detection, the Ultrameter II delivers better accuracy without calibration than a simpler instrument could using calibration solutions.

IX. MEMORY

This feature allows up to 100 readings with their temperatures to be stored simultaneously for later recall. At the same time, the TIME and DATE are also recorded. To download the memory to a computer, (ref. uDock™ IR Data Port, pg. 30).

A. Memory Storage

1. While displaying a measurement, press ▲ MS to record the displayed value.
2. "**MEMORY**" will appear and the temperature display will be momentarily replaced by a number (1-100) showing the position of the record. Figure 9 shows a reading of 1806 μS stored in memory record #4.

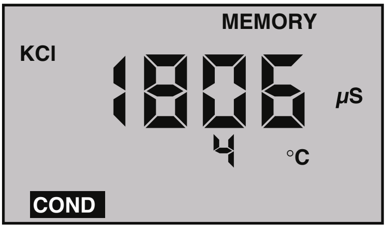


Figure 9

B. Memory Recall

1. Press any measurement key.
2. Press MR ▼, "**MEMORY**" will appear, and the display will show the last record stored.
3. Press ▲ MS or MR ▼ to scroll to the record location desired (the temperature display alternates between temperature recorded and location number).
4. Press CAL MCLR to display time and date stamp.
5. Press any measurement key to leave memory recall or allow to automatically turn off.

C. Clearing a Record/Memory Clear

After recalling a certain record location, press and HOLD CAL MCLR to clear that memory. This space will be the place for the next memory record, unless you scroll to another empty position before ending the recall sequence. The next memory stored will go into the next highest available memory location.
Example: You have locations 1-7 filled. You want to clear the conductivity reading stored in record location #**3** and replace it with a pH reading.

1. Press MR ▼ and scroll to location #**3**.
2. Press and HOLD CAL MCLR to clear old record #**3**.
3. Fill pH/ORP sensor well with sample.
4. Press pH to measure sample and press ▲ MS to store reading in location #**3**.
5. The next memory stored will go into location #**8**.
6. To clear **<u>all</u>** records: After pressing MR ▼, scroll down. "**CLr ALL**" will be displayed (see Figure 10).
7. Press CAL MCLR. All records will be cleared.

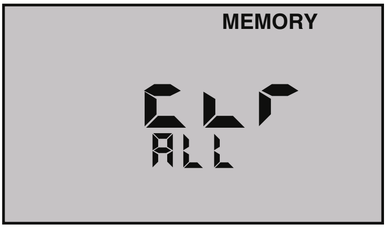


Figure 10

X. <u>TIME and DATE</u>

The Time and Date may easily be changed as you travel.

A. <u>Setting TIME</u>
Time is always displayed in 24 hour time.
Example shown in Figure 11, 16:05 equals 4:05 PM.

1. Press COND.
2. Press MR ▼ until the time is displayed (stored readings, PC OFF, CLr ALL, time i.e. "**16:05**").
3. Press CAL MCLR to initiate. **CAL** will be displayed along with the time, (see Figure 11).

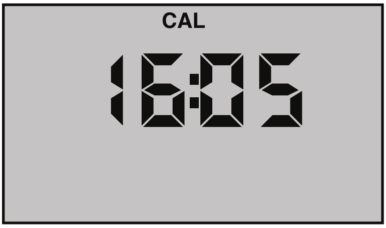


Figure 11

4. Press the ▲ MS or MR ▼ to change the time.

5. Press CAL MCLR to accept the change (new time).

B. <u>Setting DATE</u>

Example shown in Figure 12, is in US format i.e. mo/dy/yr. NOTE: The default format is US. Date format may be changed (ref. Date Format "US and International (Int)", pg. 24).

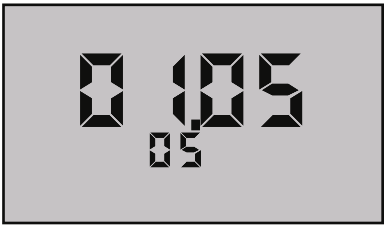


Figure 12

1. Press COND.

2. Press MR ▼ repeatedly until the date is displayed (stored readings, PC OFF, CLr ALL, time, date, i.e. **01.05/05** (January 5, 2005)).

3. Press CAL MCLR to initiate. **CAL** will be displayed along with the YEAR, (see Figure 13).

4. Press ▲ MS or MR ▼ to change the YEAR.

5. Press CAL MCLR to accept the change (new year).

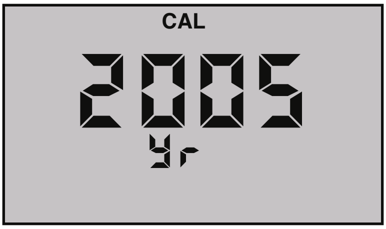


Figure 13

6. Press ▲ MS or MR ▼ to change the month.

7. Press CAL MCLR to accept the change (new month), (see Figure 14).

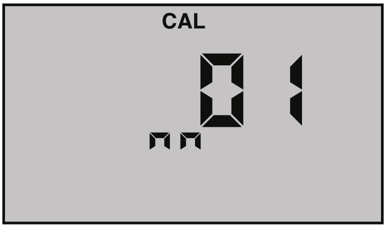


Figure 14

8. Press the ▲ MS or MR ▼ to change the day.

9. Press CAL MCLR to accept the change (new day) (see Figure 15).

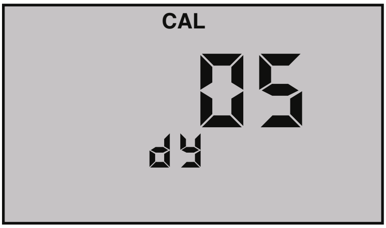


Figure 15

C. DATE FORMAT "US & International (Int)"

1. Press COND.

2. Press MR ▼ repeatedly until the format is displayed (stored readings, PC OFF, CLr ALL, time, date, date **format**).

3. Press CAL MCLR to change. Display will now indicate other format (see Figures 16 & 17).

4. Press any measurement key or allow to automatically turn off.

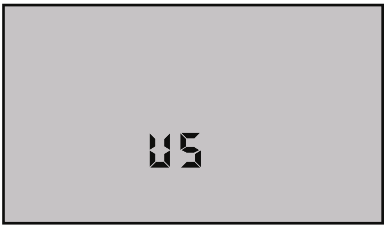


Figure 16

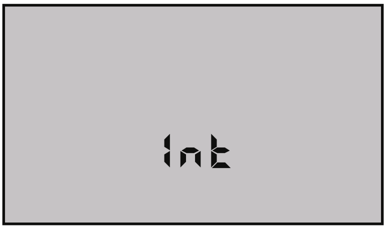


Figure 17

XI. TEMPERATURE FORMAT "Centigrade & Fahrenheit"

1. Press COND.

2. Press MR ▼ to display the stored memory records.

3. Press MR ▼ repeatedly until you pass the "**US**" or "**Int**" date

format location. The display will show a “**C**” or “**F**” (see Figures 18 & 19).

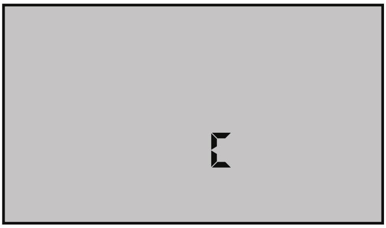


Figure 18

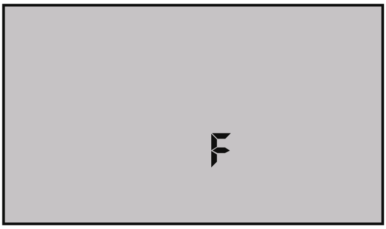


Figure 19

4. Press CAL/MCLR; the display will change to the other unit.

5. Press COND; all temperature readings are now in degrees last shown.

NOTE: *Tempco will still be shown in %/°C.*

XII. TOTAL RETURN to FACTORY SETTINGS “FAC SEL”

There may come a time when it would be desirable to quickly reset all the recorded calibration values in the instrument back to the factory settings. This might be to ensure all calibrations are set to a known value, or to give the instrument to someone else free of adjustments or recorded data for a particular application.
NOTE: All stored data will be lost.

1. Press COND.

2. Press MR ▼ to display the stored memory records.

3. Press MR ▼ repeatedly until you pass the CLr ALL and the C-F locations. The display will show a “**FAC SEL**” (see Figure 20).

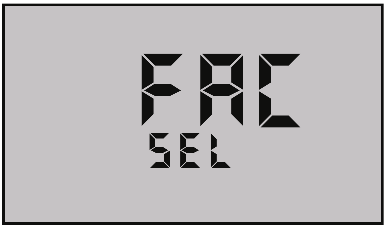


Figure 20

4. Press CAL/MCLR to accept the resetting. Display will return to Cond.

XIII. CELL CHECK

The cell check verifies the cleanliness of the conductivity/TDS/resistivity sensor. In normal use the cell may become dirty or coated and require cleaning. If the display is showing "**.00**" when the cell cup is dry, the sensor is probably clean. However, when testing high purity water in resistivity (RES) mode improved accuracy may be desired. No matter what a manufacturer claims, a sensor can and will become contaminated or coated; therefore require cleaning. A true 4-wire sensor, as in the Ultrameter II, helps to mitigate contamination, but NO SENSOR IS 100% IMMUNE.

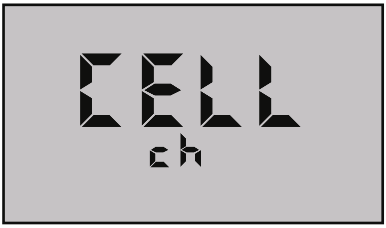


Figure 21

1. Press COND.
2. Press MR ▼ to display the stored memory records.
3. Press MR ▼ repeatedly until you pass the **FAC SEL** location. The display will show a "**CELL ch**" (see Figure 21).

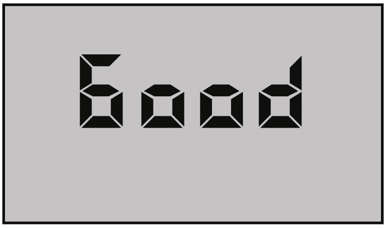


Figure 22

4. Press CAL/MCLR to test.

   If cell is clean, **Good** will momentarily be displayed (see Figure 22). If cell is dirty, **CELL cLn** will be displayed (see Figure 23), (ref. Cleaning Sensors, pg. 32).

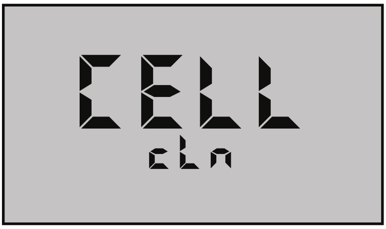


Figure 23

XIV. AUTO OFF

Auto off allows the user to adjust the time the instrument is ON (up to 75 seconds) after each press of a key. Default time is 15 seconds with 60 seconds in CAL (calibration) mode.

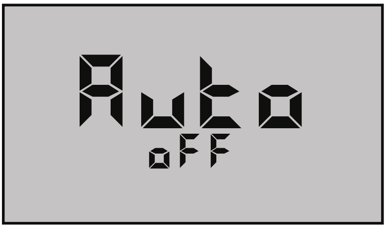


Figure 24

1. Press COND.

2. Press MR ▼ to display the stored memory records.

3. Press MR ▼ repeatedly until you pass the CELL ch location.

The display will show “**Auto oFF**” (see Figure 24).

4. Press CAL MCLR to initiate. **CAL** will be displayed along with the “**15 SEC**” (see Figure 25).

5. Press ▲ MS or MR ▼ to change the time (see Figure 26). Maximum time is shown.

6. Press CAL MCLR to accept the change (new time).

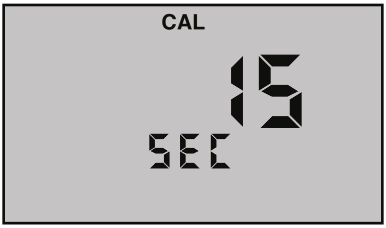


Figure 25

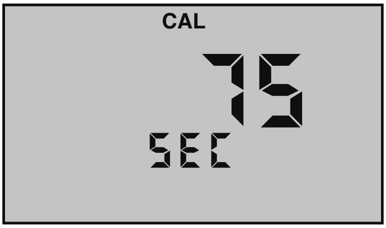


Figure 26

XV. USER MODE CALIBRATION LINC™ FUNCTION

Linc™ function allows easy calibration when in User mode and the user does not have a user standard solution to calibrate the instrument. This function will ensure more repeatable and accurate measurements than many other calibration methods. It is recommended that this function be used to provide the highest degree of confidence when the Ultrameter II is used in “User” mode. When Linc is used, the User mode is linked to another standard, i.e. if User and KCl are linked, a KCl standard solution is used to calibrate the instrument. It is that simple.

A. Calibration of Ultrameter II for use in User Mode

1. Press COND or TDS key.

2. Calibrate the unit using a Standard Solution, (ref. CALIBRATION, pg. 14).

3. Place the Ultrameter II in User mode, (ref. SOLUTION SELECTION, pg. 11).

4. Verify/Set the calibration linc. (See below – Setting User Mode Calibration Linc).

B. Setting User Mode Calibration “Linc”

The linc function sets or “links” the calibration gain factor of a Standard Solution to the User solution mode. Once set, the “linc” will stay intact with future calibrations unless the linc has been canceled. For more information on canceling the User Mode Calibration Linc refer to the section “Canceling User Mode Calibration Linc”, pg. 29.
Follow the steps below to set either the KCl, NaCl or 442 calibration factor to the User solution mode.

1. Press measurement key desired to be “Linked”, i.e. (COND), (RES) or (TDS).
2. Place the Ultrameter II in User mode, (ref. SOLUTION SELECTION, pg. 11, for selecting the User Mode).
3. Press (MR ▼) arrow key until the menu “**Linc**” appears (see Figure 27).

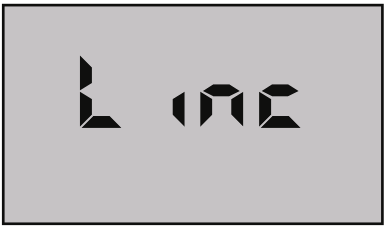


Figure 27

4. Press (CAL MCLR) key. The instrument will display “**SEL**” and the “**User**” Icon (see Figure 28).

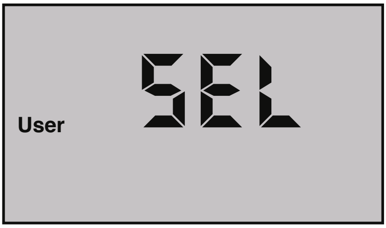


Figure 28

Any additional display of KCl, NaCl or 442 icons indicates a linc between the User solution and the other solution displayed.

5. Press (▲ MS) or (MR ▼) keys to select a Standard Solution to be linked to the User mode calibration constant, (see Figure 29). **User** linked to **KCl**.

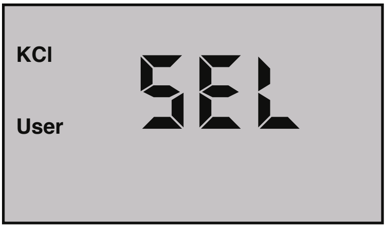


Figure 29

If none of the Solution Selection icons are displayed, (i.e. KCl, NaCl or 442) nothing has been linked to User mode.

6. Press CAL/MCLR key to accept the setting. Pressing any of the measurement keys will exit without changing the setting. User mode “linc” is now complete. The User mode will now use the calibration gain constant used for the calibration of the Standard Solution as outlined above.

C. Canceling User Mode Calibration “Linc”

The Ultrameter II must be in **User** linked mode in order to cancel the “linc”, (ref. SOLUTION SELECTION, pg. 11).

1. Press “Linked” measurement key COND, RES or TDS.

   Two solution icons will be shown in the left side of display - “**User**” and another, i.e., “**KCl**”.
2. Press MR/▼ key until the menu “**Linc**” appears, (see Figure 27).
3. Press CAL/MCLR key, the instrument will display both “**SEL**” and the “**User**” Icon.
4. Press MR/▼ key until “**User**” is the only solution icon being displayed.
5. Press CAL/MCLR key.
6. The User mode calibration “Linc” has now been canceled.

NOTES:

1. To maintain repeatability, use the same standard solutions for future calibrations.

2. Calibration of the Ultrameter II Gain Factor for User mode is not available when the calibration linc has been established. The other calibration functions (i.e. Temperature Compensation %/C settings and TDS Ratio settings) are still intact. To perform a calibration of the User mode as described in User Calibration Conductivity/TDS, pg. 15, the User Mode Linc should be canceled. See above Canceling User Mode calibration “Linc”.

3. Once a “linc” has been established for User mode, the “linc” will apply

to all measurement modes using User solution selection (i.e. TDS/User, Cond/User or Res/User).

XVI. uDock™ IR DATA PORT INSTRUCTIONS

Requires Myron L uDock™ accessory package, Model # U2CIP.
The Myron L uDock is powered via the USB port, requiring no external power source. The uDock application will operate on Windows 2000 & XP*, and Macintosh OS9.2 & OSX** based computer systems.

A. Software Installation

1. Place Myron L Ultrameter II uDock Installation CD into your computer.

2. Upon opening, select the folder for your operating system.

3. Install uDock application. See detailed installation instructions on CD.

4. Additional drivers may be required. See our website for the latest information.

B. Hardware Setup

1. Connect USB cable (provided with uDock) to your computer. Assuming your computer is on, the uDock GREEN LED will illuminate indicating there is power to the uDock and that a proper connection has been made.

C. Memory Stack Download

1. Click** or double-click* the uDock icon to open uDock application.

2. Select the proper comm port setting (first time only).

3. Place CLEAN, DRY Ultrameter II on uDock.

4. Press COND key.

5. Press and HOLD MR ▼ key until the menu “**PC OFF**” appears, (see Figure 30).

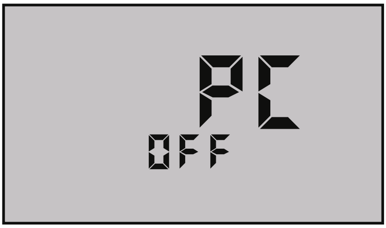


Figure 30

6. Press CAL/MCLR key. "**PC On**" will be displayed, (see Figure 31). The GREEN LED on the uDock will now be blinking periodically, indicating communication has been established between the Ultrameter II and the uDock.

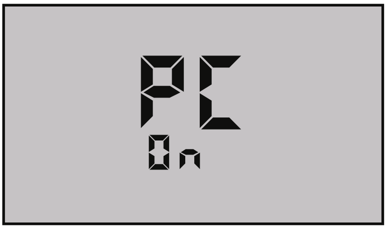


Figure 31

NOTE. "**PC Ini**" may momentarily be displayed while initializing, (see Figure 32).

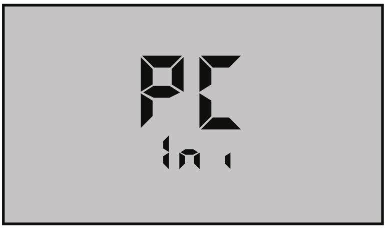


Figure 32

7. On your computer, click on the data download button. A data transfer bar will appear while the data is being downloaded.

Once downloaded, the data may be manipulated, printed or stored within the Myron L uDock application, or the data may be exported to another more powerful spreadsheet † such as Excel*.

† Please Note: Although the Myron L Company has performed extensive testing, we can not guarantee compatibility of all applications and formats. We suggest testing your application and format for compatibility before relying on it.

Additional features such as setting time and date and erasing data are available. See uDock software installation CD or visit www.myronl.com for the latest instructions.

8. Upon completion, click on the "disconnect" icon.

9. Turn off Ultrameter II PC download mode by selecting any measurement function. Failure to do so will reduce battery life.

* ™ Microsoft
** ™ Macintosh

XVII. CARE and MAINTENANCE

Ultrameter IIs should be rinsed with clean water after use. Solvents should be avoided. Shock damage from a fall may cause instrument failure.

A. Temperature Extremes

Solutions in excess of 71°C/160°F should not be placed in the cell cup area; this may cause damage. The pH sensor may fracture if the Ultrameter II temperature is allowed to go below 0°C (32°F). Care should be exercised not to exceed rated operating temperature.

Leaving the Ultrameter II in a vehicle or storage shed on a hot day can easily subject the instrument to over 66°C/150°F. This will void the warranty.

B. Battery Replacement

Dry Instrument THOROUGHLY. Remove the four (4) bottom screws. Open instrument carefully. Carefully detach battery from circuit board. Replace with 9 volt alkaline battery. Replace bottom, ensuring the sealing gasket is installed in the groove of the top half of case. Re-install screws, tighten evenly and securely.

NOTE: *Because of nonvolatile EEPROM circuitry, all data stored in memory and all calibration settings are protected even during power loss or battery replacement. However, loss of time and date may occur if battery is removed for longer than 3 minutes (180 seconds).*

C. pH/ORP Sensor Replacement (6P)

Order model RPR. When ordering, be sure to include the model and serial number of your instrument to ensure receiving the proper type. Complete installation instructions are provided with each replacement sensor.

D. Cleaning Sensors

1. Conductivity/TDS/Resistivity

The conductivity cell cup should be kept as clean as possible. Flushing with clean water following use will prevent buildup on electrodes. However, if very dirty samples — particularly scaling types — are allowed to dry in the cell cup, a film will form. This film reduces accuracy. When there are visible films of oil, dirt, or scale in the cell cup or on the electrodes, use isopropyl alcohol or a foaming non-abrasive household cleaner. Rinse out the cleaner and your Ultrameter II is ready for accurate measurements.

2. pH/ORP (6P)

The unique pH/ORP sensor in your Ultrameter II is a nonrefillable combination type which features a porous liquid junction. It should not be allowed to dry out. If it does, the sensor can sometimes be rejuvenated by first cleaning the sensor well with isopropyl alcohol or a liquid spray cleaner such as Windex™ or Fantastic™ and rinsing well. Do not scrub or wipe the pH/ORP sensor.

Then use one of the following methods:

1. Pour a HOT salt solution ~60°C/140°F, preferably potassium chloride (KCl) solution (Myron L pH/ORP Sensor Storage Solution) — HOT tap water with table salt (NaCl) will work fine — in the sensor well and allow to cool. Retest.

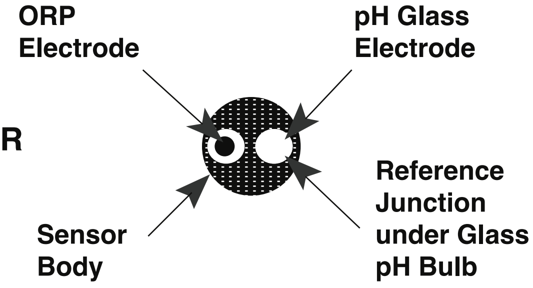
or

2. Pour DI water in the sensor well and allow to stand for no more than 4 hours (longer can deplete the reference solution and damage the glass bulb). Retest.

If neither method is successful, sensor must be replaced.

“Drifting” can be caused by a film on the pH sensor bulb and/or reference. Use isopropyl alcohol (IPA) or spray a liquid cleaner such as Windex™ or Fantastic™ into the sensor well to clean it. The sensor bulb is very thin and delicate. Do not scrub or wipe the pH/ORP sensor.

pH/ORP SENSOR
Top View



Leaving high pH (alkaline) solutions in contact with the pH sensor for long periods of time can damage it. Rinsing such liquids from the pH/ORP sensor well and refilling well with Myron L Storage Solution, a saturated KCl solution, pH 4 buffer, or a salty tap water, will extend the sensor’s useful life.

Samples containing chlorine, sulfur, or ammonia can “poison” any pH electrode. If it is necessary to measure the pH of any such sample, thoroughly rinse the sensor well with clean water immediately after taking the measurement. Any sample element which will reduce (add an electron to) silver, such as cyanide, will attack the reference electrode.

Replacement sensors are available only from the Myron L Company or its authorized distributors.

XVIII. TROUBLESHOOTING CHART

Symptom	**Possible Cause**
No **display**, even though measurement key pressed	Battery weak or not connected.
Inaccurate **pH** readings (6P)	1. pH calibration needed (ref. pH Cal., pg. 17). 2. Cross-contamination from residual pH buffers or samples in sensor well. 3. Calibration with expired pH buffers.
No response to **pH** changes (6P)	Sensor bulb is cracked or an electromechanical short caused by an internal crack.
Will not adjust down to **pH** 7 (6P)	pH/ORP sensor has lost KCl.
pH readings drift or respond slowly to changes in buffers/samples *or* "FAC" is displayed repeatedly (6P)	1. Temporary condition due to "memory" of solution in pH sensor well for long periods. 2. Bulb dirty or dried out. 3. Reference junction clogged or coated.
Unstable **Conductivity/TDS/ Resistivity** readings	1. Dirty electrodes. 2. Test samples greater than 1 megohm.
Unable to calibrate **Conductivity/TDS**	Film or deposits on electrodes.
Resistivity readings much lower than expected	1. Contamination from previous sample or from pH sensor well. 2. Carbon dioxide in test sample.

Corrective Action
Check connections or replace battery (ref. Battery Replacement, pg. 32).
1. Recalibrate instrument. 2. Thoroughly rinse sensor well. 3. Recalibrate using fresh buffers (ref. pH Buffer Solutions, pg. 37).
Replace pH/ORP sensor (ref. Replacement pH/ORP Sensor, pg. 38).
Clean and rejuvenate sensor (ref. Cleaning Sensors, pg. 32) and recalibrate. If no improvement, replace pH/ORP sensor (ref. Replacement pH/ORP Sensor, pg. 38).
Clean and rejuvenate sensor (ref. Cleaning Sensors, pg. 32) and recalibrate. If no improvement, replace pH/ORP sensor (ref. Replacement pH/ORP Sensor, pg. 38).
1. Clean cell cup and electrodes (ref. Cleaning Sensors, pg. 32). 2. Minimize test sample exposure to air (ref. Measuring Resistivity, pg. 10).
Clean cell cup and electrodes (ref. Cleaning Sensors, pg. 32).
1. Rinse cell cup more thoroughly before measurement. Ensure pH cap is snugly in place. 2. See Measuring Resistivity, pg. 10.

XIX. ACCESSORIES

A. Conductivity/TDS Standard Solutions

Your Ultrameter II has been factory calibrated with the appropriate Myron L Company NIST traceable KCl, NaCl, and our own 442™ standard solutions. Most Myron L conductivity standard solution bottles show three values referenced at 25°C: Conductivity in microsiemens/micromhos and the ppm/TDS equivalents based on our 442 Natural Water™ and NaCl standards. All standards are within ±1.0% of reference solutions. Available in 2 oz., quarts/liters, and gallon/~3.8 liter bottles.

1. Potassium Chloride (KCl)

The concentrations of these reference solutions are calculated from data in the International Critical Tables, Vol. 6. The 7000 μS is the recommended standard. Order KCl-7000.

2. 442 Natural Water™

442 Natural Water Standard Solutions are based on the following salt proportions: 40% sodium sulfate, 40% sodium bicarbonate, and 20% sodium chloride, which represent the three predominant components (anions) in freshwater. This salt ratio has conductivity characteristics approximating fresh natural waters and was developed by the Myron L Company over four decades ago. It is used around the world for measuring both conductivity and TDS in drinking water, ground water, lakes, streams, etc. The 3000 ppm is the recommended standard.
Order 442-3000.

3. Sodium Chloride (NaCl)

This is especially useful in sea water mix applications, as sodium chloride is its major salt component. Most Myron L standard solution labels show the ppm NaCl equivalent to the conductivity and to ppm 442 values. The 14.0 mS is the recommended standard. Order NaCl-14.0.

B. pH Buffer Solutions (6P)

pH buffers are available in pH values of 4, 7 and 10. Myron L Company buffer solutions are traceable to NIST certified pH references and are color-coded for instant identification. They are also mold inhibited and accurate to within ±0.01 pH units @ 25°C. Order 4, 7 or 10 Buffer. Available in 2 oz., quarts/liters, and gallon/~3.8 liter bottles.

C. pH Sensor Storage Solution (6P)

Myron L pH Sensor Storage Solution prolongs the life of the pH sensor. Available in 2 oz., quarts/liters, and gallon/~3.8 liter bottles.

D. Soft Protective Carrying Cases

Padded Cordura® Nylon carrying case features a belt clip for hands-free mobility. Two colors to choose from;
Blue - Model #: UCC
Desert Tan - Model #: UCCDT

® Registered trademark of DuPont

E. Hard Protective Carrying Cases

Large case with 2 oz. bottles of calibration standard solutions (KCl-7000, 442-3000, 4, 7, & 10 pH buffers and pH storage solution).
Model #: PKU
Small case (no calibration standard solutions) - Model #: UPP

F. Replacement pH/ORP Sensor (6P)

pH/ORP sensor is gel filled and features a unique porous liquid junction. It is user-replaceable and comes with easy to follow instructions.
Model #: RPR

G. uDock™ IR Data Port Accessory Package

This accessory allows the operator to download the Ultrameter II memory stack to a spreadsheet on a computer. The package includes a uDock, software CD, and installation and operating instructions.
Model #: U2CIP

XX. TEMPERATURE COMPENSATION (Tempco) of Aqueous Solutions

Electrical conductivity indicates solution concentration and ionization of the dissolved material. Since temperature greatly affects ionization, conductivity measurements are temperature dependent and are normally corrected to read what they would be at 25°C.

A. Standardized to 25°C

Conductivity is very accurately measured in the Ultrameter II by a method that ignores fill level, electrolysis, electrode characteristics, etc., and uses a microprocessor to perform temperature compensation. In simpler instruments, conductivity values are usually assigned an average correction similar to KCl solutions for correction to 25°C. The correction to an equivalent KCl solution is a standard set by chemists. It standardizes the measurements and allows calibration with precise KCl solutions. In the Ultrameter II, this correction can be set to other solutions or tailored for special measurements or applications.

B. Tempco Variation

Most conductivity instruments use an approximation of the temperature characteristics of solutions, perhaps even assuming a constant value. The value for KCl is often quoted simply as 2%/°C. In fact, KCl tempco varies with concentration and temperature in a non-linear fashion. Other solutions have more variation still. The Ultrameter II uses corrections that change with concentration and temperature instead of single average values. See Chart 1.

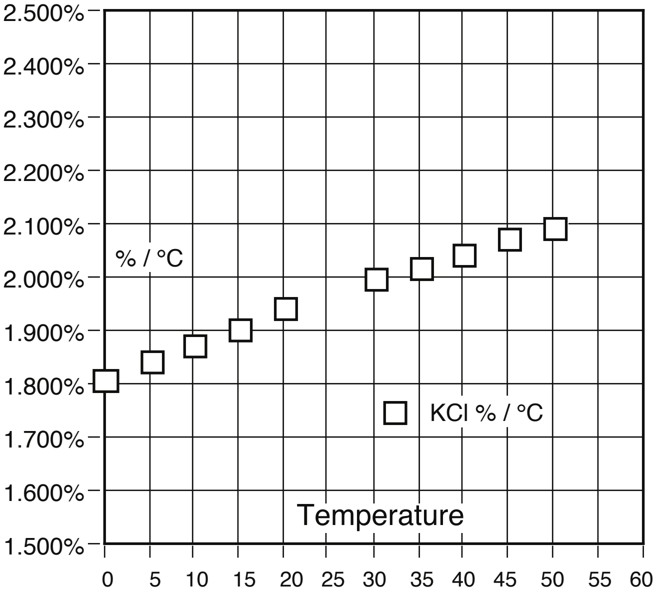


Chart 1

C. An Example of 2 different solution selections and the resulting compensation

How much error results from treating natural water as if it were KCl at 15°C?

A tap water solution should be compensated as 442 with a tempco of 1.68 %/°C, where the KCl value used would be 1.90 %/°C.

Suppose a measurement at 15°C/59°F is 900 microsiemens of true uncompensated conductivity.

Using a 442 correction of 10 (degrees below 25) x 1.68% indicates the solution is reading 16.8% low. For correction, dividing by (.832) yields 1082 microsiemens as a compensated reading.

A KCl correction of 10 (degrees below 25) x 1.9% indicates the solution is reading 19% low. Dividing by (.81) yields 1111 microsiemens for a compensated reading. The difference is 29 out of 1082 = 2.7%.

D. <u>A Chart of Comparative Error</u>

In the range of 1000 μS, the error using KCl on a solution that should be compensated as NaCl or as 442, is shown in the graph below.

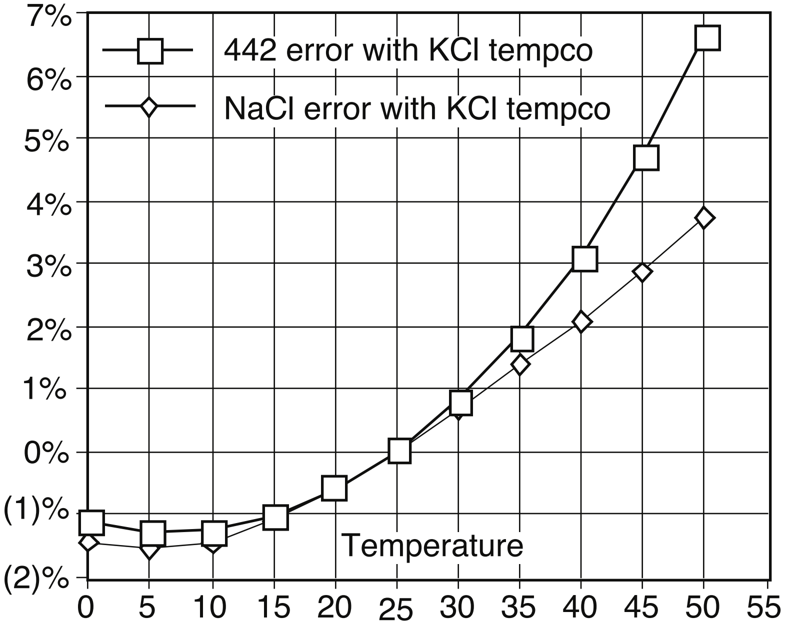


Chart 2

Users wanting to measure natural water based solutions to 1% would have to alter the internal compensation to the more suitable preloaded “442” values or stay close to 25°C. Some who have standardized to KCl based compensation may want to stick with it, regardless of increasing error as you get further from 25°C. The Ultrameter II will provide the repeatability and convertibility of data needed for relative values for process control.

E. <u>Other Solutions</u>

A salt solution like sea water or liquid fertilizer acts like NaCl. An internal correction for NaCl can be selected for greatest accuracy with such solutions. Many solutions are not at all similar to KCl, NaCl or 442. A sugar solution, or a silicate, or a calcium salt at a high or low temperature may require a “User” value peculiar to the application to provide readings close to the true compensated conductivity.

Clearly, the solution characteristics should be chosen to truly represent the actual water under test for rated accuracy of ±1%. Many industrial applications have always been relative measurements seeking a number to indicate a certain setpoint or minimum concentration or trend. The Ultrameter II gives the user the capability to take data in “KCl conductivity units” to compare to older published data, in terms of NaCl or 442, or as may be appropriate. The Ultrameter II can be used to reconcile data taken with other compensation assumptions, especially with its ability to allow custom characteristics through the USER mode.

XXI. CONDUCTIVITY CONVERSION to TOTAL DISSOLVED SOLIDS (TDS)

Electrical conductivity indicates solution concentration and ionization of the dissolved material. Since temperature greatly affects ionization, conductivity measurements are temperature dependent and are normally corrected to read what they would be at 25°C (ref. Temperature Compensation, pg. 38).

A. How it’s Done

Once the effect of temperature is removed, the compensated conductivity is a function of the concentration (TDS). Temperature compensation of the conductivity of a solution is performed automatically by the internal processor, using data derived from chemical tables. Any dissolved salt at a known temperature has a known ratio of conductivity to concentration. Tables of conversion ratios referenced to 25°C have been published by chemists for decades.

B. Solution Characteristics

Real world applications have to measure a wide range of materials and mixtures of electrolyte solutions. To solve this problem, industrial users commonly use the characteristics of a standard material as a model for their solution, like the KCl favored by chemists for its stability.

Users dealing with sea water, etc., use NaCl as the model for their concentration calculations. Users dealing with freshwater work with mixtures including sulfates, carbonates and chlorides, the three predominant components (anions) in freshwater that the Myron L Company calls “natural water”. These are modeled in a mixture called “442” which the Myron L Company markets for use as a calibration standard, as it does standard KCl and NaCl solutions.

The Ultrameter II contains internal algorithms for these 3 most commonly referenced compounds. In the LCD display, the solution type being used is displayed on the left. Besides KCl, NaCl, and 442, there is the “USER” choice. The benefit of USER is that one may enter the temperature compensation and TDS ratio by hand, greatly increasing accuracy of readings for a specific solution. That value remains a constant for all measurements, and should be reset for different dilutions or temperatures.

C. When does it make a lot of difference?

First, the accuracy of temperature compensation to 25°C determines the accuracy of any TDS conversion. Assume we have industrial process water to be pretreated by RO. Assume it is 45°C and reads 1500 μS uncompensated.

1. If NaCl compensation is used, an instrument would report 1035 μS compensated, which corresponds to 510 ppm NaCl.

2. If 442 compensation is used, an instrument would report 1024 μS compensated, which corresponds to 713 ppm 442.

The difference in values is 40%.

In spite of such large error, some users will continue to take data in the NaCl mode because their previous data gathering and process monitoring was done with an older NaCl referenced device.

Those who want true TDS readings that will correspond to evaporated weight will select the correct Solution Type. If none of the 3 standard solutions apply, the User mode must be used. Temperature Compensation (Tempco) and TDS Derivation below, details the USER mode.

XXII. TEMPERATURE COMPENSATION (Tempco) and TDS DERIVATION

The Ultrameter II contains internal algorithms for characteristics of the 3 most commonly referenced compounds. In the display, the solution type being used is displayed on the left. Besides KCl, NaCl, and 442, there is the “USER” choice. The benefit of USER mode is that one may enter the tempco and TDS conversion values of a unique solution via the keypad.

A. Conductivity Characteristics

When making conductivity measurements, the Solution Selection determines the characteristic assumed as the instrument reports what a measured conductivity would be if it were at 25°C. The characteristic is represented by the tempco, expressed in %/°C. If a solution of 100 μS at 25°C increases to 122 μS at 35°C, then a 22% increase has happened over this change of 10°C. The solution is said to have a tempco of 2.2 %/°C.

Another solution would have a different tempco because of its ionization activity, and that tempco may be a little different at a different concentration or temperature. This is why the Ultrameter II uses mathematically generated models for known salt characteristics that vary with concentration and temperature.

B. Finding the Tempco of an Unknown Solution

One may need to measure compensated conductivity of some solution unlike any of the 3 standard salts. In order to enter a custom fixed tempco for a limited measurement range, enter a specific value through the "USER" function. The tempco can be determined by 2 different methods:

1. Heat or cool a sample of the solution to 25°C, and measure its conductivity. Heat or cool the solution to a typical temperature where it is normally measured. After selecting USER function, set the tempco to 0 %/°C as in Disabling Temperature Compensation, pg. 13 (No compensation). Measure the new conductivity and the new temperature. Divide the % decrease or increase by the 25°C value. Divide that difference by the temperature difference.

2. Heat or cool a sample of the solution to 25°C, and measure its conductivity. Change the temperature to a typical measuring temperature. Set the tempco to an expected value as in User Programmable Temperature Compensation, pg. 12. See if the compensated value is the same as the 25°C value. If not, raise or lower the tempco and measure again until the 25°C value is read.

C. Finding the TDS Ratio of an Unknown Solution

Once the effect of temperature is removed, the compensated conductivity is a function of the concentration (TDS). There is a ratio of TDS to compensated conductivity for any solution, which varies with concentration. The ratio is set during calibration in USER mode as in section User Programmable Conductivity to TDS Ratio, pg. 13. A truly unknown solution has to have its TDS determined by evaporation and weighing. Then the solution whose TDS is now known can be measured for conductivity and the ratio calculated. Next time the same solution is to be measured, the ratio is known.

XXIII. pH and ORP (6P)

A. pH (6P)

1. pH as an Indicator (6P)

pH is the measurement of Acidity or Alkalinity of an aqueous solution. It is also stated as the Hydrogen Ion activity of a solution. pH measures the effective, not the total, acidity of a solution.

A 4% solution of acetic acid (pH 4, vinegar) can be quite palatable, but a 4% solution of sulfuric acid (pH 0) is a violent poison. pH provides the needed quantitative information by expressing the degree of activity of an acid or base.

In a solution of one known component, pH will indicate concentration indirectly. However, very dilute solutions may be very slow reading, just because the very few ions take time to accumulate.

2. pH Units (6P)

The acidity or alkalinity of a solution is a measurement of the relative availabilities of hydrogen (H^+) and hydroxide (OH^-) ions. An increase in (H^+) ions will increase acidity, while an increase in (OH^-) ions will increase alkalinity. The total concentration of ions is fixed as a characteristic of water, and balance would be 10^{-7} mol/liter (H^+) and (OH^-) ions in a neutral solution (where pH sensors give 0 voltage).

pH is defined as the negative logarithm of hydrogen ion concentration. Where (H^+) concentration falls below 10^{-7}, solutions are less acidic than neutral, and therefore are alkaline. A concentration of 10^{-9} mol/liter of (H^+) would have 100 times less (H^+) ions than (OH^-) ions and be called an alkaline solution of pH 9.

3. The pH Sensor (6P)

The active part of the pH sensor is a thin glass surface which is selectively receptive to hydrogen ions. Available hydrogen ions in a solution will accumulate on this surface and a charge will build up across the glass interface. The voltage can be measured with a very high impedance voltmeter circuit; the trick is to connect the voltmeter to solution on each side.

The glass surface encloses a captured solution of potassium chloride holding an electrode of silver wire coated with silver chloride. This is as inert a connection as can be made from metal to an electrolyte. It still can produce an offset voltage, but using the same materials to connect to the solution on the other side of the membrane allows the 2 equal offsets to cancel.

The problem is, on the other side of the membrane is an unknown test solution, not potassium chloride. The outside electrode, also called the Reference Junction, is of the same construction with a porous plug in place of a glass barrier to allow the junction fluid to contact the test solution without significant migration of liquids through the plug material. Figure 33 shows a typical 2 component pair. Migration does occur, and this limits the lifetime of a pH junction, from depletion of solution inside the reference junction or from contamination. The junction is damaged by drying out because insoluble crystals may form in a layer, obstructing contact with test solutions. See pH/ORP, pg. 44.

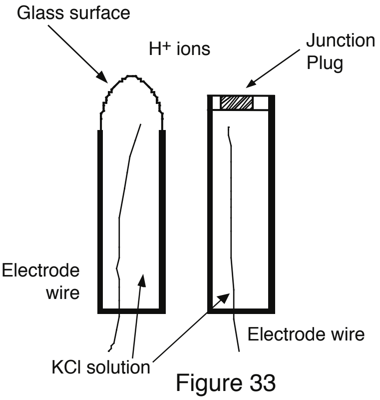


Figure 33

4. The Myron L Integral pH Sensor (6P)

The sensor in the Ultrameter II (see Figure 34) is a single construction in an easily replaceable package. The sensor body holds an oversize solution supply for long life. The reference junction "wick" is porous to provide a very stable, low permeability interface. It is located under the glass pH sensing electrode. The construction combines all the best features of any pH sensor known.

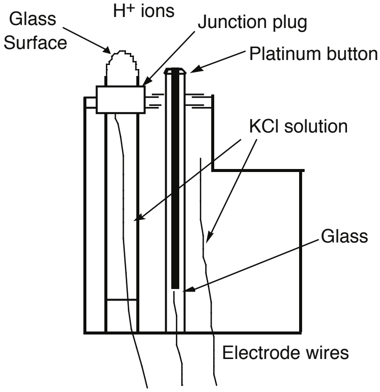


Figure 34

5. Sources of Error (6P)

The basics are presented in pH/ORP, pg. 44.

a. Reference Junction

The most common sensor problem will be a clogged junction because a sensor was allowed to dry out. The symptom is a drift in the "zero" setting at 7 pH. This is why the Ultrameter II does not allow more than 1 pH unit of offset during calibration. At that point the junction is unreliable.

b. Sensitivity Problems

Sensitivity is the receptiveness of the glass surface, which can be diminished by a film on the surface. This problem also causes long response time.

c. Temperature Compensation

pH sensor glass changes its sensitivity slightly with temperature, so the further from pH 7 one is, the more effect will be seen. A pH of 11 at 40°C would be off by 0.2 units. The Ultrameter II senses the sensor well temperature and compensates the reading.

B. ORP/Oxidation-Reduction Potential/REDOX (6P)

1. ORP as an Indicator (6P)

ORP is the measurement of the ratio of oxidizing activity to reducing activity in a solution. It is the potential of a solution to give up electrons (oxidize other things) or gain electrons (reduce).

Like acidity and alkalinity, the increase of one is at the expense of the other, so a single voltage is called the Oxidation-Reduction Potential, with a positive voltage showing, a solution wants to steal electrons (oxidizing agent). For instance, chlorinated water will show a positive ORP value.

2. ORP Units (6P)

ORP is measured in millivolts, with no correction for solution temperature. Like pH, it is not a measurement of concentration directly, but of activity level. In a solution of only one active component, ORP indicates concentration. Also, as with pH, a very dilute solution will take time to accumulate a readable charge.

3. The ORP Sensor (6P)

An ORP sensor uses a small platinum surface to accumulate charge without reacting chemically. That charge is measured relative to the solution, so the solution “ground” voltage comes from a reference junction - same as the pH sensor uses.

4. The Myron L ORP Sensor (6P)

Figure 34, pg. 45, shows the platinum button in a glass sleeve. The same reference is used for both the pH and the ORP sensors. Both pH and ORP will indicate 0 for a neutral solution. Calibration at zero compensates for error in the reference junction.

A zero calibration solution for ORP is not practical, so the Ultrameter II uses the offset value determined during calibration to 7 in pH calibration (pH 7 = 0 mV). Sensitivity of the ORP surface is fixed, so there is no gain adjustment either.

5. Sources of Error (6P)

The basics are presented in pH/ORP, pg. 44, because sources of error are much the same as for pH. The junction side is the same, and though the platinum surface will not break like the glass pH surface, its protective glass sleeve can be broken. A surface film will slow the response time and diminish sensitivity. It can be cleaned off with detergent or acid, as with the pH glass.

XXIV. SOFTWARE VERSION

Contact the Myron L Company to see if a software upgrade is available.

1. Press (COND) key.
2. Press (MR ▼) key until three numbers are displayed as shown in Figure 35.
3. Press (COND) key, instrument will time out in ~15 seconds.

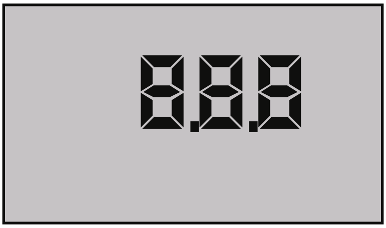


Figure 35

XXV. GLOSSARY

Anions -	Negatively charged ions. See Solution Characteristics, pg. 41.
Algorithm -	A procedure for solving a mathematical problem. See Temperature Compensation and TDS Derivation, pg. 42.
Logarithm -	An arithmetic function. See pH Units, pg. 44.
ORP -	Oxidation-Reduction Potential or REDOX, See ORP/ Oxidation-Reduction Potential/REDOX, pg. 46.
TDS -	Total Dissolved Solids or the Total Conductive Ions in a solution. See Conductivity Conversion to TDS, pg. 41.
Tempco -	Temperature Compensation See Temperature Compensation, pg. 38.
USER -	A mode of operation that allows the instrument user (operator) to set a tempco and/or a TDS factor for their specific solution type. See Temperature Compensation, pg. 38 and Temperature Compensation (Tempco) and TDS Derivation, pg. 42.

For details on specific areas of interest refer to Table of Contents.

XXVI. ADDENDUM

XXVII. NOTES

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Made In USA

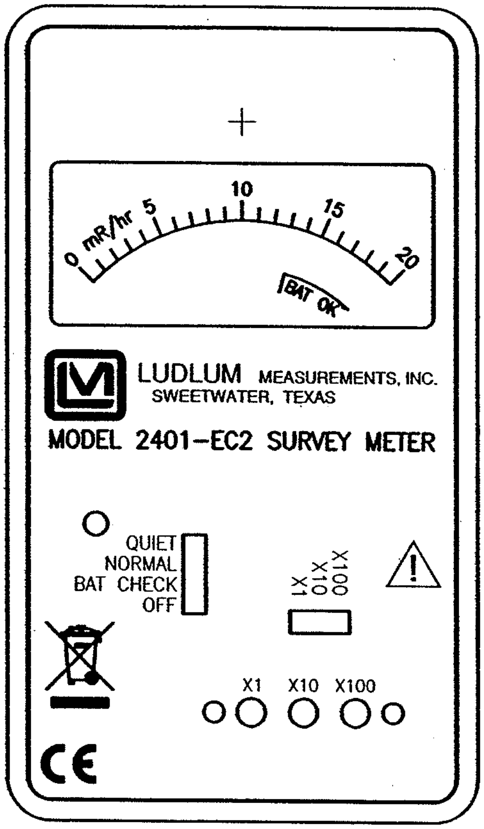
LUDLUM MODELS 2401-EC, 2401-EW, 2401-EC2 AND 2401-P POCKET SURVEY METERS

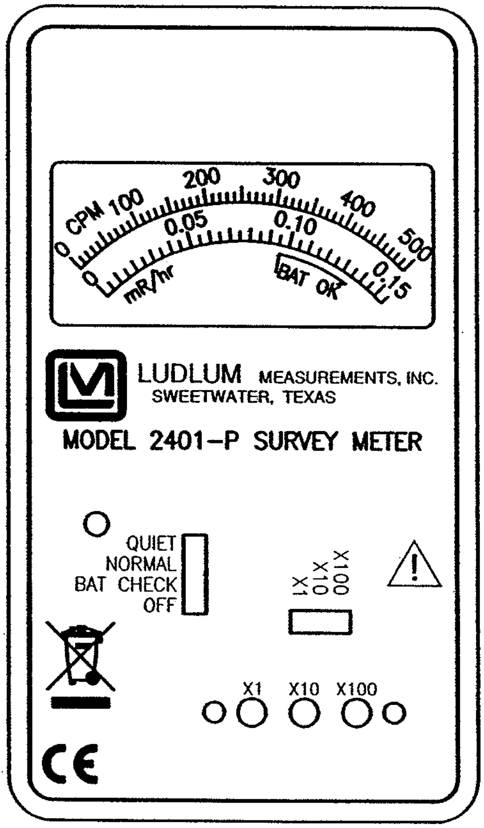
December 2006

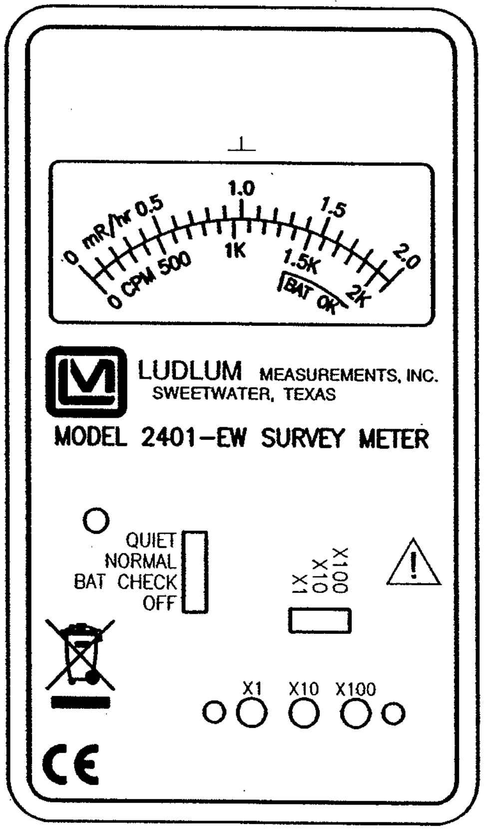
Serial Number 137772 and Succeeding Serial Numbers

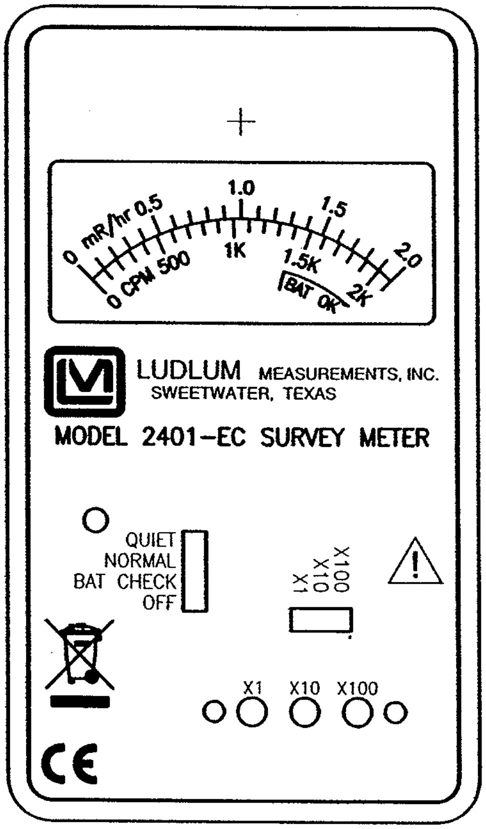
LUDLUM MEASUREMENTS, INC.
501 OAK STREET, P.O. BOX 810
SWEETWATER, TEXAS 79556
325-235-5494, FAX: 325-235-4672

REV #	ALTERATIONS	DATE	BY
1	VALID	1-15-97	TJR
2	ADDED CE MARKS	9-14-05	CMC
3	ADDED SYMBOLS	04/25/06	PW









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TITLE M 2401 SERIES					
LUDLUM MEASUREMENTS, INC. 501 OAK STREET SWEETWATER, TEXAS 79556			SERIES 397		SHEET 79

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Section 1

Introduction

The Model 2401 series of hand-held or "pocket" radiation survey instruments are designed to quickly and easily measure ionizing radiation. Different types are available featuring different internal detectors. These types are distinguished from one another by a suffix following the "Model 2401" designation. The units are self-contained and require no external accessories.

This manual applies to the following instruments in the Model 2401 series:

Model 2401-EC - contains an energy-compensated Geiger-Mueller (GM) tube detector which measures low levels of gamma radiation. One or two measurement scales are provided on the meter face (in addition to the BAT OK range). If two scales are provided, they indicate exposure rate and count rate. Examples of exposure rate units are mR/hr and mSv/h, while count rate may be measured in counts per minute (cpm) or counts per second (cps).

Model 2401-EW - has a thin end-window G-M tube detector that measures alpha, beta, and gamma radiation. The mica window has a thickness (window area density) of 1.5 - 2.0 mg/cm^2. Two measurement scales may be provided on the meter face as described above.

Model 2401-EC2 - contains an energy-compensated G-M tube detector. This is basically the same as the Model 2401-EC, with the capability of measuring higher levels of gamma radiation with corresponding measurement scales.

Model 2401-P - employs a full-size "pancake" tube detector (2-inch diameter) that can measure alpha, beta and gamma radiation. One or two measurement scales may be provided on the meter face in units of exposure rate and/or count rate as described above.

Each instrument in the Model 2401 series has a large 2.5-inch analog meter for displaying the radiation level. A 3-decade range switch allows the user to switch among the 3 ranges (×1, ×10 and ×100). A BAT CHECK position on the selector switch allows the meter to show the battery level. A QUIET position allows the user to turn the click-per-event audio off. A 9-volt battery powers the unit. Battery life is typically 250 hours at normal background levels. A steady tone from the audio speaker (whether in NORMAL or QUIET mode) indicates that the battery needs to be changed; proper instrument operation is not guaranteed while the steady tone is present.

Section 2

Getting Started

Battery Installation

Ensure the instrument selector switch is in the OFF position. Remove the four screws from the back side of the instrument and remove the back housing. Place a 9-volt battery in battery holder and press onto battery terminals. Replace the instrument housing and screws.

Caution!

Damage to the Mica window on the back side of the Model 2401-P and on the top of the Model 2401-EW may result if careful instrument handling is not practiced. The window is very fragile and may be punctured quite easily.

Battery Test

The battery should be checked each time the instrument is turned on. Slide the selector switch to the BAT CHECK position. Ensure that the meter needle deflects to the battery check portion on the meter scale. If the meter does not respond, check to see if the battery has been correctly installed. Replace the battery if necessary.

Instrument Test

After checking the battery, slide the instrument selector switch to the NORMAL position. Slide the range switch to the ×1 position. A small meter needle deflection will likely occur, due to normal background radiation. If the meter needle deflects past full-scale slide the range switch to the next highest range until a reading can be determined. The amount of deflection will depend upon the particular series of instrument (due to meter scale differences) and the amount of normal background radiation. The instrument speaker should emit a frequency (clicks) relative to the increase in meter reading.

Place the instrument selector switch in the QUIET position and note that the audible clicks are silenced. In order to preserve battery life it is recommended that the instrument selector switch be kept in the QUIET position when the audio function is not needed.

While in an area of normal background radiation, expose the center of the detector to a check source. Ensure the check source reading is within 20% of the reference reading obtained during the last calibration.

Note:

The crosshairs above the meter on the black front panel indicate the location of the center of the detector. The exception to this is the Model 2401-P where the center of the detector is visible on the back side of the instrument.

Once this procedure has been completed, the instrument is ready for use.

Operational Check

To assure proper operation of the instrument between calibrations and periods of nonuse, an instrument operational check including battery test and instrument test (as described above) should be performed prior to use. A reference reading with a check source should be obtained at the time of initial calibration or as soon as possible for use in confirming proper instrument operation. In each case, ensure a proper reading on each scale. If the instrument fails to read within 20% of a proper reading, it should be sent to a calibration facility for recalibration.

Section 3

Specifications

Detector Tubes: GM tubes, with different characteristics for various models as follows:

Model 2401-EC - energy-compensated tube; gamma

Model 2401-EW - end-window tube; alpha, beta, gamma

Model 2401-EC2 - energy-compensated tube; gamma

Model 2401-P - standard 2-inch diameter pancake tube; alpha, beta, gamma

Sensitivity: Typical values with a ^{137}Cs source, as follows:

Model 2401-EC - 1050 cpm per mR/hr

Model 2401-EW - 1050 cpm per mR/hr

Model 2401-EC2 - 120 cpm per mR/hr

Model 2401-P - 3300 cpm per mR/hr

Energy Response:

Model 2401-EC - Within 20% of true value from 60 keV to 3 MeV

Model 2401-EW - Energy dependent

Model 2401-EC2 - Within 20% of true value from 60 keV to 3 MeV

Model 2401-P - Energy dependent

Operating Voltage: Typically 550 Vdc for peanut tube detectors (as in Models 2401-EC, 2401-EW and 2401-EC2); 900 Vdc for pancake tube detector (as in the Model 2401-P).

Power: One 9-volt battery; typical life is 250 hours at normal background radiation levels.

Response Time: Typically 8 seconds from 10% to 90% of the final reading.

Accuracy: Within 10% of true reading.

Meter: 2.5-inch arc, 1 mA rugged analog meter.

Calibration Controls: Located underneath the calibration cover on the front panel, these switches allow adjustment of the ×1, ×10 and ×100 ranges.

Audio: Speaker emits a click per radiation event. The sound level is typically 70 dB at 2 feet and can be turned off by placing the selector switch in the QUIET position. The audio speaker also emits a steady tone when the battery level drops, indicating the need for battery replacement.

Size: 1.8" (4.6 cm) H × 3.3" (8.4 cm) W × 5.3" (13.5 cm) L.

Weight: 0.9 lbs (0.4 kg), including battery.

Finish: Drawn-and-cast aluminum fabrication, with beige powder coat paint and a recessed subsurface-printed membrane panel.

Section 4

Identification of Controls and Functions

Meter Face: Meter faces vary within the series though all come standard with a mR/hr scale and a BAT OK scale. In addition, most meter faces have a cpm scale. The actual radiation measurement is determined by multiplying the meter face reading by the multiple associated by the selected position of the range switch.

> **Important!**
>
> Units of exposure rate, such as mR/hr, apply to gamma radiation only. However, exposure rate readings on the Model 2401-EW, or 2401-P may be affected by alpha and beta particles if they are not intentionally blocked.

Range Switch: This is a three-position switch marked ×1, ×10, and × 100. Moving the range switch to one of the range multiplier positions (×100, ×10, ×1) provides the operator with an overall range dependant upon the series of instrument and detector used. Multiply the scale reading by the multiplier to determine the actual scale reading.

Selector Switch: Sliding the range switch from OFF to BAT provides the operator with a battery check of the instrument. A BAT OK scale on the meter face provides a visual means of checking the battery-charge status. Placing this switch in the NORMAL position places the instrument into normal operating mode and energizes the unimorph speaker located on the left side of the instrument. The number of audible clicks is relative to the meter reading; the higher the reading, the more audible clicks. To reduce battery drain, the switch should be placed in the QUIET position with the audio function is not needed.

Range Calibration Adjustments: Recessed potentiometers located under the front panel calibration cover. These controls allow for individual calibration of each range multiplier.

Crosshairs: The crosshairs above the meter on the black front panel indicate the location of the center of the detector. The exception to this is in the case of the Model 2401-P where the center of the detector is visible on the back side of the instrument. When surveying for radiation, position the instrument as close as possible to the area to be measured, with the detector centered.

Section 5

Safety Considerations and Maintenance

Environmental Conditions for Normal Use

Indoor or outdoor use

No maximum altitude with the exception of the Model 2401-P and 2401EW where an altitude of 8000 feet above sea level should not be exceeded. The later two instruments must be sealed in an airtight container when transported by air in order to prevent damage to the detector.

Temperature range of –20°C to 50°C (–4°F to 122°F). May be certified for operation from –40°C to 65°C (–40°F to 150°F).

Maximum relative humidity of 95% (non-condensing)

Pollution Degree 1 (as defined by IEC 664)

Warning Markings and Symbols

Caution!

The operator or responsible body is cautioned that the protection provided by the equipment may be impaired if the equipment is used in a manner not specified by Ludlum Measurements, Inc.

The Model 2401 Series of Instruments are marked with the following symbols:

CAUTION (per ISO 3864, No. B.3.1) – designates hazardous live voltage and risk of electric shock. During normal use, internal components are hazardous live. This instrument must be isolated or disconnected from the hazardous live voltage before accessing the internal components. This symbol appears on the front panel. **Note the following precautions:**

Warning!

The operator is strongly cautioned to take the following precautions to avoid contact with internal hazardous live parts that are accessible using a tool:

1. Turn the instrument power OFF and remove the battery.
2. Allow the instrument to sit for 1 minute before accessing internal components.

The "**crossed-out wheelie bin**" symbol notifies the consumer that the product is not to be mixed with unsorted municipal waste when discarding; each material must be separated. The symbol is placed on the front panel. See section 7, "Recycling" for further information.

Mica Window Precaution

Caution!

Damage to the Mica window on the back side of the Model 2401-P and on the top of the Model 2401-EW may result if careful instrument handling is not practiced. The window is very fragile and may be punctured quite easily.

Cleaning and Maintenance Precautions

Instrument maintenance consists of keeping the instrument clean and periodically checking the battery, slide switches and calibration. The Model 2401 series of instruments (excluding detector windows) may be cleaned externally with a damp cloth, using only water as the wetting agent. Do not immerse the instrument in any liquid. Observe the following precautions when cleaning or performing maintenance on the instrument:

1. Turn the instrument OFF and remove the battery.
2. Allow the instrument to sit for 1 minute before cleaning the exterior or accessing any internal components for maintenance.

Maintenance

RECALIBRATION

Recalibration should be accomplished after maintenance or adjustments have been performed on the instrument. Recalibration is not normally required following instrument cleaning or battery replacement

Note:

Ludlum Measurements, Inc. recommends recalibration at intervals no greater than one year. Check appropriate local procedures and regulations to determine required recalibration intervals.

Ludlum Measurements offers a full service repair and calibration department. We not only repair and calibrate our own instruments but most other manufacturer's instruments. Calibration procedures are available upon request for customers who choose to calibrate their own instruments.

SLIDE SWITCHES

Use of the instrument in extremely dusty or dirty environments may cause the slide switches (instrument selector and range switch) to operate erratically. These switches may be restored to proper operation by applying low pressure air to remove the accumulated dirt.

Section 6

Radiation Basics

Radiation and Life

Adapted from Eric J. Hall's book, "Radiation and Life"

Radiation is energy traveling through space. Sunshine is one of the most familiar forms of radiation. It delivers light, heat and suntans. We control its effect on us with sunglasses, shade, air conditioners, hats, clothes and sunscreen.

There would be no life on earth without lots of sunlight, but we have increasingly recognized that too much of it on our bodies is not a good thing. In fact it may be dangerous, so we control our exposure to it.

Sunshine consists of radiation in a range of wavelengths from long-wave infrared to short-wavelength ultraviolet, which creates the hazard.

Beyond ultraviolet are higher energy kinds of radiation which are used in medicine and which we all get in low doses from space, from the air, and from the earth. Collectively we can refer to these kinds of radiation as **ionizing radiation**. It can cause damage to matter, particularly living tissue. At high levels it is therefore dangerous, so it is necessary to control our exposure.

Background radiation is that which is naturally and inevitably present in our environment. Levels of this can vary greatly. People living in granite areas or on mineralized sands receive more terrestrial radiation than others, while people living or working at high altitudes receive more cosmic radiation. A lot of our natural exposure is due to radon, a gas which seeps from the earth's crust and is present in the air we breathe.

The Unstable Atom

Radiation comes from atoms, the basic building blocks of matter.

Most atoms are stable; a carbon-12 atom, for example, remains a carbon-12 atom forever, and an oxygen-16 atom remains an oxygen-16 atom forever, but certain atoms eventually disintegrate into a totally new atom. These atoms are said to be 'unstable' or 'radioactive'. An unstable atom has excess internal energy, with the result that the nucleus can undergo a spontaneous change towards a more stable form. This is called 'radioactive decay'.

When an atom of a radioisotope decays, it gives off some of its excess energy as radiation in the form of gamma rays or fast-moving sub-atomic particles. One can describe the emissions as gamma, beta and alpha radiation.

Apart from the normal measures of mass and volume, the amount of radioactive material is given in **curie** (Ci), a measure which enables us to compare the typical radioactivity of some natural and other materials.

Radioactivity of some natural and other materials

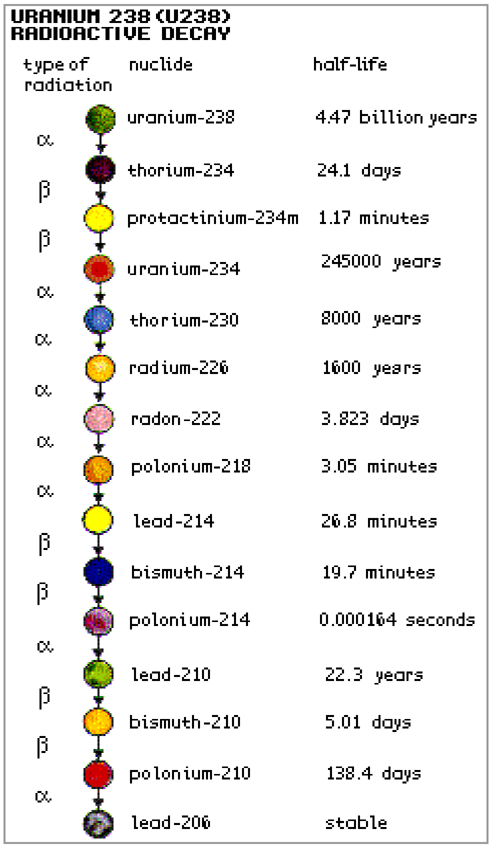
1 adult human (2.7 X 10^{-9} Ci/kg)	1.89 X 10^{-7} Ci
2.2 lbs. of coffee	2.70 X 10^{-8} Ci
2.2 lbs. of super phosphate fertilizer	1.35 X 10^{-7} Ci
The air in a 1076 sq. foot Australian home (radon)	8.12 X 10^{-8} Ci
The air in many 1076 sq. foot European homes (radon)	8.12 X 10^{-7} Ci
1 household smoke detector (with americium)	8.12 X 10^{-7} Ci
Radioisotope for medical diagnosis	1.89 X 10^{3} Ci
Radioisotope source for medical therapy	2702.7 Ci
2.2 lbs. of 50-year old vitrified high-level nuclear waste	270.27 Ci
1 luminous Exit sign (1970s)	27.027 Ci
2.2 lbs. of uranium	675.68 X 10^{6} Ci
2.2 lbs. of uranium ore (Canadian, 15%)	675.68 X 10^{6} Ci

2.2 lbs. of uranium ore (Australian, 0.3%)	13.51 X 10^{6} Ci
2.2 lbs. of low-level radioactive waste	27.03 X 10^{6} Ci
2.2 lbs. of coal ash	5.41 X 10^{-8} Ci
2.2 lbs. of granite	2.70 X 10^{-8} Ci

NB. Though the intrinsic radioactivity is the same, the radiation dose received by someone handling a kilogram of high grade uranium ore will be much greater than for the same exposure to a kilogram of separated uranium, since the ore contains a number of short-lived decay products (see section on Radioactive Decay).

Radioactive Decay

Atoms in a radioactive substance decay in a random fashion but at a characteristic rate. The length of time this takes, the number of steps required and the kinds of radiation released at each step are well known.



URANIUM 238 (U238)
RADIOACTIVE DECAY

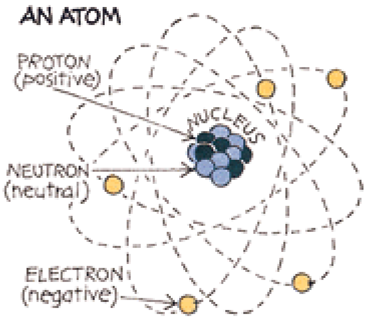
type of radiation	nuclide	half-life
α	uranium-238	4.47 billion years
β	thorium-234	24.1 days
β	protactinium-234m	1.17 minutes
α	uranium-234	245000 years
α	thorium-230	8000 years
α	radium-226	1600 years
α	radon-222	3.823 days
α	polonium-218	3.05 minutes
β	lead-214	26.8 minutes
β	bismuth-214	19.7 minutes
α	polonium-214	0.000164 seconds
β	lead-210	22.3 years
β	bismuth-210	5.01 days
α	polonium-210	138.4 days
	lead-206	stable

The half-life is the time taken for half of the atoms of a radioactive substance to decay. Half-lives can range from less than a millionth of a second to millions of years, depending upon the element concerned. After one half-life the level of radioactivity of a substance is halved, after two half-lives it is reduced to one quarter, after three half-lives to one-eighth and so on.

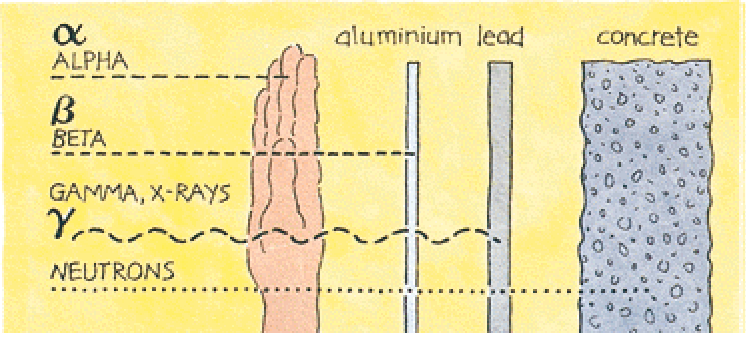
All uranium atoms are mildly radioactive. The following figure for uranium-238 shows the series of different radioisotopes it becomes as it decays, the type of radiation given off at each step and the 'half-life' of each step on the way to stable, non-radioactive lead-206. The shorter-lived each kind of radioisotope, the more radiation it emits per unit mass. Much of the natural radioactivity in rocks and soil comes from this decay chain.

Ionizing Radiation

Here we are concerned mainly with ionizing radiation from the atomic nucleus. It occurs in two forms, rays and particles, at the high frequency end of the energy spectrum.



There are several types of ionizing radiation:



X-rays and gamma rays, like light, represent energy transmitted in a wave without the movement of material, just as heat and light from a fire or the sun travel through space. X-rays and gamma rays are virtually identical, except that X-rays are generally produced artificially rather than coming from the atomic nucleus. Unlike light, X-rays and gamma rays have great penetrating power and can pass through the human body. Thick barriers of concrete, lead or water are used as protection from them.

Alpha particles consist of two protons and two neutrons, in the form of atomic nuclei. They thus have a positive electrical charge and are emitted from naturally occurring heavy elements such as uranium and radium, as well as from some man-made elements. Because of their relatively large size, alpha particles collide readily with matter and lose their energy quickly. They therefore have little penetrating power and can be stopped by the first layer of skin or a sheet of paper.

However, if alpha sources are taken into the body, for example by breathing or swallowing radioactive dust, alpha particles can affect the body's cells. Inside the body, because they give up their energy over a relatively short distance, alpha particles can inflict more severe biological damage than other radiations.

Beta particles are fast-moving electrons ejected from the nuclei of atoms. These particles are much smaller than alpha particles and can penetrate up to 5/64 of an inch of water or human flesh. Beta particles are emitted from many radioactive elements. They can be stopped by a sheet of aluminum a few millimeters thick.

Neutrons are particles which are also very penetrating. On Earth they mostly come from the splitting, or fissioning, of certain atoms inside a nuclear reactor. Water and concrete are the most commonly used shields against neutron radiation from the core of the nuclear reactor.

Note:

It is important to understand that alpha, beta, gamma and X-radiation do not cause the body, or any object around the source, to become radioactive. However, most materials in their natural state (including body tissue) contain measurable amounts of radioactivity.

Measuring Ionizing Radiation

RAD and REM

The human senses cannot detect radiation or discern whether a material is radioactive. However, a variety of instruments can detect and measure radiation reliably and accurately.

The amount of ionizing radiation, or 'dose', received by a person is measured in terms of the energy absorbed in the body tissue, and is expressed in **RAD**. One rad is 0.01 joules deposited per kilogram of mass.

Equal exposure to different types of radiation expressed as RAD, do not however, necessarily produce equal biological effects. One rad of alpha radiation, for example, will have a greater effect than one rad of beta radiation. When we talk about radiation effects, we therefore express the radiation as effective dose, in a unit called the **REM** (Roentgen Equivalent Man).

Regardless of the type of radiation, one rem of radiation produces the same biological effect. (100 rem = 1 Sv)

Smaller quantities are expressed in 'mrem' (one thousandth) or 'µrem' (one millionth of a rem). We will use the most common unit, rem, here.

What Are The Health Risks From Ionizing Radiation?

It has been known for many years that large doses of ionizing radiation, very much larger than background levels, can cause a measurable increase in cancers and leukemias ('cancer of the blood') after some years delay. It must also be assumed, because of experiments on plants and animals, that ionizing radiation can also cause genetic mutations that affect future generations, although there has been no evidence of radiation-induced mutation in humans. At very high levels, radiation can cause sickness and death within weeks of exposure - see Table (on next page).

But what are the chances of developing cancer from low doses of radiation? The prevailing assumption is that any dose of radiation, no matter how small, involves a possibility of risk to human health. However there is no scientific evidence of risk at doses below approximately 5 rem in a short period of time or about 10 rem over a period of one year.

Higher accumulated doses of radiation might produce a cancer which would only be observed several - up to twenty - years after the radiation exposure. This delay makes it impossible to say with any certainty which of many possible agents were the cause of a particular cancer. In western countries, about a quarter of people die from cancers, with smoking, dietary factors, genetic factors and strong sunlight being among the main causes. Radiation is a weak carcinogen, but undue exposure could certainly increase health risks.

On the other hand, large doses of radiation directed specifically at a tumor are used in radiation therapy to kill cancerous cells, and thereby often save lives (usually in conjunction with chemotherapy or surgery). Much larger doses are used to kill harmful bacteria in food, and to sterilize bandages and other medical equipment. Radiation has become a valuable tool in our modern world.

How Much Ionizing Radiation is Dangerous?

Radiation levels and their effects

The following table gives an indication of the likely effects of a range of whole body radiation doses and dose rates to individuals:

1,000 rem as a short-term and whole-body dose would cause immediate illness, such as nausea and decreased white blood cell count, and subsequent death within a few weeks. Between 200 and 1000 rem in a short-term dose would cause severe radiation sickness with increasing likelihood that this would be fatal.
100 rem in a short term dose is about the threshold for causing immediate radiation sickness in a person of average physical attributes, but would be unlikely to cause death. Above 100 rem, severity of illness increases with dose. If doses greater than 100 rem occur over a long period they are less likely to have early health effects but they create a definite risk that cancer will develop many years later.
Above about **10 rem**, the probability of cancer (rather than the severity of illness) increases with dose. The estimated risk of fatal cancer is 5 of every 100 persons exposed to a dose of 100rem (i.e. if the normal incidence of fatal cancer were 25%, this dose would increase it to 30%).
5 rem is, conservatively, the lowest dose at which there is any evidence of cancer being caused in adults. It is also the highest dose which is allowed by regulation in any one year of occupational exposure. Dose rates greater than 5 rem/yr arise from natural background levels in several parts of the world but do not cause any discernible harm to local populations.

2 rem/yr averaged over 5 years is the limit for radiological personnel such as employees in the nuclear industry, uranium or mineral sands miners and hospital workers (who are all closely monitored).
1 rem/yr is the maximum actual dose rate received by any Australian uranium miner.
300-500 mrem/yr is the typical dose rate (above background) received by uranium miners in Australia and Canada.
300 mrem/yr (approx) is the typical background radiation from natural sources in North America, including an average of almost 200 mrem/yr from radon in air.
200 mrem/yr (approx) is the typical background radiation from natural sources, including an average of 70mrem/yr from radon in air. This is close to the minimum dose received by all humans anywhere on Earth.
30-60 mrem/yr is a typical range of dose rates from artificial sources of radiation, mostly medical.
5 mrem/yr, a very small fraction of natural background radiation, is the design target for maximum radiation at the perimeter fence of a nuclear electricity generating station. In practice, the actual dose is less.

What is the risk estimate?

According to the Biological Effects of Ionizing Radiation committee V (BEIR V), the risk of cancer death is 0.08% per rem for doses received rapidly (acute) and might be 2-4 times (0.04% per rem) less than that for doses received over a long period of time (chronic). These risk estimates are an average for all ages, males and females, and all forms of cancer. There is a great deal of uncertainty associated with the estimate.

Risk from radiation exposure has been estimated by other scientific groups. The other estimates are not the exact same as the BEIR V estimates, due to differing methods of risk and assumptions used in the calculations, but all are close.

Risk comparison

The real question is: how much will radiation exposure increase my chances of cancer death over my lifetime.

To answer this, we need to make a few general statements of understanding. One is that in the US, the current death rate from cancer is approximately 20 percent, so out of any group of 10,000 United States citizens, about 2,000 of them will die of cancer. Second, that contracting cancer is a random process, where given a set population, we can estimate that about 20 percent will die from cancer, but we cannot say *which* individuals will die. Finally, that a conservative estimate of risk from low doses of radiation is thought to be one in which the risk is linear with dose. That is, that the risk increases with a subsequent increase in dose. Most scientists believe that this is a conservative model of the risk.

So, now the risk estimates: If you were to take a large population, such as 10,000 people and expose them to one rem (to their whole body), you would expect approximately eight additional deaths (0.08% X 10,000 X 1 rem). So, instead of the 2,000 people expected to die from cancer naturally, you would now have 2,008. This small increase in the expected number of deaths would not be seen in this group, due to natural fluctuations in the rate of cancer.

What needs to be remembered is that it is not known that 8 people will die, but that there is a risk of 8 additional deaths in a group of 10,000 people if they would all receive 1rem instantaneously.

If they would receive the 1 rem over a long period of time, such as a year, the risk would be less than half this (<4 expected fatal cancers).

Risks can be looked at in many ways. Here are a few ways to help visualize risk:

One way often used is to look at the number of "days lost" out of a population due to early death from separate causes, then dividing those days lost between the population to get an "Average Life expectancy lost" due to those causes. The following is a table of life expectancy lost for several causes:

Health Risk	**Est. life expectancy lost**
Smoking 20 cigarettes a day	6 years
Overweight (15%)	2 years
Alcohol (US Avg.)	1 year
All Accidents	207 days
All Natural Hazards	7 days
Occupational dose (300 mrem/yr)	15 days
Occupational dose (1 rem/yr)	51 days

You can also use the same approach to looking at risks on the job:

Industry Type	**Est. life expectancy lost**
All Industries	60 days
Agriculture	320 days
Construction	227 days
Mining and quarrying	167 days
Manufacturing	40 days
Occupational dose (300 mrem/yr)	15 days
Occupational dose (1 rem/yr)	51 days

These are estimates taken from the NRC Draft guide DG-8012 and were adapted from B.L Cohen and I.S. Lee, "Catalogue of Risks Extended and Updates", *Health Physics*, Vol. 61, September 1991.

Another way of looking at risk, is to look at the Relative Risk of 1 in a million chances of dying of activities common to our society:

Smoking 1.4 cigarettes (lung cancer)
Eating 40 tablespoons of peanut butter
Spending 2 days in New York City (air pollution)
Driving 40 miles in a car (accident)
Flying 2500 miles in a jet (accident)
Canoeing for 6 minutes
Receiving 10 mrem of radiation (cancer)

Adapted from DOE Radiation Worker Training, based on work by B.L Cohen, Sc.D.

Background Radiation

Naturally occurring background radiation is the main source of exposure for most people. Levels typically range from about 150-350 mrem per year but can be more than 5rem/yr. The highest known level of background radiation affecting a substantial population is in Kerala and Madras States in India where some 140,000 people receive doses which average over 1.5 rem/year from gamma radiation, in addition to a similar dose from radon. Comparable levels occur in Brazil and Sudan, with average exposures up to about 4 rem/yr to many people.

Several places are known in Iran, India and Europe where natural background radiation gives an annual dose of more than 5 rem and up to 26 rem (at Ramsar in Iran). Lifetime doses from natural radiation range up to a couple thousand rem. However, there is no evidence of increased cancers or other health problems arising from these high natural levels.

Manmade Radiation

Ionizing radiation is also generated in a range of medical, commercial and industrial activities. The most familiar and, in national terms, the largest of these sources of exposure is medical X-rays.

Natural radiation contributes about 88% of the annual dose to the population and medical procedures most of the remaining 12%. Natural and artificial radiations are not different in kind or effect.

Protection from Radiation

Radiation is very easily detected. There is a range of simple, sensitive instruments capable of detecting minute amounts of radiation from natural and man-made sources. There are three ways in which people are protected from identified radiation sources:

Limiting time: For people who are exposed to radiation in addition to natural background radiation through their work, the dose is reduced and the risk of illness essentially eliminated by limiting exposure time. Proper job planning is essential in achieving lowest exposure time. Always plan for the unexpected to eliminate delays in the exposure area.

Distance: In the same way that heat from a fire is less the further away you are, so the intensity of radiation decreases with distance from its source. Distance is the easiest, fastest and most practical way to limit exposure.

Shielding: Barriers of lead, concrete or water give good protection from penetrating radiation such as gamma rays. Highly radioactive materials are therefore often stored or handled under water, or by remote control in rooms constructed of thick concrete or lined with lead.

Standards and Regulation

Much of the evidence which has led to today's standards derives from the atomic bomb survivors in 1945, which were exposed to high doses incurred in a very short time. In setting occupational risk estimates, some allowance has been made for the body's ability to repair damage from small exposures, but for low-level radiation exposure the degree of protection may be unduly conservative.

Most countries have their own systems of radiological protection which are often based on the recommendations of the International Commission on Radiological Protection (ICRP). The 'authority' of the ICRP comes from the scientific standing of its members and the merit of its recommendations.

Who is in charge?

Ultimately, you are. All of the sources of radiation, other than natural, are regulated by laws passed by Congress. Like any other law, you have your right to voice your views and opinions about it. The regulations that control the use of radioactivity in our country are based upon recommendations of science organizations like the International Commission on Radiological Protection (ICRP), the National Council on Radiation Protection (NCRP), the International Atomic Energy Agency (IAEA), the United Nations (UN), and the Health Physics Society (HPS). Governing bodies like the Environmental Protection Agency (EPA), the Nuclear Regulatory Commission (NRC), the Department of Energy (DOE), and the Food and Drug Administration (FDA) review these recommendations and propose the regulations that industry and government must follow. These are then passed by Congress, if found to be acceptable, and published in the Code of Federal Regulations (CFRs).

Note:

The CFR limits the general public to radiation exposure of 100 mrem/year, with no more than 2 mrem of exposure in any one hour (ref. 10 CFR 20.1301).

Section 7

Recycling

Ludlum Measurements, Inc. supports the recycling of the electronics products it produces for the purpose of protecting the environment and to comply with all regional, national and international agencies that promote economically and environmentally sustainable recycling systems. To this end, Ludlum Measurements, Inc. strives to supply the consumer of its goods with information regarding reuse and recycling of the many different types of materials used in its products. With many different agencies, public and private, involved in this pursuit it becomes evident that a myriad of methods can be used in the process of recycling. Therefore, Ludlum Measurements, Inc. does not suggest one particular method over another, but simply desires to inform its consumers of the range of recyclable materials present in its products, so that the user will have flexibility in following all local and federal laws.

The following types of recyclable materials are present in Ludlum Measurements, Inc. electronics products, and should be recycled separately. The list is not all-inclusive, nor does it suggest that all materials are present in each piece of equipment:

Batteries
Circuit Boards
Glass
Plastics
Aluminum and Stainless Steel
Liquid Crystal Display (LCD)

Ludlum Measurements, Inc. products which have been placed on the market after August 13, 2005 have been labeled with a symbol recognized internationally as the "crossed-out wheelie bin" which notifies the consumer that the product is not to be mixed with unsorted municipal waste when discarding; each material must be separated. The symbol is placed on the instrument front panel and appears as such:

Section 8

Parts List

	Reference	Description	Part Number
Models 2401-EC, 2401-EW and 2401-EC2 Survey Meters	UNIT	Completely Assembled Survey Meter:	
		Model 2401-EC	48-2824
		Model 2401-EW	48-2874
		Model 2401-EC2	48-2885
Main Board, Drawing 397 × 75	BOARD	Completely Assembled Main Circuit Board	5397-075
CAPACITORS	C001	68UF, 6.3V	04-5654
	C021	470PF, 100V	04-5668
	C031-C039	470PF, 1KV	04-5693
	C041	470PF, 1KV	04-5693
	C101	10UF, 20V	04-5655
	C102	0.0015UF, 100V	04-5680
	C111	0.1UF, 50V	04-5663
	C131-C132	47PF, 100V	04-5660
	C211	10UF, 20V	04-5655
	C231	0.022UF, 50V	04-5667
	C232	27PF, 100V	04-5658
	C233	100PF, 100V	04-5661
	C0310	470PF, 1KV	04-5693
	C0311	10UF, 20V	04-5655
	C0312	27PF, 100V	04-5658
TRANSISTORS	Q021	2N7002L	05-5840
	Q031	MTD2N50	05-5855
	Q131	MMBT3904T	05-5841
	Q211	MMBT4403LT1	05-5842
	Q221	MMBT4403LT1	05-5842
	Q231	MMBT3904T	05-5841

	Reference	Description	Part Number
INTEGRATED CIRCUITS	U021	ICM7555CBA	06-6300
	U101	MAX638AESA	06-6389
	U131	MAX641BCSA	06-6388
	U211	TLC27M7ID	06-6292
	U221	CD74HC4066M	06-6323
	U231	CD74HC4538M	06-6297
DIODES	CR011	CXSH-4 EB33	07-6358
	CR031-CR034	CMPD2004S	07-6402
	CR041	CMPD2004S	07-6402
	CR101	CXSH-4 EB33	07-6358
THERMISTOR	R216	250	07-6366
SWITCHES	S111	OFF-ON-BAT-QUIET	08-6764
	S112	RANGE	08-6763
POTENTIOMETERS	R102	1M, ×1 ADJ	09-6911
	R104	1M, ×10 ADJ	09-6911
	R202	100K, ×100 ADJ	09-6930
RESISTORS	R001	165K, 125mW, 1%	12-7877
	R002	475K, 125mW, 1%	12-7859
	R021	1.00K, 125mW, 1%	12-7832
	R022	475K, 125mW, 1%	12-7859
	R031	1.00M, 125mW, 1%	12-7844
	R032	3.32M, 125mW, 1%	12-7967
	R033-R034	1.00M, 125mW, 1%	12-7844
	R035	392K, 125mW, 1%	12-7841
	R036	1.00M, 125mW, 1%	12-7844
	R101	10.0K, 125mW, 1%	12-7839
	R103	10.0K, 125mW, 1%	12-7839
	R111	100K, 125mW, 1%	12-7834
	R121	1G	12-7686
	R131	10.0K, 125mW, 1%	12-7839
	R132-R133	100K, 125mW, 1%	12-7834
	R201	1.00K, 125mW, 1%	12-7832
	R211	100K, 125mW, 1%	12-7834
	R212	665K, 250mW, 1%	12-7977
	R213	100K, 125mW, 1%	12-7834
	R214	475K, 125mW, 1%	12-7859
	R215	301, 125mW, 1%	12-7863

	Reference	Description	Part Number
	R221-R223	1.00M, 125mW, 1%	12-7844
	R231	100K, 125mW, 1%	12-7834
	R232	1.00M, 125mW, 1%	12-7844
	R233	33.2K, 250mW, 1%	12-7842
	R234	100K, 125mW, 1%	12-7834
INDUCTORS	L1	150UHY	21-9677
	L21	220UHY	21-9678
	L131	470UHY	21-9699
MISCELLANEOUS	P1	CONNECTOR-640456-2 MTA100×2, METER	13-8073
	DS11	UNIMORPH	21-9782
	B121	BATTERY HOLDER	22-9404
MISCELLANEOUS ASSEMBLY COMPONENTS	*	GM TUBE:	
		Model 2401-EC: LND71210	01-5295
		Model 2401-EW: LND712	01-5032
		Model 2401-EC2: LND71412	01-5306
	*	FP & METER ASSY.:	
		Model 2401-EW	4397-068
		Model 2401-EC	4397-069
		Model 2401-EC2	4397-070
	*	Battery, Alkaline, 9V	21-9282
	1 ea.	M 2401 COVER GASKET	7397-183
	*	CAN ×10:	
		Model 2401-EW	7397-053
		Model 2401-EC/EC2	7397-052
	1 ea.	Unimorph Gasket	7397-063
	2 ea.	Switch Slot Cover	7397-060
	1 ea.	M 2410 CAL COVER	9397-035
Model 2401-P Survey Meter	UNIT	Completely Assembled Model 2401-P Survey Meter	48-2875
Main Board, Drawing 397 × 50	BOARD	Assembled Model 2401-P Main Circuit Board	5397-054
CAPACITORS	C001	68UF, 6.3V	04-5654
	C021	470PF, 100V	04-5668
	C031-C042	470PF, 1KV	04-5693

	Reference	Description	Part Number
	C101	10UF, 20V	04-5655
	C102	0.0047UF, 100V	04-5669
	C111	0.1UF, 50V	04-5663
	C131	47PF, 100V	04-5660
	C201-C202	220PF, 100V	04-5674
	C211	10UF, 20V	04-5655
	C231	0.022UF, 50V	04-5667
	C232	47PF, 100V	04-5660
	C233	27PF, 100V	04-5658
	C234	100PF, 100V	04-5661
	C0310	27PF, 100V	04-5658
	C0311	10UF, 20V	04-5655
TRANSISTORS	Q021	2N7002L	05-5840
	Q031	MTD2N50	05-5855
	Q131	MMBT3904T	05-5841
	Q211	MMBT4403LT1	05-5842
	Q221	MMBT4403LT1	05-5842
	Q231	MMBT3904T	05-5841
INTEGRATED CIRCUITS	U021	M7555CBA	06-6300
	U101	MAX638AESA	06-6389
	U131	MAX641BCSA	06-6388
	U211	TLC27M7ID	06-6292
	U221	CD74HC4066M	06-6323
	U231	CD74HC4538M	06-6297
DIODES	CR11	CXSH-4 EB33	07-6358
	CR31- CR34	CMPD2004S	07-6402
	CR41	CMPD2004S	07-6402
	CR101	CXSH-4 EB33	07-6358
THERMISTOR	R216	250	07-6366
SWITCHES	S111	OFF-ON-BAT-QUIET	08-6764
	S112	RANGE	08-6763
POTENTIOMETERS	R101	1.00M, ×1 ADJ	09-6911
	R103	1.00M, ×10 ADJ	09-6911
	R202	100K, ×100 ADJ	09-6930
RESISTORS	R001	475K, 125mW, 1%	12-7859

	Reference	Description	Part Number
	R002	165K, 125mW, 1%	12-7877
	R021	1.00K, 125mW, 1%	12-7832
	R022	475K, 125mW, 1%	12-7859
	R031	1.00M, 125mW, 1%	12-7844
	R032	10M, 125mW, 1%	12-7955
	R033- R034	1.00M, 125mW, 1%	12-7844
	R035	392K, 125mW, 1%	12-7841
	R036	1.00M, 125mW, 1%	12-7844
	R102	10.0K, 125mW, 1%	12-7839
	R104	10.0K, 125mW, 1%	12-7839
	R111	100K, 125mW, 1%	12-7834
	R121	1G	12-7686
	R131	10.0K, 125mW, 1%	12-7839
	R132-R133	100K, 125mW, 1%	12-7834
	R201	1.00K, 125mW, 1%	12-7832
	R211	100K, 125mW, 1%	12-7834
	R212	665K, 250mW, 1%	12-7977
	R213	100K, 125mW, 1%	12-7834
	R214	475K, 125mW, 1%	12-7859
	R215	301, 125mW, 1%	12-7863
	R221- R223	1.00M 125mW, 1%	12-7844
	R231	100K, 125mW, 1%	12-7834
	R232	1.00M, 125mW, 1%	12-7844
	R233	33.2K, 125mW, 1%	12-7842
	R234	100K, 125mW, 1%	12-7834
INDUCTORS	L001	150UHY	21-9677
	L021	220UHY	21-9678
	L141	470UHY	21-9699
MISCELLANEOUS	P1	CONNECTOR 640456-2, MTA100×2, METER	13-8073
	B121	BATTERY-HLDR #1294 9V PCB	22-9404
	DS11	UNIMORPH-PKM22EPP-4001	21-9782
MISCELLANEOUS ASSEMBLY COMPONENTS	*	GM TUBE - LND7311	01-5008
	*	Tube Clip	01-5237
	*	M 2401-P FP & METER ASSY.	4397-072
	*	Battery, alkaline, 9V	21-9282
	*	Cable, Belden	21-9312
	1ea.	Unimorph Gasket	7397-063

Reference	Description	Part Number
2ea.	Switch Slot Cover	7397-060
*	M 2401-P CAN	7397-038
*	M 2401-P PANCAKE SCREEN	7397-042
*	M 2401-P TUBE HOLDER GASKET	7397-065
*	TUBE HOLDER BOTTOM BRACKET	7397-083
*	TUBE HOLDER TOP BRACKET	7397-084
*	M 2401 CAL COVER	9397-035

Section 9

Drawings

Model 2401-EC Front View, Drawing 397 × 30

Model 2401-EW Front View, Drawing 397 × 42

Model 2401-EC2 Front View, Drawing 397 × 46

Model 2401-P Front View, Drawing 397 × 41

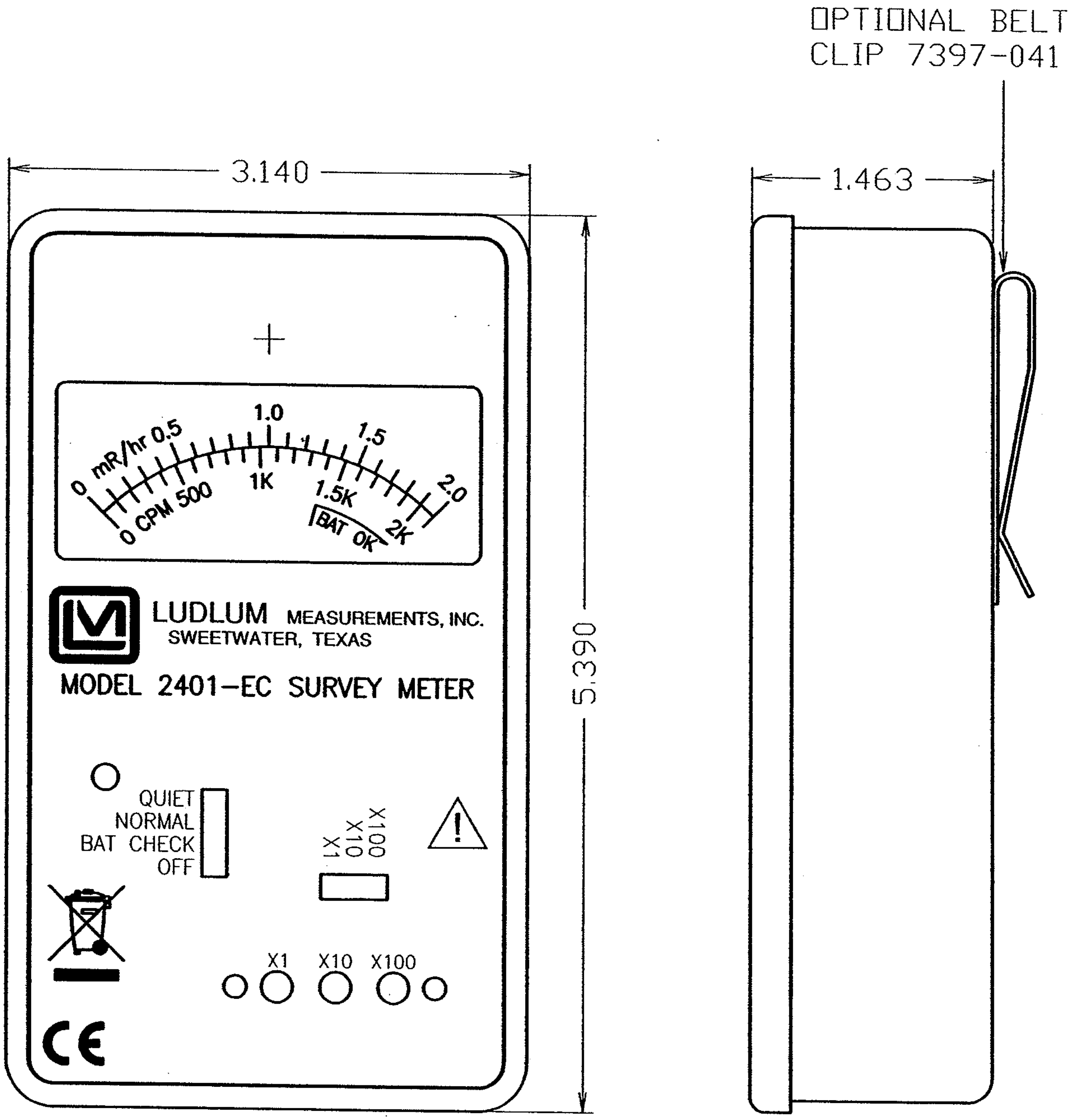
Model 2401 Main Circuit Board Schematic, Drawing 397 × 75

Model 2401 Main Circuit Board Component Layout, Drawing 397 × 76 (2 sheets)

Model 2401-P Main Circuit Board Schematic, Drawing 397 × 50

Model 2401-P Main Circuit Board Component Layout, Drawing 397 × 51 (2 sheets)

REV#	ALTERATIONS	DATE	BY
1	VALID	12-19-96	JGW
2	ADDED CE MARK	9-14-05	CMC
3	ADDED SYMBOLS	04/25/06	PW



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TITLE MODEL 2401EC							
LUDLUM MEASUREMENTS, INC. 501 OAK STREET SWEETWATER, TEXAS 79556			SERIES 397		SHEET 30		

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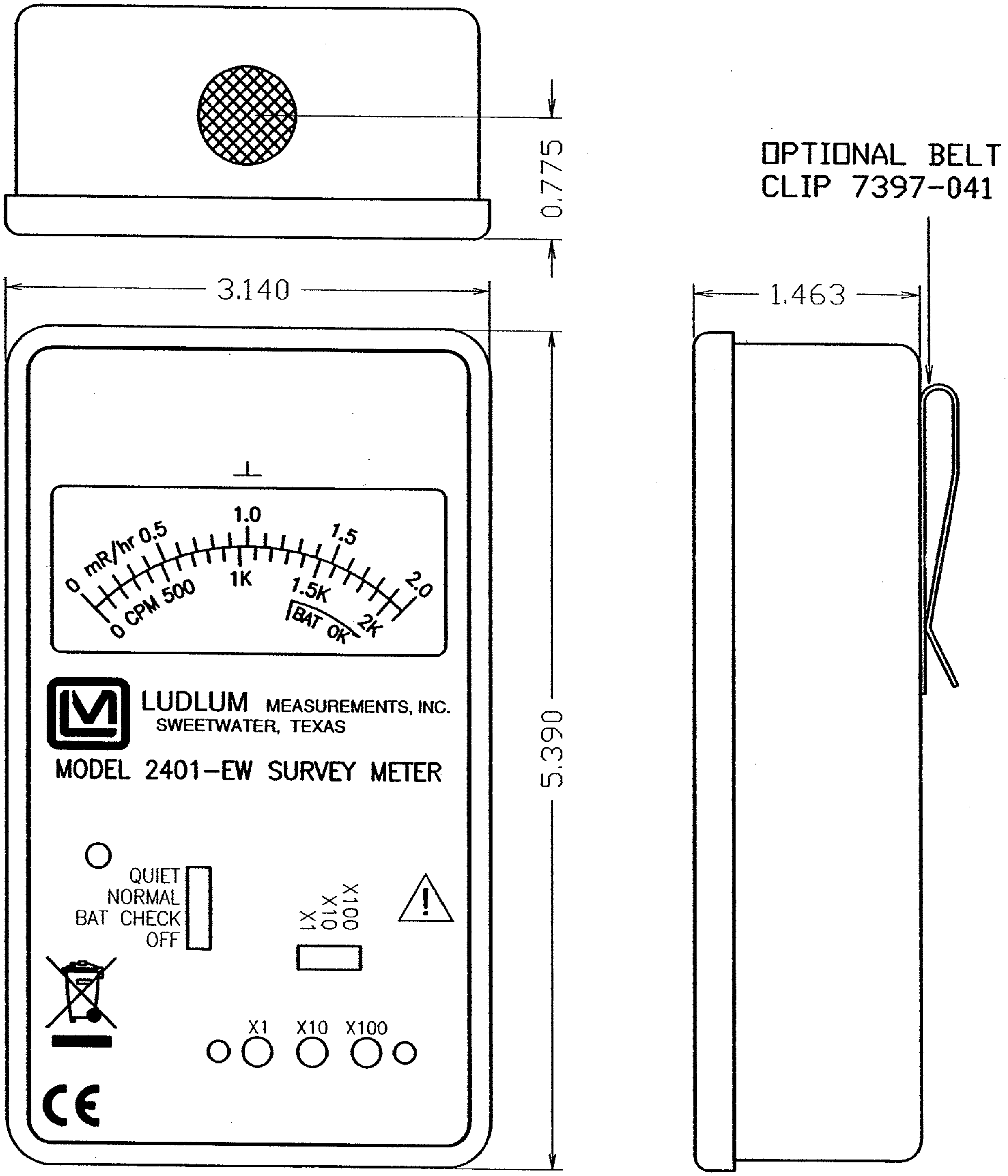

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SCALE: FULL ☒ OTHER

TITLE MODEL 2401EW

LUDLUM MEASUREMENTS, INC.
501 OAK STREET
SWEETWATER, TEXAS 79556

SERIES 397
SHEET 42

REV #	ALTERATIONS	DATE	BY
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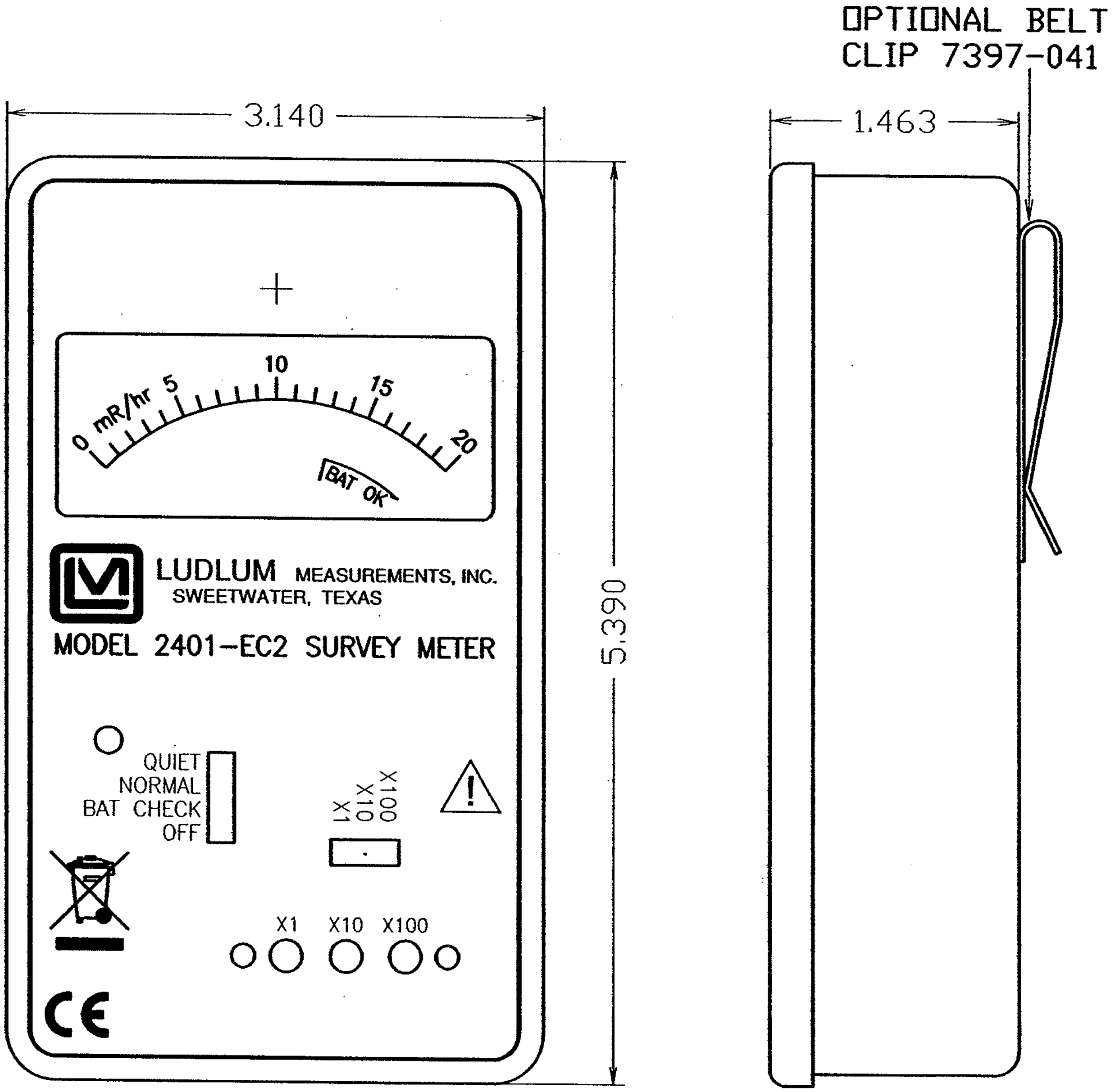

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SCALE: FULL ☒ OTHER

TITLE MODEL 2401-EC2

LUDLUM MEASUREMENTS, INC.
501 OAK STREET
SWEETWATER, TEXAS 79556

SERIES 397

SHEET 46

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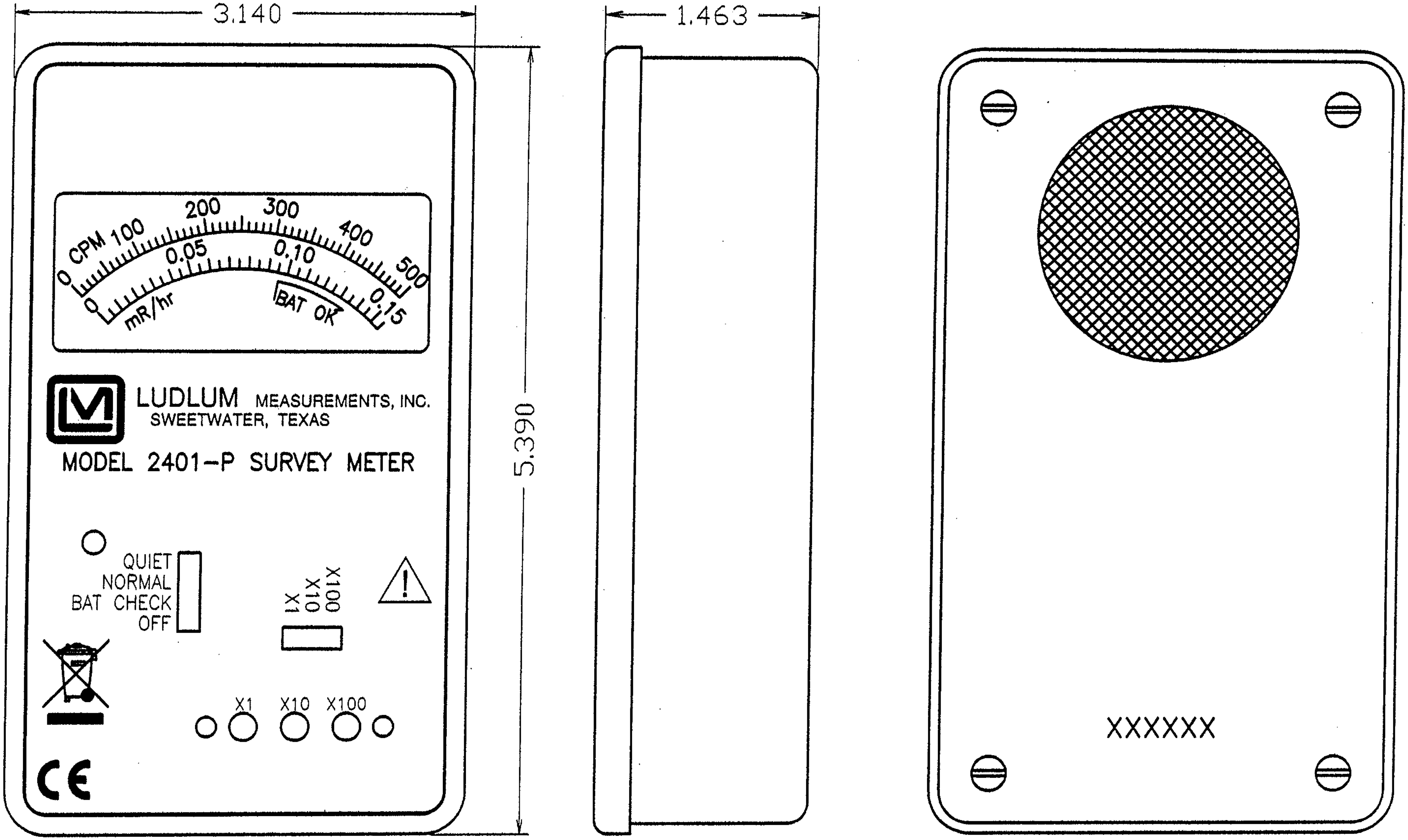

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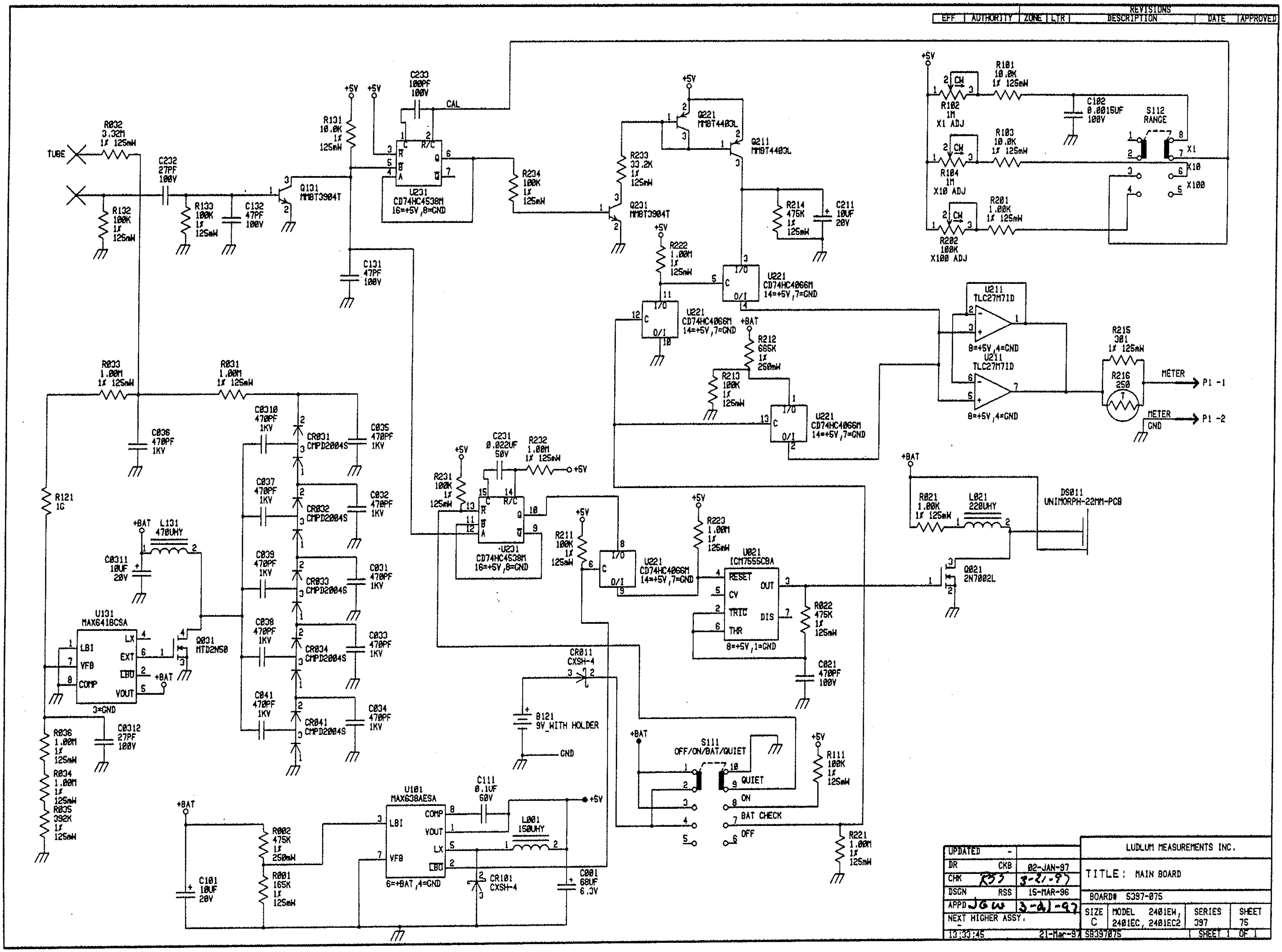
LUDLUM MEASUREMENTS, INC.
501 OAK STREET
SWEETWATER, TEXAS 79556

SERIES 397
SHEET 41



REVISIONS

EFF	AUTHORITY	ZONE	LTR	DESCRIPTION	DATE	APPROVED

LUDLUM MEASUREMENTS INC.

TITLE: MAIN BOARD

BOARD# 5397-075

UPDATED		-
DR	CKB	02-JAN-97
CHK	R55	3-21-97
DSGN	RSS	15-MAR-96
APPD	JGW	3-21-97

NEXT HIGHER ASSY.

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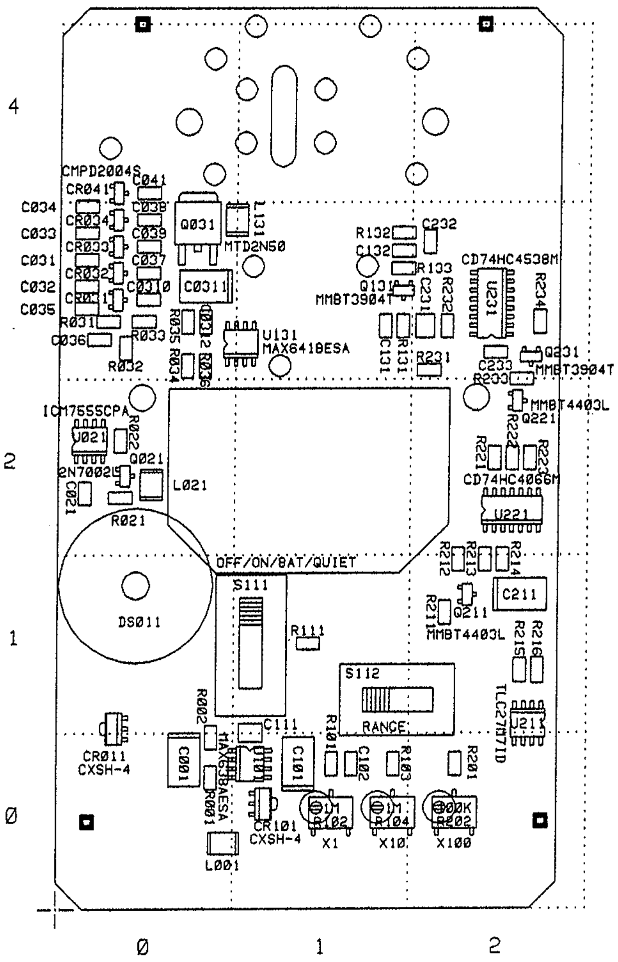

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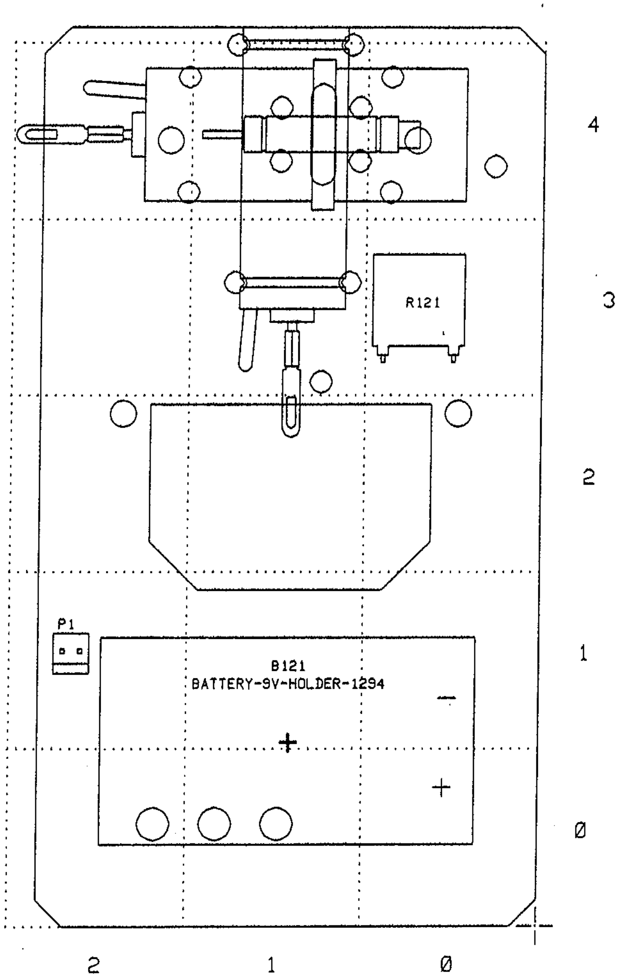

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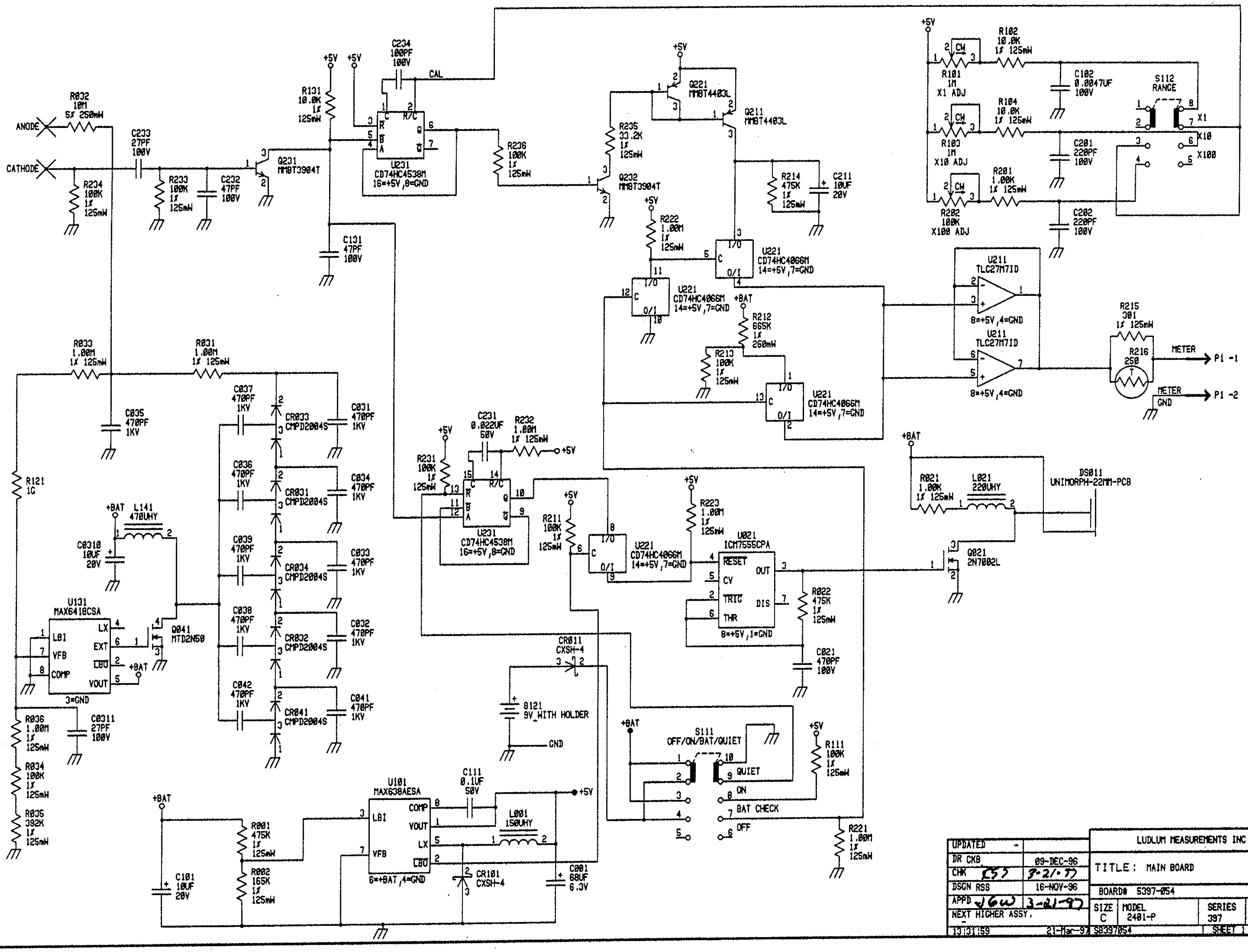
COMP PASTE ☐	COMP MASK ☐	SLDR PASTE ☐	SLDR MASK ☐	

REVISIONS						
EFF	AUTHORITY	ZONE	LTR	DESCRIPTION	DATE	APPROVED



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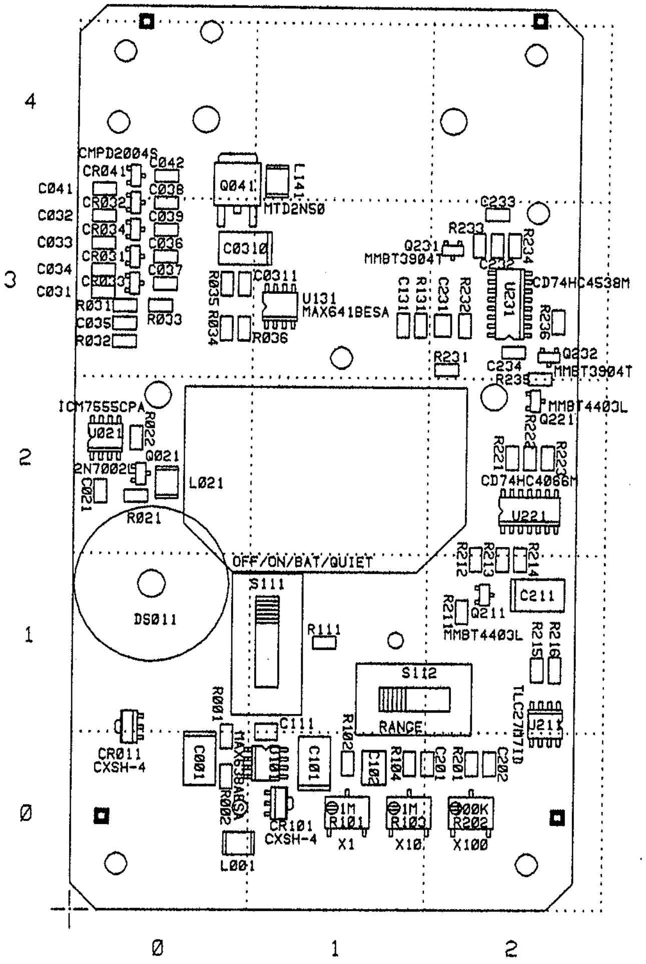

LUDLUM MEASUREMENTS INC. SWEETWATER, TX.

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REVISION	SERIES	SHEET
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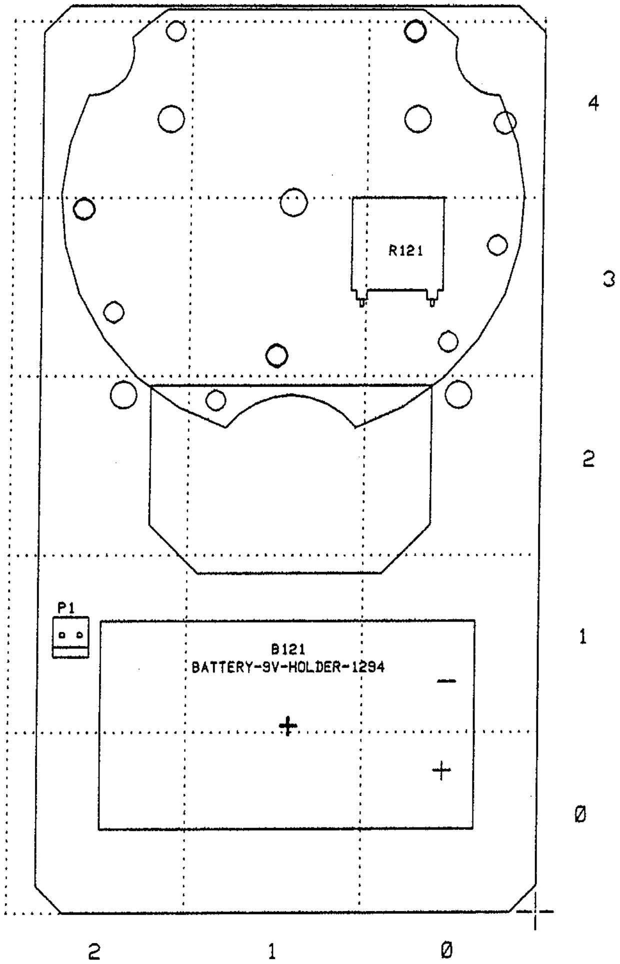

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MODEL *p*DR-1000AN/1200

*personal*DATARAM

PARTICULATE MONITOR

INSTRUCTION MANUAL
P/N (100181-00)

THERMO ELECTRON CORPORATION
ENVIRONMENTAL INSTRUMENTS
27 FORGE PARKWAY FRANKLIN MASSACHUSETTS 02038

(866) 282-0430 Toll Free
(508) 520-0430 International
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Apr2005

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WARRANTY

Seller warrants that the Products will operate substantially in conformance with Seller's published specifications, when subjected to normal, proper and intended usage by properly trained personnel, for 13 months from date of installation or 12 months from date of shipment, whichever is less (the "Warranty Period"). Seller agrees during the Warranty Period, provided it is promptly notified in writing upon the discovery of any defect and further provided that all costs of returning the defective Products to Seller are pre-paid by Buyer, to repair or replace, at Seller's option, defective Products so as to cause the same to operate in substantial conformance with said specifications. Replacement parts may be new or refurbished, at the election of Seller. All replaced parts shall become the property of Seller. Shipment to Buyer of repaired or replacement Products shall be made in accordance with the provisions of Section 5 above. Lamps, fuses, bulbs and other expendable items are expressly excluded from the warranty under this Section 8. Seller's sole liability with respect to equipment, materials, parts or software furnished to Seller by third party suppliers shall be limited to the assignment by Seller to Buyer of any such third party supplier's warranty, to the extent the same is assignable. In no event shall Seller have any obligation to make repairs, replacements or corrections required, in whole or in part, as the result of (i) normal wear and tear, (ii) accident, disaster or event of force majeure, (iii) misuse, fault or negligence of or by Buyer, (iv) use of the Products in a manner for which they were not designed, (v) causes external to the Products such as, but not limited to, power failure or electrical power surges, (vi) improper storage of the Products or (vii) use of the Products in combination with equipment or software not supplied by Seller. If Seller determines that Products for which Buyer has requested warranty services are not covered by the warranty hereunder, Buyer shall pay or reimburse Seller for all costs of investigating and responding to such request at Seller's then prevailing time and materials rates. If Seller provides repair services or replacement parts that are not covered by the warranty provided in this Section 8, Buyer shall pay Seller therefore at Seller's then prevailing time and materials rates.
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1.0 GENERAL DESCRIPTION

The Thermo Electron Corporation *personal*DataRAM™ (for *Personal* Data-logging Real-time Aerosol Monitor) is a technologically advanced instrument designed to measure the concentration of airborne particulate matter (liquid or solid), providing direct and continuous readout as well as electronic recording of the information.

The *personal*DataRAM is available in two versions: model *p*DR-1000AN and model *p*DR-1200. The model *p*DR-1000AN operates as a passive air sampler whereas the model *p*DR-1200 uses active air sampling. The user can convert from one to the other of these two versions by means of optional conversion kits offered by Thermo Electron (see Sections 4.2 and 15.0 of this manual).

The model *p*DR-1000AN passively samples (i.e., without a pump) the air surrounding the monitor; air freely accesses the sensing chamber of the instrument by means of convection, diffusion, and adventitious air motion. The model *p*DR-1200, on the other hand, requires a separate vacuum pump (not included) such as Thermo Electron's *p*DR-PU, a personal-type pump for its operation.

In addition, the model *p*DR-1200 includes a particle size-selective inlet cyclone which permits size segregated measurements (i.e., PM_{10}, $PM_{2.5}$, respirable, etc.) as well as enabling the user to perform aerodynamic particle sizing by varying the sampling flow rate. The model *p*DR-1200 incorporates, downstream of its photometric sensing stage, a standard 37-mm filter holder on which all sampled particles are collected for subsequent analysis or gravimetric referencing/calibration, if so desired.

The *personal*DataRAM is the result of many years of field experience acquired with thousands of units of its well known predecessor, the Thermo Electron/MIE MINIRAM, and embodies many technological advances made possible by the latest electronic hardware and software. The *personal*DataRAM is also a worthy miniaturized companion to the Thermo Electron DataRAM 4, a recognized paragon of portable aerosol monitors.

The *personal*DataRAM is a high sensitivity nephelometric (i.e. photometric) monitor whose light scattering sensing configuration has been optimized for the measurement of the respirable fraction of airborne dust, smoke, fumes and mists in industrial and other indoor environments.

The *personal*DataRAM is an ultra-compact, rugged and totally self-contained instrument designed for hand-held, belt-worn, as well as unattended operation. It is powered either by its internal replaceable 9V battery, or by an optional attachable rechargeable battery pack, or by an AC supply (included as standard accessory). For the model *p*DR-1200, power to an adjunct pump must be provided separately.

Zeroing is accomplished by means of a hand-inflatable “zero air” pouch included with the model *p*DR-1000AN, and by an inlet filter cartridge provided with the model *p*DR-1200. In addition, the instrument automatically checks agreement with its original factory calibration by checking its optical background during the zeroing sequence.

The *personal*DataRAM covers a wide measurement range: from 0.001 mg/m^3 (1 μg/m^3) to 400 mg/m^3, a 400,000-fold span, corresponding to very clean air up to extremely high particle levels.

In addition to the auto-ranging real-time concentration readout, the *personal*DataRAM offers the user a wide range of information by scrolling its two-line LCD screen, such as run start time and date, time averaged concentration, elapsed run time, maximum and STEL values with times of occurrence, etc.

Operating parameters selected and diagnostic information displays are also available. Furthermore, the *personal*DataRAM features complete, large capacity internal data logging capabilities with retrieval through an externally connected computer. The stored information (up to 13,000 data points) includes average concentration values, maximum and STEL values with time information as well as tag numbers.

Selectable alarm levels with built-in audible signal and switched output, a RS-232 communications port, and a programmable analog concentration output (voltage and current) are all part of this versatile instrument.

A custom software package is provided with the *personal*DataRAM to program operating/logging parameters (e.g. logging period, alarm level, concentration display averaging time, etc.) as well as to download stored or real-time data to a PC or laptop for tabular and/or graphic presentation. If required, the data can also be imported to standard spreadsheet packages (e.g. Microsoft Excel™, IBM Lotus 1-2-3™, etc.).

2.0 SPECIFICATIONS

- Concentration measurement range (auto-ranging)[1]: 0.001 to 400 mg/m^3

- Scattering coefficient range: 1.5 x 10^{-6} to 0.6 m^{-1} (approx.) @ λ =880 nm

- Precision/repeatability over 30 days (2-sigma)[2]:
  ± 2% of reading or ±0.005 mg/m^3, whichever is larger, for 1-sec. averaging time
  ±0.5% of reading or ±0.0015 mg/m^3, whichever is larger, for 10-sec. averaging time
  ±0.2% of reading or ±0.0005 mg/m^3, whichever is larger, for 60-sec. averaging time

- Accuracy[1]: ±5% of reading ±precision

- Resolution: 0.1% of reading or 0.001 mg/m^3, whichever is larger

- Particle size range of maximum response: 0.1 to 10 µm

- Flow rate range (model *p*DR-1200 only): 1 to 10 liters/minute (external pump required)

- Aerodynamic particle sizing range (model *p*DR-1200 only): 1.0 to 10 µm

- Concentration display updating interval: 1 second

- Concentration display averaging time[3]: 1 to 60 seconds

- Alarm level adjustment range[3]: selectable over entire measurement range

- Alarm averaging time[3]: real-time (1 to 60 seconds), or STEL (15 minutes)

- Datalogging averaging periods[3]: 1 second to 4 hours

- Total number of data points that can be logged in memory: 13,391

- Number of data tags (data sets): 99 (maximum)

- Logged data:

  - ❖ Each data point: average concentration, time/date, and data point number
  - ❖ Run summary: overall average and maximum concentrations, time/date of maximum, total number of logged points, start time/date, total elapsed time (run duration), STEL concentration and time/date of occurrence, averaging (logging) period, calibration factor, and tag number.

- Elapsed time range: 0 to 100 hours (resets to 0 after 100 hours)

- Time keeping and data retention: > 10 years

- Readout display: LCD 16 characters (4 mm height) x 2 lines

- Serial interface: RS-232, 4,800 baud

- Computer requirements: IBM-PC compatible, 486, Pentium, or higher, Windows™ '95 or higher, ≥ 8 MB memory, hard disk drive, CD-ROM Drive, VGA or higher resolution monitor

- Outputs:

  - ❖ Real-time digital signal (1 $\sec^{-1}$): concentration, 16-character code, simplex mode
  - ❖ Real-time analog signal: 0 to 5 V and 4 to 20 mA. Selectable full scale ranges: 0-0.1, 0-0.4, 0-1.0, 0-4.0, 0-10, 0-40, 0-100, and 0-400 mg/m^3.
  - ❖ Minimum load impedance for voltage output: 200 kΩ.
  - ❖ Maximum load impedance for current output: 300 Ω (when powered by AC power supply)
  - ❖ Alarm output: 1 Hz square wave, 5 V peak-to-peak amplitude. Load impedance > 100 kΩ

- Internal battery: 9V alkaline, 20-hour run time (typical)

- Current consumption: 15 to 25 mA (in Run Mode); 10 to 20 mA (in Ready Mode)

- AC source: universal voltage adapter (included) 100-250 V~, 50-60 Hz (CE marked)

- Optional battery pack: model *p*DR-BP, rechargeable NiMH, 72-hour run time (typical)

- Operating environment: -10° to 50° C (14° to 122° F), 10 to 95% RH, non-condensing

- Storage environment: -20° to 70° C (-4° to 158° F)

- Dimensions (max. external):

  - ❖ Model *p*DR-1000AN: 153 mm (6.0 in) H x 92 mm (3.6 in) W x 63 mm (2.5 in) D
  - ❖ Model *p*DR-1200 (including cyclone and filter holder): 160 mm (6.3 in) H x 205 mm (8.1in) W x 60 mm (2.4 in) D

- Weight:
    - Model *p*DR-1000AN: 0.5 kg (18 oz)
    - Model *p*DR-1200: 0.68 kg (24 oz)

- Cyclone (included in model *p*DR-1200 only): Model KTL

- Filter holder (included in model *p*DR-1200 only): Model MAWP037AO (with 0.8 µm pore size filter)

---

[1] Referred to gravimetric calibration with SAE Fine (ISO Fine) test dust (mmd = 2 to 3 µm, σg = 2.5, as aerosolized)
[2] At constant temperature and full battery voltage
[3] User selectable

3.0 USER GUIDELINES

3.1 Handling Instructions

The *personal*DataRAM is a sophisticated optical/electronic instrument and should be handled accordingly. Although the *personal*DataRAM is very rugged, it should not be subjected to excessive shock, vibration, temperature or humidity. As a practical guideline, the *personal*DataRAM should be handled with the same care as a portable CD player.

If the *personal*DataRAM has been exposed to low temperatures (e.g. in the trunk of a car during winter) for more than a few minutes, care should be taken to allow the instrument to return near room temperature before operating it indoors. This is advisable because water vapor may condense on the interior surfaces of the *personal*DataRAM causing temporary malfunction or erroneous readings. Once the instrument warms up to near room temperature, such condensation will have evaporated. If the *personal*DataRAM becomes wet (e.g. due to exposure to water sprays, rain, etc.), allow the unit to dry thoroughly before operating.

Whenever the *personal*DataRAM is shipped care should be taken in placing it in its carrying case and repackaging it with the original cardboard box with the factory provided padding.

3.2 Safety Instructions

- Read and understand all instructions in this manual.
- Do not attempt to disassemble the instrument. If maintenance is required, return unit to the factory for qualified service.
- The *personal*DataRAM should be operated only from the type of power sources described in this manual.
- When replacing the internal 9V battery, follow the instructions provided on the back panel of the unit.
- Shut off *personal*DataRAM and any external devices (e.g. PC or Laptop) before connecting or disconnecting them.
- Shut off *personal*DataRAM before replacing the internal battery, or when plugging in or disconnecting the AC power supply or the optional rechargeable battery pack.

3.3 Handling and Operation

3.3.1 Model *p*DR-1000AN

The model *p*DR-1000AN can be operated in any position or orientation. Exposure to high intensity fluctuating light of the interior of the sensing chamber, through the front and back slotted air openings (see Section 5.5), should be avoided. Such large intensity transients may cause erroneous readings. Direct access of sunlight to the sensing chamber should be prevented.

Typical modes of instrument support/handling include:

- Hand-held. Do not obstruct or cover the sensing chamber opening slots on front and back of unit.
- Belt attached. Use belt clip provided as standard accessory. The unit can be worn on a waist belt, or with optional shoulder belt (model *p*DR-SS) for breathing zone monitoring.
- Tabletop operation. The *p*DR-1000AN can be placed on a table either in an upright position (i.e., resting on its lower protective bumper), or on its back (i.e., resting on the rear edges of its two protective bumpers).
- Tripod mounted. The unit can be attached to any standard tripod using the threaded bushing on the bottom of the monitor (see Figure 3).
- Fixed point operation. The model *p*DR-1000AN can be mounted at a fixed location (e.g., wall or post) using the optional wall-mounting bracket, model *p*DR-WB.

3.3.2 Model *p*DR-1200

The *p*DR-1200 requires an external vacuum pump, such as a small diaphragm pump (e.g., model *p*DR-PU) for its sampling operation. The inlet of the pump must be connected by means of tubing to the hose fitting on the *p*DR-1200 37-mm filter holder attached to sensing chamber (see Figure 2).

The inlet metal tube of the cyclone can be oriented in any desired direction (i.e., upward, forward, downward or backward) by rotating the cyclone body within its holder cup on the right side of the sensing chamber (see Figure 2).

Always ensure unobstructed access to the cyclone inlet when sampling directly the air in the instrument's vicinity. Alternatively, tubing can be connected to the cyclone inlet in order to extract a sample stream from a duct, chamber or other enclosed volume.

Typical modes of instrument support/handling include:

- Hand-held. For example, using a personal type pump, clipped to the belt and using a tubing connection to the *p*DR-1200.
- Belt attached. Use belt clip kit provided as standard accessory. The unit can be worn on a waist belt, or with the optional shoulder belt (model *p*DR-SS) for breathing zone monitoring. A personal pump can then be belt-worn as well.
- Tabletop operation. The *p*DR-1200 can be placed on a table either in an upright position (i.e. resting on its lower protective bumper), or on its back (i.e. resting on its backside).
- Wall mounted for fixed point monitoring. Use optional wall mounting bracket, model *p*DR-WB, either in combination with model *p*DR-PU pump module and model *p*DR-AC power supply (powering both the *p*DR-1200 and the *p*DR-PU), or with a separate pump.

- Tripod mounted. The unit can be attached to any standard tripod using the threaded opening on the bottom base (see accessory attachment fitting on Fig. 4).

3.4 Air Sampling Guidelines

Although the *personal*DataRAM is designed primarily for intramural use, i.e. for indoor air quality, in-plant, or mining environment monitoring, its active sampling version (model *p*DR-1200) also makes it compatible with extramural use (i.e. ambient monitoring). General ambient monitoring applications, however, are performed preferentially using an appropriate inlet configuration, in order to ensure representative particle sampling under conditions of variable wind speed and direction. Consult with Thermo Electron Corporation for such outdoor applications.

For typical area monitoring applications, the *personal*DataRAM should be placed and operated centrally within the area to be monitored, away from localized air currents due to fans, blowers, ventilation intakes/exhausts, etc. This is to ensure representative sampling within the area to be assessed.

3.5 Environmental Constraints and Certifications

The *personal*DataRAM is designed to be reasonably dust and splash resistant, however, it is not weatherproof. To operate the unit outdoors provisions should be made to protect it from environmental extremes outside its specified range, and <u>from any exposure to precipitation</u>.

The *personal*DataRAM has received intrinsic safety approval (No. 2G-4126-0) from the U.S. Mine Safety and Health Administration (MSHA) for use in coal-mining environments containing methane gas. The MSHA approval (type 2G) closely resembles the standard intrinsic safety rating as defined by Class 1, Div. 1, Group D. This approval makes the MIE *personal*DataRAM the only commercially produced direct reading dust monitor so certified by MSHA and, therefore, the only instrument of this type permitted to be used routinely in U.S. coal mines and similar environments.

The *personal*DataRAM is certified for compliance with the electromagnetic radiation limits for a Class A digital device, pursuant to part 15 of the FCC Rules. The unit also complies and is marked with the CE (European Community) approval for both immunity to electromagnetic radiation and absence of excessive emission interference.

4.0 ACCESSORIES

4.1 Standard Accessories

The *personal*DataRAM is provided to the user with the following standard accessories:

- Soft-shell carrying case (Thermo Electron model *p*DR-CC-1)
- Digital communications cable (Thermo Electron model *p*DR-DCC)
- Analog signal/alarm output cable (Thermo Electron model *p*DR-ANC)
- Communications software disk (Thermo Electron model *p*DR-COM)
- Z-Pouch zeroing kit (Thermo Electron model *p*DR-ZP [for use with *p*DR-1000AN only])
- Zeroing filter cartridge and tubing (Thermo Electron model *p*DR-ZF)(for use with *p*DR-1200 only)
- Belt clip kit (Thermo Electron model *p*DR-CA)
- AC power supply (and charger for optional Thermo Electron model *p*DR-BP) (Thermo Electron model *p*DR-AC)
- Metal cyclone (Thermo Electron model *p*DR-GK2.05)(for use with *p*DR-1200 only)
- 37-mm filter holder and hose fitting (Thermo Electron model *p*DR-FH)(for use with *p*DR-1200 only)
- Instruction manual

4.2 Optional Accessories

The following optional accessories are available from Thermo Electron for use with the *personal*DataRAM:

- Rechargeable battery module (Thermo Electron model *p*DR-BP)
- Shoulder strap (Thermo Electron model *p*DR-SS)
- Remote alarm unit (Thermo Electron model *p*DR-RA)
- Wall mounting bracket (Thermo Electron model *p*DR-WB)
- Active sampling kit to convert model *p*DR-1000AN to model *p*DR-1200 (Thermo Electron model *p*DR-ASC)
- Upper bumper kit to convert model *p*DR-1200 to model *p*DR-1000AN (Thermo Electron model *p*DR-UB)
- Attachable pump unit (Thermo Electron model *p*DR-PU)(for use with *p*DR-1200 only)

5.0 INSTRUMENT LAYOUT

The user should become familiar with the location and function of all externally accessible controls, connectors and other features of the *personal*DataRAM. Refer to Figures 1 through 6.

All user related functions are externally accessible. All repair and maintenance should be performed by qualified Thermo Electron personnel. Please contact the factory if any problem should arise. Do not attempt to disassemble the *personal*DataRAM, except as described in Section 12.0 (Maintenance), **otherwise voiding of instrument warranty will result.**

5.1 Front Panel

Refer to Figures 1 (for model *p*DR-1000AN) or 2 (for model *p*DR-1200) for location of controls and display.

The front panel contains the four touch switches (keys) and the LCD screen required for the operation of the *personal*DataRAM.

The four touch switches provide tactile ("popping") feedback when properly actuated.

The ON/OFF key serves only to turn on the unit (while it is in the off state), and to turn it off (when it is operating).

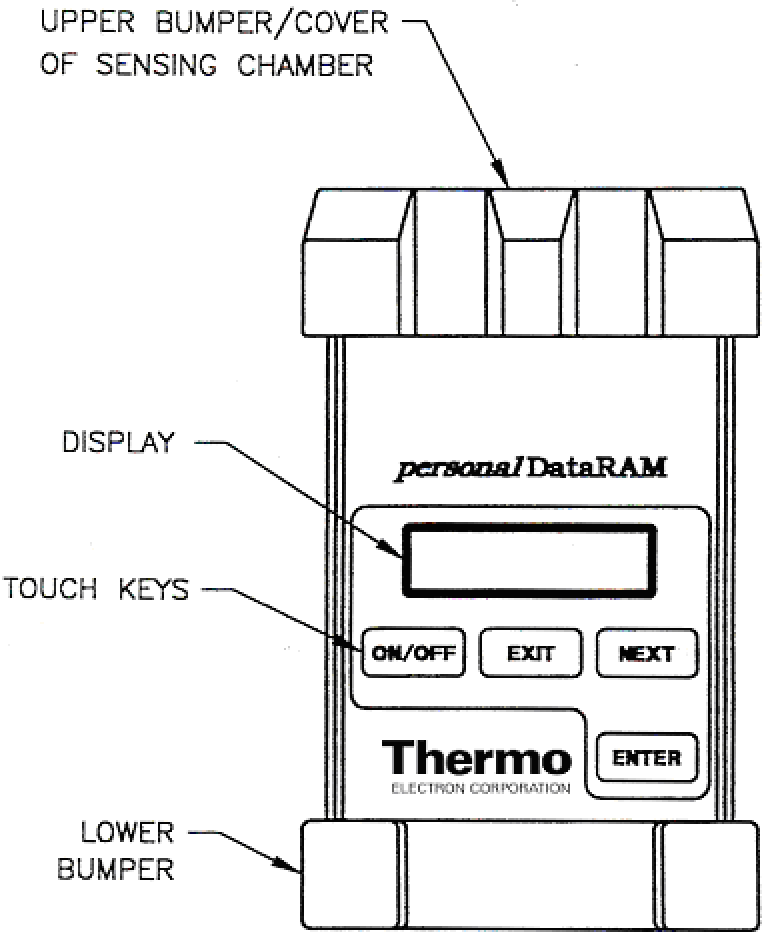


Figure 1 – FRONT PANEL (MODEL pDR-1000AN)

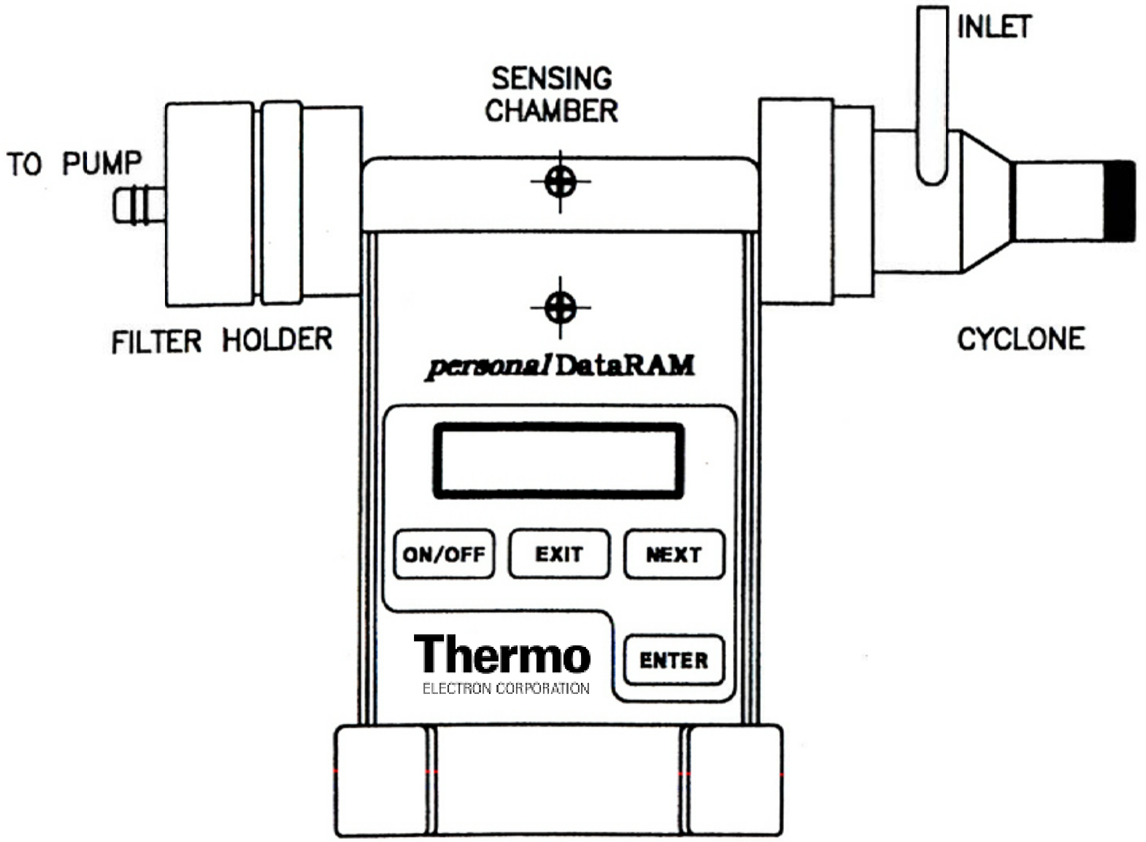


Figure 2. MODEL pDR-1200 WITH CYCLONE & 37MM FILTER HOLDER

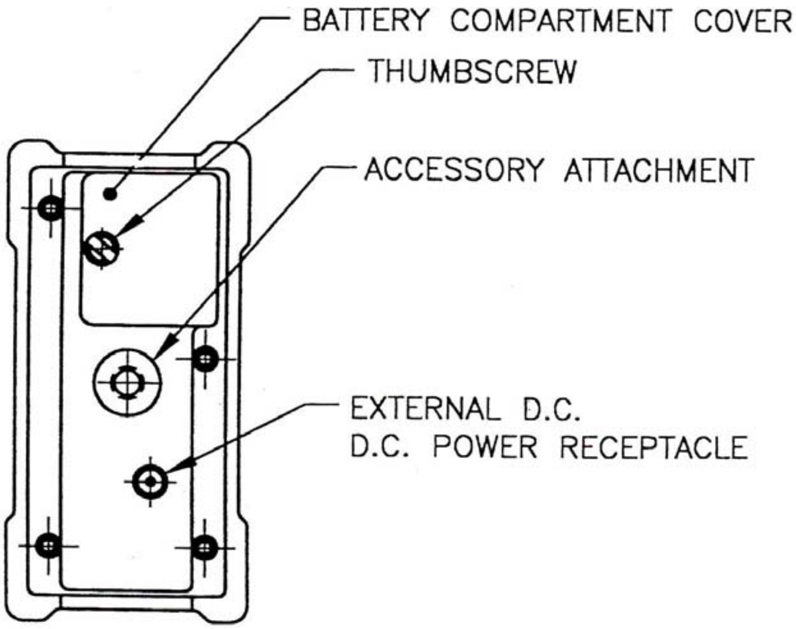


Figure 3 – BOTTOM BASE (MODEL pDR–1000AN)

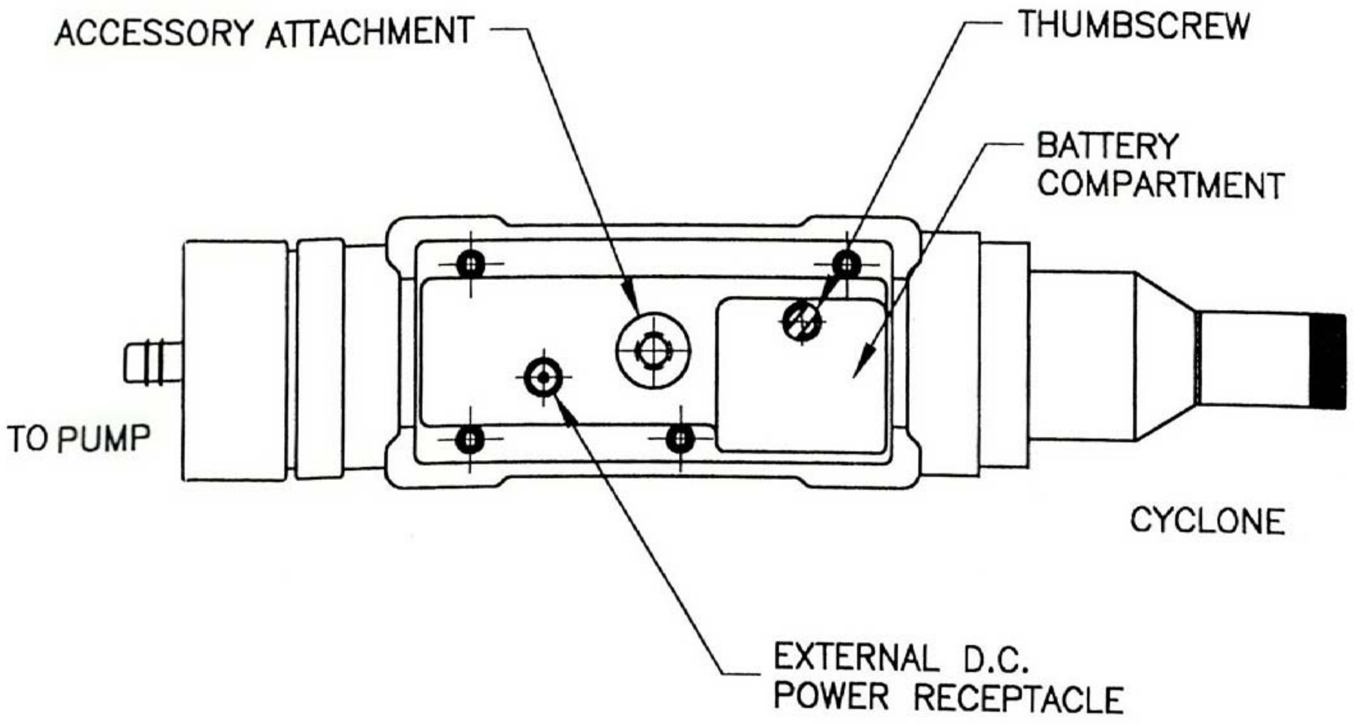


Figure 4 – BOTTOM VIEW (MODEL pDR–1200)

The EXIT and ENTER keys serve to execute specific commands that may be indicated on the screen, and the NEXT key generally serves to scroll the displayed information, e.g. to review the operating parameters that have been programmed, display maximum/STEL values, diagnostic values, etc.

If an incorrect command is keyed (e.g. ENTER when the *personal*DataRAM displays real-time concentration) a beep is heard to alert the user.

The two-line, 16-character per line LCD indicates either measured values of concentration (instantaneous and time averaged on the same screen), elapsed run time, maximum and STEL (short term excursion limit) values, operating and logging parameters, diagnostics, or other messages.

The acoustic alarm transducer is located directly behind the center of the Thermo Electron Corporation logo on the front panel.

5.2 Bottom Base

Refer to Figures 3 (for model *p*DR-1000AN) or 4 (for model *p*DR-1200). The base of the *personal*DataRAM contains the following: a) internal battery compartment cover, b) external DC power input receptacle, and c) threaded bushing for the attachment of optional battery pack, tripod, or other mounting/support hardware.

Only the internal battery compartment cover should be opened by the user, for removal and replacement of the on-board 9V battery. Removal of the base plate could result in voiding of instrument warranty.

5.3 Right Side Panel

Refer to Figures 5 (for model *p*DR-1000AN) or 6 (for model *p*DR-1200) which shows the manner of attachment of the belt clip assembly (belt clip should be attached only if required by the user). The right side panel (as viewed from front panel) contains the RJ-12 6-contact modular jack connector receptacle for digital (RS-232) communications and analog signal output. This connector also provides the alarm output control for a remote/auxiliary alarm signal. The contacts (from top to bottom) are:

1: 4 – 20 mA analog output (positive)
2: Alarm output
3: Digital data transmission
4: Digital input
5: Common ground (signal returns)
6: 0 to 5 V analog output (positive)

The digital communications cable provided as a standard accessory is to be inserted into this receptacle for interconnection to a computer (for data downloading or to reprogram parameters). The analog output cable is provided with flying leads for interconnection with other data processing and/or control systems.

WARNING: The modular jack receptacle on the side of the *personal*DataRAM should be used only for communications with computers and alarm circuitry. **Do not, under any circumstance, connect any communications equipment (e.g., telephone) to this receptacle.**

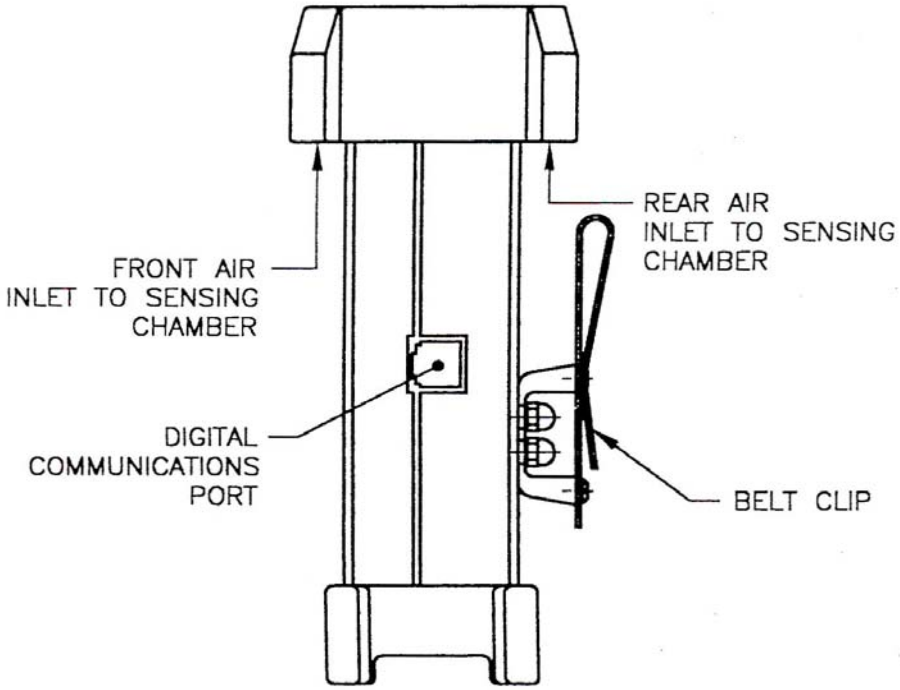


Figure 5 – RIGHT SIDE PANEL (MODEL pDR–1000AN)
(SHOWN WITH BELT CLIP ATTACHED)

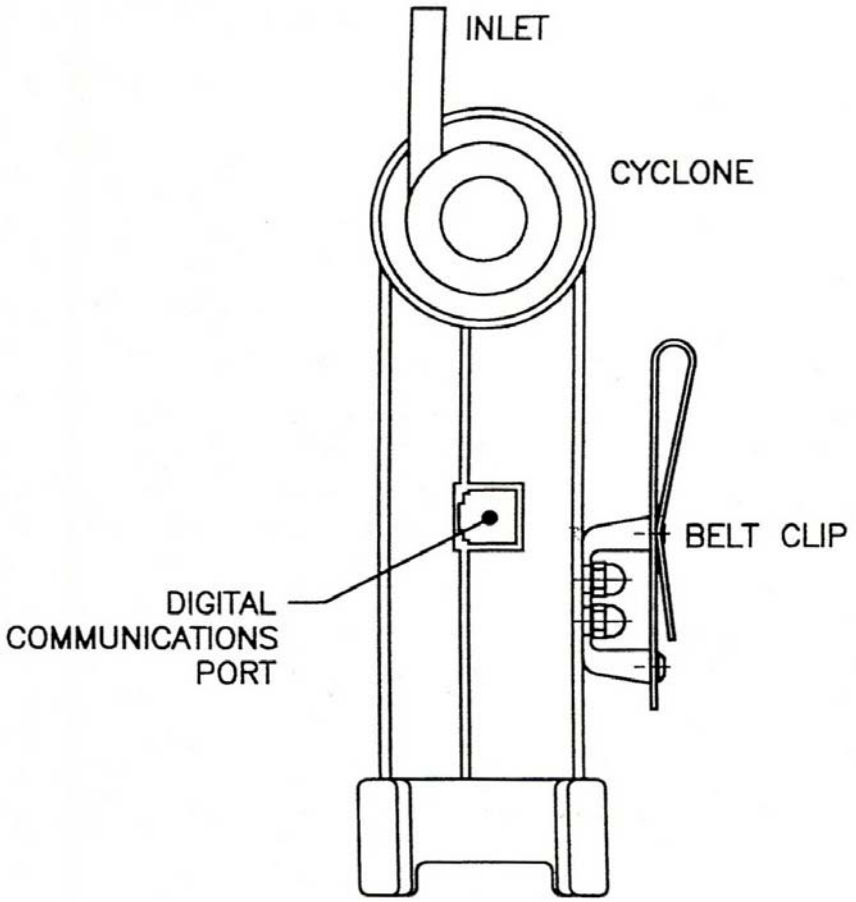


Figure 6 – RIGHT SIDE VIEW (MODEL pDR–1200)
(SHOWN WITH BELT CLIP ATTACHED)

5.4 Back Panel and Belt Clip

The back panel consists of a label with important user information on safety procedures and certifications, model and serial numbers, etc. and is provided with mounting hardware for the attachment of the belt clip kit (see Figures 5 or 6 for mounting configuration of the belt clip).

5.5 Sensing Chamber

Referring to Figure 1 or 2, the upper mid-section of the *personal*DataRAM contains the optical sensing chamber. This chamber is the only internal section that the user should access for maintenance purposes (see Section 12.2).

On the model *p*DR-1000AN, air enters the sensing chamber through the two slot shaped inlets (one on the front and other on the back) under the protective bumper. During instrument operation those two openings should remain unobstructed in order to ensure free access of the surrounding air. When the model *p*DR-1000AN is used as personal monitor, i.e., clipped to a person's belt, the rear air inlet opening may be partially obstructed, but care should be exercised in ensuring that the front air inlet remains free of any obstructions.

On the model *p*DR-1200, air enters the sensing chamber through the opening in the cyclone receptacle cup (black cup on right side of sensing chamber), passes through the photometric stage, and exits through the opening in the filter holder receptacle cup (black cup on left side of sensing chamber), after which the air passes through the filter.

6.0 PREPARATION FOR OPERATION

6.1 Battery Installation

When shipped from the factory, the *personal*DataRAM will arrive without its replaceable 9V battery installed. Two fresh alkaline batteries (Duracell® type MN1604) are factory packed separately in the carrying case, one of which should be installed in the *personal*DataRAM when preparing it for operation.

NOTE: Whenever the *personal*DataRAM is to be left unused for an extended time (i.e. longer than a month), the 9V battery should be removed from the unit.

Removing the battery will lose neither the program, time/date keeping, nor stored data.

To install the battery proceed as follows:
- Hold the *personal*DataRAM upside down.
- Loosen thumbscrew that secures the battery compartment cover (see Figure 3 or 4), and remove that cover.

- Observe battery polarity and the back panel battery orientation pattern (the negative battery terminal is the one closer to the side of the instrument).
- Insert the battery by sliding it in until it bottoms out. It should protrude slightly above the bottom surface of the instrument.
- Place battery compartment cover over battery and, while pushing down the cover firmly (taking care that the cover seats flush on the bottom surface of the *personal*DataRAM), tighten thumbscrew securely.

6.2 Battery Replacement

Normally, only a 9V Duracell® type MN1604 alkaline batteries should be used with the *personal*DataRAM in accordance the MSHA intrinsic safety approval.

Only fresh batteries should be used in order to ensure the maximum operating time. The *personal*DataRAM shuts itself off whenever the battery voltage falls below 6 volts (while retaining all programming and data). A fresh 9V alkaline battery, at room temperature, should provide typically 20 hours of continuous operation (please note that not all manufacturers produce batteries of equal capacity). Intermittent operation should extend the total running time because of partial battery recovery effects.

The approximate remaining battery capacity is indicated by the *personal*DataRAM (see Section 8.2) in increments of 1%, starting from 99%. If the remaining battery capacity is 40% or less, immediate restarting after shut off is automatically inhibited to prevent incomplete runs. If, nevertheless, a new run is to be initiated with low remaining battery capacity, do not shut off the *personal*DataRAM at the end of the previous run (i.e., remain in the Ready Mode, see section 7.0).

When significantly extended operating times are required (beyond the typical 20 hours), the use of either lithium or zinc-air batteries can be considered. The use of such alternative battery types can provide about 2 to 3 times longer operation than alkaline batteries.

6.3 AC Power Supply

A universal line voltage AC to DC power supply (Thermo Electron model *p*DR-AC) is provided as standard accessory with the *personal*DataRAM. This power supply can be used with any line with a voltage between 100 and 240 VAC (50 to 60 Hz). When using that power supply, its output plug should be inserted into the external DC receptacle at the base of the *personal*DataRAM (see Figure 3 or 4). Insertion of that connector automatically disables the internal 9V battery of the instrument. Removal of the *p*DR-AC plug from the instrument automatically re-connects the internal 9V battery.

NOTE: Before plugging in or unplugging the external power supply, the *personal*DataRAM must be shut off.

6.4 Rechargeable Battery Module

A rechargeable battery pack (Thermo Electron model *p*DR-BP) is available as an optional accessory. This unit attaches directly to the base of the *personal*DataRAM.

The *p*DR-BP contains a sealed nickel-metal-hydride battery (NiMH), which provides typically 72 hours of continuous operation between successive charges (for 3-hour charging).

The use of the *personal*DataRAM, in combination with the *p*DR-BP connected to the AC power line ensures totally uninterruptible operation over an indefinite period. In this operating mode, line power interruptions lasting up to 72 hours have no effect on measurement run continuity.

To attach the *p*DR-BP to the *personal*DataRAM, the instrument should be shut off. Carefully plug the *p*DR-BP into the external DC receptacle on the *personal*DataRAM. Rotate the large thumbscrew at the opposite end of the *p*DR-BP tightening it firmly. The *p*DR-BP can be recharged by means of the AC power supply of the *personal*DataRAM.

Detailed instructions for the use of the rechargeable battery module are furnished with that accessory.

6.5 Zeroing the personalDataRAM

One of the most important steps to be performed by the user before initiating a measurement run with the *personal*DataRAM is to zero the instrument. This is required to ensure maximum accuracy of concentration measurements, especially at low levels, i.e. below about 0.1 mg/m^3.

During the 2-minute pre-run automatic zeroing sequence (see Section 8.1), the *personal*DataRAM registers its own optical background, stores that level in its memory, and then subtracts that background from all measured concentration values, until the zero is updated again by the user.

Although zeroing can be performed as often as desired (e.g., before every run), in practice it should not be necessary to do so more than once-a-month or even less frequently, except if average particulate concentrations should exceed about 0.5 mg/m^3.

6.5.1 Zeroing the model *p*DR-1000AN

Zeroing of the model *p*DR-1000AN requires a particle-free environment such as a clean room, clean bench, duct or area directly downstream of a HEPA filter, or the *p*DR-1000AN Z-Pouch (standard accessory). In some cases, a very clean, well air-conditioned office may offer a sufficiently low particle concentration environment (i.e., ≤ 5 $\mu g/m^3$) for zeroing, as determined by another monitor (e.g., Thermo Electron DataRAM 4).

To zero the model *p*DR-1000AN by means of its Z-Pouch, proceed as follows:

- Wipe the outside surfaces of the *p*DR-1000AN to remove as much dust from those surfaces as possible before placing the instrument inside the Z-Pouch.
- In a reasonably clean environment, open the zipper of the Z-Pouch and place the *p*DR-1000AN inside it. Close the zipper shut.
- Open the small nipple on the Z-Pouch, and insert the fitting of the hand pump/in-line filter unit into the nipple.
- Start pumping the hand-pump until the Z-Pouch begins to bulge, and proceed with the steps in Section 8.1, pressing the keys of the instrument through the wall of the Z-Pouch. Then slowly continue to pump to maintain positive pressure within the Z-Pouch.
- After completing the zeroing (step 2. of Section 8.1) procedure, open the Z-Pouch zipper and remove the *p*DR-1000AN. Close the zipper and flatten the Z-Pouch while plugging its nipple, in order to prevent dust contamination of the interior of the Z-Pouch.
- The *p*DR-1000AN is now zeroed and ready for a measurement run.

6.5.2 Zeroing the model *p*DR-1200

To provide the particle-free air required to zero the *p*DR-1200, either of two methods can be used: a) place the instrument on a clean-air bench or in a clean room, or b) connect to the cyclone inlet the green zeroing filter cartridge supplied with the *p*DR-1200. In either case, proceed as follows:

- After implementing either of the two methods, above, run the attached pump for at least one minute (e.g., at 2 liters/minute), and then proceed as described in Section 8.1 of this instruction manual, while continuing to run the pump (or leaving the unit in the clean air environment).
- Once the CALIBRATION: OK message appears on the *p*DR-1200 display, stop the pump and disconnect the zeroing filter cartridge from the cyclone inlet (or remove *p*DR-1200 from clean bench/room).
- The *p*DR-1200 is now zeroed and ready for a measurement run.

Note: While the *p*DR-1200 is used to monitor high dust concentrations (≥ 0.5 mg/m^3), the flow through its sensing chamber should not be stopped before purging it, which can be done by connecting the green zeroing filter to the cyclone inlet and continuing to run the pump for about 2 minutes before shutting it off. This is to prevent dust contamination of the sensing chamber.

6.6 *p*DR-1200 Filter Holder Installation

The 37-mm filter holder provided with the *p*DR-1200 must be installed before operation of the instrument, in order to connect a sampling pump. To install the filter holder, remove protective cover, and insert the open collar over the black attachment cup with the external o-ring, on the left side of the *p*DR-1200 sensing chamber. Ensure complete insertion.

To replace the membrane filter separate the two sections of the plastic holder prying them apart with screwdriver or a coin. Make sure to place backing under the membrane filter before rejoining the two plastic rings.

7.0 OPERATING MODES

The *personal*DataRAM has several different operating modes which will be described in what follows. The specific commands and displays within each of these operating modes will be explained in detail in Section 8.0. A complete flow chart of keystrokes and screens is provided in Section 16.0.

7.1 Start-Up Mode

The *personal*DataRAM enters the Start-Up Mode as soon as the instrument is switched on. The user then has the choice to:

a) Wait before proceeding;
b) Zero the instrument and check its readiness; or
c) Proceed directly to the Ready Mode.

7.2 Ready Mode

Once the *personal*DataRAM is in the Ready Mode, the user is presented with the following alternatives:

a) Start a run immediately, or after any of the subsequent steps;
b) Review (by scrolling the display) all operating parameters, status and diagnostic data;
c) Activate or deactivate the logging function; activate, select (instantaneous or STEL), or deactivate alarm;
d) Program parameters or output logged data through a computer.

7.3 Run and Logging Mode

The Run Mode is the measurement/logging mode. The user can operate the *personal*DataRAM in this mode either with or without data logging. For example, the instrument may be used first as a survey monitor without logging, for walk-through assessment of an industrial plant, before deciding where to set up the unit for continuous monitoring and logging.

7.3.1 Data Logging

In order to activate the logging function, the unit must be in (or returned to) the Ready Mode (see Section 8.2).

If data logging has been enabled, the data will be logged in the next free (unrecorded) tag or data set. For example, if data had been recorded previously in tags # 1, 2 and 3 then, when a new run is initiated, the new data will be stored in tag #4. The data can be separated into number of sets (tags) up to a total of 99.

Any number of individual data points can be stored in a given tag, i.e. up to a maximum of 13,000 points (i.e. the total memory capacity of the *personal*DataRAM) assuming that no other data had been logged in other tags. This means that the total memory capacity of 13,000 data points can be grouped into any number of the available 99 data sets (tags).

7.3.2 Clearing of Memory

Data recorded in the *personal*DataRAM memory can be erased either through an external PC command using the Thermo Electron *p*DR-COM Custom Communications software provided as a standard accessory, or resetting the instrument (see Section 8.5). The PC method permits to erase the data in any number of selected tags, whereas the resetting method results in the deletion of all data stored in the *personal*DataRAM.

7.3.3 Run Mode Display and Commands

When a measurement run has been initiated (see Section 8.3), the user has the following display choices:

a) Instantaneous and time-averaged concentrations (both on the same screen);
b) Elapsed run time, and run start time and date (both on the same screen);
c) Maximum displayed concentration from run start, and time/date at which current maximum occurred;
d) Short term excursion limit (STEL) from run start, and time/date at which current STEL occurred;
e) Remaining battery charge, and (if logging function is enabled) remaining free memory.
f) Analog output concentration range (if enabled)

The user can command the termination of the run at any time returning it to the Ready Mode. To download logged data into a PC, the *personal*DataRAM must be in the Ready Mode. No changes in the program parameters or operating conditions can be made while in the Run Mode.

The *personal*DataRAM can be shut off from any of the three operating modes. Even if shut off while in the Run Mode, the instrument will save all stored data.

8.0 OPERATION

8.1 Start-Up

	KEY	DISPLAY	NOTES
1.	**ON/OFF**	START ZERO:ENTER GO TO RUN: NEXT	Before starting a run with the *personal*DataRAM, zero it (see Section 6.5) and key **ENTER** while the unit is exposed to particle-free air. Alternatively, key **NEXT** to go to RUN/READY mode. If **ENTER** is keyed:
2.	**ENTER**	ZEROING V2.00	Keep clean air flowing while ZEROING is displayed* for 1.1 min., followed by one of these screens:
		CALIBRATION: OK	or,
		BACKGROUND HIGH	or,
		MALFUNCTION	If CALIBRATION: OK, then go to step 3. If one of the other two screens is displayed, consult Section 12.0.
3.	**NEXT**	START RUN: ENTER READY: NEXT	To start a measurement run key **ENTER** (Section 8.3, step 1). To set up for a run and scroll logging/operating parameters, key **NEXT** (see Section 8.2).
4.	**ON/OFF**	TURN OFF PDR? Y:ENTER N:NEXT	Keying **ON/OFF** while the unit is operating will elicit this message to prevent accidental shut off. To confirm shut down, key **ENTER**. To continue operation, key **NEXT**.

*The number following the V on the screen refers to the installed firmware version.

8.2 Setting Up For A Run (Ready Mode)

	KEY	DISPLAY	NOTES
1.	**NEXT**	LOGGING DISABLED	This screen indicates the logging status. To enable the logging function, key **ENTER**. Toggling of the on/off logging status can be done by keying ENTER.
2.	**ENTER**	LOG INTRVL 600s TAG#: 4	This message indicates that logging is enabled. Example is for 10-min log period, selected through the PC (see Section 9.0), and next free tag is #4.
3.	**NEXT**	ALARM: OFF	This screen indicates the alarm status. Keying **ENTER** repeatedly toggles through the 3 alarm modes:
4.	**ENTER**	ALARM: INSTANT LEVEL:1.50 mg/m^3	This enables the alarm based on the real-time concentration. The level (e.g. 1.50 mg/m^3) must be set on the PC.
5.	**ENTER**	ALARM: STEL LEVEL:0.50 mg/m^3	This enables the alarm based on the 15-min STEL value. The level (e.g. 0.50 mg/m^3) must be set on the PC.
6.	**NEXT**	ANALOG OUTPUT: DISABLED	This screen indicates the analog signal output status. Keying ENTER will enable the analog output. Toggling the analog output on/off can be done by keying **ENTER**:
7.	**ENTER**	ANALOG OUTPUT: 0 – 0.400 mg/m^3	This enables the analog output. The concentration range (e.g., 0 – 0.400 mg/m^3) must be set on the PC.
8.	**NEXT**	CAL FACTOR: 1.00 DIS AVG TIME 10s	This screen displays the calibration factor and the display averaging time. Edit via PC

9.	**NEXT**	BATTERY LEFT 83% MEMORY LEFT 96%	This screen displays the remaining battery charge, and the remaining percentage of free memory.
10.	**NEXT**	CONNECT TO PC	When this screen has been selected, the operating parameters can be edited and/or the logged data can be downloaded via the PC (see Section 9.0). If **NEXT** is keyed again, the screen returns to RUN/READY:
11.	**NEXT**	START RUN: ENTER READY: NEXT	The instrument is now ready to run following the procedure in section 8.3.

8.3 Measurement Run Procedure

	KEY	DISPLAY	NOTES
1.	**ENTER**	LOGGING DISABLED	or, if logging was enabled:
		LOG INTRVL 600s TAG #: 4	Logging status will be displayed for 3 seconds.
		CONC*0.047 mg/m^3 TWA 0.039 mg/m^3	After a 3-second delay, the concentration screen appears values shown here are examples). CONC is the real-time and TWA is the time-averaged concentration. The "*" appears only if logging has been enabled.
2.	**EXIT**	TERMINATE RUN? Y:ENTER N:EXIT	To terminate the current run and return to the Ready Mode, key **ENTER**. To continue the run, key **EXIT**.
3.	EXIT	CONC*0.047 mg/m^3 TWA 0.039 mg/m^3	Keying **NEXT** successively scrolls the display to show various run values (elapsed run time, maximum, STEL, etc.). Keying **EXIT** returns to the concentration display.

4.	**NEXT**	ET 06:12:49 ST 08:18:26MAY15	This screen shows the elapsed run time (ET) and the run start time/date (ST).
5.	**NEXT**	MAX: 0.113 mg/m^3 T 10:08:44 MAY15	This screen shows the maximum concentration of current run and time/date of occurrence.
6.	**NEXT**	STEL:0.058 mg/m^3 T 09:59:22 MAY15	This screen shows the 15-min STEL value of the current run and the time/date of occurrence.
7.	**NEXT**	BATTERY LEFT 83%	or, if logging was enabled:
		BATTERY LEFT 83% MEMORY LEFT 96%	This screen shows the amount of usable charge left in the battery and, if logging has been enabled, the overall amount of free memory left.
8.	**NEXT**	ANALOG OUTPUT: 0 – 0.400 mg/m^3	This screen shows the status of the analog signal output, and the range, if this output has been enabled.
9.	**NEXT**	CONC*0.047 mg/m^3 TWA 0.039 mg/m^3	The last **NEXT** command returns the display to the concentration screen.
10.	**EXIT**	TERMINATE RUN? Y:ENTER N:NEXT	As indicated in step 2, to end current run, key **ENTER**, to return to the Ready Mode:
11.	**ENTER**	START RUN: ENTER READY: NEXT	This keystroke terminates the current run and returns the unit to the Ready Mode.

If during a run the instrument memory is filled completely, or if all 99 tags have been used, the run is automatically terminated and the display will indicate:

RUN TERMINATED
FULL MEMORY

If a new run is initiated after the memory has been filled, the *personal*DataRAM can be operated only as a monitor without logging. The memory must then be cleared (see Section 7.3.2) first before logging can be enabled again.

8.4 Abbreviated Run Start/Stop Instructions

To power-up and start a measurement run without zeroing and without logging, proceed as follows:

- Key sequentially **ON/OFF, NEXT** and **ENTER**.

To terminate run and shut down, proceed as follows starting from the concentration screen (otherwise key **EXIT** first):

- Key sequentially **EXIT**, **ENTER**, **ON/OFF** and **ENTER**.

8.5 Resetting Procedure

The *personal*DataRAM memory can be reset through commands entered on its own keypad (i.e. without requiring a PC).

Resetting accomplishes the following:

- Erases all stored data from memory;
- Resets all parameters and operating conditions to their default values and conditions; and
- Cancels the zero correction offset.

WARNING: THE RESET TEST WILL ERASE ALL DATA STORED IN MEMORY AND SET ALL PARAMETERS TO FACTORY DEFAULT SETTINGS. DOWNLOAD ANY DATA BEFORE THE RESET PROCEDURE.

The procedure to reset the instrument is as follows:

Starting with the unit shut off, press the **EXIT** and **ENTER** keys at the same time, and while holding down those two keys, press **ON/OFF**. The screen will then indicate: PDR SELF-TEST...
and several diagnostic screens will appear in rapid sequence (see Section 16.0, Resetting/Electronics Checking Mode), ending in the message TESTING COMPLETE. The unit will shut off. When turned on again, the *personal*DataRAM memory will have been reset, as described above.

The **default** values and operating conditions of the *personal*DataRAM are:

- Logging period (LOG INTRVL): 60 seconds
- Logging status: disabled (LOGGING DISABLED)
- Alarm level: 1 mg/m^3

- Alarm status: disabled (ALARM: OFF)
- Analog output: 0 to 4 mg/m^3
- Analog output status: disabled (ANALOG OUTPUT :DISABLED)
- Real-time display averaging time (DIS AVG TIME): 10 seconds
- Calibration factor (CAL FACTOR): 1.00

When turning on the *personal*DataRAM after resetting the instrument, it should be zeroed (see steps 1 and 2 of Section 8.1) before a run is initiated. Otherwise, its internal optical background level will not be subtracted from the indicated concentration readings. Alternatively, if the instrument is not zeroed after resetting, it will indicate its unsubtracted optical background when run under particle free conditions.

9.0 COMMUNICATIONS WITH COMPUTER

9.1 Hardware and Software Requirements

The computer requirements to install the software provided with the *personal*DataRAM (Thermo Electron *p*DR-COM) are the following:

- IBM-PC compatible
- 486, Pentium, or better processor
- Minimum operating system: Windows 95™ or better
- ≥ 8 MB of RAM
- 2 MB of hard drive space
- CD-ROM drive
- VGA or higher resolution monitor

NOTE: When large files are logged in the *personal*DataRAM in one single tag, a faster computer speed is required to handle the data. For example, if all 13,000 data points are logged in one tag, a Pentium I or II processor with a minimum speed of 166 MHz will be required. If, however, the maximum number of data points per tag is 1,000 or below, a 33 MHz, 486 DX processor will suffice.

Thermo Electron custom hardware and software (provided as standard accessories):

- Digital communications cable (Thermo Electron model pDR-DCC)
- CD-ROM disk (Thermo Electron model 100034-00)

9.2 Software Installation Procedure

To install the Thermo Electron provided software in the computer, proceed as follows:

1. Insert the CD-ROM disk labeled "*p*DR-COM" into computer.

2. For Windows 95™ or higher users, select **Start** and then **Run**.
3. Type in on the **Command Line**: **x: install** (where "x" is the CD-ROM drive).
4. The message "**Do you wish to install pDR-COM?**" will appear. Click **OK** to continue, or **Cancel**.
5. A message appears allowing the option to change the default directory:
6. "**C:\PDRCOM**". It is advisable to leave the default directory (unless you address the hard drive by a different letter), and select **OK**.
7. After a successful installation, the message "**Installation Complete!**" will appear.

9.3 Communication Between personalDataRAM and Computer

To effect the communication between the *personal*DataRAM (via the *p*DR-COM software installed in the computer as described in the preceding section) and the PC, proceed as follows:

1. Connect the *personal*DataRAM to one of the computer's serial ports using the *p*DR-DCC cable provided by Thermo Electron. This cable has a 9-pin female connector for the computer port.

2. Key **ON/OFF** the *personal*DataRAM and then key **NEXT** repeatedly until CONNECT TO PC is displayed on the *personal*DataRAM.

3. On the computer, double click on the ***p*DR-COM** icon. A four-tabbed notebook display should appear. Click on the **Com Port Select** and select the port to which the pDR-DCC cable has been connected.

4. From the four-tabbed notebook displayed on the computer screen select the tab with the desired option. The options are:

- **Main:** This page allows the user to input the *personal*DataRAM serial number (or any other desired label), and select the Serial Com Port.

- **Logged data:** This page allows the user to download, tabulate, print data, or transfer to a CSV file the data stored in the *personal*DataRAM. This page also serves to display real-time numerical data when the computer is connected to the *personal*DataRAM in the Run Mode.

- **Graph data:** This page enables the downloading and graphing of stored data to the computer screen and to a printer. In the Run Mode, this page displays the real-time data in graphic format.

- **Configure *p*DR:** This screen allows the user to edit the operating/logging parameters. Click on the item to be edited and select or type in the new value.

To review the parameter values currently programmed into the *personal*DataRAM, click on **Get configuration**. After editing the parameters, click on **Set configuration** to input the new values into the *personal*DataRAM program.

Most operations within *p*DR-COM are self-evidently labeled, including fly-over dialog boxes. In addition, instructions may be found in the On-line Help files by selecting **Help** and then **Contents**.

The following operating/logging parameters of the *personal*DataRAM are selected (edited) via the computer:

- Current date (month and day of the month)
- Current time (hour, minute and second)
- Display averaging time (1 to 60 seconds, in 1-second increments)
- Calibration factor (0.01 to 9.99, in 0.01 increments)
- Logging interval (1 to 14,400 seconds, in 1-second increments)
- Analog output full scale concentration (0.1, 0.4, 1, 4, 10, 40, 100, or 400 mg/m^3)
- Analog output status (enabled, or disabled) (can also be selected directly through *personal*DataRAM keyboard, see Section 8.2)
- Alarm level (0.001 to 409.599 mg/m3, in 1-µg/m^3 increments)
- Alarm mode (Off, Instantaneous, or STEL) (can also be selected directly through *personal*DataRAM keyboard, see Section 8.2)

The serial number of the *personal*DataRAM is transferred automatically to the PC and displayed on its screen.

In addition, the user can input any other identification for the instrument (up to 20 characters).

9.4 Real-Time RS-232 Output

During the RUN mode, the *personal*DataRAM can communicate real-time concentration data through its serial port via the *p*DR-COM software package. This software application decodes the data and displays it on the computer screen in both graphical and tabulated form.

In order to use this output with some other application, the following information will enable the user to decipher the encoded output signal.

The communication settings for the digital output of the *personal*DataRAM are:

Baud rate:	4800 bps or 9600 bps
Data bits:	8
Stop bits:	1
Parity:	none
Flow control:	Xon/Xoff

Every second during a run, the *personal*DataRAM serial port will output a sixteen-character code. It consists of two brackets with 14 hexadecimal digits between them, representing sum check (2 digits), sensed concentration (8 digits), and calibration factor (%, 4 digits). The concentration in $\mu g/m^3$ is obtained by multiplying the sensed concentration times the calibration factor and dividing by 100.

10.0 ANALOG SIGNAL OUTPUT

10.1 Analog Output Description

The *personal*DataRAM incorporates the capability to provide both a voltage and a current signal output directly proportional to the sensed concentration of airborne particulates. Both these analog signal outputs are concurrently available. These outputs are provided, principally, for fixed-point applications with hard-wired installations, such as for continuous HVAC monitoring and control.

The particulate concentration range corresponding to the output voltage and current ranges (0 to 5 V and 4 to 20 mA) can be user selected (via a PC). The most sensitive range available is 0 to 0.100 mg/m^3, and the least sensitive range is 0 to 400 mg/m^3. For example, if the user selects the analog output range of 0 to 0.400 mg/m^3 then the analog output signal levels, at a concentration of 0.200 mg/m^3, would be 2.5 V and 12 mA.

Selection of the concentration range of the analog output must be performed on the PC. This range is independent of the digital display, data logging and real-time digital output range which are controlled automatically (auto-ranging).

Enabling the analog output increases the current consumption from the power source (battery or power supply) of the *personal*DataRAM by typically 5 mA when no load is connected to the analog signal current output. If such a load is connected then the current consumption of the *personal*DataRAM further increases by the magnitude of the output signal current (up to a maximum increment of 20 mA). Therefore, when not using the analog output, it is advisable to disable that output (see Section 8.2) in order to minimize power consumption (this is important only when powering the *personal*DataRAM from a battery source).

10.2 Analog Output Connection

The *personal*DataRAM is provided with a cable (model *p*DR-ANC) which has a 6-contact plug at one end and flying leads at the other. There are 4 leads for the analog and alarm outputs. The additional two contacts of the connector are used only for digital communication with a PC, for which a separate cable (model *p*DR-DCC) is provided.

Counting from top to bottom on the *personal*DataRAM connector receptacle, contact #1 is the positive 4 – 20 mA analog output, contact #2 is the alarm output, contact #5 is the common ground (return for all signals), and contact #6 is the positive 0 – 5 V analog output.

For the 0 – 5 V output signal, the externally connected load must have an impedance of more than 200 kilo-ohms. For the 4 – 20 mA output signal, the externally connected load must have an impedance of less than 200 ohms when powering the *personal*DataRAM with a battery, or less than 300 ohms when using the its AC supply.

Since both voltage and current outputs are present at the same time, both can be used concurrently, if so required.

The accuracy of the analog output signals is better than 1% of the reading with respect to the digital reading.

11.0 ALARM

11.1 Alarm Description and Operation

The *personal*DataRAM alarm function is provided both as an audible signal as well as an electrical output. The audible alarm consists of a series of beeps generated by an on-board piezo-transducer. The electrical output, available at the digital communications port, consists of a 1 Hz square wave signal which can be used to trigger/activate other equipment through an appropriate interface (consult with the factory).

The alarm function can be enabled/disabled by the user through the *personal*DataRAM keyboard (see Section 8.2). Setting of the alarm level must be performed on the PC (see Section 9.0).

The alarm is triggered whenever the preset alarm level is exceeded based either on: a) the displayed real-time concentration, if ALARM: INSTANT was selected (see Section 8.2), or b) a 15-minute running average concentration, if ALARM: STEL was selected. When the concentration falls below that level the alarm condition stops. While the alarm is on the user can stop it (i.e. silence the alarm) by pressing any key of the *personal*DataRAM. If the concentration continues to exceed the set alarm level after 10 seconds, however, the alarm restarts.

11.2 Alarm Output

A pulsed voltage output is available on the *personal*DataRAM in synchronism with the audible signal. This signal consists of a 1 Hz square wave with an amplitude level of 5 V pp. An externally connected load should have an impedance of no less than 100 kilo-ohms. This alarm output signal is available at pins 2 and 5 (counting from top to bottom) of the 6-contact output/communications port on the side of the *personal*DataRAM (see Figure 5 or 6).

11.3 Remote Alarm Unit

An alarm relay unit (Thermo Electron model *p*DR-RA) is available as an optional accessory for the *personal*DataRAM. The *p*DR-RA, when connected to the alarm output of the *personal*DataRAM, provides a switched output triggered by the alarm signal of the monitor. This switched output (up to 8 amperes, 250 volts) can be used to activate or deactivate other equipment (e.g. ventilation systems, machinery, etc.), or to control remotely located (by wire connection) alarm indicators (e.g. buzzers, lights, etc.).

12.0 MAINTENANCE

12.1 General Guidelines

The *personal*DataRAM is designed to be repaired at the factory. Access to the internal components of the unit by others than authorized personnel voids warranty. The exception to this rule is the occasional cleaning of the optical sensing chamber.

Unless a MALFUNCTION message is displayed, or other operational problems occur, the *personal*DataRAM should be returned to the factory once every two years for routine check out, testing, cleaning and calibration.

12.2 Cleaning of Optical Sensing Chamber

Continued sampling of airborne particles may result in gradual build-up of contamination on the interior surfaces of the sensing chamber components. This may cause an excessive rate of increase in the optical background. If this background level becomes excessive, the *personal*DataRAM will alert the user at the completion of the zeroing sequence, as indicated in Section 8.1, by the display of a BACKGROUND HIGH message. If this message is presented, the *personal*DataRAM can continue to be operated providing accurate measurements. However, it is then advisable to clean the interior of the sensing chamber at the first convenient opportunity, proceeding as indicated below.

12.2.1 Model *p*DR-1000AN

- Remove the two screws on the top of the large protective bumper that covers the sensing chamber (see Figure 1);
- Remove the large protective bumper by lifting it firmly upwards and away from the sensing chamber;
- Remove the socket-head screws on the front and back black covers that were exposed by removal of the large top bumper. Lift away the freed front and back covers of the sensing chamber; set them aside carefully and such that they can be reattached in the same position as they were previously; avoid touching the dull black side of these plates;

- Using filtered (particle-free) pressurized air, blow the inside of the sensing chamber taking great care in not marring or scratching any of the exposed surfaces;
- Reposition the two sensing chamber cover plates in the same location (front and back) as they had been originally. Insert and tighten socket head screws firmly making sure that the two plates are aligned perfectly with the top of the sensing chamber;
- Reposition large protective bumper over sensing chamber pushing down until properly seated. Insert the two top screws holding down the bumper and tighten gently (do not over-tighten);
- Check optical background by zeroing the *p*DR-1000AN as indicated in Section 8.1. If the sensing chamber cleaning was performed correctly, the message CALIBRATION: OK should be displayed at the end of the zeroing period.

12.2.2 Model *p*DR-1200

- Remove the two screws (one in the front and one in the back) holding the front and back gasketed covering plates of the sensing chamber, and set these plates aside, such that they may be reattached in the same location as they were previously.
- Using filtered (particle-free) pressurized air, blow the inside of sensing chamber taking great care in not marring or scratching any of the exposed surfaces.
- Reposition the two sensing chamber cover plates in the same location (front and back) as they had been originally. Insert and tighten socket head screws firmly making sure that the two plates are aligned perfectly with the top of the sensing chamber.
- Check optical background by zeroing the pDR-1200 as indicated in Section 8.1. If the sensing chamber cleaning was performed correctly, the message CALIBRATION: OK should be displayed at the end of the zeroing period.

12.3 Cyclone Cleaning (Model *p*DR-1200 only)

The cyclone will require occasional cleaning. It is advisable to do so whenever the sensing chamber of the *p*DR-1200 is cleaned (see above). To clean the cyclone, remove it from its black attachment cup on the sensing chamber, and unscrew the grit pot (narrower knurled end). Use clean pressurized air to blow out the grit pot and through all openings of cyclone body. Reattach grit pot to cyclone body and insert cyclone body into attachment cup making sure it is fully inserted.

13.0 CALIBRATION

13.1 Factory Calibration

Each *personal*DataRAM is factory calibrated against a set of reference monitors that, in turn, are periodically calibrated against a gravimetric standard traceable to the National Institute of Standards and Testing (NIST).

The primary factory reference method consists of generating a dust aerosol by means of a fluidized bed generator, and injecting continuously the dust into a mixing chamber from which samples are extracted concurrently by two reference filter collectors and by two master real-time monitors (Thermo Electron DataRAM 4) that are used for the routine calibration of every *personal*DataRAM.

The primary dust concentration reference value is obtained from the weight increase of the two filters due to the dust collected over a measured period of time, at a constant and known flow rate. The two master real-time monitors are then adjusted to agree with the reference mass concentration value (obtained from averaging the measurements of the two gravimetric filters) to within ±1%.

Three primary, NIST traceable, measurements are involved in the determination of the reference mass concentration: the weight increment from the dust collected on the filter, the sampling flow rate, and the sampling time. Additional conditions that must be met are: a) suspended dust concentration uniformity at all sampling inlets of the mixing chamber; b) identical sample transport configurations leading to reference and instrument under calibration; and c) essentially 100% collection efficiency of filters used for gravimetric reference for the particle size range of the test dust.

The test dust used for the Thermo Electron factory calibration of the *personal*DataRAM is SAE Fine (ISO Fine) supplied by Powder Technology, Inc. It has the following physical characteristics (as dispersed into the mixing chamber):

- Mass median aerodynamic particle diameter: 2 to 3 µm
- Geometric standard deviation of lognormal size distribution: 2.5
- Bulk density: 2.60 to 2.65 g/cm3
- Refractive index: 1.54

13.2 Field Gravimetric Calibration

If desired, the *personal*DataRAM can be calibrated gravimetrically for a particular aerosol (dust, smoke, mist, etc.) under field conditions (actual conditions of use). To effect such calibration in the particle environment of interest, proceed as indicated below.

For field calibration of the model *p*DR-1000AN, a personal type filter sampler is placed side-by-side (collocated) to the *p*DR-1000AN to be calibrated, and the two units should be started simultaneously. For the model *p*DR-1200, its own filter and attached pump can be conveniently used for the same purpose.

- Weigh and load into filter holder a fresh membrane filter.
- Start pump.
- Immediately turn on *personal*DataRAM and start a run such that the pump and the *personal*DataRAM are started nearly simultaneously.

The duration of this comparison run should be sufficient to collect a mass of at least 1 mg on the reference filter (in order to permit accurate weighing of the collected mass by means of an analytical balance). The time-weighted average (TWA) reading of the *personal*DataRAM can be used to estimate the required sampling time to collect the above-mentioned mass on the filter. To estimate the required sampling time (ET as measured on the *personal*DataRAM) in minutes, read the TWA value (see Section 8.3) after an elapsed time (ET) of one minute or more, and apply the following relationship:

$$ET \geq 500/TWA$$

For example, if TWA = 2.5 mg/m^3, then ET ≥ 200 minutes (approximately 3 hours). If the TWA value changes significantly as the run proceeds, recalculate the required ET accordingly.

At the end of the run (after time ET has elapsed), record TWA, ET and the flow rate Q used to sample the air. Weigh the filter on an analytical balance and obtain Δm, the mass increment due to the collected particles.

Calculate the average gravimetric concentration C, as follows:

$$C = 1000\ \Delta m/ETxQ$$

Compare the recorded value of TWA and the calculated value C, and calculate the calibration factor to be programmed into the *personal*DataRAM (see Section 9.0) as follows:

$$CAL\ FACTOR = C/TWA$$

For example, if C was found to be 3.2 mg/m^3, and TWA had been determined to be 2.5 mg/m^3, the CAL FACTOR equals 1.28. Select this value on the PC, as described in Section 9.0. This completes the gravimetric calibration of the *personal*DataRAM for a specific aerosol.

13.3 Scattering Coefficient Calibration

Users interested in using the *personal*DataRAM for scattering coefficient measurements (e.g., for atmospheric visibility monitoring) should contact the factory. A special primary Rayleigh scattering calibration for such purpose can be performed by the factory.

13.4 Internal Span Check

The zeroing procedure (see Section 8.1) and the resulting normal diagnostic display of "CALIBRATION: OK" (step 2) informs the user that the instrument's calibration agrees with the original factory setting. This is an internal span check that consists of an automatic comparison between the initial (factory) optical background of the *personal*DataRAM (registered in its non-volatile memory), and the current optical background sensed during the zeroing sequence.

14.0 PARTICLE SIZE CLASSIFICATION (model *p*DR-1200 only)

The particle size selective cyclone of the *p*DR-1200 provides the user with two important capabilities: a) to measure the particulate matter concentration of a specific aerodynamic size fraction, and b) to determine the mass median size of a particle population. These two applications will be discussed in what follows. For both these applications, a variable measured flow rate pump is required, such as the model *p*DR-PU (for which a separate instruction manual is provided).

14.1 Size Fractionated Monitoring

The *p*DR-1200 can be used to monitor a specific particle size fraction below a selectable cut off equivalent aerodynamic diameter. The particle size cut point can be selected by adjustment of the sampling flow rate. The higher the flow rate through the cyclone the smaller the cut off particle diameter. Figure 7 is a graph showing the dependence of the particle cut off size in micrometers as a function of the sampling flow rate in liters per minute. The cut off size is the particle aerodynamic diameter at which the collection efficiency of the cyclone is 50%, or conversely, the size at which the cyclone transmission is 50%. For example, to obtain a particle size cut off of 2.5 µm (i.e., PM2.5), the required sampling flow rate is 4 liters/minute. A that flow rate only particles smaller than (approximately) 2.5 µm are allowed to pass into the *p*DR-1200 sensing stage, to be monitored and then to be collected on the filter.

As can be seen on Fig. 7, the lowest particle size cut for the GK 2.05 cyclone included with the *p*DR-1200 is about 1 µm, and the largest is about 12 µm. For particle size classification outside this range, consult with the factory.

14.2 Particle Sizing

The selectable particle size capability of the cyclone, in combination with the concentration measuring capability of the photometric system of the *p*DR-1200 permits the user to determine the mass median aerodynamic particle diameter of an aerosol, i.e., of the airborne particle population being sampled.

One simple procedure to determine the median particle size is as follows (please refer to the graph of Fig. 7):

- Remove cyclone from its black attachment cup and set cyclone aside
- Start pump and sample aerosol at a flow rate between 2 and 4 liters/minute
- Press ON key on pDR-1200 panel and after about one minute key NEXT and then ENTER
- After an elapsed time (ET) of about one minute, read and note TWA concentration
- Shut off pump
- Plug in cyclone into its attachment cup

- Start pump and run at about 1 liter/minute. Observe real-time concentration (CONC) reading
- Increase flow rate very slowly and gradually until CONC reading is one-half of the initial concentration measured without the cyclone. Continue sampling at this flow rate for about one minute and confirm that TWA reading is about one-half of the initial one. Otherwise readjust flow rate. Note final flow rate at which the TWA value has decreased to one-half the value noted without the cyclone.
- Enter the final flow rate for which the TWA value is one-half of the initial value into the graph of Fig. 7 and read the corresponding D50 particle size in micrometers. This represents the mass median particle diameter of the aerosol.

For example, if the TWA value without the cyclone was 0.8 mg/m^3, and the flow rate (with the cyclone attached) required to reduce the TWA to 0.4 mg/m^3 is 2 liters/minute, the mass median particle size (as obtained from the curve of Fig. 7) is approximately 5.5 μm.

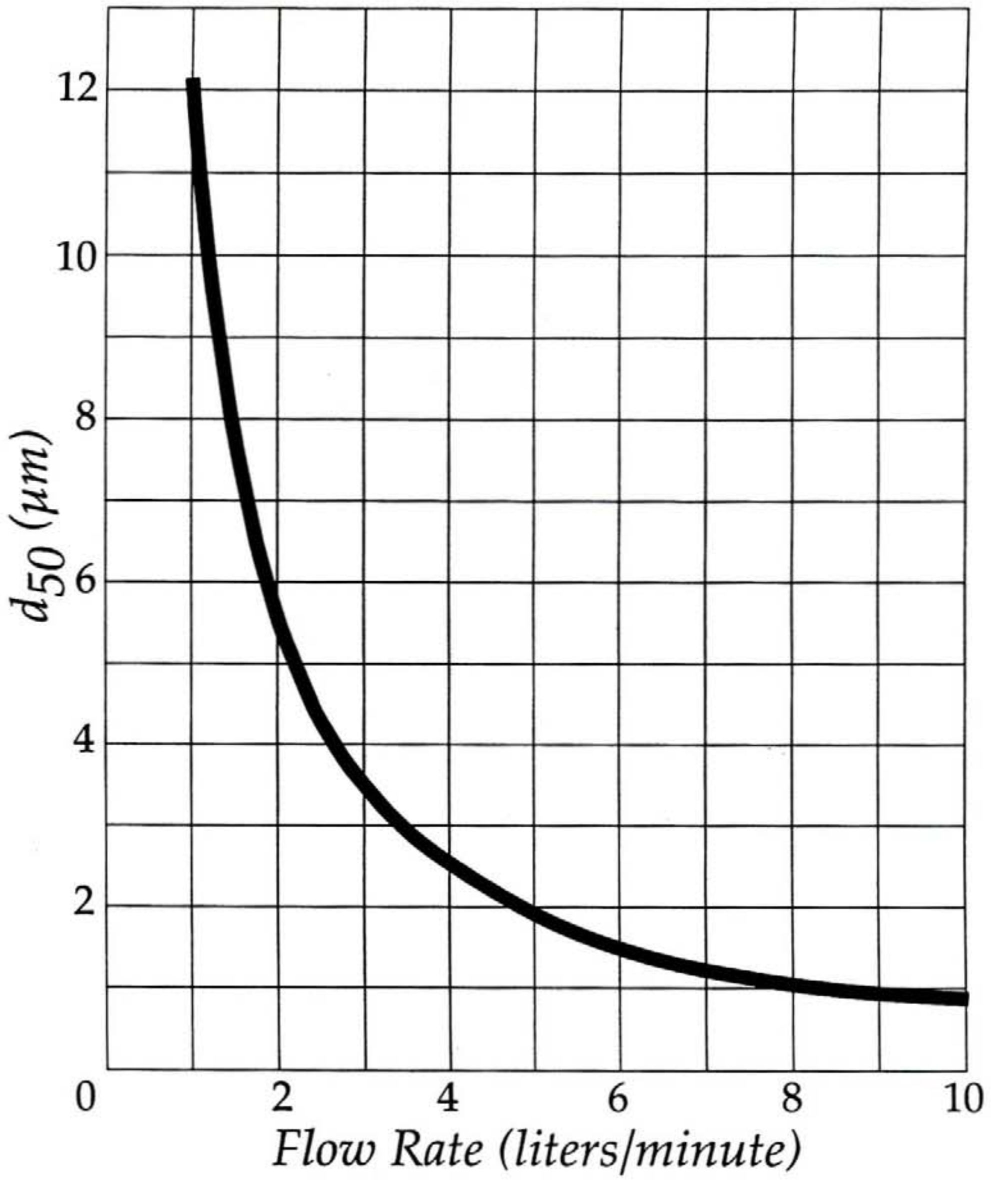


Figure 7. GK 2.05 Cyclone Cut Point (d_{50}) as a Function of Flow Rate

15.0 CONVERSION BETWEEN *personal*DataRAM VERSIONS

The *personal*DataRAM user has the option to convert from a model *p*DR-1000AN to a model *p*DR-1200 or vice versa using the appropriate conversion kit. To convert from a *p*DR-1000AN to a pDR-1200 (i.e., from a passive air sampling configuration to an active one), the user requires the model *p*DR-AS conversion kit. To convert from a *p*DR-1200 to a *p*DR-1000AN (i.e., from an active air sampling configuration to a passive one), the user requires the model *p*DR-UB conversion kit.

15.1 Conversion Procedure From *p*DR-1000AN to *p*DR-1200

To effect this conversion, use model *p*DR-AS conversion kit. As you remove parts from the *p*DR-1000AN, in order to attach the conversion kit components, store these parts carefully for possible future re-conversion. Proceed as follows:

- Remove the two screws on the top of the large protective bumper that covers the sensing chamber (see Figure 1). This bumper is not used on the *p*DR-1200;
- Remove the large protective bumper by lifting it firmly upwards and away from the sensing chamber;
- Reinsert in the upper two threaded holes and tighten the two screws that had held the protective bumper;
- Remove the socket-head screws on the front and back black covers that were exposed by removal of the large top bumper. Lift away the freed front and back covers of the sensing chamber; store them carefully for future use, ensuring that their surfaces are not scratched or marred;
- Position one of the two gasketed (soft rubber) sensing chamber cover plates provided in the conversion kit on the front side of the sensing chamber. Insert and tighten the included socket head screw firmly making sure that the plate is aligned perfectly with the top of the sensing chamber. Similarly, attach the other cover plate on the back side of the sensing chamber;
- Identify the two black cups of the *p*DR-AS conversion kit. One of them has an external o-ring (filter holder cup), and the other has no o-ring (cyclone cup); refer to Figures 2 and 4 for the location of these cups on the *p*DR-1200 sensing chamber. These cups can be installed on either side of the sensing chamber, i.e., the cyclone can be either on the left or the right side of the sensing chamber (Figure 2 shows the case where the cyclone is on the right side);
- Attach one cup to the left side of the sensing chamber using the two black socket head screws. Tighten screws firmly. Similarly, attach the other cup to the right side of the sensing chamber;
- Take the cyclone/filter holder unit provided as part of the conversion kit, and separate the 37-mm plastic filter holder from the metal cyclone by firmly pulling the two units apart;
- Carefully slide the large open end of the plastic filter holder over the cup with the external o-ring, previously attached to the sensing chamber. Ensure that the cup is fully inserted into the filter holder;

- Carefully insert the large diameter open end of the metal cyclone into the other cup on the opposite side of the sensing chamber. The cyclone inlet (small short metal tube on side of cyclone) can be oriented as desired (upwards, as shown in Figure 2, sideways, downwards, etc.). Ensure that the cyclone is fully inserted into the cup;
- When ready to operate, connect a length of tubing between the barbed fitting at the downstream end of the plastic filter holder and the pump to be used in combination with the *p*DR-1200.
- Perform a zeroing sequence (see Sections 6.5.2 and 8.1) before starting a run. This completes the conversion of the *p*DR-1000AN to the *p*DR-1200.

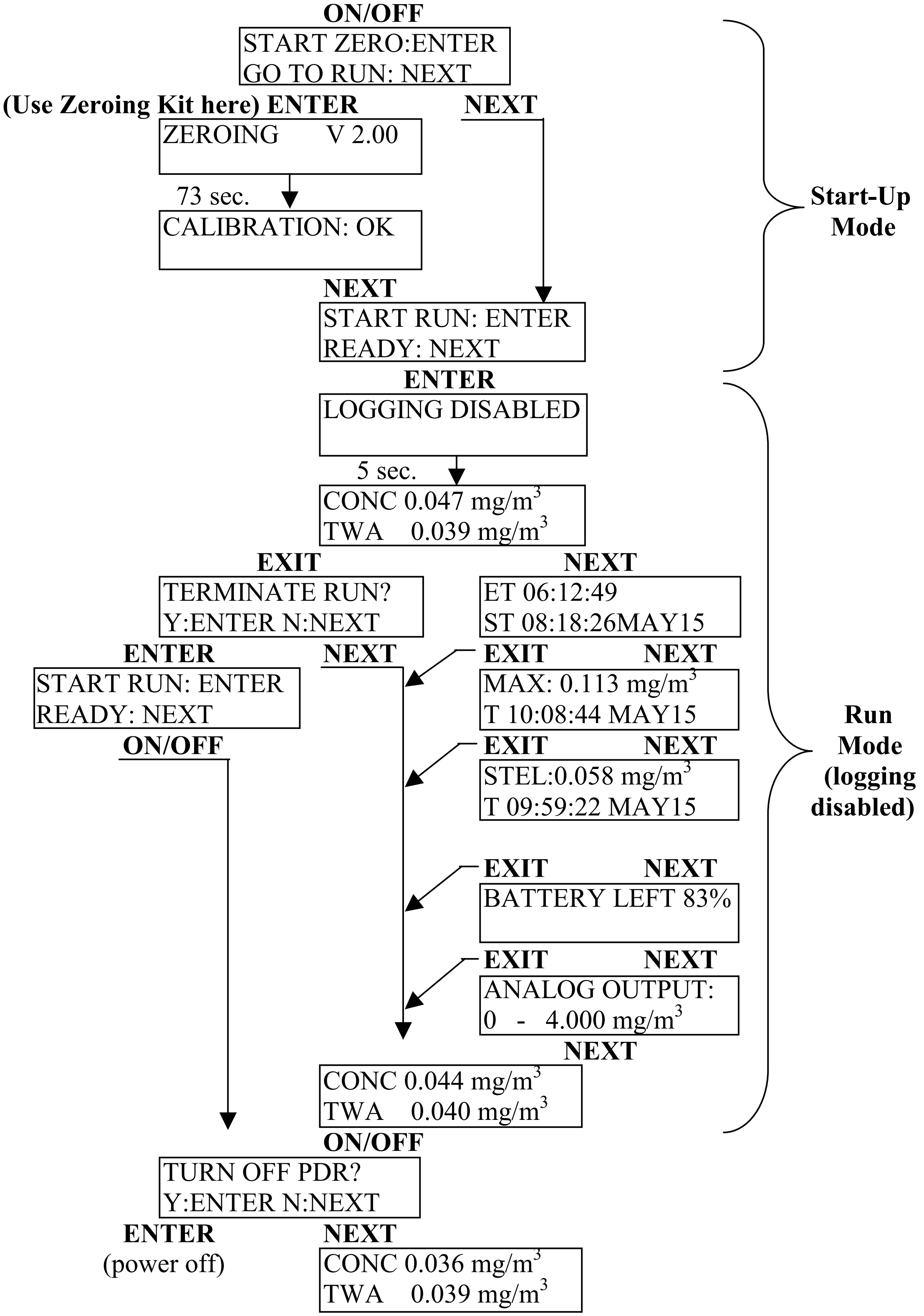
15.2 Conversion Procedure from *p*DR-1200 to *p*DR-1000AN

To effect this conversion use model *p*DR-UB conversion kit. As you remove parts from the *p*DR-1200, in order to attach the conversion kit components, store these parts carefully for possible future re-conversion. Proceed as follows:

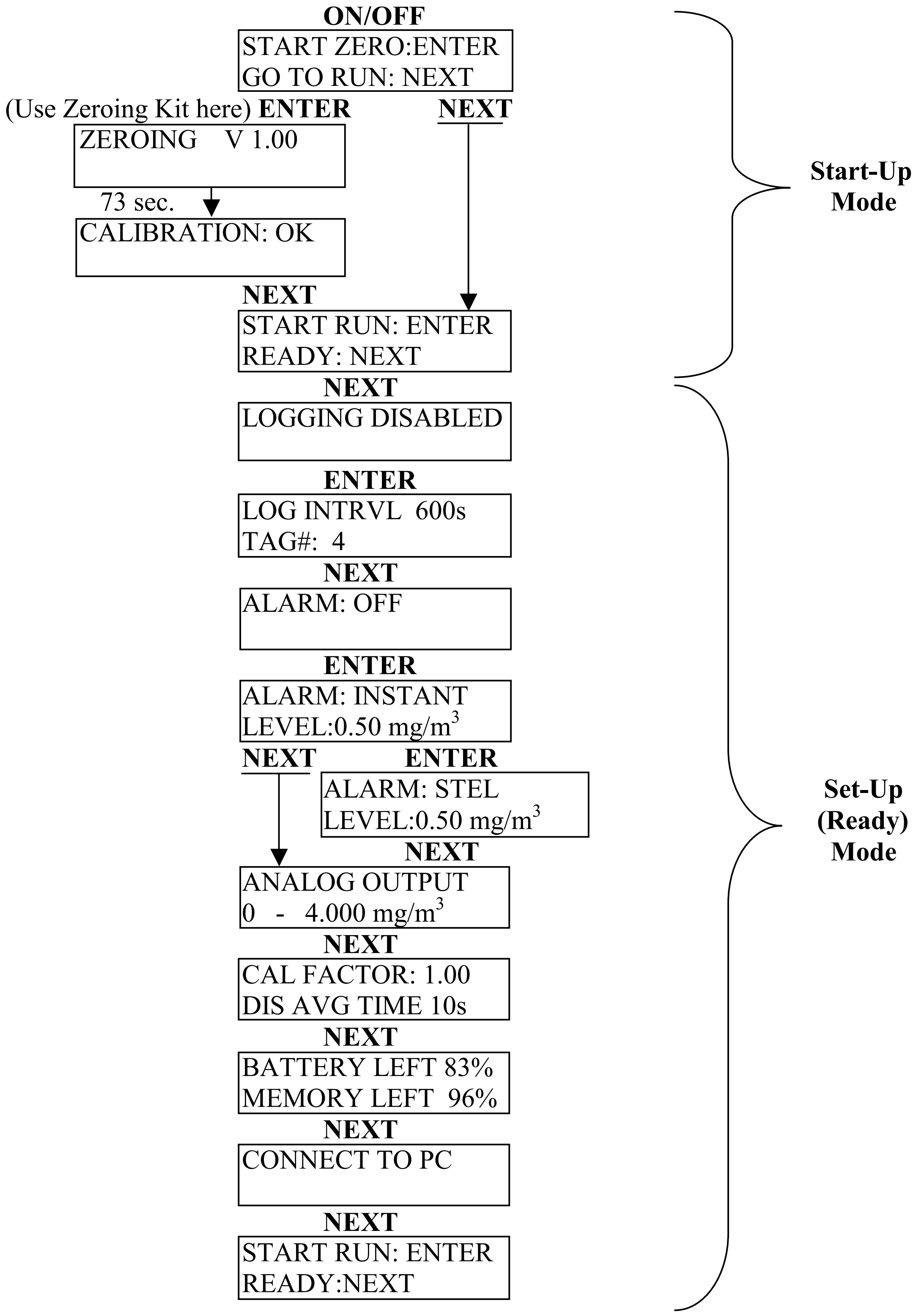
- Pull off both the cyclone and the filter holder from their respective cups on the two sides of the sensing chamber;
- Loosen the two screws that hold each of the two cups on the sides of the sensing chamber (total of 4 screws), and remove the two side cups;
- Loosen the single screw on each of the two (front and back) gasketed sealing covers enclosing the sensing chamber, and remove the two covers;
- Identify the two flat sensing chamber cover plates provided in the conversion kit; one face of each of each of these two plates has a dull black finish (antireflective); avoid touching those surfaces;
- Position one of the two sensing chamber cover plates over the open front of the sensing chamber with the dull surface on the inside, and such that the hole in the plate is aligned with the corresponding threaded mounting hole on the upper wall of the sensing chamber. Insert and tighten firmly black socket head screw provided with the conversion kit, making sure that the plate is aligned perfectly with the top of the sensing chamber. Similarly, attach the other cover plate to the rear of the sensing chamber, with the dull surface facing inward;
- Loosen and remove the two small screws on the top surface of the sensing chamber;
- Position large protective bumper (provided in the conversion kit) over sensing chamber pushing down until properly seated. Insert the two top screws (two shiny Phillips-head screws provided in the conversion kit) into the two holes in the bumper while holding down the bumper, and tighten gently (do not over-tighten) making sure that the heads of these screws are well inside their cavities in the bumper;
- Perform a zeroing sequence (see Sections 6.5.1 and 8.1) before starting a run. This completes the conversion from a *p*DR-1200 to a *p*DR-1000AN.

16.0 SEQUENCE OF KEYSTROKES AND SCREENS (*p*DR-1000AN/1200, ADR-1200S and HPM-1000)

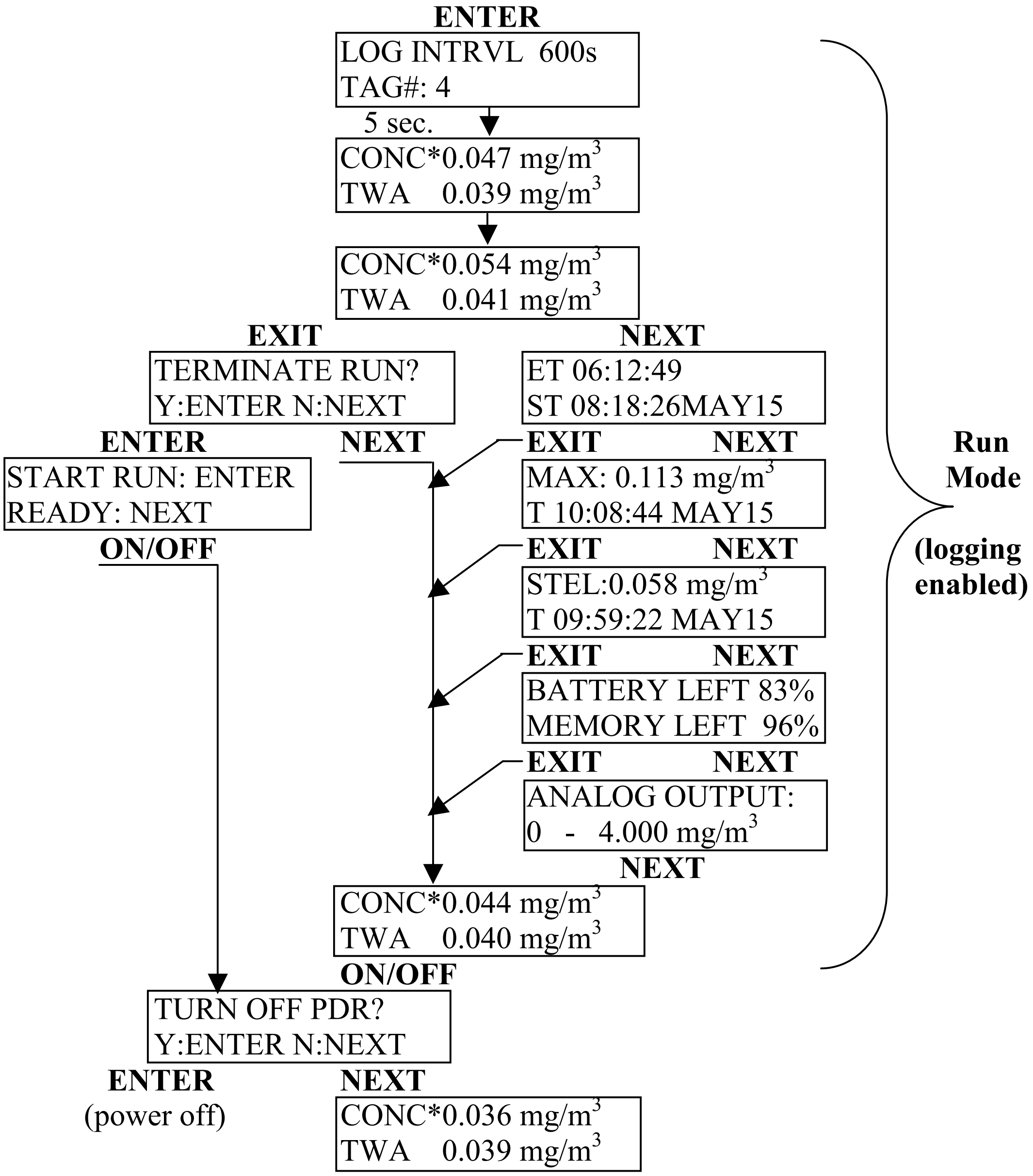
Start-Up and Survey Run Mode (Without Data Logging)



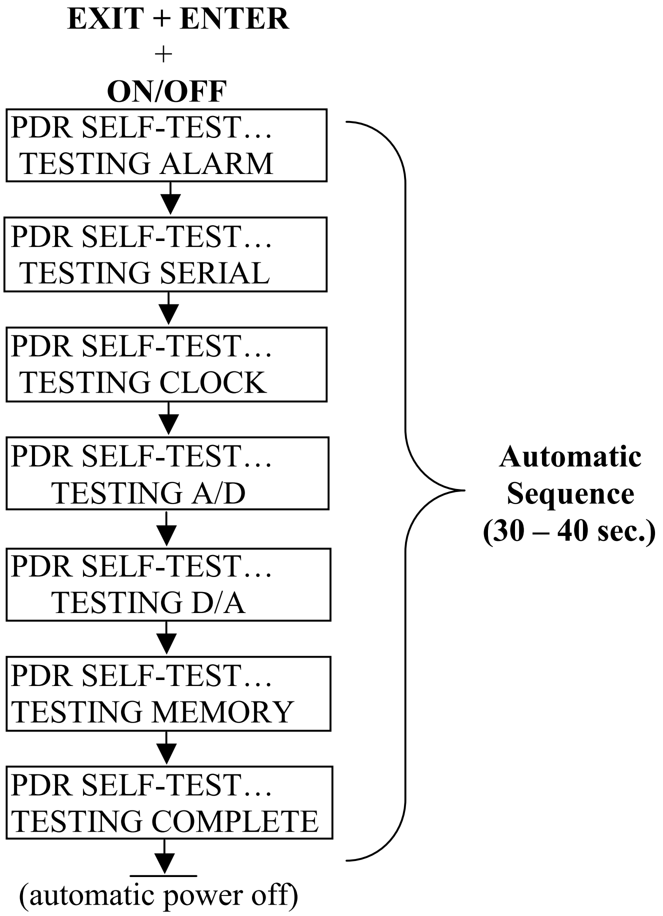
Start-Up, Set-Up and Run Mode (With Data Logging)



(Continues on next page)


ENTER
LOG INTRVL 600s
TAG#: 4
5 sec.
CONC*0.047 mg/m^3
TWA 0.039 mg/m^3
CONC*0.054 mg/m^3
TWA 0.041 mg/m^3
EXIT
TERMINATE RUN?
Y:ENTER N:NEXT
NEXT
ET 06:12:49
ST 08:18:26MAY15
ENTER
NEXT
START RUN: ENTER
READY: NEXT
ON/OFF
EXIT
NEXT
MAX: 0.113 mg/m^3
T 10:08:44 MAY15
EXIT
NEXT
STEL:0.058 mg/m^3
T 09:59:22 MAY15
EXIT
NEXT
BATTERY LEFT 83%
MEMORY LEFT 96%
EXIT
NEXT
ANALOG OUTPUT:
0 - 4.000 mg/m^3
NEXT
CONC*0.044 mg/m^3
TWA 0.040 mg/m^3
ON/OFF
TURN OFF PDR?
Y:ENTER N:NEXT
ENTER
(power off)
NEXT
CONC*0.036 mg/m^3
TWA 0.039 mg/m^3
Run
Mode
(logging
enabled)

Resetting/Electronic Checking Mode



NOTE: After the preceding resetting sequence, the instrument should be zeroed; otherwise its optical background will remain unsubtracted.

17.0 SERVICE LOCATIONS

For additional assistance, Environmental Instruments Division has service available from exclusive distributors worldwide. Contact one of the phone numbers below for product support and technical information.

866-282-0430 Toll Free
508-520-0430 International

GILAIR-5 CONSTANT FLOW AIR SAMPLING PUMP

- **External Filter Housing**

  Clear External filter housing allows an immediate visual inspection of filter's condition.

- **Flow Fault & Test Indicators**

  Flow Fault indicator lights up if unit operates outside ± 5% of set flow rate. Battery Test indicator lights up when battery can provide a minimum of 8 hours of operation over operating range.

- **Basic, Clock, & Program Models**

  Basic model is easy to use. Clock model provides elapsed-time clock display. Program model provides delay start times up to 9999 mins.

- **Optional Low Flow Modules**

  Constant Low Flow module allows sampling from 5-500 cc/min. Constant Pressure (Multiflow) Module allows sampling from 1-750 cc/min.

PRODUCT SPECIFICATIONS

PERFORMANCE

Flow Range	1- 5000 cc/min (Total), 850 - 5000 cc/min (High Flow); 5-500 cc/min (Constant Low Flow); 1-750 cc/min (Constant Pressure)
Constant Flow Control	Better than ± 5% of set flow (after calibration)
Pressure Range	5000cc up to 8" $H_2$0 back pressure 4000cc up to 15" $H_2$0 back pressure 3000cc up to 23" $H_2$0 back pressure 2000cc up to 26" $H_2$0 back pressure 1000cc up to 25" $H_2$0 back pressure 850cc up to 20" $H_2$0 back pressure
Run Time	8 hour minimum
Flow Fault	If flow changes exceed 5%, fault icon appears. If fault exceeds 30 seconds, pump shuts down. Pump attempts to restart every 3 minutes for up to 1 hour

ENVIRONMENTAL

Temperature Ranges

Operating	32°F to 104°F (0°C to 40°C)
Storage	-49°F to 113°F (-45°C to 45°C)
Charging	41°F to 104°F (5°C to 40°C)

Humidity Ranges

Operating	0-85 %RH, non-condensing
Storage	0-100 %RH, non-condensing

GENERAL

Display Messages	LAST, CAL, SHUT/OFF (Clock, Program); E, PC, P1-P6, OLD (Program)
Controls	Power Switch, Flow Control Screw, ▲ & ▼ Buttons (Clock, Program), Programming (PROG) Button (Program)
Indicators	Elapsed Time (Clock, Program)
Icons (LCD)	Low Battery, Flow Fault, Clock (Clock & Program)
Dimensions	4.1W x 3.9H x 2.0D inches 10.4W x 9.9H x 5.1D cm
Weight	22.5 oz. (638 g)

ELECTRICAL

Battery Pack	Removable, Sealed, Rechargeable Nickel-Cadmium
Interface Connectors	Charging Jack
Charging Time	14-18 hours

APPROVALS

CE	EMC EMI/RFI, EN 55 022 Class B; IEC 801-2, 3

Intrinsic Safety

UL	Class I, Div 1, Groups A, B, C, D; T3C
CENELEC	EEx ia IIC T4

ORDERING INFORMATION

Description	Part Number
GilAir-5 R Sampling Pump, Basic	800883-111
GilAir-5 RC Sampling Pump, Clock	800885-111
GilAir-5 RP Sampling Pump, Program	800884-111
GilAir-5 R Sampling Pump, Basic, Starter Kit, 120V	800883-111-1201
GilAir-5 RC Sampling Pump, Clock, Starter Kit, 120V	800885-111-1201
GilAir-5 RP Sampling Pump, Program, Starter Kit. 120V	800884-111-1201
GilAir-5 R Sampling Pump, Basic, Starter Kit, 230V	800883-111-2301
GilAir-5 RC Sampling Pump, Clock, Starter Kit, 230V	800885-111-2301
GilAir-5 RP Sampling Pump, Program, Starter Kit. 230V	800884-111-2301
Single-Station Charger (120 VAC)	401224
Single-Station Charger (230 VAC) [euro plug]	401225-1
Five-Station Charger (120 VAC)	850069
Five-Station Charger (230 VAC)	850070
Battery Pack, Blue	800869
Low Flow Module, Constant Flow, Blue	800518
Low Flow Module, Multi-Flow, Blue	800519

For a complete listing of pump models, kit configurations, and pump accessories, refer to the Gilian Catalog.

*For more information on this pump and other Gilian products, please call **800-451-9444**, ext 782 and ask for our full product catalog.*

SENSIDYNE®

"The Standard for Professionals"™

16333 Bay Vista Dr. • Clearwater, Florida 33760 USA
800-451-9444 • 727-530-3602 • Fax: 727-539-0550
www.sensidyne.com • E-mail: info@sensidyne.com

R9 Laboratory SOP 490

Determination of Asbestos in Bulk Materials By Polarized Light Microscopy

Summary

This SOP applies to the examination of bulk materials for asbestos using polarized light microscopy. The bulk materials may include insulation materials, automotive brake materials, and a variety of other building materials suspected of containing asbestos fibers. This SOP is intended to be a qualitative technique that determines the presence (>1%) or absence of asbestos although volume percent estimates of the asbestos content can be made. It is intended for use with friable materials but can be used with materials such as tiles if fibrous components are clearly present and can be physically separated from the binder material. This SOP is based on the USEPA Interim Method for the Determination of Asbestos in Bulk Insulation Materials and ASTM Standard Method of Testing For Asbestos Containing Materials by Polarized Light Microscopy (ASTM D22.05) but does not address the point counting or the X-ray powder diffraction techniques described in the EPA method.

Samples are first examined at low power (10X-30X magnification) with a binocular microscope for homogeneity, the presence or absence of fibrous components, preliminary fiber identification and an estimation of fiber content. If no fibers are apparent with examination under low power, the absence of fibers is confirmed by examination by polarized light microscopy. If fibrous components are present, the sample is then subsampled and examined by polarized light microscopy using the central stop dispersion staining technique, cross polarization, and retardation to possibly identify the fibrous components and/or confirm the presence or absence of asbestos fibers.

http://www.epa.gov/region09/lab/sops/sop490.html

Appendix G

Field Forms

Daily Field Report
Iron King Mine – Humboldt Smelter Superfund Site

EPA Personnel: ___________________ Site Manager: ________________________ Date: ___________________________

1.0 SITE INVESTIGATION ACTIVITIES/PROGRESS

2.0 WEATHER:

3.0 HEALTH AND SAFETY:

3.0 ACTIVITIES PLANNED FOR NEXT WORKING DAY

4.0 ISSUES AND CONCERNS

Iron King Mine - Humboldt Smelter Superfund Site
Soil Boring Log

Boring:
Sheet **of**

PROJECT: Iron King Mine - Humboldt Smelter		**CONTRACTOR:**	**MONUMENT:**
PROJECT NO.: 14342.34		**DRILLER:**	**RISER:**
LOCATION:		**RIG TYPE:**	**SCREEN:**
TOTAL DEPTH:		**METHOD:**	**FILTER PACK:**
DATE:		**CASING ID:**	**SEAL:**
START TIME:	**FINISH TIME:**	**BORING ID:**	**GROUT:**
LOGGED BY:			**GROUND ELEV.:**

Sample Lab Analysis	**Depth Range**	**Blows/6 inches**	**Recovery (%)**	**USCS**	**Depth (ft.)**	**LITHOLOGIC DESCRIPTION**	**Graphic Log**
					0		
					0.5		
					1		
					1.5		
					2		
					2.5		
					3		
					3.5		
					4		
					4.5		
					5		
					5.5		
					6		
					6.5		
					7		
					7.5		
					8		
					8.5		
					9		
					9.5		

Groundwater Depth (ft.) **Date/Time**

Comments:

Iron King Mine - Humboldt Smelter Superfund Site
Monitoring Well Sampling

Site: Iron King Mine - Humboldt Smelter Superfund Site		Client: EPA Region 9 through EPA Region 6 RAC 2 Contract
Project No.: 14342.34	Sample ID:	Well No.:
Purge Date/Time:		Sample Date/Time:
Purged By:		Sampled By:

Depth Measurement Ref. Point* ______ Well Casing ID: 2" 4" 6" Other ______

Original DTW ______ Final DTW ______

2" - 0.16
4" - 0.65 gals/ft (=) ______ gals/csg. vol. (x) ______ csg. vol. (=) ______ Total Purge Gals.
6" - 1.47
Other ______

* All depths in feet below reference point on wellhead, generally Top of Casing; DTW = Depth to Water;

PURGING METHOD:

Purging Equipment (Make, Model, etc.) ______

Purge Water Containerized? (Yes / No) Purging Equipment Decontaminated? ☐ Yes ☐ No

Average Purging Rate: ______ gpm Weather ______

Actual Time (min.)	Vols. Purged (gals.)	Depth to Pump Intake (ft.)	Depth to Water (ft.)	Temp (^{o}C)	pH	Cond. (mS/cm)	Turbidity (NTA)	D.O. (mg/L)	Salinity (%)	Comments

SAMPLE COLLECTION:

Analysis	Method	Container	# Bottles	Preservative

Colllection Method: ______

Sampler: ______

Remarks:

Iron King Mine - Humboldt Smelter Superfund Site
Tap Water Sampling Data Sheet

Monitoring Well Development Log

Site:		Client:
Project No.:	Sample ID:	Well No.:
Development Start Date/Time:		Development End Date/Time:
Developed By:		

Depth Measurement Ref. Point* ______________ Well Casing ID: 2" 4" 6" Other ______

Depth to top and bottom of screened interval ______________________

Original DTW ______________ Final DTW ______________

DEVELOPMENT METHOD:

☐ Submersible Pump
☐ Centrifugal Pump
☐ Gas Lift/Displacement Pump
☐ Dedicated Bladder Pump
☐ Peristaltic Pump
☐ Inertial Lift Pump
☐ Bladder Pump
☐ Hand Pump
☐ Other ___________
☐ Bailer
☐ SS
☐ Tef
☐ PVC

Development Equip. (Make, Model, etc.) ______________________________________

Development Water Containerized? (Yes / No)

Development Equip. Decontaminated? ☐ Yes ☐ No

Average Development Rate: ____________________ gpm

Weather ______________________________

Actual Time (min.)	Vols. Purged (gals.)	Depth to Pump Intake (ft.)	Depth to Water (ft.)	Temp (^{o}C)	pH	Cond. (mS/cm)	Turbidity (NTA)	D.O. (mg/L)	Salinity (%)	Comments

* All depths in feet below reference point on wellhead, generally Top of Casing; DTW = Depth to Water

Sheet _____ of _____
Date: ____________

Iron King Mine - Humboldt Smelter Superfund Site
Tap Water Sampling Data Sheet

Well ID: ____________ **Sample ID:** ____________ **Sample Time:** ____________

Well owner/location/residence:

Street address:

Filtration system? (circle one) Y N	Sampling personnel:
Start purge time:	Weather:
End purge time:	Purge Rate (gal/min):

Sample collected at (circle as appropriate): Wellhead tap In-line House tap

Field Parameters:

Time:					Within	Circle One:	
Specific Conductance:					**10%**	us/cm	ms/cm
pH:					**+/- 0.5**		
Temperature:					**+/- 1 C**	F°	C°
ORP:						mV	

Notes/Comments:

Well Configuration

Recorded By: ____________

IRON KING MINE – HUMBOLDT SMELTER SUPERFUND SITE
SURFACE WATER AND SEDIMENT SAMPLING FORM

Project: Iron King Mine – Humboldt Smelter Superfund Site Sample ID.:__________

Date: __________ Time: __________

Sampled By:__________

Weather Conditions:__________

Sample Location:__________

Sample Location Description:__________

Sample Depth: __________

Surface Water Flow Rate: __________

Surface Water Type: __________

Sample Condition (i.e. Turbidity, Odor, Etc.):__________

Collection Method: __________

Collection Time:__________

Water Parameters: pH______ Cond.______ T(C) ______ D.Oxygen:______

Analysis	Containers	Sample Preparation/Preservation

Comments: __________

Iron King Mine - Humboldt Smelter Superfund Site
Utilities and Structures Checklist

Area of Interest: ____________________ **Prepared By:** ____________________

Location: ____________________ **Date:** ____________________

One Call Checklist	Number	Date Called	Date Scheduled	Date Field Verified
One Call Number (State)				
Client				
City/County/Other				

Utilities & Structures Type	Present	Not Present	How Marked?[1]	Company	Name	Signature
Natural Gas Line						
Steam Line						
Water Line (public/private)						
Sewer Line (public/private)						
Storm Drain						
Telephone/Fiber Optic Lines (overhead/buried)						
Electric Power Lines (overhead/buried)						
AST/UST Product Tank/Lines						
Septic Tank/Drain Field						
Petroleum Products Lines						
Cable (TV)						
Switch/Signal (Railroad)						
Sprinkler System						

(1)Flags, paint on pavement, wooden stakes, etc.

Drilling or Excavation Sites. Attach a map of the property showing the proposed drilling or excavation site (or if sites are widely separated, several maps) clearly indicating the area(s) checked for underground utilities or underground structures and the location of above-ground power lines.

IRON KING MINE – HUMBOLDT SMELTER SUPERFUND SITE

XRF STARTUP AND CALIBRATION CHECKLIST

☐ **STEP 1:** Prior to operation each day, turn on the XRF instrument and allow it to run for 15 minutes to stabilize.

☐ **STEP 2**: Prior to any sample or standard analysis, calibrate the XRF instrument using the self-calibration mode in accordance with procedures outlined in the User's Guide.

☐ **STEP 3:** Record XRF instrument specification information provided in the SETUP menu specific to the Cd-109 source prior to conducting sample analysis.

☐ **STEP 4:** Check the date and time stamp for sample analysis provided by the XRF instrument to ensure accuracy; make any changes SETUP menu.

☐ **STEP 5:** Following instrument calibration, provide a source check of the **low-level** standard using a 120-second count time and record concentration of lead. The certified **low-level** standard value for lead is **18.9 ppm** ("CCRMP LOW").

☐ **STEP 6:** Provide a source check of the **mid-level** standard using a 120-second count time; record concentration of lead. The certified **mid-level** standard value for lead is **500 ppm** ("RCRA Pb 180-436").

☐ **STEP 7:** Provide a source check of the **high-level** standard using a 120-second count time; record concentration of lead. The certified **high-level** standard value for lead is **5,532 ppm** ("NIST 2710 HIGH").

☐ **STEP 8:** Calculate comparability values for each of the standard source checks as follows:

(Measured Concentration / Known Concentration of Standard) x 100

Any values exceeding 20% difference (80% to 120%) will be noted and immediately discussed with the QA manager.

☐ **STEP 9:** Conduct source checks outlined in Steps 5 through 8 **prior to sample analysis each day**, **at the midpoint of the workday**, and **at the end of each day**. Results should be recorded and any deviations noted.

☐ **STEP 10:** Analyze the instrument **BLANK** ("SiO_2 BLANK") **prior to sample analysis each day**, **at the end of each day,** and **~ 1 per every 20 samples** using a 120-second count time. If the lead concentration exceeds its method detection limit, then the probe window and the check sample should be checked for contamination.

Recorded by: ________________________________

Date/Time: ________________________________

IRON KING MINE – HUMBOLDT SMELTER SUPERFUND SITE

PRIVATE PROPERTY SAMPLE COLLECTION CHECKLIST

☐ **STEP 1:** Notify the tenant by telephone (if requested) and/or knock on the door.

☐ **STEP 2:** Survey the private property and locate 5 sampling locations in exposed sod/soil areas; each exposed area should be ≤ 2500 ft^2. Sampling locations should be as equidistant from each other as conditions allow.

☐ **STEP 2**: Mark the 5 sampling locations using a pin flags and photograph the locations during sampling (include photograph of front of structure(s) with street number showing).

☐ **STEP 3:** Collect and record the following data and measurements (not to scale):
- Dimensions and description (exterior color[s]) of the residential structure
- Dimensions of any impervious areas (driveways, concrete, gravel, sidewalks, etc.)
- Distances from property line to each outside wall of the structure
- Distances between sampling locations and other property features

☐ **STEP 4:** Create a sketch of the structure(s) and property that presents the following information:
- Locations of the 5 sampling locations (for each “yard”)
- Dimensions collected in Step 3 on the sketch, as appropriate
- Address, Sample ID, and photograph directions/locations.

☐ **STEP 5:** Using Geoprobe tooling, collect a 1½-foot soil core at each of the 5 marked sampling locations:
- Following each soil core sample, remove the acetate sleeve, label the top and bottom of each soil core with a permanent marker.
- Place end caps at the open end of each soil core (acetate sleeve).
- Label each sleeve with the applicable sample ID.
- Place a large rubber band around the 5 sleeves (soil cores)
- Backfill each of the borings with play sand.
- Remove the pin flags.

☐ **STEP 6:** To collect the 0 - 0.08 foot (1 inch) bgs soil interval at each of the 5 sampling locations, use the following procedures:
- Using a sharpshooter, carefully remove a minimum 4-inch by 4-inch square of sod (as applicable) adjacent to each corresponding soil boring.
- Use a disposable poly scoop/trowel (or sharpshooter if soil is too hard), collect the top 1 inch of soil from each of the 5 sampling locations and place the 5 aliquots into a large 10” x 12” aluminum pan.
- Replace the sod (as applicable); add play sand, as necessary, to level the sod.

☐ **STEP 7:** Before leaving the property, homogenize the 1-inch soil sample within the 10” x 12” aluminum pan to create a composite sample.

☐ **STEP 8:** Transfer the homogenized composite sample into a resealable plastic bag labeled with the Sample ID.

☐ **STEP 8:** Collect and record GPS coordinates from NE corner of the property boundary.

☐ **STEP 9:** Decontaminate the Geoprobe tooling and sharpshooter.

☐ **STEP 10:** If tenant not home, leave sampling notification on front door.

Sample Address: ______________________________
Sample ID: ______________________________
Collected by: ______________________________
Date/Time: ______________________________
GPS Coord: ______________________________

IRON KING MINE – HUMBOLDT SMELTER SUPERFUND SITE

XRF SAMPLE PREPARATION CHECKLIST

☐ **STEP 1:** Wearing "clean" nitrile gloves, transfer the homogenized composite sample from the labeled resealable bag to a small, oblong aluminum pan (loaf pan); place the remaining soil in storage.

☐ **STEP 2**: Write the Sample ID on the aluminum pan with a permanent marker.

☐ **STEP 3:** Dry the sample in the convection oven at ≤150°C (300°F) for 2 - 4 hours.
Date/Time: ____

☐ **STEP 4:** Wearing "clean" nitrile gloves, grossly sieve the sample using a "clean" No. 10 (2 mm) sieve to remove any large debris, such as sticks, rocks, etc.

☐ **STEP 5:** Place the grossly sieved material into a clean resealable bag labeled with the Sample ID and an "UNSIEVED" designation.

☐ **STEP 6:** Remove a portion of the "UNSIEVED" material and finely sieve using a "clean" No. 60 (250 µm) sieve to obtain the fine fraction.

☐ **STEP 7:** Place the finely "SIEVED" material into a clean resealable bag labeled with the Sample ID and a "SIEVED" designation.

☐ **STEP 8:** Return any remaining "UNSIEVED" material to the resealable bag labeled "UNSIEVED."

☐ **STEP 9:** Place a pre-sized sheet of Mylar™ film (X-ray window film) over the Teflon™ XRF sample collar.

☐ **STEP 10:** Gently fit the Teflon™ XRF sample sleeve into the sample collar so that the Mylar™ film forms a taut, even surface (X-ray window); this forms the XRF sample cup.

☐ **STEP 11:** Place approximately 5 grams of sample material into a Teflon™ XRF sample cup (about ½ to ¾ full). Tap the sample cup gently to settle the sample material flush against the Mylar™ film surface.

☐ **STEP 12:** Place a paper disk barrier on the sample material followed by some fiberglass packing material to create a uniform soil surface flush with the window.

☐ **STEP 13:** Snap the Teflon™ XRF sample cap onto the sample cup to seal the sample.

☐ **STEP 14:** Label the Teflon™ XRF sample cap with the Sample ID (either with a pre-made label or ultra-fine permanent marker). ***Be very careful not to damage the Mylar™ film surface (X-ray window).***

☐ **STEP 15:** Place the sample cup into 1-quart resealable bag (bag may also be labeled with the Sample ID) and store in a cooler at ambient temperature.

Sample Address: ________________________________
Sample ID: ________________________________
Sampler(s): ________________________________
Sample Date/Time: ________________________________

Appendix I

EPA Region 9 Sample Coordination Center Superfund Analytical Request Form

REGION 9 SAMPLE COORDINATION CENTER (RSCC)
SUPERFUND ANALYTICAL REQUEST FORM

Section 1

Sampling Event Name: Iron King Mine – Humboldt Smelter – Field Investigation 01			
Site Name: Iron King Mine – Humboldt Smelter Superfund Site		**Sampling Dates:** 11 August – 26 September 2008	
[X] **RI/FS** [ ] **RA** [ ] **Enforcement** [ ] **PA/SI** [ ] **Emergency Resp.** [ ] **Fed. Facilities**			
Site Spill ID: 09MX	**OU:** 00	**CERCLIS ID:** AZ0000309013	
EPA Project Manager: Leah Butler		**Phone: 415-972-3199**	**Mail Code:** SFD-8-2

Section 2

Sampling Organization (if other than above): EA Engineering, Science, & Technology, Inc.	
Mailing Address: 405 South Highway 121; Building C, Suite 100; Lewisville, TX 75067	
Project Manager: Doug McReynolds	**E-mail:** dmcreynolds@eaest.com
Office Phone: 972-459-5046	**Office Fax:** 972-315-5181
Sampler (if different from above): Amber Mason	**E-mail:** amason@eaest.com
Office Phone: 972-315-3922	**Mobile Phone:** 214-529-8906

Section 3

Title of QA plan or addendum to existing plan under which this sampling event will occur: The Iron King Mine – Humboldt Smelter Superfund Site Sampling and Analysis Plan (SAP) will function as the Field Sampling Plan and Quality Assurance Project Plan. The SAP will be submitted to EPA Region 9 for consideration on or before 18 July 2008. **EPA Quality Assurance Office DCN (if available):** Unavailable

In compliance with EPA Order 5360.1, the EPA Region 9 Quality Management Plan, Section 1.1.2, states that, "An appropriate QA planning document … will be developed and approved for each environmental data collection activity prior to the initiation of data collection."

Section 4

Type of Data Deliverable	**Data Distribution (include e-mail address if appropriate)**
Hard copy report	1. EPA Remedial Project Manager (RPM) Leah Butler
Electronic report copy	1. EPA RPM Leah Butler Butler.Leah@epamail.epa.gov 2. EA Doug McReynolds dmcreynolds@eaest.com
Electronic Data Deliverable (EDD) for R9 Lab Results*	1. EPA RPM Leah Butler Butler.Leah@epamail.epa.gov 2. EA Doug McReynolds dmcreynolds@eaest.com

* Excel table. Other EDD formats may be available upon request

Section 5
(Fill in table or attach copy of analytical description from Sampling and Analysis Plan)

Analysis (method, CLP SOW number, or R9 Lab SOP number)	Matrix	No. of samples	TAT (days)*	Review/ Validation*
TAL Metals (including Mercury and Cyanide) ILM05.4	Soil/ Sediment	532 Samples (475 Field Samples 57 Duplicates)	35	Validated Level III or Better
TAL Metals (including Mercury and Cyanide) ILM05.4	Soil/ Sediment	33 Samples (30 Field Samples 3 Duplicates)	7 (72-Hour Preliminary)	Validated Level III or Better
Volatile Organic Compounds SOM01.2	Soil/ Sediment	55 Samples (49 Field Samples 6 Duplicates)	35	Validated Level III or Better
Semi-Volatile Organic Compounds SOM01.2	Soil/ Sediment	55 Samples (49 Field Samples 6 Duplicates)	35	Validated Level III or Better
Pesticides/Aroclors SOM01.2	Soil/ Sediment	55 Samples (49 Field Samples 6 Duplicates)	35	Validated Level III or Better
Perchlorate EPA Method 314.0	Soil/ Sediment	92 samples (82 Field Samples 10 Duplicates)	35	Validated Level III or Better
Nitrate and Sulfate EPA Method 300.0	Soil/ Sediment	92 samples (82 Field Samples 10 Duplicates)	35	Validated Level III or Better
Dioxins and Furans DLM02.0	Soil/ Sediment	54 samples (49 Field Samples 5 Duplicates)	35	Validated Level III or Better
Synthetic Precipitation Leaching Procedure TAL Metals (including Mercury and Cyanide) EPA Method 1312	Soil/ Sediment	27 samples (23 Field Samples 4 Duplicates)	35	Validated Level III or Better
Lead and Arsenic Speciation	Soil/ Sediment	25 samples (21 Field Samples 4 Duplicates)	35	Validated

Analysis (method, CLP SOW number, or R9 Lab SOP number)	Matrix	No. of samples	TAT (days)*	Review/ Validation*
pH EPA Method 9045	Soil/ Sediment	55 samples (50 Field Samples 5 Duplicate)	35	Validated Level III or Better
Asbestos Region 9 Lab SOP 490 (ASTM D22.05)	Soil	6 samples (5 Field Samples 1 Duplicate)	35	Validated Level III or Better
TAL Metals (including Mercury and Cyanide) ILM05.4	Water	295 samples (226 Field Samples 30 Duplicates 39 Equip Rinsates)	35	Validated Level III or Better
Volatile Organic Compounds SOM01.2	Water	67 samples (8 Field Samples 2 Duplicate 19 Equip Rinsates 19 Field Blanks 19 Trip Blanks)	35	Validated Level III or Better
Semi-Volatile Organic Compounds SOM01.2	Water	29 samples (8 Field Samples 2 Duplicates 19 Equip Rinsates)	35	Validated Level III or Better
Perchlorate EPA Method 314.0	Water	77 samples (37 Field Samples 5 Duplicates 35 Equip Rinsates)	35	Validated Level III or Better
Nitrate, Nitrite, and Sulfate EPA Method 300.0	Water	77 samples (37 Field Samples 5 Duplicates 35 Equip Rinsates)	35	Validated Level III or Better
Anions/Cations (see Analyte list below) EPA Method 300.0 and 6020 Anions via Region 9 Lab SOP 530	Water	14 (10 Field Samples 1 Duplicates 3 Equip Rinsates)	35	Validated Level III or Better

Analysis (method, CLP SOW number, or R9 Lab SOP number)	**Matrix**	**No. of samples**	**TAT (days)***	**Review/ Validation***
Total Dissolved Solids EPA Method 160.1	Water	14 (10 Field Samples 1 Duplicates 3 Equip Rinsates)	35	Validated Level III or Better
Pesticides/Aroclors SOM01.2	Water	15 Equip Rinsates	35	Validated Level III or Better
Dioxins and Furans DLM02.0	Water	5 Equip Rinsates	35	Validated Level III or Better
Particulate Matter 10, Total Suspended Particulates, Metals Gravimetric, Inductively Coupled Plasma – Mass Spectrometer (ICP-MS)	Air	90 Samples	14	Validated Level III or Better

* See instructions

For CLP VOCs and/or SVOCs, are matrix spike/matrix spike duplicate (MS/MSD) required for this project? __X___Yes ______No

Section 6
Include (or attach separately) any discussion of expanded or reduced analyte lists, required reporting limits, specialized preparation or analytical procedures, etc.

The matrix concentrations will vary depending on analysis and collection location. Historical data has shown that water concentrations range from low to medium and solid concentrations range from low to high. Air sample concentrations are anticipated to be low. Concentrations (low, medium, or high) of samples will be noted on traffic reports when samples are shipped to the appropriate laboratory.

Anions: Fluoride, Chloride, Nitrite, Bromide, Nitrate, Ortho-phosphate, and Sulfate

Cations: Sodium, Potassium, Calcium, Magnesium, Ferrous Fe+2, and Ferric Fe+3

A full documentation package, including raw data and sample custody documentation, will be generated and kept on file at the EPA Region 9 Laboratory. If you would like to request additional review and/or validation of the data, please contact Rose Fong or Carl Brickner at the Region 9 Quality Assurance Office.