APPENDIX B

QUALITY ASSURANCE PROJECT PLAN

VOLUNTARY REMEDIATION PROGRAM (VRP)
INVESTIGATION WORK PLAN
FREEPORT-MCMORAN SIERRITA INC.
GREEN VALLEY, ARIZONA

VOLUME II OF II

APPENDIX B – QUALITY ASSURANCE PROJECT PLAN

APRIL 2008

Prepared for:

Freeport-McMoRan Sierrita Inc.
6200 West Duval Mine Road
Green Valley, AZ 85622-0527

Prepared by:

URS Corporation
333 East Wetmore Road
Tucson, AZ 85705

TABLE OF CONTENTS

LIST OF TABLES

LIST OF APPENDICES

APPROVAL SHEET
QAPP ADDENDUM
Sierrita VRP
April 2008

Ned Hall, Project Manager Freeport-McMoRan Sierrita Inc. (520) 648-8857	Date
Marianne Burrus, Quality Assurance Officer URS Corporation – Phoenix Office (602) 861-7473	Date
Joey Pace, Project Manager Arizona Department of Environmental Quality (602) 771-4574	Date

1.0 INTRODUCTION

URS Corporation (URS) has prepared this Quality Assurance Project Plan Addendum on behalf of Freeport-McMoRan Copper & Gold Sierrita Inc (FCX Sierrita) formerly Phelps Dodge Sierrita Inc. in support of site characterization activities conducted at the Sierrita Mine located near Green Valley, Arizona. The site characterization is to be performed under the Arizona Department of Environmental Quality's (ADEQ) Voluntary Remediation Program (VRP). ADEQ's VRP program is defined by Arizona Revised Statutes (ARS) Title 49, Sections 49-171 through 49-188.

This Addendum is intended to be used as a supplement to the established Quality Assurance Project Plan (QAPP) currently used by Sierrita titled, *Quality Assurance Project Plan for Aquifer Characterization Plan*, dated August 11, 2006 (Hydro Geo Chem 2006). By using this established QAPP as the basis for continued work at the Sierrita Mine, Sierrita hopes to promote consistent standards and procedures for data collection throughout the project area.

Together, these documents (referred to as "QAPP") provide field and laboratory personnel with instructions regarding activities to be performed before, during, and after field sampling activities. These instructions are intended to ensure data collected for use in project decisions will be of the type and quality needed and expected for their intended purpose.

The purpose of this QAPP addendum, is to designate and document the specifications and methods that will be employed to establish technical accuracy and precision, statistical validity, and documentary evidence of environmental data generated during the VRP sampling program. Where the two documents differ, this Addendum takes precedence over the established QAPP for the VRP sampling program. Because only the exceptions and additions to the established QAPP will be discussed in this document, a copy of the QAPP is included in Appendix A.

The following table contains a cross-reference between the two documents and the required elements specified by the United States Environmental Protection Agency (EPA) and ADEQ. This cross-reference is provided to assist the reader in determining where the required elements are addressed in the QAPP and Addendum.

QUALITY ASSURANCE /R-5 ELEMENTS		COMMENT ADDRESSED	
		QAPP	ADDENDUM
A1	Title and Approval Sheet	-	i
A2	Table of Contents	-	ii
A3	Distribution List	-	Table 1.0
A4	Project Organization	-	Section 2.0
A5	Problem Definition/Background	-	Section 1.0
A6	Project/Task Description	-	Section 1.0
A7	Quality Objectives and Criteria for Measurement Data	Section 3.3	Section 3.0
A8	Special Training/Certification	Sections 4.1	Sections 4.1/5.1
A9	Documents and Records	Sections 4.6/5.6	-
B1	Sampling Process Design	-	Section 4.0
B2	Sampling Methods Requirements	-	Section 4.0
B3	Sample Handling and Custody Requirements	Sections 4.2.3/5.2	-
B4	Analytical Methods Requirements	-	Sections 4.4/5.2
B5	Quality Control Requirements	-	Sections 4.5/5.3
B6	Instrument/Equipment Testing, Inspection and Maintenance	Sections 4.5/5.5	-
B7	Instrument/Equipment Calibration and Frequency	Section 5.5	Tables 5/6
B8	Inspection/Acceptance of Supplies and Consumables	Section 4.5	-
B9	Data Acquisition For Non-Direct Measurements	NA	N/A
B10	Data Management	Section 6.0	-
C1	Assessments and Response Actions	-	Sections 4.7/5.3.2
C2	Reports to Management:	Sections 5.6/6.4	-
D1	Data Review, Verification, and Validation	Section 6.2	-
D2	Verification and Validation Methods	Section 6.2	Section 6.0
D3	Reconciliation with User Requirements	Sections 3.3/ 6.2	-

1.1 PROJECT DESCRIPTION

On June 19, 2007 Sierrita submitted an application to enter into the ADEQ's VRP program to evaluate certain operations and constituents that are not considered by other regulatory programs such as the Mitigation Order On Consent, Docket No. P-50-06, and the Sierrita area wide Aquifer Protection Permit (APP) No. P-101679. Those operations include:

- facilities that ceased operation and/or were closed prior to implementation of the Sierrita APP (historical operations),
- selected operations exempt from regulation under the APP,
- operations "to be closed" under the APP, and
- active operations with the potential to release mining related constituents.

Additionally, uranium impacts to groundwater will be evaluated.

The primary objectives of this work plan are to:

1. Assess potential impacts to soil, groundwater and sediment from past releases and historical Sierrita operations for constituents of interest (COIs). COIs shall include uranium and other mining-related metals (arsenic, barium, beryllium, cadmium,

chromium, cobalt, copper, lead, manganese, mercury, molybdenum, nickel, and selenium).

2. Assess potential impacts to sediment and groundwater for COIs at areas downgradient of active Sierrita operations.
3. Evaluate background uranium concentrations in groundwater through the installation of monitoring wells at background locations in mineralized bedrock formations.
4. Refine the preliminary site conceptual model for uranium in groundwater with respect to sources and migration pathways, including consideration of background conditions.

The scope presented in the Work Plan is intended to be the first phase of the site characterization to be completed under the VRP. The primary focus of the first phase of work will be to assess potential releases from former areas of operation, and to develop a concise conceptual site model and background conditions for uranium in groundwater. If needed, the second phase of work will include follow-up investigation of operations where releases to soil, sediment or groundwater have been identified in the first phase of the characterization, and a further refinement of the groundwater conceptual site model through additional groundwater well installation and/or sampling.

More detail description of project specific objectives is presented in the VRP Work Plan, Section 1.0.

1.2 PROJECT SCHEDULE

An estimated schedule for the planning and first phase of site characterization activities is shown on Figure 1. The field activities starting with pre-mobilization are estimated to begin following review and approval of the VRP Work Plan and QAPP.

2.0 PROJECT ORGANIZATION

The organizational structure is designed to provide project control and proper quality assurance/quality control (QA/QC) for the VRP sampling program. The distribution list for this Addendum and a project directory is included in Table 1. The roles and responsibilities of the key personnel are described below.

2.1 ADEQ PROJECT MANAGER

Ms. Joey Pace, the ADEQ Project Manager, will conduct regulatory oversight of the work plan and provide regulatory review and approval of documents, reports, schedules, and other communications submitted pursuant to the VRP.

2.2 PROJECT DIRECTOR

Mr. Stuart Brown, the Freeport-McMoRan Copper and Gold Inc. (FCX) Project Director, has the overall responsibility for implementing the work plan. He will direct the schedule and scope of the project and provide fiscal oversight for resources required.

2.3 SIERRITA PROJECT MANAGER

The Sierrita Project Manager, Ned Hall, will direct Sierrita sampling activities and has the responsibility to ensure that Sierrita personnel are properly trained and to ensure the quality of the data collected by Sierrita. He will work with the URS Project Manager to provide resources for implementation of VRP tasks. Mr. Hall will be the primary point of contact with the ADEQ Project Manager.

2.4 SIERRITA QUALITY ASSURANCE MANAGER

The Sierrita QA Manager, Billy Dorris, will provide QA documentation, review, and verification of field and laboratory data collected by Sierrita. He will also ensure that records are properly stored in Sierrita files and electronic databases and coordinates transfer of data with the URS QA Manager.

2.5 URS PROJECT MANAGER

The URS Project Manager, Steven Vaughn, will direct field activities for the VRP, and ensures that all personnel are properly trained, and adequate resources are available. The URS Project Manager will also work with the URS QA Manager to provide QA checks of data quality and to

implement corrective actions. The URS Project Manager is responsible for providing final review and approval of documents, reports, plans, schedules, and other communications submitted to ADEQ pursuant to the VRP. The URS Project Manager will periodically review and provide any needed updates to the QAPP.

2.6 URS PROJECT QUALITY ASSURANCE MANAGER

The URS Project Quality Assurance (QA) Manager will work directly with the Sierrita Project Manager and other project personnel. Ms. Marianne Burrus of URS will serve as the URS Project QA Manager. Ms. Burrus will have the responsibility to ensure all laboratory procedures follow those protocols established in the QAPP and meet the regulatory guidance. Ms. Burrus' additional responsibilities for the project include coordinating data receipt from the laboratory and performing data verification/validation tasks. If the URS QA officer determines that laboratory procedures do not adhere to the established protocols and the data integrity may be impacted, it is his/her responsibility to inform the URS Project Manager.

2.7 URS PROJECT HEALTH AND SAFETY MANAGER

The URS Project Health and Safety Manager (HSM), Armando Jimenez, will work directly with the URS Project Manager and other project personnel. The HSM has the responsibility to monitor and verify that the work is performed in accordance with the HSP. The URS HSM will advise the URS Project Manager regarding health and safety issues but will function independently of the URS Project Manager.

2.8 URS SITE SAMPLE MANAGER

The URS Site Sample Manager, Lorena Leal will report to the URS Site Manager and be in communication with the field staff and Project Chemist. The URS Site Sample Manager will inspect samples to confirm adequate sample volume has been collected for analyses requested, complete preservation, if required, and perform a radiation screen of the samples. The URS Site Sample Manager will be responsible for documentation, packaging, and shipment of samples to the analytical laboratory. Documentation to be completed will include:

- Chain-of-Custody (COC) form
- Sample label
- Custody seal

- Courier/transportation forms
- Records retention at the site

2.9 PROJECT STAFF

Each member of the project staff will be responsible to the URS Project Manager for completion of assigned project activities. Members of the project staff are responsible for understanding and implementing their project tasks along with associated QA/QC procedures.

2.10 FIELD AND LABORATORY SUBCONTRACTORS

URS may delegate to others, in writing, the responsibility of establishing and executing certain portions of the project, but shall retain responsibility for their conformance with contractual scopes of work. When organizations other than URS are involved in the execution of activities covered by the requirements of the QAPP or project-specific Sampling and Analysis Plan (SAP), the activities will be monitored by the URS Project Manager and URS project staff as appropriate. Subcontractor activities shall be monitored against technical requirements specified in the Scope of Work, which is generated during the procurement process. When non-conformances are identified, the URS Project Manager and URS QA Manager will determine if the project objectives have been affected. Resolution of non-conformances will be made and, if necessary, corrective actions implemented. In the case of ACZ Laboratory, the subcontracted laboratory, performance will be measured through the data review and validation process. The laboratory QA Manager will be responsible for assuring data generated are of the quality specified in the scope of work and for documenting any non-conformances and associated corrective actions required during the analysis of project samples.

2.11 ADDENDUMS TO QAPP

Addenda and/or revisions to this QAPP can be initiated by ADEQ, URS, or ACZ Laboratories; however, the appropriateness of an addendum or revision is determined by the Sierrita project manager. In general, an addendum will be written when unforeseen or significant changes have occurred. A revision will not be required for minor changes in scope. The revision shall be inserted into the document, replacing the original pages and a copy shall be given to all parties (ADEQ, URS, and ACZ Laboratories).

3.0 DATA QUALITY OBJECTIVES

This section addresses the data quality objectives (DQOs) process applied in development of the Sierrita VRP QAPP. The DQO process is a systematic planning tool based on the Scientific Method for establishing criteria for data quality and for developing data collection designs. Establishing formal DQOs during the QAPP stage of a project allows clear and unambiguous definition of project objectives, decisions, and decision criteria so that data of sufficient type, quality, and quantity are generated to meet project objectives. The formal implementation of a DQO process brings structure to the planning process, thereby resulting in defensible decision making.

3.1 SPECIFYING QUALITY OBJECTIVES

This section provides the output from the DQO process applied for the Sierrita VRP. The work plan focuses on groundwater, surface and subsurface soil, and stream sediment at the Sierrita Mine and Background Areas. The VRP work plan has been divided into two primary areas: (1) facilities investigations and (2) site wide groundwater study.

For the first phase of the VRP sampling program, there are 10 facilities to be closed. These facilities primarily consist of historic operations that may have impacted local soil, sediment, or groundwater. In addition, the groundwater investigation will focus on radionuclides and metals present in groundwater upgradient and downgradient of the Sierrita Mine. The specific sampling rationale for each facility and groundwater are presented on Tables 4-1 and 4-3 of the VRP Work Plan. The table presents the problem statement, impacted media, objective of the investigation, and the proposed sampling approach to satisfy the objective.

3.2 RELEVANT ACTION LEVELS

There are numerous regulatory standards that are potentially relevant to the Sierrita Mine VRP Investigation. Tables 2 and 3 summarize potentially relevant action levels and the laboratory method reporting limits for metals and radionuclides in groundwater and soil, respectively. As Tables 2 and 3 indicate, the method reporting limits for each metal and radionuclide are lower than their respective Aquifer Water Quality Standard (AWQS), Soil Remediation Level (SRL) and Groundwater Protection Limit (GPL). The following paragraphs present a brief discussion of each action level.

- Aquifer Water Quality Standards (AWQS) are groundwater quality standards set by ADEQ, for the protection and maintenance of aquifer water quality, effective December 31, 2002.
- The Groundwater Protection Level (GPL) is considered a screening method for determining levels protective of groundwater and is considered a "worst case" correlation between total metals in the soil and the leachable fraction. The minimum GPLs are conservative, assuming that all of the "worst case" leachable metals reach groundwater regardless of depth.
- Soil Remediation Levels (residential and non-residential) were promulgated into rule in 1997 under the Arizona Administrative Code R18-7-201 and amended by final rulemaking effective May 5, 2007. They were originally derived from Arizona Health Based Guidance Levels that were formulated in 1990. Residential site-specific remediation level means a level of contaminants remaining in the soil after remediation that results in a cumulative excess lifetime cancer risk between 1×10^{-6} and 1×10^{-4} and a Hazard Index no greater than 1 based on residential exposure assumptions. Non-residential site-specific remediation levels means a level of contaminants remaining in soil after remediation that results in a cumulative excess lifetime cancer risk between 1×10^{-6} and 1×10^{-4} and a Hazard Index no greater than 1 based on non-residential exposure assumptions.

4.0 FIELD ACTIVITIES

The quality of data collected in an environmental study is critically dependent upon the quality and thoroughness of field sampling activities. General field operations and practices and specific sample collection and inventory will be well planned and carefully implemented. Table 6 presents the analytical parameters for this project. The VRP site characterization SAP provides detailed descriptions of the sampling program.

4.1 SPECIAL TRAINING REQUIREMENTS/CERTIFICATION

In addition to the training and certifications listed in Section 4.1 of the established QAPP, the following is required during the VRP sampling program.

- All employees will have 40-hour Hazardous Waste operations and Emergency Response training with current 8-hour refresher training in accordance with 29 CFR 1910.120.
- All employees will have Mine Safety and Health Administration (MSHA) training with current 8-hour refresher training as required by 30 CFR Subpart 48.
- At least one employee at the site will have current first aid and cardiopulmonary resuscitation (CPR) training and the URS Site Manager will have site supervisor training.
- All site personnel will also participate in an initial site orientation meeting and daily "tailgate" safety meetings to discuss the effectiveness of health and safety procedures, control measures, and the need for their revision.
- U.S. Department of Transportation and International Air Transport Association (IATA) regulations require that employees involved with transporting hazardous materials complete specific training requirements. Site personnel will be trained regarding hazardous materials transportation prior to shipment of any hazardous materials.

4.2 SAMPLE COLLECTION AND PREPARATION PROCEDURES

Standard sample collection procedures and data collection forms have been developed for sampling and related data gathering activities. The purpose for these procedures is to obtain samples that represent the environment under investigation. The procedures that will be used for sample collection and preparation for this investigation are included in the project SOPs (Appendix B), while the data collection forms used to document this investigation are included as Appendix C.

A description of sample equipment to be used and a discussion of steps taken to mitigate sample contamination are included in the Work Plan and supporting SOPs. A discussion of sample type (grab or composite), location and collection technique is also included in the Work Plan. Sample preservation, container, volume, and maximum holding time requirements are summarized in Table 4. As available, certified clean sample containers will be procured from a subcontracted analytical laboratory or vendor for use in sample collection.

4.3 FIELD DECONTAMINATION PROCEDURES

Disposable sampling equipment will be used when possible. Dedicated purging and sampling pumps will be used to collect groundwater samples. Non-expendable equipment used to collect, handle, or measure samples will be decontaminated. The general decontamination procedures for equipment include (1) an initial washing in a solution of Alconox® and water, (2) thoroughly rinsing them with tap water, and (3) then final rinsing with deionized water.

Down-hole drilling and sampling equipment will be decontaminated prior to arrival on-site. This cleaning process shall consist of a high-pressure hot water cleaning. The subcontractors will also decontaminate all down-hole drilling equipment, that may come in contact with sampled media, by steam cleaning prior to advancing to the next boring or location. Decontamination fluids will be contained and containerized for proper disposal as described in the following section.

4.4 FIELD SCREENING METHODS

The following screening methods will be performed in the field at the time of groundwater sampling: pH, temperature, specific conductance, Eh, turbidity, and dissolved oxygen. These measurements will be taken at the sampling location using portable field instruments at the time of sample collection. Calibrations, QC checks, frequency of QC checks, acceptance criteria, and corrective actions for the field parameters and all other screening methods is summarized in Table 5. All field instrument calibration, QC check, and corrective action information will be recorded in a field log book. Field equipment that will be used during this investigation is listed in the Work Plan.

Field equipment will stored in a clean, secure location when not in use. Equipment will receive routine maintenance checks in order to minimize equipment breakdowns in the field. The maintenance of the equipment will be performed in accordance with manufacturer operation manuals and documented in maintenance logbooks. Daily inspections for visible signs of wear or breakage will be performed. If a piece of equipment is unusable due to breakage, it will be repaired if possible, removed from service, or replaced. Instruments such as the pH/conductivity/

temperature/turbidity meter(s) will also be checked daily for proper operation using calibration standards or standard reference materials.

4.5 FIELD QC SAMPLES

Field QC samples will be collected to verify sampling and analytical precision, accuracy, and representativeness. During this sampling program field QC will include the collection of equipment blanks, field duplicates, and performance evaluation samples (as described below). A summary of the number of QC samples to be collected and analyzed during this investigation is summarized in Tables 4 and 5.

4.5.1 Equipment Blank

An equipment blank is a sample of reagent grade water poured into or over or pumped through the sampling device, collected in a sample container, and transported to the laboratory for analysis. Equipment blanks are used to assess the effectiveness of equipment decontamination procedures used to prevent cross-contamination between sampling locations. The frequency of collection for equipment blanks shall be a minimum of 1 equipment blank for every 20 environmental samples collected with a given type of sampling equipment, and only for sampling equipment which is decontaminated and reused to collect environmental samples. Equipment blanks will be prepared in a manner identical to samples and shall be analyzed for all laboratory analyses requested for the environmental samples collected at the site using the subject equipment.

4.5.2 Field Duplicate

A field duplicate sample is a second discrete sample volume collected at the same location as the original sample; homogenization is not performed between the original sample and the field duplicate. Aqueous field duplicate samples are collected from successive volumes from the same sample source and device (e.g., bailers). Sediment field duplicates are collected in succession from the same sample source and device. Duplicate samples are collected using identical recovery techniques, and treated in an identical manner during storage, transportation, and analysis. The sample containers are assigned an identification number in the field such that they cannot be identified (blind duplicate) as duplicate samples by laboratory personnel performing the analysis. Specific locations are designated for collection of field duplicate samples prior to the beginning of sample collection.

Field duplicate sample results are used to assess precision of the sample collection process. The frequency of collection for field duplicates is a minimum of 1 duplicate sample from each group of 20 environmental samples of a given matrix.

4.5.3 Performance Evaluation Samples

Double blind performance evaluation (PE) samples may be submitted to ACZ Laboratories during any sampling program at the direction of ADEQ or URS. The following QC issues may trigger the need for the submission of PE samples:

- continued quality issues detected through the data verification/validation process
- unexpected or unexplained sample results

If requested, double blind PE samples will be prepared by Environmental Resources Standards, or a similar supplier, in similar sample containers as the project field samples and shipped from the field to the laboratory for analysis. The double blind PE samples will be prepared using National Institute of Standards and Testing certified standards. The project-specific PE samples will contain known concentrations of the analytes of interest. Laboratory results will be evaluated against the original Certificates of Analyses for precision and accuracy. URS will provide to ADEQ an analysis of the PE results including required corrective action, if any.

4.6 INVESTIGATION DERIVED WASTE

URS will manage and track all waste materials generated during the investigation activities. URS will coordinate with Sierrita to establish a waste accumulation area for temporary storage of field generated waste, such as personal protective equipment (PPE), soil cuttings, drilling fluids, and development water and purged water. Other wastes will include discarded materials resulting from field activities that, in their present form, possess no inherent value such as disposable sampling tools, bags, paper towels etc. The wastes will be divided into soil, water, and PPE. All waste will be properly labeled, sampled, and inventoried for future disposal.

URS and its subcontractors will contain small quantities of soil and potentially-contaminated water in 55-gallon drums. Roll off bins may be used for containing soil cuttings. Samples of solid and liquid IDW will be collected and submitted to an analytical laboratory for analysis. Based on analytical results received, soils and sediments may be re-used if concentrations are below residential SRLs or recycled if the material has legitimate copper or molybdenum values. Liquid IDW may be re-used or recycled through mine operations if the liquid is free of excess contamination or if the liquid has legitimate copper of molybdenum values, respectively. IDW

that is not recycled or re-used by Sierrita will be transported to an approved disposal. Sierrita will retain copies of load tickets and disposal manifests.

4.7 SAMPLING CORRECTIVE ACTION PROCESS

During pre-mobilization activities for the VRP field investigation, a field reconnaissance will be completed to locate and stake each proposed sampling location. Any location accessibility problems will be identified at that time and the Site Manager will propose an alternate location meeting the data need intended by the original location. This decision would be made with concurrence from the URS Project Manager. If an alternate location is not available or accessible which still meets the original data need, the URS Project Manager will determine the proper course of action. Any changes to the QAPP and SAP will be documented in the field logbook.

Any serious flaws noted during implementation of the SAP will be documented in the field logbook and brought to the attention of the URS Project Manager as necessary to determine what corrective actions might be necessary and appropriate.

Any serious flaws noted prior to demobilization from the VRP field investigation which result in lost data will be rectified as achievable prior to demobilization. For example, any missed sample holding times may require the collection of additional sample prior to demobilization to satisfy the original data need.

5.0 ANALYTICAL LABORATORY PROCEDURES

This section describes the analytical laboratory procedures to be used to provide data necessary to meet the project objectives. Upon receipt of samples from the field activities, the analytical laboratory will be responsible for sample handling, analysis, and reporting. The analytical laboratory for this sampling program will be ACZ Laboratory of Steamboat Springs, CO. The laboratory selection process and general QC requirements for the designated laboratory are summarized below.

5.1 LABORATORY SELECTION

The designated laboratory for non-radionuclide analysis will be licensed by Arizona Department of Health Services (ADHS) to perform each analysis requested, as required by ADHS. In addition, the laboratory contracted to complete analytical work should, at a minimum:

- Have the ability to accept radioactive material.
- Have the ability to meet the selected regulatory action levels. The relevant action levels area listed in Tables 2 and 3.
- Have the ability to complete the required QA/QC elements outlined in this Addendum.

Additionally, the laboratory completing radiological parameters should:

- Possess an appropriate Nuclear Regulatory Commission and/or state radioactive materials license, or be federally exempt from being required to possess such a license for the radionuclides.
- Demonstrate successful participation in nationally recognized QA programs such as the Quality Assurance Program for the Department of Energy; or the December 1998 discontinued EPA/Las Vegas Inter-comparison Program for Groundwater.

AZC Laboratory's Quality Assurance Plan is included as Appendix D. ACZ Laboratory's SOPs for the required methods are controlled documents prepared by the laboratory and are not included in this QAPP Addendum. These documents are on file with Arizona Department of Health Services, the State of Arizona's laboratory licensing agency.

The turn around time for sample analysis and data reporting will be determined based on the laboratories selected and the project schedule once a field investigation start date has been

established. Laboratory-required turn around times will be defined in the laboratory technical SOW.

5.2 ANALYTICAL METHODS

This section identifies the analytical methods used during the analysis of samples and calibration procedures and frequencies for laboratory instruments that will be used for the generation of data. Table 4 summarizes the analyses that will be completed during this investigation. All definitive methods and some screening methods will be conducted at the analytical laboratory. Tables 5 and 6 present a summary of the calibration and QC procedures for screening and definitive methods. For all definitive methods of analysis used during this investigation, method performance requirements are specified in the methods, and augmented by this QAPP.

The required limits of detection for the laboratory data will depend on the potentially relevant action levels selected for this sampling program. A summary of potentially relevant action levels for metals and radionuclides in groundwater and soil is given in Tables 2 and 3. The designated laboratory's practical quantitation limit (PQL) for a constituent must be below its action level. The PQLs listed are analytical goals and should be attained when analyzing clean samples. However, sample dilutions may be necessary to bring high-level analyte concentrations into an accepted calibration range. Detection limits for non-detected analytes within those samples will be raised according to the level of the necessary dilution. Additionally, for a given method, intra-element interference and/or matrix effects may preclude the attainment of the desired detection limits.

All soil and sediment sample results will be reported on a dry-weight basis. However, laboratories will also report the percent solids for each sediment sample analyzed. The end use of the data may be either a wet-weight basis or a dry-weight basis depending on the criteria to be satisfied.

5.3 LABORATORY QUALITY CONTROL

The purpose of this QA/QC program is to produce data of known quality that satisfy the project objectives and that meet or exceed the requirements of the standard methods of analysis. This program provides a mechanism for ongoing control and evaluation of data quality measurements through the use of QC materials. QC samples will be collected as part of the overall QA/QC program. Analytical parameters, sample quantities, types and numbers of containers, number and types of QA/QC samples, sample preservatives, and sample holding times are listed in Table 4.

The laboratory QC samples have been selected based on established analytical method requirements. The required laboratory QC samples are outlined below; however, additional QC samples may be required by the designated laboratory to satisfy the laboratory internal QC policies. In addition, the analytical laboratory must adhere to ADEQ Policy No. 0154.000, *Addressing Spike and Surrogate Recovery as They Relate to Matrix Effects in Water, Air, Sludge and Soil Matrices Policy* and Policy 0155.000, *Analytical Methods Having Provisions for a One-point Calibration and Continuing Calibration Verification Constraints*.

5.3.1 QC Procedures and Samples

QC procedures used to assess data quality include the assessment of QC samples, a comparison of total and dissolved metals concentrations, a cation-anion balance, and a reconciliation of data quality with end-use objectives.

Laboratory QC samples (e.g., blanks and laboratory control samples) shall be included in the preparation batch with the field samples as applicable for each given method. An analytical batch is a number of samples (not to exceed 20 environmental samples) that are similar in composition (matrix) and that are extracted or digested at the same time and with the same lot of reagents. The term analytical batch also extends to cover samples that do not need separate extraction or digestion (e.g., volatile analyses by purge and trap). This analytical batch is a number of samples (not to exceed 20 environmental samples) that are similar in composition (matrix) and analyzed sequentially. The identity of each analytical batch shall be unambiguously reported with the analyses so that a reviewer can identify the QC samples and the associated environmental samples.

Additional QC checks for the definitive analytical methods are specified in the methods and will be followed. The additional checks may include initial calibration, continuing calibration checks, calibration blanks, post digestion spikes, and dilution tests. The acceptance criteria for each of these checks are specified in the analytical methods and the laboratory SOPs. The general QC acceptance criteria and corrective actions for the required non-radiological analytical methods are listed in Tables 4 and 5.

5.3.1.1 Laboratory Control Sample

The laboratory control sample (LCS) is well-characterized, laboratory-generated sample used to monitor the laboratory's day-to-day performance of analytical methods. The LCS may be a purchased standard, or a method blank spiked with known concentrations of target analytes. The LCS is carried through each step of the preparation and analytical method. An LCS shall be

included at the frequency specified in each method. LCS should be reported in %R and used to assess the accuracy and precision (use of LCSD) of the analytical process independent of matrix effects. Controlling lab operations with LCS (rather than surrogates or MS) offers the advantage of being able to differentiate low recoveries due to procedural errors with those due to matrix effects. It is recommended that all target analytes be included in the LCS.

Whenever an analyte in an LCS is outside the acceptance limit, method-specified corrective action shall be performed. After the system problems have been resolved and system control has been reestablished, all samples in the analytical batch shall be reanalyzed for the out-of-control analyte(s).

5.3.1.2 Matrix Spike/Matrix Spike Duplicate

A matrix spike (MS) and matrix spike duplicate (MSD) is an aliquot of sample spiked with known concentrations of all or a sunset of analytes. The spiking occurs prior to sample preparation and analysis. The MS/MSD shall be designated on the chain of custody. The MS/MSD is used to document the bias of a method due to sample matrix. Consequently, MSs and MSDs are not used to control the analytical process. A minimum of one MS and one MSD sample shall be analyzed for every 20 environmental samples of a given matrix. Project-specific MS/MSD are required for this project.

5.3.1.3 Surrogates

Surrogates (sometimes referred to as system monitoring compounds) are organic compounds that are similar to the target analyte(s) in chemical composition and behavior in the analytical process, but that are not normally found in environmental samples. Surrogates are used to evaluate accuracy, method performance, and extraction efficiency. Surrogate spikes are generally added for organic analyses only. Surrogates shall be added to environmental samples, controls, and blanks, in accordance with the method requirements.

Whenever a surrogate recovery is outside the acceptance limit, method-specified corrective action must be performed. After any system problems have been resolved and system control has been reestablished, re-prepare and re-analyze the sample.

5.3.1.4 Internal Standards

An internal standard (IS) is a standard of known concentration added to each sample and carried through the entire determination procedure as a reference for calibrating and controlling the precision bias of the analytical method.

When the IS results are outside of the acceptance limits, method-specified corrective actions shall be performed. After any system problems have been resolved and system control has been reestablished, all samples analyzed while the system was malfunctioning shall be reanalyzed.

5.3.1.5 Interference Check Sample

The interference check sample (ICS), used in inductively coupled plasma (ICP) analyses only, contains both interfering and analyte elements of known concentrations. The ICS is used to verify background and interelement correction factors and is run at the beginning and end of each run sequence.

When the interference check sample results are outside of the acceptance limits stated in the method, corrective action shall be performed. After any system problems have been resolved and system control has been reestablished, reanalyze the ICS. If the ICS result is acceptable, reanalyze all affected samples.

5.3.1.6 Method Blank

A method blank is an analyte-free matrix to which all reagents are added in the same volumes or proportions as used in sample processing. The method blank shall be carried through the complete sample preparation and analytical procedure and is used to document contamination resulting from the analytical process. A method blank shall be included in every analytical batch.

The presence of analytes in a method blank at concentrations equal to or greater than the method-specified thresholds indicates a need for corrective action. Corrective action shall be performed to eliminate the source of contamination prior to proceeding with analysis. After the source of contamination has been eliminated, all samples in the analytical batch shall be re-prepared and reanalyzed. No analytical data shall be corrected for the presence of analytes in blanks.

5.3.1.7 Cation-Anion Balance

Cation-anion balance will be evaluated for groundwater samples for which both cation and anion concentrations are reported. Concentrations of dissolved major cations (calcium, magnesium, sodium, potassium, and others as appropriate) and total ammonia will be compared to concentrations of major anions (sulfate, chloride, carbonate, bicarbonate, and others as appropriate). If the cation-anion ratio does not balance, the laboratory may be requested to re-digest (cations) and/or reanalyze the subject samples.

5.3.2 Corrective Action

The analytical laboratories will be required to submit case narratives with each analytical data package. The case narrative must document out-of-control events. In addition, any out-of-control occurrence must be reported to the Project QA Manager or designee as soon as possible so that the Project QA Manager can assess the out-of-control event and determine the appropriate course of action based on the overall project objectives, critical nature of the data and project schedule. At a minimum, the laboratory will report the types of out-of-control occurrences, how these occurrences are documented, and who is responsible for correction and documentation. Corrective action will be taken at any time during the analytical process when deemed necessary based on analytical judgment or when QC data indicate a need for action. Laboratory corrective actions may include, but are not limited to:

- Reanalysis,
- calculation checks,
- instrument recalibration,
- preparation of new standards/blanks,
- re-extraction/digestion, and
- additional training of analysts.

The following items must be documented for out-of-control incidents so that corrective action may be taken to set the system back "in control." These items will constitute a corrective action report and will be signed by the laboratory director and the laboratory QA contact:

- where the out-of-control incident occurred,
- when the incident occurred and was corrected,
- who discovered the out-of-control incident,
- who verified the incident,
- the scope of the problem,
- the corrective action implemented, and
- who corrected the problem.

6.0 DATA REVIEW AND QUALIFIACTION

During this sampling program, in addition to the data review requirements outlined in Section 6.2 of the established QAPP, the following elements are required.

- The designated laboratory must qualify all outliers according to ADEQ Data Qualifiers (see Appendix E).
- ADEQ requires that 100% of the data be verified in accordance with an approved checklist detailing the review. URS will provide, with the data verification memo, a data validation catalog table. Included on the table will be the list of all samples collected and required parameters. Although not anticipated, URS will perform full validation of any data at the request of ADEQ. In that event, URS will request all required data and laboratory documentation from the designated laboratory.

TABLES

TABLE 1
DISTRIBUTION LIST AND PROJECT DIRECTORY

Name	Project Role	Street Address	City and State	Zip Code	Phone and Fax Numbers
Joey Pace	ADEQ Project Manager	1110 West Washington Street	Phoenix, AZ	85007	Phone: 602-771-4574 Email: pace.joey@azdeq.gov
Stuart Brown	Bridgewater Group Project Director	4500 SW Kruse Way Suite 110	Lake Oswego, OR	97035	Phone: 503-675-5252 Email: sbrown@bridgeh2o.com
Ned Hall	Sierrita Project Manager	6200 West Duval Mine Road P.O. Box 527	Green Valley, AZ	85622-0527	Phone: 520-648-8857 Email: Ned_Hall@fmi.com
Steven Vaughn	URS Project Manager	333 E Wetmore Rd, Suite 400	Tucson, AZ	85705	Phone: 520-407-2845 Email: steven_vaughn@urscorp.com

TABLE 2
RELEVANT GROUNDWATER STANDARDS & LABORATORY REPORTING LIMITS
(milligrams per liter unless noted)

	AWQS	Laboratory Method Reporting Limit (mg/L)
Aluminum	NE	0.03
Antimony	0.006	0.0004
Arsenic	0.05	0.0005
Barium	2	0.003
Beryllium	0.004	0.0001
Cadmium	0.005	0.0001
Calcium	NE	0.2
Chromium (total)	0.1	0.01
Cobalt	NE	0.01
Copper	NE	0.01
Iron	NE	0.02
Lead	0.05	0.0001
Magnesium	NE	0.2
Manganese	NE	0.005
Mercury	0.002	0.0002
Molybdenum	NE	0.01
Nickel	0.1	0.01
Potassium	NE	.3
Selenium	0.05	0.0001
Sodium	NE	0.3
Thallium	0.002	0.0001
Zinc	NE	0.01
Gross Alpha (pCi/L)	15 pCi/L	2 pCi/L
Beta emitters (pCi/L)	4 millirem/year*	4 pCi/L
Radium 226+228 (pCi/L)	5 pCi/L	1 pCi/L
Uranium	NE	0.0001
Uranium Isotopes (pCi/L)	NE	0.2 pCi/L
Alkalinity as CaCO3	NE	2
Chloride	NE	1
Fluoride	NE	0.1
Sulfate	NE	10
Nitrate+Nitrite	NE	0.02

Key: pCi/L - PicoCuries per Liter
NE – None Established
*AWQC is 4 millirem/year or approximately 50 pCi/L

TABLE 3
RELEVANT SOIL STANDARDS AND LABORATORY REPORTING LIMITS
(milligrams per kilogram unless noted)

Analyte	GPL	Residential SRL			Non-residential SRL	Laboratory Method Reporting Limit (mg/Kg)
		Carcinogen				
		10^{-6} Risk	10^{-5} Risk	Non-Carcinogen		
Aluminum	NE			76,000	920,000	3
Antimony	35			31	410	0.04
Arsenic	290	10	10	10	10	0.05
Barium	12,000			15,000	170,000	0.3
Beryllium	23			150	1,900	0.2
Cadmium	29			39	510	0.01
Chromium (total)	590			NE	NE	20
Chromium III	NE			120,000	1,000,000	1
Cobalt	NE	900	9,000	1,400	13,000	1
Copper	NE			3,100	41,000	1
Iron	NE			NE	NE	2
Lead	290			400	800	0.01
Magnesium	NE			NE	NE	20
Manganese	NE			3,300	32,000	0.5
Mercury	12			23	310	0.02
Molybdenum	NE			390	5,100	1
Nickel	590			1,600	20,000	1
Potassium	NE			NE	NE	30
Selenium	290			390	5,100	0.1
Sodium	NE			NE	NE	30
Thallium	12			5.2	67	0.01
Zinc	NE			23,000	310,000	1
Radium 226+228 (pCi/g)	NE			NE	NE	1.5
Uranium	NE			16	200	0.01
Uranium Isotopes (pCi/g)	NE			NE	NE	0.3

Key: GPL - Groundwater Protection Level
SRL - Soil Remediation Level
NE – None Established
pCi/g - PicoCuries per gram

TABLE 4
QC SAMPLE SUMMARY AND SAMPLE CONTAINERS AND PRESERVATIVES

Analytical Parameter	Analytical Method (or equivalent)	Definitive or Screening Method	Sample Matrix	Estimated Number of Samples					Preservation	Number/ Minimum Volume of Container(s)	Sample Hold Time (from collection)
				Estimated Number of Field Samples	LAB QC Samples		FIELD QC Samples				
					MS	MSD or DUP	Field Dup	Equip. Blank			
Metals	SW-846 6010B	Definitive	Soil/ Sediment	380	19	19	19	19	Cool to 4 °C	1 4-oz glass	180 days
Diss. Metals	EPA 200.7 & 200.8	Definitive	Water	328	16	16	16	16	pH < 2 with HNO_3	1 1-liter poly	180 days
Anions	EPA 300.0	Definitive	Water	328	0	0	16	0	Cool to 4°C	1 250-ml poly	48 hours for NO_2, 28 days for all else
Anions	EPA 300.0	Definitive	Soil/ Sediment	380	19	19	19	19	Cool to 4°C	1 16-oz glass	28 days
pH	SW-846 9040B	Screening	Water	328	0	0	16	0	NA	Poly or glass	Analyze Immediately
pH	SW-846 9045C	Screening	Soil/ Sediment	380	0	0	19	0	Cool to 4 °C	1 4 oz. Poly or glass	Analyze Immediately
Temperature	EPA 170.1	Screening	Water	328	0	0	16	0	NA	Poly or glass	Analyze Immediately
Specific Conductance	EPA 120.1	Screening	Water	328	0	0	16	0	NA	Poly or glass	Analyze Immediately
Eh	ASTM 1498	Screening	Water	328	0	0	16	0	NA	Poly or glass	Analyze Immediately
Turbidity	EPA 180.1	Screening	Water	328	0	0	16	0	NA	Poly or glass	Analyze Immediately
Dissolved Oxygen	EPA 360.1	Screening	Water	328	0	0	16	0	NA	Poly or glass	Analyze Immediately
TDS	EPA 160.1	Screening	Water	328	0	0	16	0	Cool to 4 °C	1 100-ml poly	7 days
Alkalinity	Std. Method 2320B	Screening	Water	328	0	0	16	0	Cool to 4 °C	1 250-ml poly	14 days
Gross Alpha Gross Beta	EPA 900.0	Screening	Water	328	0	0	16	16	pH < 2 with HNO_3	1-gallon poly	6 months
U-234, U-235, U-238	Eichrom ACW03	Definitive	Water	328	16 **(a)**	16 **(a)**	16	16	pH < 2 with HNO_3	1-gallon poly	6 months
U-234, U-235, U-238	Eichrom ACW03	Definitive	Soil/ Sediment	380	19 **(a)**	19 **(a)**	19	19	None	1 4-oz glass	6 months

TABLE 4
QC SAMPLE SUMMARY AND SAMPLE CONTAINERS AND PRESERVATIVES

Analytical Parameter	Analytical Method (or equivalent)	Definitive or Screening Method	Sample Matrix	Estimated Number of Samples					Preservation	Number/ Minimum Volume of Container(s)	Sample Hold Time (from collection)
				Estimated Number of Field Samples	LAB QC Samples		FIELD QC Samples				
					MS	MSD or DUP	Field Dup	Equip. Blank			
Ra-226	EPA 903.0	Definitive	Water	328	16 **(a)**	16 **(a)**	16	16	pH < 2 with HNO_3	1-gallon poly	6 months
Ra-226	EPA 9315	Definitive	Soil/ Sediment	380	19 **(a)**	19 **(a)**	19	19	None	1 4-oz glass	6 months
Ra-228	EPA 904.0	Definitive	Water	328	16 **(a)**	16 **(a)**	16	16	pH < 2 with HNO_3	1-gallon poly	6 months
Ra-228	EPA 9320	Definitive	Soil/ Sediment	380	19 **(a)**	19 **(a)**	19	19	None	1 4-oz glass	6 months

Notes:

(a) As spiking standards are available.

SW846: Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, Final Update III, December 1996.

EPA: USEPA Office of Research and Development, Environmental Monitoring and Support Laboratory, Methods for Chemical Analyses of Water and Wastes, March 1983

Std. Methods: Standard Methods for the Examination of Water and Wastewater, 17th Edition, 1989

QC: Quality Control
MS: Matrix Spike
MSD: Matrix Spike Duplicate
DUP: Matrix Duplicate
Equip: Equipment
Eh: Oxidation reduction potential
Diss: Dissolved
TDS: Total Dissolved Solids
COD: Chemical Oxygen Demand
HCl: Hydrochloric Acid
oz: ounce
pH: negative log, hydrogen ion activity
HNO_3: Nitric Acid
H_2SO_4: Sulfuric Acid
°C: Degrees Celsius
ml: milliliter
poly: polyethylene
NA: Not Applicable

TABLE 5
SUMMARY OF GENERAL CALIBRATION AND QC PROCEDURES
FOR NON-RADIOLOGICAL SCREENING METHODS

Method	Applicable Parameter	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action*
EPA 120.1	Conductance	Calibration check with KCl standard	Once per day at beginning of testing	± 5%	If calibration is not achieved, check meter, standards, and probe; recalibrate
		Method blank (using DI water)	Once per day at the beginning of testing	< Quantitation Limit (1μS/cm)	Check meter, replace if necessary, check water, recalibrate
		Standard check	At each sample location	± 5%	Correct problem, recalibrate
		Method duplicate	10% of field samples	RPD ≤ 10%	Correct problem, repeat measurement
EPA 180.1	Turbidity	Calibration check with one formazin standard per instrument range used	Once per day at the beginning of testing	± 5 units 0-100 range ± 0.5 units 0-0.2 range ± 0.2 units 0-1 range	If calibration is not achieved, check meter; replace if necessary, recalibrate
		Method blank (using DI water)	Once per day at the beginning of testing	< Quantitation Limit (1 NTU)	Check meter, replace if necessary, check water, recalibrate
		Method duplicate	10% of field samples	RPD ≤ 20%	Correct problem, repeat measurement
SW-846 9040B & 9045C	pH (water & aediment)	2-point calibration with pH buffers	Once per day	± 0.05 pH units for every buffer	If calibration is not achieved, check meter, buffer solutions, and probe; replace if necessary; repeat calibration
		pH 7 buffer (standard check)	At each sample location (water only)	± 0.2 pH units	Correct problem, recalibrate
		Method duplicate	10% of field samples	± 0.2 pH units	Correct problem, repeat measurement
EPA 170.1	Temperature	Method duplicate	10% of field samples	± 1.0 °C	Correct problem, repeat measurement
		Factory calibration	Once at factory	± 1.0 °C	Check meter, replace if necessary
EPA 360.1	Dissolved Oxygen	Calibration (as applicable for instrument used)	Once per day	To barometric pressure uncorrected for altitude	NA
		Method Duplicate	10% of field samples	± 0.2 mg/L	Correct Problem, repeat measurement

TABLE 5
SUMMARY OF GENERAL CALIBRATION AND QC PROCEDURES
FOR NON-RADIOLOGICAL SCREENING METHODS

Method	Applicable Parameter	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action*
		Colorimetric check	10% of field samples	RPD ≤ 20%	Correct problem, repeat measurement
ASTM 1498	Eh	Sensitivity Verification	Daily	Eh should decrease when pH is increased	If Eh increases, correct the polarity of electrodes. If Eh still does not decrease, clean electrodes and repeat procedure
		Calibration check with one standard	Once per day	Two successive readings ± 10 millivolts	Correct problem, recalibrate
		Standard check	At each sample location	± 10 millivolts	Correct problem, recalibrate
		Method Duplicate	10% of field samples	± 50 millivolts	Correct problem, repeat measurement
EPA 160.1	Filterable Residue	Analytical Balance check with a standard weight	Once per day at the beginning of testing	± 0.1 milligram	Correct problem, adjust balance
		Method Duplicate	1 per batch or 5%	RPD ≤20%	Analyze third aliquot. If still out, flag data
EPA 160.2	Non-filterable Residue	Analytical Balance check with a standard weight	Once per day at the beginning of testing	± 0.1 milligram	Correct problem, adjust balance
		Method Duplicate	1 per batch or 5%	RPD ≤20%	Analyze third aliquot. If still out, flag data
Std. Method 2320B	Alkalinity	Method Duplicate	1 per batch or 5%	RPD ≤20%	Analyze third aliquot. If still out, flag data

*All corrective actions shall be completed as necessary upon QC check failure, documented, and the records shall be maintained.

SW846: Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, Final Update III, December 1996.
EPA: USEPA Office of Research and Development, Environmental Monitoring and Support Laboratory, Methods for Chemical Analyses of Water and Wastes, March 1983
Std. Methods: Standard Methods for the Examination of Water and Wastewater, 17th Edition, 1989

QC: Quality Control
KCl: Potassium Chloride
%: Percent
°C: Degrees Celsius
RPD: Relative Percent Difference
mg/l: milligrams per liter
NA: Not Applicable

TABLE 6
SUMMARY OF GENERAL CALIBRATION AND QC PROCEDURES FOR NON-RADIOLOGICAL DEFINITIVE METHODS

Analytical Methods	Analysis	Quality Control Check	Frequency and Acceptance Criteria	Corrective Action
EPA 300.0	Anions by IC	Initial calibration curve	Daily R $\geq$ 0.995	Rerun calibration standards
		Instrument Performance Check Sample (IPC)	Analyze after ICAL $\pm$ 10%	Reanalyze IPC; if second analysis still out, recalibrate and reanalyze all samples since last compliant IPC
		Calibration Blank	Analyze with each IPC < MDL	Determine cause of blank problem, reanalyze all samples since last compliant calibration blank
		Laboratory Reagent Blank (LRB)	One per batch or one per 20 samples, whichever is more frequent < PQL	Determine cause of blank problem, reanalyze set if necessary
		Lab Fortified Blank	One per batch (one per 20 samples) $\pm$ 10%	Correct problem and reanalyze batch
		Spiked Samples	One per batch (one per 20 samples) $\pm$ 20%	If LFB OK flag sample suspect due to matrix
		Duplicates	One per batch (one per 20 samples) 25% RPD	Reprep dups and reanalyze
SM2320B	Alkalinity	Method Blank	One per batch (one per 20 samples) < PQL	Determine cause of blank problem, reanalyze set if necessary
		Lab Control Samples	One per batch (one per 20 samples) $\pm$ 10%	Reprep batch and reanalyze
		Duplicates	One per batch (one per 20 samples) 20% RPD	Reprep batch and reanalyze
EPA 200.7	ICP Metals	Initial calibration minimum of a blank and one standard	Per instrument manufacturer's specifications R $\geq$ 0.995, Attachment C, SOP #7.04, Section 9	Rerun calibration standards.
		Continuing calibration Instrument Performance Check (IPC)	Beginning, end and after every 10 samples After initial cal; $\pm$ 5% after subsequent cal; $\pm$ 10%	Re-analyze standard; if second analysis out, recalibrate, re-run all samples since last compliant IPC
		Lab Fortified Blank	One per batch (one per 20 samples) $\pm$ 15%	Rerun batch

TABLE 6
SUMMARY OF GENERAL CALIBRATION AND QC PROCEDURES
FOR NON-RADIOLOGICAL DEFINITIVE METHODS

Analytical Methods	Analysis	Quality Control Check	Frequency and Acceptance Criteria	Corrective Action
		Calibration blank	After each IPC < IDL	Rerun blank, if second CCB analysis out, recalibrate and reanalyze all samples since last compliant CCB
		Laboratory Reagent Blank/ Method Blank	One per 20 samples < 2.2x the analyte MDL or < 10% of sample concentration	Determine cause of problem, redigest set if necessary and reanalyze
		QC check standard (second source)	Beginning, end and after every 10 samples ± 10%	Recalibrate
		Laboratory Duplicates	One per 10 samples (if MSD not analyzed) Attachment C, SOP #7.04, Section 9.10	
		Spike Samples (Lab Fortified Sample Matrix)	One per 10 samples ± 30 %, ≤ 20 RPD	Redigest, or if LFB OK flag data as suspect due to matrix interference
SW846 6010B	ICP Metals	Initial Calibration – minimum of a blank and one standard	Per instrument manufacturer's specifications	Recalibrate
		Initial Calibration Verification (ICV)	At the beginning of operation and as needed ± 10%	Recalibrate
		Continuing Calibration Verification (CCV)	Beginning, end and after every 10 samples < ± 3x IDL unless the results are < $1/10^{th}$ of the action level and no sample is within 10% of the action level	Recalibrate and reanalyze all samples since last compliant calibration blank
		Internal Standards (IS)	± 20% intensity level agreement between ICV and CCV	Recalibrate and reanalyze all samples
		Method Blank	One per batch (one per 20 samples) Not > MDL	Determine cause of problem, redigest set if necessary
		Spiked Samples (MS)	One per batch or 20 samples, whichever is more frequent	Flag data as suspect due to matrix interference
		Matrix duplicates	One per batch or 20 samples, whichever is more frequent 20% RPD if sample value > 10x IDL	Re-prep samples and reanalyze
		Interference Check Sample (ICS)	Beginning and every 8 hours % R = 90 - 110	Recalibrate and rerun all samples since last compliant check sample

TABLE 6
SUMMARY OF GENERAL CALIBRATION AND QC PROCEDURES
FOR NON-RADIOLOGICAL DEFINITIVE METHODS

Analytical Methods	Analysis	Quality Control Check	Frequency and Acceptance Criteria	Corrective Action
		LCS	One per batch or 20 samples, whichever is more frequent $\pm$ 20%	Recalibrate
SW846 7470A	Mercury	Initial calibration (5 std, 1 blank)	Each day of analyses $R \geq 0.995$	Recalibrate
		Continuing calibration)	After each 10 samples $\pm$ 20%	Recalibrate, reanalyze previous 10 samples
		Matrix spike/matrix spike duplicate	One per batch (one per 20 samples) $\pm$ 15%	Reanalyze batch or run by MSA
		Method Blank	One per batch (one per 20 samples) < 2.2x MDL or < 10% of sample concentration	Reprocess samples
		Continuing Calibration Blank (CCB)	After ICAL, every 10 samples, and end of run < RL	
		QC Check Standard	After each calibration $\pm$ 10%	Recalibrate
		LCS	One per batch (one per 20 samples) $\pm$ 10%	Recalibrate

SW846: Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, Final Update III, December 1996.
EPA: USEPA Office of Research and Development, Environmental Monitoring and Support Laboratory, Methods for Chemical Analyses of Water and Wastes, March 1983
SM: Standard Methods for the Examination of Water and Wastewater, 17th Edition, 1989

APPENDIX A

SIERRITA MINE QAPP

QUALITY ASSURANCE PROJECT PLAN
FOR AQUIFER CHARACTERIZATION PLAN

Prepared for:

Phelps Dodge Sierrita, Inc.
6200 West Duval Road
Green Valley, Arizona 85614

Prepared by:

HYDRO GEO CHEM, INC.
51 West Wetmore Road
Tucson, Arizona 85705
(520) 293-1500

August 11, 2006

APPROVAL & DISTRIBUTION SHEET
QUALITY ASSURANCE PROJECT PLAN
FOR AQUIFER CHARACTERIZATION PLAN
PHELPS DODGE SEIRRITA MINE, PIMA COUNTY, ARIZONA

_____ Stuart Brown Bridgewater Group, Inc. Project Director (503) 675-5252 date: _____	_____ E.L. (Ned) Hall Phelps Dodge Sierrita, Inc. Project Manager (520) 648-8700 date: _____
_____ Bill Dorris Phelps Dodge Sierrita, Inc. Quality Assurance Manager (520) 648-8873 date: _____	_____ James R. Norris Hydro Geo Chem, Inc. Project Manager (520) 293-1500 ext. 112 date: _____
_____ Kimberly Garcia Hydro Geo Chem, Inc. Quality Assurance Manager (520) 293-1500 ext. 123 date: _____	_____ Field Technician date: _____
_____ Scott Habermehl ACZ Laboratories Analytical Laboratory Project Manager (800) 334-5493 date: _____	_____ Kirsten Russell ACZ Laboratories Analytical Laboratory QA Manager (800) 334-5493 date: _____
_____ Subcontractor date: _____	_____ Subcontractor date: _____

ACRONYM AND ABBREVIATION LIST

°C	degrees Celsius
μmhos/cm	micro mhos per centimeter
ACP	Aquifer Characterization Plan
ACZ	ACZ Laboratories, Inc.
ADEQ	Arizona Department of Environmental Quality
ADHS	Arizona Department of Health Services
AZPDES	Arizona Pollutant Discharge Elimination System
ARS	Arizona Revised Statutes
bgs	below ground surface
CLP	Contract Laboratory Program
COC	chain-of-custody
DGP	De Minimus General Permit
DQI	data quality indicator
DQO	data quality objective
DTW	depth to water
EPA	U.S. Environmental Protection Agency
FS	Feasibility Study
ft	feet
HGC	Hydro Geo Chem, Inc.
ID	identification
in	inch
LCS	laboratory control sample
MDL	method detection limit
mg/L	milligrams per liter
MO	Mitigation Order on Consent Docket No. P-50-06, dated June 8, 2006
MHSA	Mine Health and Safety Administration
MS/MSD	matrix spike/matrix spike duplicate
nm	nanometer
OHSA	Occupational Health and Safety Administration
PDSI	Phelps Dodge Sierrita, Inc.
PDSTI	Phelps Dodge Sierrita Tailing Impoundment
PQL	practical quantitation limit
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
RPD	relative percent difference
SOP	standard operating procedure
TDS	total dissolved solids
USCS	Unified Soil Classification System

CROSS-REFERENCE OF QUALITY ASSURANCE ELEMENTS

The following table contains a cross reference between this document and the elements specified by the Arizona Department of Environmental Quality (ADEQ) in its *Quality Assurance Project Plan Review*, based on the U.S. Environmental Protection Agency (EPA) *Requirements for Quality Assurance Plans for Environmental Data Operations*, EPA QA/R-5 (EPA, 2001a).

QUALITY ASSURANCE /R-5 ELEMENTS	COMMENT ADDRESSED
A1, Title and Approval Sheet	**Cover, Pg. i**
A2, Table of Contents	**Pg. vii**
A3, Distribution List	**Pg. i**
A4, Project Organization	**Section 2, Figure 1**
A5, Problem Definition/Background	**Section 1.1**
A6, Project/Task Description	**Section 1.1**
A7, Quality Objectives and Criteria for Measurement Data	**Section 3**
A8, Special Training/Certification	**Sections 4.1, 5.1**
A9, Documentation and Records	**Sections 4.6, 5.7**
B1, Sampling Process Design	**Sections 4.2, 4.3**
B2, Sampling Methods Requirements	**Sections 4.2, 4.3**
B3, Sample Handling and Custody Requirements	**Sections 4.2.3, 5.2**
B4, Analytical Methods Requirements	**Section 5.3**
B5, Quality Control Requirements	**Sections 4.2.1.5, 5.4**
B6, Instrument/Equipment Testing, Inspection, and Maintenance	**Sections 4.5., 5.5**
B7, Instrument/Equipment Calibration and Frequency	**Sections 4.5, 5.5**
B8, Inspection/Acceptance of Supplies and Consumables	**Sections 4.5**
B9, Data Acquisition for Non-Direct Measurements	**N/A**
B10, Data Management	**Section 6**
C1, Assessments and Response Actions	**Sections 4.7, 5.7, 6.4**
C2, Reports to Management	**Sections 5.6, 6.4**
D1, Data Review, Verification, and Validation	**Section 6.2**
D2, Verifications and Validation Methods	**Section 6.2**
D3, Reconciliation with User Requirements	**Section 6.2**

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLES

FIGURES

APPENDICES

1. INTRODUCTION

This Quality Assurance Project Plan (QAPP) describes the quality assurance levels and procedures for field operations and the associated laboratory and data management activities that will be conducted for the Aquifer Characterization Plan (ACP) contained in the *Work Plan to Characterize and Mitigate Sulfate with Respect to Drinking Water Supplies in the Vicinity of the Phelps Dodge Sierrita Tailing Impoundment, Pima County, Arizona* (Work Plan). The Work Plan was developed pursuant to Mitigation Order on Consent Docket No. P-50-06 (MO) between Phelps Dodge Sierrita, Inc. (PDSI) and the Arizona Department of Environmental Quality (ADEQ). Section III.A.2 of the MO states that a QAPP, with a schedule for implementation, will be provided with the Work Plan. Components of the QAPP are to define, "the sulfate plume characterization and assessment objectives," and describe "the methods, organization, analyses, and quality assurance and quality control" needed to meet the objectives of the Work Plan. Hydro Geo Chem, Inc. (HGC) prepared this QAPP on behalf of PDSI.

1.1 Background and Project Description

The Phelps Dodge Sierrita Tailing Impoundment (PDSTI) is one of several tailing impoundments in the Pima mining district. It is located approximately 25 miles south of Tucson and 2 miles east of Green Valley in Pima County, Arizona. In the 1970s, groundwater in the vicinity of PDSTI and other tailing impoundments in the Pima mining district was found to

contain elevated concentrations of sulfate. The origin of the sulfate was identified as the seepage from various tailing impoundments into the underlying aquifer.

Groundwater sampling in the Green Valley area has identified a groundwater plume with sulfate concentrations exceeding 250 milligrams per liter (mg/L). The zone of elevated sulfate extends from the base of the PDSTI northeastward to the western edge of Green Valley and northward to approximately Duval Mine Road.

In June 2006, PDSI and ADEQ entered into the MO to address sulfate attributable to the PDSTI. To meet the MO requirements, the Work Plan proposes an ACP and a Feasibility Study (FS) for the sulfate mitigation. The ACP will determine the nature, extent, fate, and transport of sulfate in groundwater and will gather information needed to develop mitigation action alternatives for drinking water supplies consistent with the MO. This QAPP pertains to data collection activities for the ACP for use in characterizing the sulfate plume and conducting the FS.

1.2 Quality Assurance Project Plan Overview

Quality assurance (QA) is a planned, systematic set of activities designed to ensure that a product or service meets defined standards of quality within a stated level of confidence. Quality control (QC) is the routine application of procedures for obtaining prescribed performance standards for monitoring and measuring. This QAPP provides the QA/QC procedures needed to provide confidence that the data generated during ACP activities are appropriate for their

intended use, are legally defensible, and are of sufficient quality to support decisions concerning characterization of sulfate in groundwater and development of the Mitigation Plan. The QA/QC program described in this QAPP covers procedures to be followed for field activities, sample handling, chain-of-custody (COC) documentation, laboratory analyses, and data management.

Portions of the groundwater sampling described in the ACP will be conducted by PDSI as part of their routine monitoring activities. The sampling protocols and QA/QC procedures for data collected by PDSI will be governed by the *Quality Assurance/Quality Control Plan for Water Monitoring, Phelps Dodge Sierrita, Inc.* (PDSI, 2005a) and *Standard Operating Procedures - Water and Environmental Sample Collection, Phelps Dodge Sierrita* (PDSI, 2005b) which are provided in Appendix A. QA of data collected under the direction of HGC will be governed by this QAPP. This QAPP is designed to be generally consistent with PDSI (2005a) and PDSI (2005b) and the following documents:

- *EPA Guidance for Quality Assurance Project Plans*, EPA/240/R-02/009. (EPA, 2002a),
- *Guidance on Systematic Planning Using the Data Quality Objective Processes*, EPA/540/B-06/001. (EPA, 2006).
- *EPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review, Final* (EPA, 2004).
- *ADEQ Quality Management Plan*, EQR00-01. (ADEQ, 1999).

1.3 Quality Assurance Project Plan Distribution

The HGC QA Manager is responsible for ensuring that each project member has access to the most current version of the QAPP, including all subsequent addenda or revisions. The project members include, but may not be limited to, all individuals named on the signature page of this QAPP and all subcontractors performing field operations and laboratory analyses. The QAPP will be reviewed yearly by the HGC Project Manager to address any changes in data collection requirements. If revisions are made to the QAPP, they will be made under the direction of the HGC Project Manager and a revised document will be issued a sequential revision number and a new signature page.

1.4 Quality Assurance Project Plan Organization

This QAPP begins by describing the project organization and QA responsibilities for ACP activities (Section 2). It then defines the data quality objectives for data generated by activities conducted for the ACP (Section 3). Finally, it gives the QA/QC procedures, for field, analytical laboratory, and data management activities (Sections 4, 5, and 6).

2. PROJECT ORGANIZATION AND RESPONSIBILITIES

An organizational chart indicating the relationships and lines of communication among project participants is provided in Figure 1. As depicted in Figure 1, there are parallel project management and QA responsibilities between PDSI and HGC. PDSI is responsible for implementing and reporting environmental monitoring activities for its routine groundwater monitoring and additional sampling to be identified by and conducted for the ACP. For Task 2.2 of the ACP, PDSI will conduct groundwater monitoring at selected monitoring wells already sampled under the PDSI monitoring plan. PDSI will conduct these monitoring activities independent from field activities conducted by HGC. Data collected by PDSI will be used by HGC for groundwater monitoring under the ACP. HGC will coordinate and oversee ACP tasks, such as groundwater sampling of wells not routinely monitored by PDSI and the installation, testing, and sampling of new wells. The roles and responsibilities of the individuals given in Figure 1 are described below.

2.1 ADEQ Project Manager

The ADEQ Project Manager conducts regulatory oversight of the Work Plan activities and provides regulatory review and approval of documents, reports, plans, schedules, and other communications submitted pursuant to the MO.

2.2 Phelps Dodge Corporation Project Director

The Phelps Dodge Corporation Project Director has the overall responsibly for implementing the Work Plan. The Project Director will direct the schedule and scope of operations and provide fiscal oversight for resources needed for Work Plan activities.

2.3 PDSI Project Manager

The PDSI Project Manager directs PDSI sampling activities. The PDSI Project Manager has the responsibility to ensure that PDSI personnel are properly trained, and, in cooperation with the PDSI QA Manager, to ensure the quality of data collected by PDSI. The PDSI Project Manager will work with the HGC Project Manager to provide resources for implementation of ACP tasks.

2.4 PDSI QA Manager

The PDSI QA Manager provides QA documentation, review, and verification of field and laboratory data collected by PDSI, identifies data quality deficiencies, and initiates corrective action. The PDSI QA Manager also ensures that records are properly stored in PDSI files and electronic databases and coordinates transfer of data with HGC QA Manager.

2.5 HGC Project Manager

The HGC Project Manager directs field activities for the ACP, ensures that all personnel are properly trained, and ensures adequate resources for the completion of ACP tasks. The HGC Project Manager also works with the HGC QA Manager to provide QA checks of data quality and to implement corrective actions. The HGC Project Manager is responsible for providing final review and approval of documents, reports, plans, schedules, and other communications submitted to ADEQ pursuant to the MO. The HGC Project Manager will periodically review and provide any needed updates to the QAPP.

2.6 HGC QA Manager

The HGC QA Manager reviews data and documentation from ACP activities to ensure compliance with the provisions of this QAPP, initiates corrective actions, and ensures that records are properly stored in HGC files and electronic databases. The HGC QA Manager will also coordinate data transfer with the PDSI QA Manager and be responsible for entry of data collected by PDSI into the HGC database.

2.7 Field Technicians

Field technicians are all personnel (geologists, hydrologists, or environmental technicians) performing field activities described in the ACP, including groundwater sampling, lithologic and borehole logging, well construction oversight, and aquifer testing. All field technicians should

be adequately trained for the activities that they will perform, and they are responsible for ensuring the quality of their own work, including complete and accurate documentation.

2.8 Laboratory Project Manager

The Laboratory Project Manager ensures that laboratory resources are available, reviews final analytical reports produced by the laboratory, reviews and directs compliance with the QAPP, coordinates scheduling of laboratory analyses, and supervises in-house COC procedures. The Laboratory Project Manager also has the responsibility of submitting analytical reports to HGC.

2.9 Laboratory QA Manager

The Laboratory QA Manager maintains laboratory QA procedures and QA/QC documentation, conducts periodic internal laboratory audits, and recommends corrective actions when necessary. The Laboratory QA Manager is responsible to ensure that laboratory procedures are in compliance with this QAPP.

2.10 Drilling Subcontractors

Drilling subcontractors are responsible for the specific drilling, well construction, and well sampling activities for which they are contracted. They are also responsible for being properly licensed and trained to perform these activities.

3. DATA QUALITY OBJECTIVES

The primary data collection activities for the ACP are water level measurement, collection and analysis of water quality samples, lithologic logging of boreholes, and aquifer testing. Data collected by these activities will be used by PDSI and ADEQ to characterize the extent of sulfate in groundwater and to develop and evaluate mitigation alternatives for drinking water supplies. The overall QA objective is to implement field procedures, laboratory analyses, and reporting that will provide results that are scientifically valid and legally defensible. Data Quality Objectives (DQOs) are qualitative and quantitative objectives that specify the quality of data needed from a sampling program. Data Quality Indicators (DQIs) aid in this goal by specifying criteria for data types, quality, quantity, and applications that are needed to minimize decision errors due to data uncertainties. This section discusses DQOs, QA deliverables, and the DQIs used to evaluate if the DQOs have been met for field operations and laboratory analyses.

3.1 Data Quality Objectives

The DQOs for this project are:

- Collection of water level data of sufficient quantity and representativeness to evaluate potentiometric conditions during seasonal high (summer) and low (winter) pumping conditions.
- Collection and laboratory analysis of water samples of sufficient quality to define the lateral and vertical distribution of sulfate and to characterize water quality parameters pertinent to the identification and evaluation of potential water treatment technologies for the FS.

- Collection of lithologic information of sufficient accuracy to develop a reliable understanding of subsurface materials.

- Collection of aquifer test data of sufficient quality to estimate hydraulic properties of subsurface materials.

- Water flow rate and volume measurements of sufficient accuracy to support estimation of hydraulic properties and major components of the water budget.

3.2 Quality Assurance of Deliverables

The QA program should ensure the quality of all deliverables from field activities, laboratory analyses, and data processing. The U.S. Environmental Protection Agency (EPA) has identified five levels of QA/QC. The QA/QC level required for a project depends on the purpose of that project and the data deliverables requested. Levels I through IV are defined in Table 1. Level V refers to non-conventional parameters and is not applicable to this QAPP. The relevance of levels I through IV to this QAPP is discussed below.

- **$** Level I analytical methods are required for field data collection. Field data will be generated using portable instruments that are regularly calibrated. Level I methods will be implemented in the field and include the use of pH, temperature, and electrical conductivity meters, as well as other instruments.

- **$** Level II may be used for screening-level measurements such as in-field sulfate detection. In general, however, Level II is not pertinent to this QAPP because it does not provide adequate accuracy or sensitivity.

- **$** Level III analytical methods are required for the majority of project data collected per this QAPP. For most groundwater samples, the quality of laboratory data must be sufficient to monitor current groundwater conditions. Additionally, the data must be of sufficient quality to meet all objectives identified for this project.

- **$** Level IV consists of a highly accurate and rigorous QA/QC review that would only be undertaken in this project if there was a persistent problem identified with analytical results. HGC may request a Level IV "Contract Laboratory Program (CLP)-

equivalent" QC package from the laboratory and independent validation of the data. PDSI may request a Level IV "CLP-equivalent" QC package for all or some percentage of the data. Data validation documentation will be consistent with *Laboratory Documentation Required for Data Evaluation* as established by EPA Region IX QA Office (2001b).

3.3 Data Quality Indicators

Field and laboratory data will be evaluated using the following DQIs: precision, bias, accuracy, representativeness, comparability, completeness, and sensitivity. If laboratory data DQIs do not meet the data acceptance criteria, the reason will be noted in the case narrative submitted to HGC. If DQI acceptance criteria are not met, corrective actions to be taken may include additional sampling and/or re-analysis.

3.3.1 Precision

Precision is "the measure of agreement among repeated measurements of the same property under identical, or substantially similar, conditions" (EPA, 2002a). For this QAPP, data precision is measured by calculating the relative percent difference (RPD) of the analytical results for field and laboratory duplicates. RPD is calculated using the following formula:

$$RPD = \frac{x_1 - x_2}{x_m} \times 100 \qquad (1)$$

where x_1 is the analytical result from the original sample
x_2 is the analytical result from the duplicate sample
x_m is the mean of the two samples

Acceptance criteria for precision of laboratory duplicates will be set by method guidance or in-house laboratory limits, whichever is more stringent. The default acceptance criteria for field duplicates from groundwater samples will be an RPD of less than 20%, which is the criteria listed in EPA functional guidelines (EPA, 2004).

3.3.2 Bias

Bias is "the systematic or persistent distortion of measurements that causes consistent errors in one direction" (EPA, 2002a). Bias can be caused by matrix interferences that either enhance or suppress the response of an instrument to the presence of a constituent. Bias is addressed both in the field and in the laboratory by calibration of instruments and consistent application of standardized procedures (Sections 4.5 and 5.4).

3.3.3 Accuracy

Accuracy is "a measure of the overall agreement of a measurement to a known value" (EPA, 2002a). Accuracy can be decreased by errors related to both precision and bias. A measured value is of acceptable accuracy when it does not differ beyond acceptable limits from the true value or the known concentration of a spike or standard. Accuracy of analytical results is measured by calculating the percent recoveries of surrogates, matrix spikes, and blank spikes. Laboratory accuracy is expressed as the percent recovery (%R), calculated as follows:

$$\%R = \frac{x_s - x}{T} \times 100 \qquad (2)$$

where x_s is the measured value of the spiked sample
x is the measured value of the unspiked sample
T is the true value of the spike solution added

Acceptance criteria for laboratory accuracy are set by the stricter of in-house limits or method guidance (Section 5.4).

3.3.4 Representativeness

Representativeness is a qualitative measure that conveys "the degree to which sample data accurately and precisely represents a characteristic of the environmental condition being measured" (EPA, 2002a). Representativeness is best satisfied by ensuring that sampling procedures, locations, and quantities are selected properly. Field data will be considered representative when obtained by adherence to sample identification and collection techniques and decontamination procedures (Section 4.2). In addition, proper laboratory analytical procedures and methods are mandatory to ensure representativeness of field data (Section 5).

3.3.5 Comparability

Comparability is a qualitative expression of the confidence with which one data set is comparable to and/or compatible with previous and subsequent data. Comparability is achieved by adhering to standardized methods and QA procedures established in this QAPP during sample collection, handling, and analysis. The comparability of laboratory data is achieved through

compliance with analytical method protocols. Comparability is enhanced when the same laboratory is used to analyze samples from successive sampling events and when data is reported in consistent and standard units of measurement.

3.3.6 Completeness

Completeness is a measure of the amount of valid data needed to be obtained from a sampling campaign or measurement program. Completeness will be expressed as the percentage of the total number of each type of sample or measurement that satisfies the QA/QC criteria for this project. Percent completeness will be calculated as follows:

$$\left(\frac{number\ of\ \ valid\ data\ obtained}{number\ of\ \ valid\ data\ \ possible}\right)\times 100 \qquad (3)$$

Completeness will be calculated and reported by the HGC QA Manager. Adherence to this QAPP is expected to yield data sets that will be at least 90% complete. Common factors that reduce data completeness include the following:

- The laboratory did not analyze the sample for the requested parameter.
- The laboratory did not analyze the sample following the correct method.
- The laboratory did not provide the correct sensitivity.
- The laboratory rejected data due to QC failure.
- The data reviewer rejected data due to QC failure.

3.3.7 Sensitivity

Sensitivity is a measure of "the capability of the method or instrument to discriminate between measurement responses representing different levels of a variable of interest" (EPA, 2002a). Sensitivity requirements for field measurement instruments are as follows:

- Water levels probes = 0.01 foot (ft).
- Temperature meters = 1 degree Celsius (°C).
- pH meters = 0.1 standard units.
- Electrical conductivity meters = 10 micromhos per centimeter (µmhos/cm).
- Pressure transducers = 0.01 ft water head or as appropriate for pressure rating.
- Flow meters = 5 percent of measured flow rate.
- Togopgraphic survey instruments = 0.01 ft horizontal and vertical.
- Borehole depth measurement devices = 0.1 ft.

Sensitivity requirements for analytical laboratories are generally described by the analytical method detection limits (MDLs). A MDL is the minimum amount of an analyte that can be consistently measured and reported with a high degree of confidence that the analyte concentration is above a background response. A practical quantitation limit (PQL) is that amount that can be consistently quantified with acceptable precision and accuracy. Target PQLs for each analyte will be set by method guidance or laboratory specifications, whichever is stricter (Section 5.3).

4. FIELD ACTIVITIES

This section gives the QA procedures that will be used for field activities, including groundwater sampling (water level measurement and water quality sampling), drilling and well construction, and aquifer testing. It also describes the procedures for equipment care, investigation derived waste management, and field documentation. Field activities will be documented in a dedicated field logbook or on field forms as described in Section 4.6. Sampling conducted by PDSI should conform to PDSI's quality assurance/quality control plan and standard operating procedures for environmental sampling which are included in Appendix A of this QAPP. HGC has reviewed PDSI's plans and procedures and has determined that the data generated in accordance with them will be acceptable for use.

4.1 Certification and Preliminary Activities

All field staff shall have Occupational Safety and Health Administration (OSHA) 40-hour training and certification as described in the Code of Federal Regulations (CFR), Title 29, Section 1910.120. Staff working within the PDSI property boundaries shall also have site-specific hazard awareness training and Mining Safety and Health Administration (MSHA) training as prescribed in 30 CFR Subchapter H. All certified field operations personnel must annually complete OSHA and MSHA refresher courses to maintain their certifications. All personnel and subcontractors will have appropriate licensure and certification as required by law

to perform their specific field operation. In particular, drillers will have a current well driller's license issued by the Arizona Department of Water Resources (ADWR).

Prior to starting field activities, the HGC Project Manager will obtain necessary permits, notify property owners of scheduled field activities, and locate all subsurface utilities near areas where drilling will occur. Required permits may include an ADEQ Arizona Pollutant Discharge Elimination System (AZPDES), De Minimus General Permit (DGP), an ADWR drilling permit, and an ADWR groundwater withdrawal permit. The HGC Project Manager will complete and submit Notice of Intent to Drill a Well forms to ADWR for all proposed wells. The HGC Project Manager will locate subsurface utilities by requesting a Blue Stake Survey at least 72 hours, but not more than 2 weeks, prior to drilling.

4.2 Groundwater Sampling Activities

The ACP specifies groundwater sampling from existing PDSI wells and from existing privately-owned wells. Most samples taken from existing wells will be taken from the screened interval of the well without regard to collection depth within the screen (Section 4.2.1). Depth-specific sampling that will collect water samples at discrete depths within the well screen will also be conducted (Section 4.2.2). All groundwater sampling activities will be consistent with the procedures outlined in EPA-approved methodologies, ADEQ sampling guidance documents, and this section so that data obtained from the sampling activities is of sufficient quality to meet the DQOs (Section 3). QA procedures for sampling activities are described below. Following the description of QA procedures, protocols for sample handling from the collection site to the

analytical laboratory are provided. Sample receipt and handling by the analytical laboratory are discussed in Section 5.2.

4.2.1 Groundwater Sampling from Existing Wells

Groundwater sampling will be conducted in a variety of well types including monitoring wells, active production wells, and possibly, private wells. For wells with a dedicated pump, that pump will be used for purging and sampling. If a well does not have a dedicated pump, a decontaminated, portable, submersible pump will be used to purge the well and collect groundwater samples. Prior to sampling, well construction specifications will be obtained from the well owner or ADWR records. Upon arrival at the sampling location, the sampling personnel will document the condition of the well in the field notebook or on a sampling form. Groundwater sampling then will be conducted using the following steps:

1. Depth-to-water (DTW) measurement.
2. Well purging and collection of groundwater indicator parameters.
3. Sample collection and labeling.
4. Equipment decontamination.

QA procedures for these steps are described below.

4.2.1.1 Depth to Water Measurements

Water level measurements will be taken in both pumping and non-pumping wells, if possible. For wells that are not being continuously pumped, the static DTW in wells will be measured prior to purging and sampling and will be recorded as a static pumping level. For wells that are being pumped, the pumping water level will be measured and the DTW will be recorded as a dynamic water level. The following QA procedures will be followed when making the DTW measurements:

- Use a decontaminated electronic well sounder probe capable of measuring water levels with an accuracy of 0.01 ft (Section 3.3.7).
- Verify the well identification (ID) and check to ensure that measurement equipment is operating properly.
- Record the well ID, top of casing elevation, and surface elevation, if known.
- Measure DTW from the surveyed measuring point on the top of well casing or from the north side of the top of the inner well casing if the casing has no surveyed measuring point.
- Record the DTW to the nearest 0.01 foot.
- Take DTW measurement a second time to verify that a correct measurement has been made. The two measurements should agree to within 0.03 ft.

4.2.1.2 Well Purging and Collection of Indicator Parameters

After taking DTW measurements and prior to taking groundwater samples, the wells will be purged of resident water so that groundwater samples will be representative of water from the formation. The HGC Project Manager will determine the needs for a DGP for purge water once sample locations are selected. While purging the well, groundwater indicator parameters

(pH, electrical conductivity, and temperature) will be measured. Groundwater purging and indicator parameter measurements will adhere to the following QA practices:

- Calculate the wetted casing volume based on the DTW measurement and well construction.
- Collect the indicator parameters readings at regular time or pumped volume intervals, and record the readings on a groundwater sampling form.
- If possible, purge the well of three wetted casing volumes and allow indicator parameters to stabilize so that consecutive parameter measurements (collected at approximately one-half casing volumes apart) are within the following: pH - 0.3 standard units, temperature - 2 °C, and electrical conductivity - 100 µmhos/cm.
- Permit any well that goes dry during pumping to recover at least 50% of its starting water elevation prior to groundwater sampling.

No more than five wetted casing volumes need to be pumped regardless of parameter stabilization; however, parameter instability may indicate a problem with the measurement instrument(s). If stabilized parameters cannot be obtained, field instruments will be re-calibrated (Section 4.5.2). For wells that are being pumped when sampling personnel arrive (e.g., production wells), the sampling personnel do not need to purge the well if it has been pumping continuously for a period sufficient to remove three wetted casing volumes. DTW and field parameters should still be measured and recorded.

4.2.1.3 Groundwater Sample Collection

Two types of groundwater samples will be collected at each sampling location: filtered (0.45 micron) samples will be collected for analysis of dissolved constituent concentrations and unfiltered samples will be collected for analysis of total constituent concentrations.

All groundwater samples will be analyzed for major element ions (calcium, magnesium, sodium, potassium, chloride, sulfate, nitrate, nitrite, and fluoride) and wet chemistry (alkalinity, total dissolved solids, and pH) for characterizing the general water chemistry and sulfate. Groundwater samples from select wells will also be analyzed for the following constituents needed to evaluate water treatment for the FS: aluminum, ammonia, barium, chemical oxygen demand, ferrous and total iron, manganese, phosphate, selenium, soluble and colloidal silica, strontium, sulfide, total organic carbon, silt density index, turbidity, and bacteria (total plate count). Table 2 lists the analytical suites for characterization of general chemistry and for characterization of water treatment constituents. Table 2 lists analytical methods; target method detection limits; and filtration, preservation, and holding time requirements.

The HGC QA manager will be responsible for ensuring that the analytical laboratory provides pre-preserved sample containers for all samples. Duplicate samples, equipment blank samples, and field duplicate samples will be collected as described in Section 4.2.1.5. QA practices for collecting groundwater samples are as follows:

- Verify that sample containers have been properly prepared, including addition of any preservative required (Table 2).

- Minimize the lag time between filtered and unfiltered samples by setting up the sample containers near the sampling location and by first taking the filtered sample.

- Install a new (unused) 0.45 filter in-line to the pump discharge and collect a filtered sample from the filtered discharge. If the in-line filter cannot be connected to the pump discharge from the well, collect a sample aliquot, then filter the aliquot using a portable pump and the in-line filter.

- Take the unfiltered samples directly from the pump discharge.

Sample containers do not need to have zero headspace since volatilization of analytes is not a concern.

4.2.1.4 Sample Labeling

Each sample will be uniquely labeled with permanent indelible ink either directly on the container or on a water-proof label that is affixed to the container. For consistency between samples collected by PDSI and samples collected by HGC, the samples will be labeled following the identification instructions given in Procedure DH-B and DH-D of PDSI (2005b) (Appendix A). This labeling system provides an alphanumeric identifier for each well. Samples from wells not given an area/type designator in PDSI (2005b) will be labeled according to the identification used in the ACP or by the well owner. Each sample will also be labeled with the date and time of sample collection, the analysis requested, and the preservative used.

4.2.1.5 Field Quality Control Samples

Field QC samples will be collected to verify sampling and analytical precision, accuracy, and representativeness. Two types of field QC samples will be used as QC check samples: field duplicates and field blanks. Field duplicates will be collected to assess analytical precision (Section 3.3.1). Field blanks will be collected to check for the introduction of contamination in sample handling, shipment, storage, or analysis. These field QC samples will be assigned a unique ID so that the laboratory does not know they are QC samples; however, the QC sample IDs will be clearly noted in the field logbook and on the groundwater sampling form. The collection of field duplicates, and field blanks is described below.

- Field Duplicate Samples are samples that are collected at the same time and location as another groundwater sample. The field duplicate and its partner sample will be split samples collected from the same aliquot of water. The field duplicate will be collected by first obtaining a groundwater sample in a large sampling container, and then distributing the water into sample bottles for analysis of like analytes (e.g. fill bottles for anion analysis from the same sample draw). Field duplicates of filtered and unfiltered water will be collected at a frequency of at least one per 20 samples and will be numbered and packaged following the procedures given in Procedure QC-A of PDSI (2005b) (Appendix A).

- Field Blank Samples will be collected from laboratory-grade de-ionized water that is poured directly into a sample container while in the field. Field blank samples will be subject to the same sampling procedures as samples being collected from a designated sampling location, including container type and preparation, storage, and handling. Field blanks will be collected following the procedure given in Procedure QC-B of PDSI (2005) (Appendix A). One field blank will be collected for every 20 samples. The HGC QA Manager will be responsible for having the analytical laboratory supply laboratory grade de-ionized water along with the pre-preserved sample containers.

4.2.1.6 Equipment Decontamination

Properly decontaminated sampling equipment will help prevent errors due to cross-contamination. Prior to the start of sampling, all reusable equipment will be decontaminated according to Procedure DM-A of PDSI (2005b) (Appendix A). This includes non-dedicated groundwater pumps, reusable bailers, DTW probes, and any other equipment brought onsite. Cleaned equipment should not lie on the ground or any unclean surfaces. Disposable, single-use equipment such as filters, bailers, sampling spigots, and nylon string will be used at a single sample collection location and then discarded.

4.2.2 Depth-Specific Sampling from Existing Wells

The ACP calls for depth-specific groundwater samples to be collected at discrete depths within the well's screened interval. The depth-specific sampling will consist of logging the groundwater inflow velocity along the wells screened interval and collecting groundwater samples at discrete depths. The depth-specific sampling will be a one-time sampling event to provide unique information on the vertical distribution of sulfate. Depth-specific samples will be collected at intervals of approximately 50 ft or as appropriate depending on site-specific well and sampling conditions. Groundwater sampling and inflow logging are explained below.

4.2.2.1 Groundwater Inflow Logging

Groundwater inflow logging will be conducted for wells specified in the ACP. The inflow logging will map the vertical profile of groundwater influx along the wells' screened

interval for the purpose of identifying potential preferential zones of groundwater movement and sulfate transport. The logging will be accomplished using the BESST, Inc. Dye Tracer Velocity Profiling technique. A description and brief SOP of this technique is provided in Appendix B. Prior to flow logging, the field technician will perform checks of sampling equipment, including tubing, dye-tracer, and monitoring apparatus. During logging, the field technician will follow the SOP for the BESST, Inc. Dye Tracer Velocity Profiling Technique and note any deviations from the technique in the field logbook. Electronic data will be downloaded daily, as discussed in Section 4.6.

4.2.2.2 Depth-Specific Groundwater Sampling

The DTW procedures in Section 4.2.1.1 will be followed for depth specific samples, although purging will not be conducted. For wells with a dedicated pump, depth-specific sampling will be accomplished using BESST Inc. HydroBooster™ groundwater sampling technique (BESST technique). The BESST technique provides depth-specific groundwater sampling from a well without first having to remove the pump. A brief SOP for the BESST technique is provided in Appendix B. For wells that do not have a dedicated pump, depth-specific samples may be collected using the BESST technique or devices such as a discrete interval sampler (e.g., Solinst Model 425; www.groundwatersoftware.com) or a low-flow submersible pump lowered to the appropriate depths. Selection of the sampling device will depend on well depth and access. QA practices for depth-specific sampling include the following:

- Perform checks of sampling equipment and document site conditions in the field logbook.

- Obtain permission and necessary permits to sample. Permission should be obtained from the well owner. A DGP will be obtained to discharge any purge water if it is determined necessary by the HGC Project Manager.

- Follow the SOPs given for the depth-specific sampling method (Appendix B).

- For wells where inflow logging was conducted, attempt to collect groundwater samples from the same vertical locations as used for inflow logging.

- Label the sample with the depth at which the sample was collected in addition to the other labeling requirements discussed in Section 4.2.1.4.

Groundwater samples collected by depth-specific methods will be unfiltered and analyzed for sulfate only. The sulfate analytical method is listed in Table 2.

4.2.3 Sample Custody and Handling

Groundwater samples will be stored in coolers with ice (4 ºC ± 2º) from the time they are collected until they arrive at the laboratory. COC documentation will be maintained from the time of collection until the samples are analyzed to ensure the defensibility of the results. Further instructions on sample custody and shipping are specified below.

4.2.3.1 Sample Custody and COC Documentation

Samples are in the sampler's custody upon collection. The custody of the samples will be the responsibility of the sampler until the samples are delivered or shipped to the laboratory. A

sample is considered to be under a person's custody if one or more of the following conditions are met:

- The sample is in the person's physical possession.
- The sample is in the view of the person after that person has taken possession.
- The sample is secured by that person so that no one can tamper with the sample.
- The sample is secured by that person in an area that is restricted from unauthorized personnel.

Custody of samples will be documented from the time of sample collection to completion of the analyses using COC forms. An example COC is provided in Figure DH-A of PDSI (2005b) (Appendix A). COC forms will be filled out and will accompany the samples when shipped to the laboratory. The COC form will identify the contents of each shipment. The COC form will remain in the sampler's possession until the samples have been hand delivered or shipped to the laboratory. The sampling team leader or designee will sign the COC form in the "relinquished by" box and note the date and time the samples were relinquished. A properly completed COC form will specify:

- The project name, all required signatures, dates, and times that samples were relinquished and accepted.
- Analyses requested, time and date of sampling, and sample matrix.
- Unique field identification of each sample.
- Number of containers submitted.
- Temperatures upon receipt by the analytical laboratory.

4.2.3.2 Sample Shipping

Procedures for packing and transporting samples to the laboratory may vary depending on whether samples are hand delivered to the laboratory by field personnel or delivered via a commercial shipping service such as Federal Express or United Parcel Service. The method of sample shipment will be noted on the COC form. Table 3 provides a checklist for shipping requirements.

If samples are shipped by a delivery service, all U.S. Department of Transportation (DOT) regulations for packaging and shipment must be followed. Each sample will be packaged and transported according to the procedures outlined below, which meet DOT requirements.

- Ice will be placed in a sturdy plastic bag to prevent leaking. Samples will be protected by bubble wrap, foam, or some other packing material. Sufficient packing material will be used to prevent sample containers from making contact during shipment. Enough ice will be added to maintain the cooler temperature at 4°C ± 2°, until receipt by the laboratory. The plastic bag will be twisted and secured with a twist tie or cable tie.

- The COC records will be signed by the person relinquishing possession of the samples and will be placed inside a plastic bag. The bag will be sealed and taped to the inside of the cooler lid. The shipping address will be verified before the samples are relinquished to the courier.

- The cooler will be closed and taped shut with packing tape around both ends.

- One or more signed custody seals consisting of tape imprinted with the date and initials of the sampler(s) will be placed on the cooler so that the cooler cannot be opened without the seal(s) being broken. Additional seals may be used if the sampler or shipper determines more seals are necessary. Wide, clear tape will be placed over the seal(s) to help ensure against accidental breakage.

- The cooler will be transferred to the courier along with a completed shipping bill.

4.3 Drilling and Well Construction Activities

As described in the ACP, drilling and well construction activities will be conducted to install monitoring wells at offsite locations. These activities involve the following:

- Licensure and Permits
- Drilling of boreholes
- Lithologic logging of boreholes
- Reconnaissance water quality sampling of drilling return water
- Well construction
- Well completion
- Well development
- Hydraulic testing and water sampling of new wells

QA procedures for these activities are discussed below.

4.3.1 Licensure and Permits

All drilling, well construction, and well development activities will be performed by a drilling contractor who is licensed by ADWR. Prior to drilling, well development, and hydraulic testing of wells, applicable forms and permits will be filed and obtained from ADWR and ADEQ. These forms and permits may include a Notice of Intent to Drill, a well permit, a Groundwater Withdrawal Permit, and a DGP to discharge groundwater to the ground surface.

Drilling activities, including drilling progress, setbacks, and milestones will be noted in the field logbook or appropriate forms.

4.3.2 Borehole Drilling

Proposed approximate drilling locations are given in the ACP. Drilling for offsite monitoring wells will be accomplished using a reverse circulation, air-rotary method to drill a small diameter pilot hole for collection of cuttings and water samples for determination of subsurface lithology and water quality. Mud-rotary methods may be needed for parts of the pilot hole depending on hole conditions and the advice of the driller. If additional wells are installed at the pilot hole location, they will be installed using mud rotary methods. Well design will be based on the results of lithologic sampling and water quality data collected during drilling. The drilling methods outlined here may be modified based on the judgement of the site geologist or recommendations from the drilling contractor.

The site geologist has responsibility of logging the borehole drilling and making sure that boreholes are satisfactorily drilled according to the requirements of the ACP. The site geologist will follow the QA practices given below when logging boreholes.

- Prior to drilling, measure (to ± 0.01 ft) and record the size and length of the drill, sub-assembles, and drill rods. Know and document the relationship between the number of drill rods in the ground and the depth of the borehole.
- Give constant attention to drilling progress, including the number of drill rods in the ground and verify that the driller is in agreement with the depth estimates.

- Immediately discuss any suspected deviations in drilling progress with the driller. Record deviations in the field logbook and immediately report them to the HGC Project Manager.

- Record the following in the field notebook or on the borehole log along with the corresponding depths and times: groundwater depth, observed changes in drilling conditions, and any materials added to the borehole.

4.3.3 Lithologic Logging

Lithologic logging of boreholes for offsite wells will be conducted by the site geologist. The lithology will be logged at 10-ft intervals or more frequently if needed to note significant changes in material properties. Materials used for lithologic logging will be collected from the air-rotary cyclone or mud return. To ensure comparability between lithologic descriptions between different locations logging will be conducted according to the specifications of American Society for Testing and Materials (ASTM) D2488-00. A copy of this ASTM standard is provided in Appendix C. Logging will, as a minimum, note the following:

- Soil type or rock lithology
- Color (using a Munsell color chart)
- Unified Soil Classification System (USCS) classification symbol or lithologic name
- Grading (for coarse grained soils)
- Moisture
- Structure
- Local or geologic name, if applicable
- Visual estimates for percent gravel, sand, silt, and clay
- Reaction with hydrochloric acid

4.3.4 Reconnaissance Groundwater Sampling from Boreholes

Grab samples of groundwater will be collected from the air rotary return for reconnaissance estimation of sulfate concentrations with depth. Grab sampling will commence when the borehole reaches the groundwater table and will continue at approximately 40-ft intervals to the bottom of the borehole if there is sufficient water in the return. The sulfate concentration in samples will be estimated using an electrical conductivity meter and a portable spectrophotometer.

Procedures for borehole water sampling are below.

- Collect return water in a decontaminated container.
- Measure indicator parameters (temperature, pH, and electrical conductivity) as soon as possible so that temperature does not significantly increase.
- Collect sample for spectrophotometer measurement. When water is turbid, the sample for spectrophotometer measurement can be set aside to allow solids to settle. The groundwater sample for spectrophotometer measurement will be collected from the clearest portion of the settled water.
- If the sample concentration is greater than the spectrophotometer range, the sample will be diluted with laboratory grade de-ionized water until the sulfate concentration is in the measurable range. Record the dilution factor in the field notebook.
- Record the indicator parameter measurements and field-measured sulfate concentrations in the field notebook along with the name of the boring, the depth of the casing at the time of sample collection, and the date and time of the measurements.

Unfiltered water samples for laboratory confirmation field analyses will be collected periodically if sufficient water is available. The labeling and handling of confirmatory samples

will follow those for unfiltered samples of existing wells (Sections 4.2.1.3 and 4.2.3) except that sample depth will be identified in the sample ID.

4.3.5 Well Construction

Well construction materials will be determined by the the site geologist in consultation with the HGC Project Manager and the driller. Materials will be determined according to the purpose of the well, site geologic conditions, and the quality of water samples collected during drilling. As a general rule, well casings for wells deeper than 500 feet will be 4-in or 5-in diameter, and will be constructed of low-carbon (= 0.3%) steel. Casing may be 4-in or 5-in in diameter, schedule 80 PVC for wells less than 500 feet deep. Annular materials including filter pack, bentonite pellet seals, and bentonite grout will be applied through a tremie pipe. From 0 to 20 feet below ground surface (bgs), grout will be a bentonite/cement mixture. To ensure that wells are properly constructed, the field technician will observe the following:

- Prior to well construction, estimate the amount of materials (e.g., well casing, packing material, and grout) needed to construct the well. During well construction, immediately notify the driller of a potential problem if the materials needed for well construction are significantly more or less than estimated.
- Prepare and use a well-construction diagram to monitor the progress of the well construction. Record the progress in the field notebook or on a well construction form.
- Periodically have the driller measure the depth of the filter pack and check to make sure that "bridging" of the packing material does not occur. A tightly fitting rubber surge block may be used in wetted portions of the well screen to compact the filter pack.

4.3.6 Well Completion

Surface completion of all wells include a watertight well plug or cap fitted to the well casing. The north side of the top of the casing will be notched to establish a permanent measurement datum. This datum will be surveyed to ± 0.01 ft by a licensed surveyor contracted by PDSI. A surface vault will be installed around the well casing and cemented in place. The well name and the ADWR well registry number will be stamped into the vault lid. The well registry number will also be written near the top of the well casing near the top with permanent black marker. After the well is completed, the DTW with be measured and recorded.

4.3.7 Well Development

Following well completion, the well will be developed using the following procedure:

1. The base of the well will be measured to determine whether any sediment has accumulated in the well.
2. The wetted portion of the well screen will be surged with a tightly fitting rubber surge block to dislodge any material finer than the screen slot size.
3. Air lifting or bailing will be used to remove sediments from the well.
4. The well will be pumped for at least three purge volumes to complete development.

4.3.8 Hydraulic Testing and Water Sampling

A 10- to 24-hour pumping test will be conducted at each new well to estimate the hydraulic conductivity of the formation. Prior to the pumping test, the HGC Project Manager will contact ADWR to determine the need for a groundwater withdrawal permit. The pumping test will be conducted using the guidelines provided below:

1. Obtain a DGP from ADEQ prior to conducting a pump test.

2. Prior to beginning the test, measure the static water level using a well sounder. Install a pressure transducer connected to a data logger. Be certain to install the transducer below the anticipated draw-down level. Measure the static water level with the pressure transducer and verify the transducer DTW measurement by using a sounder probe.

3. Select the pumping rate for the test so that it is similar to the well development pumping rate. Use a constant pumping rate throughout the test.

4. Measure DTW levels during the test with a pressure transducer/data logger assembly and periodically verify it with a sounder probe. At a minimum, take measurements according to the following schedule:

Time of Pump Test	Measurement Interval
0 to 15 minutes	1 minute
15 to 50 minutes	5 minutes
50 to 100 minutes	10 minutes
100 to 500 minutes	30 minutes
500 to 1000 minutes	60 minutes
> 1000 minutes	4 hours

5. Ensure that water discharged during the pumping test is directed down gradient of the well so that re-infiltration of the discharge water does not affect the test results.

6. Continue pumping long enough to collect sufficient draw-down data. Ideally, pumping will be continued for 1000 minutes or longer; although, the work location or other constraints may dictate a shorter pumping period.

7. After pumping is discontinued, measure the recovery of water levels in the well at frequency intervals similar to those used for the active pumping period. Continue measurements until the water level in the well has recovered to within 90 percent of its pre-pumping level.

After the end of each pumping test, a groundwater sample from the test well will be collected just prior to pump shutdown following the sample collection and handling procedures given in Sections 4.2. Pumping test results will be interpreted using analytical software such as the Well Hydraulics Interpretation Program (HGC, 1987) or AQTESOLV (Hydro Solve, Inc., 2000).

4.4 Investigation-Derived Waste Management

Investigation-derived wastes are expected to be purge water, drill cuttings, any drilling fluids, and development water. Prior to initiation of field activities, the HGC Project Manager will contact ADEQ to determine the need for a DGP for the release of purge water. DGP is expected to be needed for the release of development water. Cuttings and drilling fluids will be collected in tanks or rolloff containers and transported to PDSM for disposal according to methods approved by the PDSI Project Manger. This may include spreading cuttings in a thin layer over the ground.

4.5 Field Equipment and Consumables

4.5.1 Field Equipment Maintenance and Calibration

The field technician will be responsible for properly maintaining and calibrating all field equipment. Operation, calibration, and maintenance procedures for all equipment will be kept accessible when equipment is being used, calibrated, or serviced. Measurement equipment will be calibrated when it is first used and recalibrated periodically based on the recommendations in the instrument's operations manual. Maintenance practices also will follow the manufacturers' recommendations. All calibration and maintenance will be recorded on a maintenance record that is readily available for reference in the field.

Precautionary measures will be taken to avoid equipment problems. Some precautionary measures are listed below.

- Keep spare parts such as batteries and probes on hand.
- Store equipment in a cool, clean, dry place when not in use.
- Clean equipment after each use.
- Keep sensitive parts covered and protected from potential hazards.
- Inspect equipment for potential problems prior to use.
- Keep battery packs charged.

Should a piece of equipment become inoperable, it will be removed from service and tagged to indicate that repair, recalibration, or replacement is needed. The HGC QA Manager

will be notified when equipment needs to be repaired or replaced so that prompt service can be performed or substitute equipment can be obtained. Instrument problems encountered during the field program will be recorded and, if possible, resolved in the field.

4.5.2 Electrical Conductivity, Temperature, and pH Measuring Equipment

A multi-probe meter with automatic temperature correction of electrical conductivity measurements will be used to measure indicator parameters. The instrument will be properly stored and calibrated each day that it is in use. The instrument probes will be triple-rinsed with deionized water and stored according to the manufacturer's specifications after use. The electrical conductivity probe will be calibrated before each sampling event using a commercial standard. Because electrical conductivity measurements may be correlated with, and used for, sulfate ion estimation, electrical conductivity measurements must be accurate and temperature corrected. The pH probe will be calibrated with two buffers that have pH values that bracket the anticipated pH values for the samples to be tested. Because the groundwater is neutral to alkaline, pH 7 and pH 10 buffers will be used. The calibration will be checked at least once every 4 hours thereafter, and the probe will be recalibrated, if necessary.

4.5.3 Water Level Measuring Equipment

Each electric sounder probe should be checked for accuracy at least once every 3 months. The accuracy will be checked by comparing the depth markings on the probe tape with the markings on a graduated steel tape. The sounder will also be checked after any incident that may

alter the instrument's accuracy. If the difference between markings on the steel tape and on the sounder probe tape exceeds 0.05 ft per 100 ft, a correction factor will be determined and applied to DTW measurements. The sounder probe will be kept clean and functional. Portions of the cable that are submerged below fluid levels in wells will be properly cleaned, as described in the decontamination procedures outlined in Section 4.2.1.6.

4.5.4 Pressure Transducers and Data Loggers

The pressure transducer should be capable of measuring water levels with a sensitivity of 0.01 ft although the transducer accuracy may differ depending on pressure rating. The data logger may be internal to the pressure transducer or a separate instrument, but it must be programmable to collect pressure data at a minimum frequency consistent with the schedule given in Section 4.3.7. The accuracy of the pressure transducer will be periodically verified using the sounder probe. Data collected by the data logger will be downloaded daily. Maintenance for the pressure transducer/data logger assembly will follow the guidelines of the operations manual. The assembly will be stored in a clean, secure location when not in use.

4.5.5 Flow Meters

Flow meters will be capable of measuring flow rates in the range needed for well development and hydraulic testing. The flow meters will have a sensitivity of approximately 5 percent of the measured flow rate. Maintenance and calibration of flow meters will follow the guidelines of the operations manual.

4.5.6 Spectrophotometer

The spectrophotometer used to measure sulfate concentrations in the field will be a multi-wavelength unit designed for field analysis. A Hach DR-2500 spectrophotometer, or equivalent, will be used. Depending on reagents, the DR-2500 has a range of 2 to 900 mg/L sulfate. Maintenance and calibration of the spectrophotometer will follow the guidelines noted in the operations manual. The unit will be stored in a clean, secure location when not in use.

4.5.7 Consumables

The field technician, under the direction of the HGC QA Manager, has the responsibility for performing daily checks of consumables and for ensuring that there is adequate supply. Consumables include the following:

- Groundwater sampling containers prepared with preservatives.
- Sample identification labels and packing supplies.
- Coolers and ice for sample storage and transport.
- Disposable gloves for groundwater sampling.
- Markers and/or ink pens for sample labeling and for recording field activities.
- Detergent and water for decontamination.
- Laboratory grade de-ioned water for QC samples.

4.6 Field Documentation and Reporting

Field notes will be maintained for all sampling, drilling, well construction, well development, and pump test activities. The field logbook will be a bound, water resistant notebook with consecutively numbered pages. Documentation in the field logbook will be sufficient to reconstruct a field activity, including any corrective actions taken, without relying on memories from field team members. At a minimum, the information specified in Procedure DH-A of PDSI (2006) will be recorded in the field logbook (Appendix A). Deviations from the ACP or this QAPP also will be noted in the logbook. Field logbooks will be clearly identified on the cover with the project name and each page of the logbook should note the date that the entry was made. Entries will be made in blue or black ink. Incorrect entries will be crossed out with a single stroke and the change will be initialed and dated by the person making it. Manually recorded data will be transferred to an electronic format after field activities are concluded. Specialized information for some tasks may be recorded on field forms developed for that data type (e.g., groundwater sampling forms, geologic logs, well construction logs). When combined with the field logbook, these comprise the field record for the ACP.

At the end of each day, the carbon copy of the pages of the day's entries in the field logbook will be removed, or the pages will be photocopied, and stored in a secure area. Field forms and any other field checklists also will be photocopied and stored at the end of each day. This practice will protect against lost data should the logbook or forms be lost or destroyed. Data measured by field instruments and recorded in digital storage devices will be downloaded daily for processing. At least once a week, all data that was collected in the field, including field

notes, field forms, checklists, and electronic data, will be presented to the HGC QA Manager for review and verification.

4.7 Field Corrective Action Procedures

Corrective action procedures will be taken for all field nonconformances. Nonconformances are defined as events or measurements that are either unexpected or do not meet established acceptance criteria and that might affect data quality if uncorrected. Examples of nonconformances include:

- Incorrect use of field equipment.
- Field instrument failure.
- Improper sample collection, preservation, and shipment procedures.
- Incomplete field documentation, including COC records.
- Incorrect decontamination procedures.
- Incorrect collection of QC samples.

The appropriate corrective action will depend on the nonconformance. In cases where immediate and complete corrective action can be implemented by field personnel, corrective actions should be completely described in the field logbook. If a nonconformance can not be completely and immediately corrected in the field, the individual involved with the field activity will immediately notify the HGC QA Manager and corrective actions will be taken as described in Section 6.5.

5. ANALYTICAL LABORATORY PROCEDURES

Upon receipt of samples from HGC field activities, the analytical laboratory will be responsible for sample handling, analysis, and reporting. Analytical laboratory procedures must be conducted in a consistent, accurate, and quality controlled manner so that the data generated from field activities is useful for achieving the purposes of the Work Plan. This section discusses the following items related to QA of analytical laboratory procedures:

- Licensure
- Sample receipt and handling
- Analytical methods
- Laboratory QC samples
- Laboratory equipment
- Reporting
- Corrective action

PDSI currently uses ACZ Laboratories, Inc. of Steamboat Springs, Colorado (ACZ) for analysis of samples. For consistency, samples collected by HGC will be analyzed by ACZ; however, alternative laboratories may be used at the discretion of the HGC Project Manager. Therefore, the analytical laboratory requirements are discussed generically.

5.1 Licensure

The designated analytical laboratory and any laboratories to which sample analyses will be subcontracted shall be licensed by Arizona Department of Health Services (ADHS) to perform each analysis requested, unless ADHS licensure is not provided or required for that particular method. If the status of the laboratory's license changes, or if laboratory performance is unsatisfactory, an alternate licensed analytical laboratory may be selected to perform the analyses. A laboratory performing analyses will notify the HGC Project Manager for approval prior to subcontracting analyses to another licensed laboratory. Documentation verifying the subcontracted laboratory's ADHS license must be received by the HGC Project Manager prior to performance of the analytical services.

5.2 Sample Receipt and Handling

When the samples arrive at the laboratory, the laboratory will check samples for label identifications and complete, accurate COC documentation. The sample condition will be checked and recorded on the COC. Any discrepancies between the COC documentation and sample labels, any inaccurate or incomplete sample preservation, or any problem encountered that may compromise the sample integrity must be noted and communicated to the person submitting the samples and to the PDSI or HGC QA Managers.

A unique laboratory ID number will be assigned to each sample. This number will be cross-referenced to the sample field ID to avoid the possibility of mislabeling. Analytical reports will contain both laboratory ID numbers and field IDs for sample results. Access to the sample

control area will be restricted to prevent unauthorized contact with samples, extracts, or documentation. All samples and extracts will be maintained by the laboratory until at least 30 days following the release of the final report. A detailed description of the laboratory sample receiving, custody, login, and tracking procedures will be contained in the laboratory's QA plan and/or SOP.

Samples may be shipped from one laboratory to another for analysis. Laboratories will package and transport samples as described in Section 4.2.3. The temperature inside the cooler will be checked and documented on the COC by the receiving laboratory upon receipt of the samples. Samples shall then be placed immediately on ice or in a refrigerator at 4 °C ± 2° at the receiving laboratory.

5.3 Analytical Methods

Samples collected as part of the ACP will be analyzed for the following major element ions and parameters: calcium, magnesium, sodium, potassium, sulfate, chloride, fluoride, nitrate-nitrite, silica, hardness, total dissolved solids, alkalinity, and pH. Water samples will be analyzed using the methods specified in Table 2. If analyses by alternative methods are deemed necessary or more appropriate by the Laboratory Project Manager, they will first be approved by the HGC QA Manager and by ADEQ. The following documents can serve as a guide in selecting alternative methods.

- *Analytical Methodologies Designed for Testing Conducted Under the Clean Water Act*, CFR, Title 40, Part 136.

- *National Primary Drinking Water Regulations Analytical Methodologies*, cited in the Federal Register under the National Primary Drinking Water Regulations. These may be used to evaluate groundwater concentrations as they pertain to human receptors of drinking water.

- *Standard Methods for the Examination of Water and Wastewater* American Public Health Association, 1995). These are EPA-approved methods for analysis of inorganic compounds and can be used to evaluate surface water or groundwater samples.

The laboratory performing sample analysis should use the most efficient and cost-effective approach to achieve the accuracy and precision requirements of this QAPP. Target method detection limits (MDLs) are given in Table 2 of PDSI (2005a) (Appendix A). If sample dilution is necessary due to a relatively high concentration of an individual compound or if there is interference, the MDLs and other DQIs may not be achieved for every analyte. Similarly, matrix interferences may cause surrogate and analyte recoveries to fall outside of the required percent recoveries listed in the laboratory's SOPs. The laboratory will document all analyte and matrix interferences in all laboratory reports and evaluate the possible matrix effects using ADEQ policy 0154.000 *Addressing Spike and Surrogate Recovery as They Relate to Matrix Effects in Water, Air, Sludge and Soil Matrices* (ADEQ, 1998a). Analytical data will be qualified by the ADEQ Data Qualifiers (Appendix D).

If laboratory results are outside any of the method acceptance criteria or the acceptance criteria listed in the laboratory's SOPs, the laboratory will document the deviations in the case narrative. If deviations are the result of laboratory procedures, the laboratory will take the appropriate corrective action, such as re-analysis of samples or a detailed review of instrument output.

5.4 Laboratory Quality Control

QC of laboratory operations consists of documentation of all actions taken by personnel regarding issues such as equipment maintenance, reagent purity, standards traceability, waste disposal, and corrective action systems. These policies should be specified in each laboratory's QA manual.

The designated laboratory should be familiar with and follow ADEQ Policies related to QA/QC of laboratory results such as Policy 0154.000, *Addressing Spike and Surrogate Recovery as They Relate to Matrix Effects* (ADEQ, 1998a), and Policy 0155.000, *Analytical Methods Having Provisions for a One-point Calibration and Continuing Calibration Verification Constraints* (ADEQ, 1998b). Laboratory QA/QC procedures will be in accordance with method requirements and as described in each laboratory's QA plan and/or SOP. The laboratories' QA plan and SOP will be provided by the laboratory if requested.

Laboratory QC also includes the routine measurements taken within the laboratory to verify the integrity of analysis, data processing, and record maintenance. The laboratory will analyze internal QC samples as required by the analytical methods to ensure analytical precision, accuracy, and representativeness. Field samples and laboratory QC samples will be analyzed to a minimum reporting limit as specified by the method, or in-house requirements, whichever is stricter. The precision acceptance criteria for those analytes (RPD; Section 3.3.1) and accuracy

(percent recovery; Section 3.3.3) also will be based on the stricter of in-house laboratory established limits or method requirements.

Typical laboratory QC samples include blank spikes, laboratory control samples (LCSs), method blanks, surrogates, matrix spike/matrix spike duplicate (MS/MSD) analysis, internal (reference) standards, and duplicate samples. These samples are described below:

- The blank spike is a sample of water demonstrated to be free of matrix interference and has non-detectable concentrations of the target analyte to which a known amount of the analyte is added. ADEQ Policy 0154.000 (ADEQ, 1998a) requires a blank spike and a blank spike duplicate to be analyzed to demonstrate both precision and accuracy when the MSs are unacceptable because of matrix interference. The percent recovery of the blank spike and blank spike duplicate pair is used to evaluate the accuracy and recovery of each preparation and analytical batch, and may be used to establish statistical control of the analysis.

- The LCS is a standard or sample that is derived from a different source (i.e., different vendor or lot number) than the standards that are used to calibrate the instrument. It is used as a cross-check to verify the accuracy of the calibration and typically must be analyzed once for every instrumental calibration (ADEQ Policy 0154.000 (ADEQ, 1998a)).

- A method blank is a sample of water that has non-detectable concentrations of the target analytes. For most methods, at least one method blank is prepared for every batch of 20 samples. The method blank is taken through the entire analytical process as part of the sample batch to demonstrate that contamination did not occur during the testing.

- A surrogate is a compound that is expected to perform similarly to the compounds being analyzed in the laboratory method. The surrogate is not normally found in the environment and can therefore be used to monitor the recovery efficiency of the analytical process.

- The MS/MSD is used to demonstrate both the precision and accuracy of the test and the presence or absence of matrix interferences. The MS/MSD is prepared by spiking a sample with a known concentration of the target compounds and taking it through the entire analytical process as part of the sample batch.

- Internal standards are reference samples that contain a known concentration of the analyte. The internal standards are used to test the accuracy of the instruments and analytical methods.

- Duplicate samples are taken from the same aliquot as the environmental sample being tested. The duplicate sample is analyzed within the same batch and in exactly the same manner as the original aliquot. Duplicate samples evaluate the analytical precision at the concentration of the environmental sample.

5.5 Laboratory Equipment

All laboratory equipment will be maintained and calibrated as described in the laboratory's QA plan and SOPs. Any equipment problems that may affect data quality will be documented in the case narrative. Regular calibration of laboratory instruments is essential to ensure that the analytical system is operating correctly and functioning at the proper sensitivity to meet established detection limits. Each instrument will be calibrated with standard solutions appropriate for the type of instrument and the linear range established for the analytical method. Each analytical method contains requirements for the number and concentration of calibration standards, which are described in the laboratory's QA plan.

ADHS has established criteria for instrument calibration and the quantification of analytes as part of the Laboratory Licensure program. All analyses must be consistent with these requirements, and quantification of analytes must be consistent with the reporting requirements of ADHS (the lowest calibration concentration will be at or below the reporting level). Each calibration will then be verified through the use of statistical tests (e.g., a Pearson's Correlation Coefficient or relative standard deviation calculations), initial and continuing calibration verification standards and blanks, and LCSs prior to the sample results being approved.

5.6 Laboratory Data and Reporting

Laboratories will be expected to provide preliminary analytical data reports within 15 working days of receiving the samples and final reports shortly thereafter. Laboratory data reports will be sent to the HGC QA Manager in hard and electronic formats from the designated laboratory. Analytical laboratories will be expected to store the original hard copy and electronic reports for 5 years. The laboratories will be expected to notify HGC prior to destruction of records. The requirements for the content and the handling of hard and electronic reports are given below.

5.6.1 Hardcopy Data

Analytical data will contain the necessary sample results and QC data to evaluate the DQOs defined for this project (Section 3). Omissions or insufficient levels of detail will be corrected at the laboratory's expense. The laboratory reports will be consistent with EPA Level III documentation (Section 3.2) and include, at a minimum, the following:

- Case narrative (including a complete description of any analytical difficulties or QA/QC deficiencies encountered during sample analysis), sample number cross-reference, COC documentation, and method references.
- Analytical results with cross-reference to analytical batch.
- Surrogate recoveries (as applicable).
- Blank results.

- LCS recoveries.
- Sample spike recoveries.
- Duplicate sample results or duplicate spike recoveries.
- Outliers qualified according to ADEQ Data Qualifiers (Appendix D).

The laboratory report, as defined above, will be submitted to the QA Manager for use in the data verification/validation process. If requested, the laboratory will make supporting documentation consistent with EPA Level IV (Section 3.2.). The following QC issues may trigger the need for the submission of Level IV documentation:

- Continued quality issues detected through the data verification/validation process
- Unexpected or unexplained sample results

5.6.2 Electronic Data

An electronic data report will be submitted by the laboratory in a format that is compatible with HGC's database. HGC's QA Manager will verify that the report is in an acceptable format and that all elements needed are present. HGC's QA Manager will enter the analytical data into a temporary database for verification before it is uploaded to the permanent database or used in any reports or calculations.

5.7 Laboratory Corrective Action Procedures

The internal laboratory corrective action procedures and a description of out-of-control situations requiring corrective action will be contained in the laboratory QA plan. At a minimum, corrective action will be implemented when control chart warnings, control limits, sample holding times are exceeded, or if the method QC requirements are not met. Out-of-control situations that cannot be resolved within 2 days of identification will be reported to HGC. In addition, a corrective action report, signed by the Laboratory Project Manager and the Laboratory QA Manager, will be provided for the project files. HGC's Project Manager can request the re-analysis of any or all of the data acquired since the system was last in control.

6. DATA MANAGEMENT

Reports and documentation from activities conducted under the direction of HGC will be submitted to the HGC QA Manager. The QA Manager has the responsibility of processing these data and evaluating and maintaining the data quality. The sequence for processing field and analytical data is shown in Figure 2. This process consists of the following items:

- Data compilation
- Data entry into temporary database
- Data review and verification
- Data entry into permanent database
- Reporting
- Corrective Action

6.1 Data Compilation and Entry to Temporary Database

6.1.1 Field Data

The field logbook and other field forms generated from field activities directed by HGC will be submitted to the HGC QA Manager at least once per week for review. The HGC QA Manager will review the field logbook and field forms using the checklist provided in Table 4. This review will consist of checking for incomplete documentation and anomalous data entries.

The HGC QA Manager will immediately contact the person submitting the field forms to verify or correct missing or anomalous entries. When the problems are resolved or if no problems are found, the information will be entered into a temporary data base for the sampling event.

6.1.2 Laboratory Data

Hardcopy and electronic laboratory reports will be reviewed for completeness (Table 4). Electronic data deliverables will be entered into a temporary database for review by the QA Manager. Hardcopy laboratory reports will be stored in HGC's files.

6.2 Data Review, Verification, and Validation

Data verification is "the process of evaluating the completeness, correctness, and conformance/compliance of a specific data set against the method, procedural, or contractual requirements" (EPA 2002b). Data validation is "an analyte- and sample-specific process that extends the evaluation of data beyond method, procedural, or contractual compliance (i.e., data verification) to determine the analytical quality of a specific data set" (EPA 2002b).

Data validation is not expected for this project. Data validation would require a thorough review of all the field data and/or the analytical laboratory results to provide data documentation consistent with EPA Level IV requirements. This level of review will not be performed unless there are persistent concerns regarding the quality of field or laboratory data. If persistent

concerns do arise and an EPA Level IV package is deemed necessary, 100% of the affected data will undergo data validation (Section 6.4).

During review and verification, project data will be stored in a temporary database accessible only by personnel authorized by the HGC Project Manager. Results of the data verification will be documented and summarized in a data verification report that is sent to the HGC Project Manager and placed in the HGC project files (Section 6.4). The HGC QA Manager also will prepare a draft report of the new data that have been entered and reviewed against original input data. Any comments or required revisions will be noted on the draft report. Once all data verification issues have been resolved, the verified data will be entered into the permanent database. Data collected under the direction of PDSI will be reviewed and verified according to the provisions of its quality assurance plan (PDSI, 2005a) (Appendix A). Once data has been verified by the PDSI QA Manager and entered into the PDSI database, the data can be transferred to HGC without re-verification by the HGC QA Manager.

6.2.1 Field Data

The HGC QA Manager will review and verify all field data to evaluate their completeness and check for data anomalies prior to entry into the permanent project database. Where appropriate, DQI's will be evaluated as described in Section 3.3. The data quality assessment checklist, provided in Table 4, will be completed as part of this review.

6.2.2 Laboratory Data

The HGC QA Manager will verify analytical data by reviewing it for compliance with the QA/QC specifications outlined in the analytical methods and Table 4 of this QAPP. After the data have been verified, the HGC QA Manager will determine whether the DQOs have been met. Data verification flags will be applied to those sample results that fall outside acceptance criteria specified in the analytical methods, the laboratory SOPs, and this QAPP and therefore did not meet the DQOs. Data verification flags to be used for this project are defined by the ADEQ Data Qualifiers (Appendix D). Data verification flags will indicate whether results are considered anomalous, estimated, or rejected. Only rejected data are considered unusable for decision-making purposes, however, other qualified data may require further verification. All corrective action to be taken by the laboratory should be completed as described in Section 5.7 and 6.5 prior to the final review of the data.

6.2.3 Final Data Assessment

All field and laboratory data will undergo a final data assessment (Table 4). This assessment involves checking data entered into the temporary database with the original data source and, where appropriate, comparing data against time series plots to check for data anomalies. The final assessment also will verify that all QA issues have been resolved and proper corrective actions have been taken.

6.3 Data Storage and Data Transfer

Data generated by PDSI will be shared with HGC so that a comprehensive database of all ACP activities can be maintained. Data will be exchanged only after being verified. To the degree possible, data transfer should be performed electronically to eliminate human transcription errors. When electronic data transfer is not possible, a staff member will manually input data to the database, and another staff member will proof these manually entered data to ensure that they are correct before they are uploaded and reported. Key data that cannot be verified will be brought to the attention of the appropriate QA Manager. All reported results are ultimately stored in the permanent project database along with original copies of field notes, monitoring forms, and laboratory reports being stored in PDSI or HGC project files.

6.4 Reporting

A data verification report will be prepared by the HGC QA Manager for each sampling event, or on another routine basis, as specified by the HGC Project Manager. The report will summarize data flags, document corrective actions, and evaluate the data quality against the DQO's. Each report also will include a summary of any significant QA/QC problems. If data quality problems necessitate data validation and reporting, the content and frequency of such reports will be identified in the verification report.

The HGC QA Manager will assemble a data package for each sampling event or field activity. Where applicable, the data package is to include the following:

- Field documentation of monitoring, sample collection, and handling records (Sections 4.2.3 and 4.6)
- Field equipment calibration and decontamination records (Sections 4.5.2 and 4.2.1.5)
- QC sample collection records (Section 4.2.1.4)
- COC forms (Section 4.2.3)
- Sample receipt records and shipping bills (Section 4.2.3)
- Laboratory analytical reports including laboratory QC summaries (Sections 5.6)
- Data Quality Assessment Checklist (Table 4)

6.5 Corrective Action

The QA Manager and Project Manager will promptly and thoroughly act to correct any nonconformance that is expected to compromise the quality of the project data. Rapid and effective corrective action minimizes the possibility of questionable data or documentation. All QA problems and corrective actions will be documented by the HGC QA Manager and explained to the HGC Project Manager in a brief memorandum. This documentation will provide a complete record of QA activities and also will help to identify long-term corrective actions that may be necessary. After the source of the error is determined and remedied, the HGC QA Manager will ensure that all suspect data are either deleted from the permanent database or re-collected.

Corrective action procedures will depend on the nonconformance. For a nonconformance that can be easily corrected, immediate corrective actions can be taken in the field or laboratory.

Often, the source of the problem is obvious and can be corrected at the time of observation. Nonconformances that have substantial impact on data quality will require the completion of a Corrective Action Request Form (Figure 3). This form may be filled out by any project individual who suspects that any aspect of data integrity is being compromised by a nonconformance. Each form is limited to a single nonconformance. Copies of the corrective action request form will be given to the HGC Project Manager and be placed in the project file. The HGC Project Manager and QA Manager will meet along with other staff as necessary to discuss the appropriate steps to resolve the problem. Issues that may be discussed include the following:

- Determination of when and how the problem developed
- Assignment of responsibility for problem investigation and documentation
- Determination of the corrective action to be implemented to eliminate the problem
- Development of a schedule for completion of the corrective action
- Assignment of responsibility for implementing the corrective action
- Documentation and verification that the corrective action has eliminated the problem

The HGC Project Manager can require field and/or laboratory activities to be limited, discontinued, or repeated until the corrective action is complete and the nonconformance eliminated. The HGC Project Manager should continue to monitor the status of corrective actions and periodically (as determined in the corrective action report) complete a corrective action status report. This report should briefly describe the problem, the individual who identified it, and list the personnel who are responsible for the determination and implementation of the corrective action. Completion dates for each phase of the corrective action procedure will

also be listed in the status report, along with the date for the designated personnel to review and check the effectiveness of the solution. A follow-up date will also be listed to check that the problem has not reappeared. This follow-up will be conducted to ensure that the solution has adequately and permanently corrected the problem.

7. REFERENCES

ADEQ. 1998a. 0154.000. Addressing Spike and Surrogate Recovery as they relate to water, air, soil, and sludge matrices policy. October 23, 1998.

ADEQ. 1998b. 0155.000. Analytical Methods Having Provisions for a One-Point Calibration and Continuing Calibration Verification Constraints Policy. October 23, 1998.

ADEQ. 1999. Quality Management Plan. EQR00-01. October 1, 1999.

American Public Health Association. 1995. Standard Methods for the Examination of Water and Wastewater. 19th Edition.

EPA. 2001a. Requirements for Quality Assurance Plans for Environmental Data Operations. EPA QA/R-5. March, 2001.

EPA. 2001b. Laboratory Documentation Required for Data Evaluation. EPA R9QA/004.2. August 2001. (Appendix B).

EPA. Region IX QA Office, 2001. Laboratory Documentation Required for Data Evaluation. R9QA/004.2. August 2001.

EPA. 2002a. EPA Guidance for Quality Assurance Project Plans. EPA/240/R-02/009. December 2002.

EPA. 2002b. Guidance on Environmental Data Verification and Data Evaluation. EPA/240/R-02/004. November 2002.

EPA, 2004. EPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review, Final. EPA 540-R-04-004. October 2004.

EPA. 2006. Guidance on Systematic Planning Using the Data Quality Objectives Process. EPA QA/G-4. February 2006.

Hydro Geo Chem (HGC). 1987. WHIP Well Hydraulics Interpretation Program Version 3.2. Users Manual. February 1987.

Hydro Solve, Inc. 2000. AQTESOLVE for Windows User's Guide. Reston, Virginia: Hydro Solve, Inc.

PDSI, 2005a. Quality Assurance/Quality Control Plan for Water Monitoring, Phelps Dodge Sierrita, Inc. June 2005.

PDSI, 2005b. Standard Operating Procedures – Water and Environmental Sample Collection Procedures. March 2005.

TABLES

TABLE E.1
Summary of EPA Analytical Levels

EPA Analytical Level	Type of Analysis	Accuracy	Sensitivity	Level of Documentation
Field Check Level 1	Temperature, pH, and specific conductivity measurement using portable instruments.	**Low;** provides general indication of contamination.	**Low to moderate;** at least sufficient to screen for general levels of ions. Instruments may not be sensitive to some chemicals.	**Low;** often digital readout of final result only or visual indication of concentration range (e.g., by change in color.)
Routine Screening Level II	Preliminary analyses of sulfate using in-field method.	**Moderate;** provides data typically as concentration ranges	**Moderate to high;** sufficient to document presence or absence of selected chemicals.	**Low;** often only the final quantitative results without supporting quality assurance data.
Level III	Analysis of major element ions using standard EPA procedures.	**High;** provides data of known bias and precision for an overall accuracy level that is useful for most applications.	**Moderate to high;** sufficient to document presence or absence of a wide range of chemicals.	**Low to moderate;** summary of quality assurance results is provided but is usually not adequate for an independent verification of results.
Program Specific Level IV	Standard analyses of major element ions using EPA procedures.	**High;** similar accuracy as Level III with a focus on confirmation of results.	**Moderate to high;** similar sensitivity as Level III but most standardized protocols focus on characterization of waste materials.	**Rigorous;** standardized data package of sample and quality assurance results is sufficient for independent verification of results.

The QC requirements may be specially defined for each level. For example:

-- Level I requirements may include running only a standard and a blank.
-- Level II requirements may include a blank and running multiple standards to determine the range.
-- Level III requirements would include the QA/QC required by the method.
-- Level IV requirements would include Level III requirements, plus any additional steps you would like the laboratory to take, such as CLP protocols.

TABLE E.2
Groundwater Sampling and Analysis Requirements

Analyte	Method	MDL (mg/L)	Container	Preservation	Holding Time	Filtered (F), Unfiltered (U)
Constituents for General Chemistry						
pH	EPA 150	N/A	500 mL plastic or glass	N/A	analyze immediately	U
Temperature (C^o)	Thermometric	N/A	500 mL plastic or glass	N/A	analyze immediately	U
Conductivity	Conductance	N/A	500 mL plastic or glass	N/A	analyze immediately	U
TDS	SM 2540C/160.1	10	250 mL HDPE	4º C	7 days	F
Total Alkalinity (as $CaCO_3$)	SM 2320B	2	500 mL HDPE	4º C	14 days	U
Chloride	EPA 300.0	1	250 mL HDPE	4º C	28 days	F
Fluoride	EPA 300.0	0.1	250 mL HDPE	4º C	28 days	F
Nitrate	EPA 300.0	0.02	250 mL HDPE	4º C	48 hours	F
Nitrite	EPA 300.0	0.02	250 mL HDPE	4º C	48 hours	F
Sulfate	EPA 300.0	10	250 mL HDPE	4º C	28 days	U, F
Calcium	EPA 200.7	0.2	250 mL HDPE	4º C; HNO_3 to pH < 2	6 months	F
Magnesium	EPA 200.7	0.2	250 mL HDPE	4º C; HNO_3 to pH < 2	6 months	F
Potassium	EPA 200.7	0.3	250 mL HDPE	4º C; HNO_3 to pH < 2	6 months	F
Sodium	EPA 200.7	0.3	250 mL HDPE	4º C; HNO_3 to pH < 2	6 months	F
Constituents for Water Treatment Evaluation						
Ammonia	EPA 350.1	0.05	500 mL HDPE	4º C; H_2SO_4 to pH < 2	28 days	F
Barium	EPA 200.8	0.0001	250 mL HDPE	4º C; HNO_3 to pH < 2	6 months	F
Strontium	EPA 200.7	0.01	250 mL HDPE	4º C; HNO_3 to pH < 2	6 months	F
Ferrous Iron	EPA 3500	0.01	250 mL HDPE	4º C; HNO_3 to pH < 2	6 months	F
Iron (total)	EPA 200.7	0.02	250 mL HDPE	4º C; HNO_3 to pH < 2	6 months	U
Manganese	EPA 200.7	0.005	250 mL HDPE	4º C; HNO_3 to pH < 2	6 months	F
Boron	EPA 2007	0.01	250 mL HDPE	4º C; HNO_3 to pH < 2	6 months	F
Aluminum	EPA 200.7	0.03	250 mL HDPE	4º C; HNO_3 to pH < 2	6 months	F
Phosphate	EPA 365.1	0.01	250 mL HDPE	4º C	48 days	F
Sulfide	EPA 376.2	0.02	125 mL HDPE	4º C; Zn acetate; pH>9 NaOH	7 days	F
Silica (total)	EPA 200.7	0.2	125 mL HDPE	4º C	28 days	U
Silica (soluble)	EPA 200.7	0.2	125 mL HDPE	4º C	28 days	F
Selenium	EPA 200.7	0.004	250 mL HDPE	4º C; HNO_3 to pH < 2	6 months	F
Total organic carbon	EPA 415.1	1	250 mL HDPE	4º C; HCl or H_2SO_4 to pH < 2	28 days	U
Chemical Oxygen Demand	EPA 410.4	10	250 mL HDPE	4º C; H_2SO_4 to pH < 2	28 days	F
Total hardness	SM 2340B	Calculation	N/A	N/A	N/A	F
Silt density index (SDI)	ASTM D4189-82	N/A	500 mL HDPE	N/A	N/A	U
Bacteria (count/ml)	EPA 9222D	1 cfu / 100mL	100 mL HDPE (Sterile)	4º C; H_2SO_4 to pH < 2	24 hrs.	U
Turbidity	EPA 180	N/A	500 mL HDPE	N/A	48 hrs.	U

TABLE E.3
Sample Shipment Checklist

Sample Handling Checklist	Yes	No	Not Applicable
Sample bottles are free of defects and in their original packaging:			
Field Duplicate samples named with unrecognizable IDs and actual locations recorded in field logbook			
Samples labeled with:			
Sample Name/Date (e.g., LE-1-041604)			
Analyses Required			
Sample Matrix			
Filtered or Unfiltered			
Sampler's Initials			
Preservative			
COC filled out with:			
Project Name, required signatures, dates, and times			
Analytical Suite required			
Date and time of sampling, sample IDs, sample matrix			
Number of containers submitted			
QA Sample IDs, matrices, date and time of sampling			
Samples stored on sufficient ice to remain at 4ºC until arrival at lab			
Sample package will not leak during shipment			
Sign COC to relinquish sample custody, remove pink slip, and enclose original in sample shipment			
Samples shipped withing 48 hours of collection			

Notes:
COC = Chain of Custody
QA = Quality Assurance
ID = Identification

TABLE E.4
Data Quality Assessment Checklist

	Yes	No	Not Applicable
Data Compilation			
Field Data			
Field Logbook Entries Current			
Field Sampling Forms Completed			
Borehole and Lithologic Logging Forms Completed			
Well Construction Diagrams Completed			
Hydraulic Testing Forms Completed			
Anomalous Data Entries Resolved			
Chain of Custody Forms Completed			
Correct Analyses Requested			
Laboratory Data			
Hard Copy Reports Received			
Electronic Reports Received			
Case Narrative and QC Summaries Included in Report			

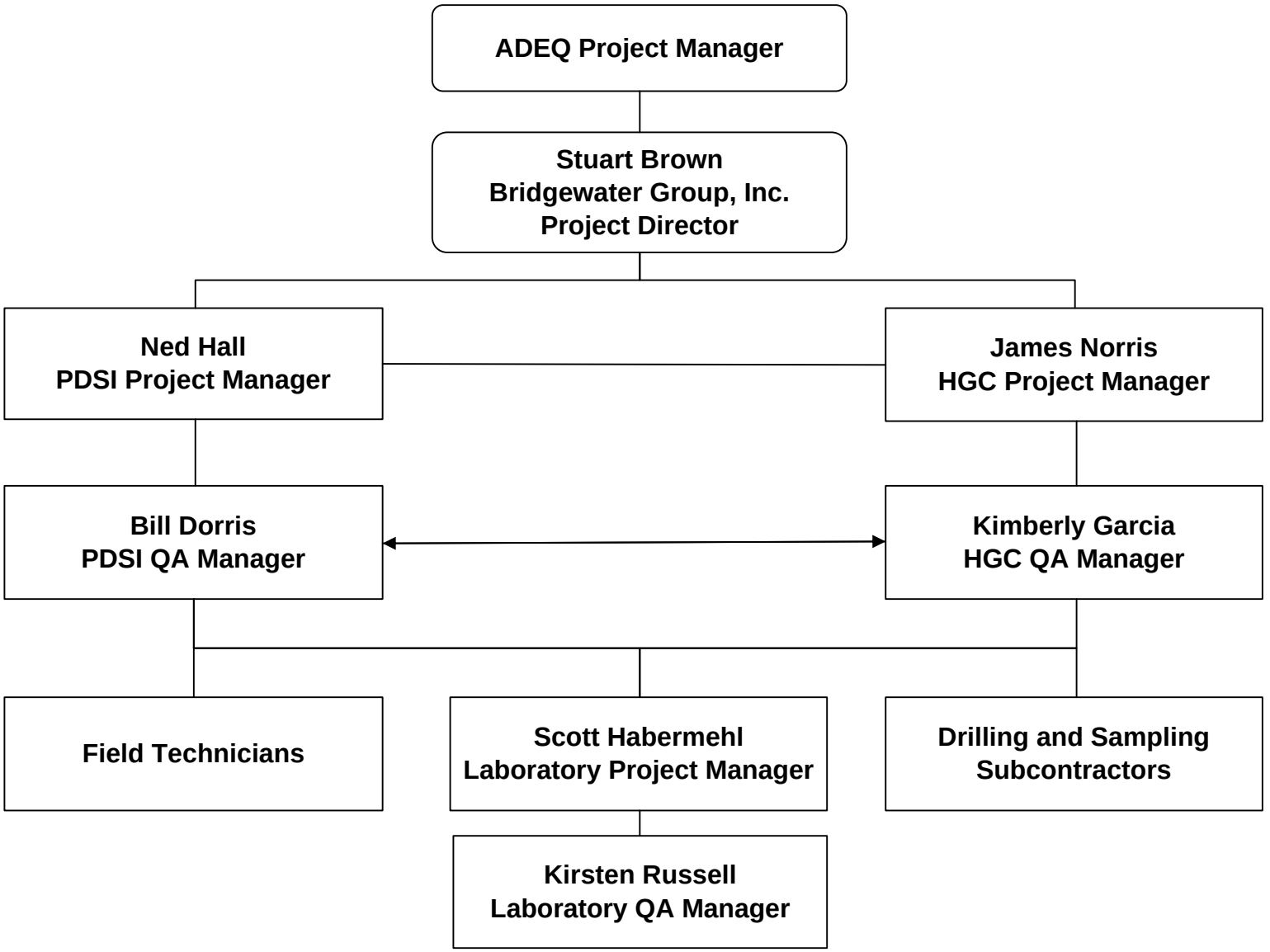
Data Review and Verification			
Field Data **Groundwater Sampling**			
Monitoring Conducted at Correct Locations			
Measuring Point for Water Levels is Consistent			
Field Equipment Calibration Requirements Met			
Field Equipment Decontaminated Before Uses			
Purge Parameters Stabilized Prior to Sample Collection			
QC Samples Taken at Appropriate Frequency			
Drilling and Well Construction			
Lithologic Logging per ASTM Standards			
Reconnaisance Borehole Sampling Completed			
Portable Spectrophotometer Samples			
Laboratory Samples			
Wells Properly Constructed			
Hydrualic Testing Properly Conducted			
Laboratory data			
All Required Analyses Performed			
Holding Times and Temperatures Met			
Laboratory QC Samples Within Acceptable Limits			
Field QC Samples Within Acceptable Limits			
MDLs < Target MDLs			

Final Data Quality Assessment Checklist:	Yes	No	Not Applicable
Data Entry Checked Against Original			
Time-Series of Analytical and Field Data Checked for Anomalies			
QA Issues Resolved and Documented			
Corrective Action Taken and Documented			

Notes:

QC = Quality Control
QA = Quality Assurance
MDLs = Method Detection Limits
PQLs = Practical Quantification Limits
RAOs = Mitigation Order Objectives

FIGURES

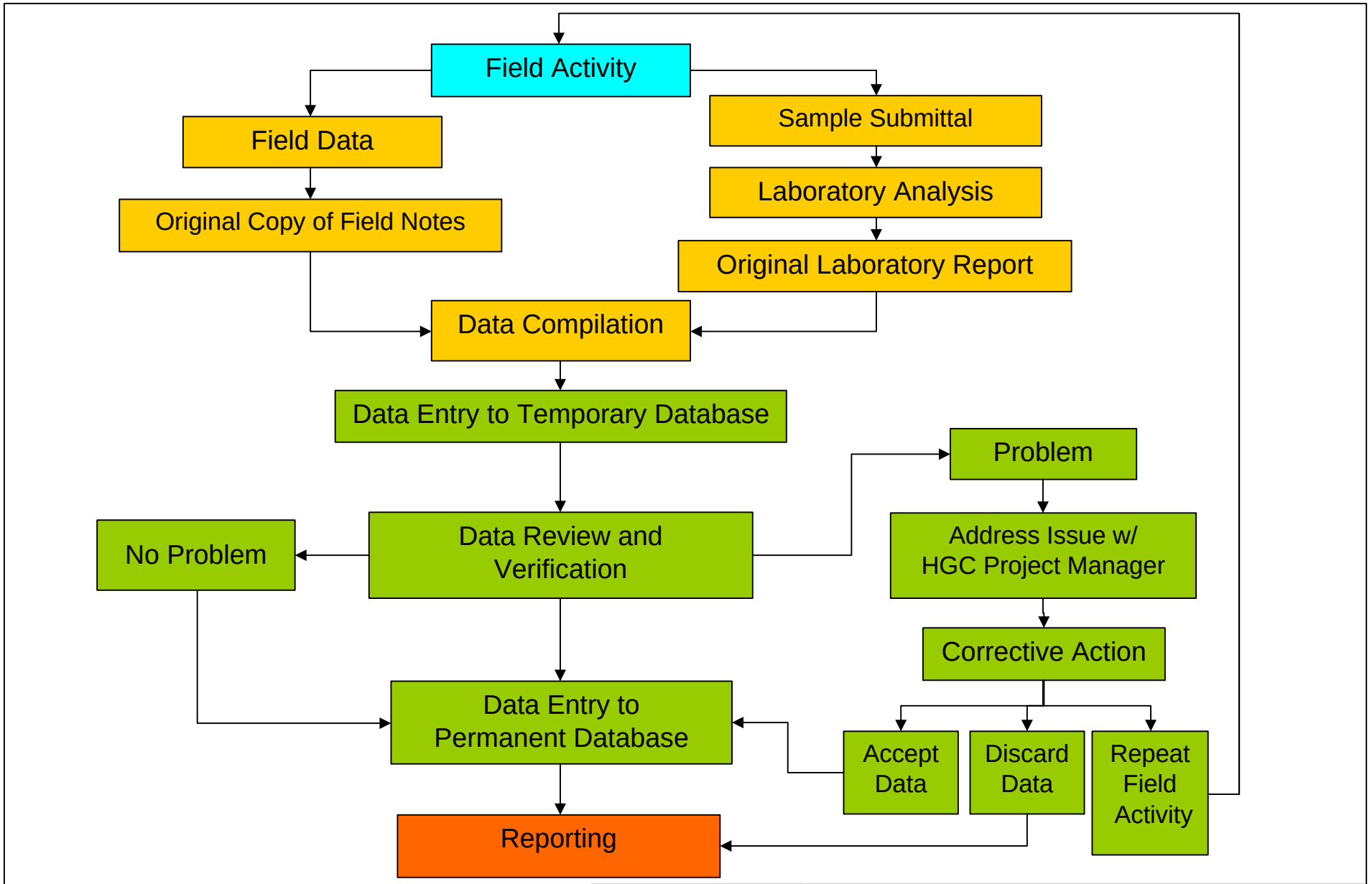


HYDRO GEO CHEM, INC.

ORGANIZATIONAL CHART

APPROVED	DATE	FIGURE
NWH	8/1/06	**E.1**

H:\78300\WorkingQAPP\OrgChart: OrgChart



HYDRO GEO CHEM, INC.

FIELD AND ANALYTICAL DATA PROCESSING SEQUENCE

APPROVED	DATE	FIGURE
NWH	7/6/06	**E.2**

H:\78300\WorkingQAPP\OrgChart: ActivityFlowChart

FIGURE E.3
CORRECTIVE ACTION FORM

Service or Activity:_____Date:_____
_____

Contractor or Support Organization:_____
Date Discovered:_____ Location:_____
Notation in Logbook Vol. No. _____ Page_____ Date_____

Nature of Alteration: Description of Alteration and Apparent Cause:
( )Procedural Deficiency _____
( )Data Deficiency _____
( )Instrumentation Def. _____
( )Other _____

Recommended Disposition: Justification for Recommended Disposition:
( )Accept Deviation _____
( )Modify Plan/Procedure _____
( )Repeat Service/Activity _____
( )Terminate, Recommended Corrective Action:_____
( )Conditional Acceptance*_____
*State Conditions_____
_____
Originator:_____ Organization:_____ Phone: _____
Corrective Action Verification:
( ) Verified (note any appropriate conditions):_____
_____
_____
( ) Cannot verify (note reasons for lack of verification):_____
_____
_____
Project QA:_____ Date:_____
(Use space below for comments or extensions to the above topics.)

APPENDIX A

PHELPS DODGE SEIRRITA
QUALITY ASSURANCE/QUALITY CONTROL PLAN
AND FIELD SAMPLING PLAN

QUALITY ASSURANCE/ QUALITY CONTROL PLAN

FOR

WATER MONITORING

Green Valley, Arizona

June, 2005 (Original)

TABLES

CHECKLISTS

SECTION 1
INTRODUCTION

This Quality Assurance Quality Control Plan (QAQCP) for Water Monitoring establishes the protocols necessary to achieve data quality objectives (DQOs) defined to insure the highest quality of data is obtained through recorded field and laboratory measurements. Different monitoring programs will identify criteria and frequency for monitoring Sierrita's mine and surrounding properties groundwater and surface water systems. The data collected will be used to establish background data for current and historical local conditions.

This document includes discussions of: 1) project management and responsibilities, purpose of sample collection, matrix to be sampled, analytes or compounds to be measured, applicable technical, regulatory, or program action criteria, personnel qualification requirements for collecting samples 2) sampling and analytical procedures holding times, number and type of quality assurance quality control samples to be taken 3) Identification of ADHS/EPA certified laboratories to analyze collected samples, provisions for proficiency demonstration by laboratory for contract awarding, required laboratory quality control (QC) results to be reported 4) guidelines for data verification and reporting, data acceptance criteria, quality control checks, performance and systems audits, corrective actions, and quality assurance reporting.

SECTION 2
PROJECT MANAGEMENT AND RESPONSIBILITIES

All personnel involved in the investigation and in the generation of data are implicitly a part of the overall project and quality assurance program. Certain individuals have specifically delegated responsibilities, as described below. Personnel assigned to each position will be identified in each specific project plan.

2.1 PROJECT MANAGER

The Project Manager is responsible for fiscal oversight, direction and scheduling of the project work plan, and ensuring that all work is conducted in accordance with established standard operating procedures. In cooperation with the Quality Assurance Manager, the Project Manager will evaluate project objectives and based on audit findings, QC checks, and data review, determine the necessary corrective actions if needed

2.2 QUALITY ASSURANCE MANAGER

The Quality Assurance Manager is responsible for the evaluation and update of this Quality Assurance Quality Control Plan. The Quality Assurance Manager will evaluate the need for corrective actions and make recommendations to the Project Manager. The Quality Assurance Manager will be responsible for the review and update of the Quality Assurance Quality Control Plan annually. The Quality Assurance Manager is responsible for the collection of water samples according to established schedules and will ensure that work is done according to specified procedures.

2.3 SAMPLING CREW

Sampling Crew personnel are responsible for following procedures for sample collection, including complete and accurate documentation. These personnel, as well as all staff members involved with the project, are responsible for ensuring the quality of their own work. Personal qualification requirements for these individuals include but not limited to,

a thorough understanding of standard operating procedures for water sampling, decontamination, and field documentation.

SECTION 3
QUALITY ASSURANCE QUALITY CONTROL OBJECTIVES FOR MEASUREMENT

Quality assurance (QA) is defined as the process used to ensure that data, which provides the basis for decision making, are technically sound, statistically valid, and properly documented. Quality control (QC) procedures are the tools utilized to assure the monitoring processes are adequate and up to specified standards. This section discusses the objectives for the measurement of data in terms of precision, accuracy, representativeness, comparability, and completeness (PARCC). These objectives are based on the intended use of the data, available laboratory procedures, and available resources. Procedures on collecting quality control samples to evaluate field activities are described in greater detail in Section 6.

3.1 OVERALL QUALITY ASSURANCE OBJECTIVE

The overall quality assurance objective is to validate the integrity of the data for its future use. Specific data quality requirements such as; target detection limits, criteria for accuracy and precision, sample representativeness, data comparability and data completeness are identified in this document.

Data Quality Objectives (DQOs) are quantitative and qualitative measures that specify the required standards for the collected data. The DQOs purpose is to define an acceptable level of uncertainty in the evaluation of collected data.

The data collected during the course of each specific project will be used to determine; constituents that are present (qualitative), the types or classes of constituents that are present, the quantities or concentrations of constituents that are present (quantitative), the distribution of constituents with respect to potential sources, the trends in concentrations and plume movements, and the hydrologic and geochemical conditions, which control water movement.

3.2 PROJECT INVESTIGATION QUALITY OBJECTIVE

The project investigation quality objective is to maximize confidence in the data in terms of PARCC.

If there are only two analytical points used for comparison (such as; original sample point vs. blind duplicates), precision will be calculated as relative percent difference (RPD). Precision will be calculated as a computed outlier statistic (T_n) if there are more than two analytical points. The RPD is calculated as the difference between two results, relative to their arithmetic mean, and expressed as a percent:

$$RPD = 100\% * \left[\frac{X1 - X2}{\left(\frac{X1+X2}{2}\right)} \right]$$

The outlier statistic (T_n) is calculated by completing the following steps:

A. Order data from highest to lowest.
B. If the data resembles a lognormal distribution, compute logarithm values of the data points.
C. Calculate the mean and standard deviation.

The standard deviation of a series of data is calculated as follows;

where: $\bar{x}$ = The Arithmetic Mean of the Measurements(x);

where: n = The Number of Measurements;

where: s = Standard Deviation;

$$s = \sqrt{\Sigma (x - \bar{x})^2 / n - 1}$$

The T_n is then calculated as the largest value minus the mean, divided by the standard deviation (USEPA 1989):

where: $\bar{x}$ = The Arithmetic Mean of the Measurements(x);

where: X_n = The Largest or Smallest Value of all Measurements;

where: s = Standard Deviation;

$$T_n = \frac{(X_n - \bar{x})}{s}$$

T_n is then compared to the tabulated values in table 3, based on the sample size n. If T_n is greater or less than the tabulated value, then the measurement is identified as an outlier (USEPA 1989). The Environmental Data Management Systems (EDMS) database conducts an automatic outlier statistical analysis using this method.

Submission of field blanks will provide a check with respect to data accuracy. Evaluating the results of blanks to monitor contaminants, which may be introduced, can assess accuracy during sampling, preservation, handling, shipping, and analysis. The DQO for field blanks is to have no quantifiable amounts of analytes above target quantitation limits.

Section 6 identifies the frequency for which blank and duplicate samples will be collected and analyzed such that a specific degree of precision and accuracy may be calculated. Quantitative objectives are summarized in Table 1.

Accuracy may be measured and expressed as % Recovery and is calculated as followed;

$$\%\text{Recovery} = 100\% * \frac{\text{Analytical Value}}{\text{True Value}}$$

$$\%\text{Recovery on a spike } (\%R_{sp}) = 100\% * \left[\frac{(\text{Spiked sample - Sample value})}{\text{Spiked sample}} \right]$$

To assure sample representativeness, all sample collection and measurements will be performed in accordance with both the protocol outlined in this QAQCP and procedures outlined in the *Standard Operating Procedures – Water and Environmental Sample Collection* manual.

In order to evaluate comparability, such that observations and conclusions can be directly compared with previous data, standardized methods of field analysis, sample collection, and preservation will be consistently used. These methods are also documented in the *Standard Operating Procedures – Water and Environmental Sample Collection* manual.

3.3 LABORATORY QUALITY OBJECTIVE

The laboratory quality objective is to ensure PARCC with respect to analytical results. The designated laboratory will demonstrate analytical precision and accuracy through the analyses of blind standards, duplicates, matrix spike duplicates, spike recoveries, and TDS and ion balances. Laboratory data quality objectives require that the QA guidelines specified in the EPA analytical methodology are followed.

ADHS/EPA certified laboratories approved to analyze samples collected are identified in the contact information below. All laboratories have demonstrated proficiency by achieving PARCC objectives.

ACZ Laboratories
2773 Downhill Drive
Steamboat Springs, Colorado 80487
ADHS#:*AZ0102*
Contact: Scott Habermechl
(800) 334-5493
Approved for: Ground Water, Surface Water, & Waste Water

Aerotech Environmental Laboratories
4455 South Park Avenue Suite #110
Tucson, Arizona 85714
ADHS#: *AZ0609, AZ0610, AZ0611*
Contact: Lorena Leal
(520) 807-3801
Approved for: Drinking, Surface, and Waste Water

Energy Laboratories
2393 Salt Creek Highway
Casper, Wyoming 82601-9654
ADHS#: *AZ0647*
Contact: Cheryl Garling
(888) 235-0515
Approved for: Radiochemical Analysis

3.4 DATA MANAGEMENT OBJECTIVE

The data management objective is to accurately and completely document field and laboratory activities and results. All aspects of sample collection, shipment, and analysis will be performed in conjunction with sufficient QA/QC documentation. The procedures for documentation of field activities and measurements are contained within the *Standard Operating Procedures – Water and Environmental Sample Collection* manual. This includes the use of Field Log Books, Field Data entry computers, sample container labeling and chain-of-custody forms. Field data are entered into the Environmental Data

Management Systems (EDMS) database. For laboratory data, the designated Laboratory Manager will verify results and submit a signed certificate of analysis to the Project Manager. In coordination with the designated Laboratory and Project Managers, the Quality Assurance Manager will also verify that the completed data are properly submitted on the electronic reporting system for downloading to the EDMS database. Field documents will be downloaded and/or filed (with actual file locations noted) in the Environmental Department Filing System.

SECTION 4
SAMPLING AND ANALYTICAL PROCEDURES

This section summarizes sampling and analytical procedures used in water monitoring activities.

4.1 SAMPLING PROCEDURES

The purpose of water sampling is to obtain specimens that accurately represent site conditions. Procedures have been developed for the water monitoring program to ensure that representative samples are collected. The *Standard Operating Procedures – Water and Environmental Sample Collection* manual contains procedures for all field activities, which are currently implemented.

4.2 ANALYTICAL PROCEDURES

Samples will be analyzed for the specified parameters identified by the individual project. Table 2 identifies the analytical method and target detection limits established for each parameter. Analytical methods are selected by laboratory personnel to meet the target detection limits where possible. Measurements to be conducted in the field may include measuring temperature, specific conductivity, pH, depth of water and flow rates. Methods for conducting measurements and requirements for sample containers, preservation and holding times for each sample are provided in the *Standard Operating Procedures – Water and Environmental Sample Collection* manual.

SECTION 5
DATA VERIFICATION, REDUCTION, AND REPORTING

Data verification is necessary to ensure the integrity of the data is maintained. An audit trail shall be developed for those data that require reduction. Data generated during field measurements, observations, and field instrument calibrations, should be written in indelible ink in a bound Field Logbook provided. Sampling crew personnel are responsible for proof reading all field data inputs. The Quality Assurance Manager will review a minimum of ten percent of data transfers to ensure the integrity of field documentation.

The Quality Assurance Manager will conduct data verification reviews to assess performance in achieving quality assurance objectives. Such reviews include a verification that: 1) the samples were analyzed and reported in the appropriate units; 2) the samples were properly preserved and did not exceed holding times; 3) quantitation limits were achieved; and, 4) method blanks have been analyzed and contain no cross contamination.

Data reduction for laboratory analyses will be conducted by the designated contract laboratory in accordance with EPA procedures for each method. Analytical results can be entered into the electronic data reporting system and delivered to the Quality Assurance Manager for uploading to the EDMS. Results will also be printed out on a Certificate of Analysis. After entering and/or uploading the data to the EDMS, the data will be archived on the network drive or on a writeable CD.

The Certificate of Analysis will be submitted to the Project Manager (for review) and filed in the Environmental Department Filing System. If a revised data report has been issued, changes to results in the EDMS will be documented in the notes status sections within each sampling event and a revised Certificate of Analysis will be submitted to the Project Manager. In the event a revised certificate is issued, the Quality Assurance Manager shall verify that the data stored on the EDMS matches that on the Certificate of Analysis.

A data control program will follow to ensure that all documents generated during each specific project are accounted for upon project completion. Accountable documents include: Field Log Books, Field Data Sheets, Analytical Request Sheet/Sample Chain of Custody, Sampling Log, correspondence, analytical reports, quality assurance reports, and audit reports. The Quality Assurance and each Project Managers are responsible for maintaining the Environmental Department Filing System. The Environmental Department Filing System is where all accountable documents will be filed and/or inventoried (with actual file locations noted).

Data will be available for reviewed as deemed necessary by each Project Manager and interpreted through the use of water quality contour maps, hydraulic head and water table maps, and/or simple statistics. A monthly review with a brief report identifying data outliers and corrections to the data will be generated.

SECTION 6
QUALITY CONTROL

6.1 QUALITY CONTROL CHECKS FOR FIELD ACTIVITIES

Samples used for Quality Control for field activities will consist of trip and equipment rinse blanks along with blind duplicates. Quality control samples are used to measure accuracy and precision affected by field activities. These activities are summarized below in more detail:

Trip Blanks

Trip blanks will consist of laboratory grade, deionized water (Type I reagent water) in each sample container along with the preservatives required for the analysis. Preservatives for each analyte are specified in the *Standard Operating Procedures – Water and Environmental Sample Collection* manual. The trip blank sample will be analyzed for the analytical suite with the most required analytes, to ensure all possible constituents are being evaluated. These blanks will be prepared by field samplers and accompany the Sampling Crew during the sampling process. The blanks will serve as a quality check on container cleanliness, external contamination, and the analytical method. Trip blanks will be collected every time an equipment blank sample is collected from any of the pieces of equipment. These blanks will be preserved, field tested, documented, and transported in the same manner as the routine samples.

Equipment Rinseate Blanks

Equipment rinseate blanks will be collected to ensure that sampling equipment is clean and that the potential for cross-contamination has been minimized by the equipment decontamination procedures. These blanks will be collected after the decontaminating process of a sampling device is complete. The sample will be collected from the last portion of deionized water rinse that has come in contact with the equipment. An equipment rinseate blank will be collected at a rate of one in every twenty (20) sample

locations collected by each sampling device and in conjunction with a trip blank. The equipment blank sample will be analyzed for the analytical suite with the most required analytes, to ensure all possible constituents are being evaluated. For groundwater monitoring, equipment blanks will be collected from mobile equipment sampling. These blanks will be collected, preserved, field tested, documented, and transported in the same manner as the routine samples.

Blind Duplicates

Blind duplicate samples will be collected as an exact representation of a specific monitoring location. The duplicate sample will be taken at the same time and from the same source as the predetermined location to be compared. The duplicate will allow a determination of overall analytical precision for the designated laboratory. The blind duplicate samples will be collected at a rate of one in every ten (10) water samples collected from varying sample locations. These duplicates will be collected, preserved, field tested, documented, and transported in the same manner as the routine samples.

Procedures

The *Standard Operating Procedures – Water and Environmental Sample Collection* manual provides instructions for the collection and submittal of the QC samples described above. The analytical results for the field QC samples will be entered into the EDMS and evaluated monthly and routinely reported by the Quality Assurance Manager.

6.2 QUALITY CONTROL CHECKS FOR ANALYSES

Matrix spiking will be used to measure recoveries of analytes in order to monitor matrix efforts and for comparison to the established accuracy objective. All matrix spiking will be conducted by the designated laboratory as specified by the requirements of Arizona Department of Health Services.

Matrix Spike Samples

Matrix spike samples will be selected and spiked by laboratory personnel. Once a quarter a matrix spike sample will be submitted to the laboratory for analysis. The sample will be spiked in the laboratory with a known concentration. The spike will be used to measure the performance of the complete analytical system including potential chemical interference. Field matrix spikes may be submitted in cases where matrix problems that may be associated with particular samples (such as high TDS samples) are being evaluated by the specific project. Results from the matrix spike sample will indicate the validity of data results and the laboratory quality assurance manager will take corrective actions or omitted data as needed.

Laboratory Duplicates

Laboratory duplicate samples will be analyzed as an exact representation of a specific sample. The duplicate sample will be a spilt aliquot of a sample being prepared and analyzed within the same batch. These duplicates will measure precision of analytical performance. At least one duplicate will be spilt in every ten samples analyzed.

Reference Standards

At a frequency of one in every ten samples analyzed, a reference standard sample will be analyzed using a certified standard. The reference sample will be a commercial certified standard having the chemical composition similar to the water being submitted for analysis. This sample will be analyzed for the analytical suite with the most required analytes, to ensure all possible constituents are being evaluated

Internal Reference Samples

The use of several different internal reference standard samples is employed for laboratory quality assurance. The blanks are prepared in the laboratory with known concentrations of specific analytes with the intent of achieving recovery objectives with

and/or without potential chemical interference. The purpose is to identify analytical shifts in data for samples with known problematic matrices. Internal reference samples include reagent, fortified, and interference blanks.

Procedures

All internal quality control checks to be performed by the designated laboratory will be in compliance with regulations enforced by the Arizona Department of Health Services. The Laboratory QA Manager will submit the results of these checks along with the results of the analysis for the batch of samples submitted.

6.3 PERFORMANCE AND SYSTEMS AUDITS

Audits are conducted periodically to determine the accuracy of the total measurement system or its component parts. System audits will be conducted to evaluate quality control procedures. Performance audits will be conducted for field methodologies established in the *Standard Operating Procedures – Water and Environmental Sample Collection* manual and for data management activities. Field activities include, but are not limited to, equipment calibration and maintenance, well evacuation, sample collection, and equipment decontamination.

The Quality Assurance Manager will schedule a minimum of one unannounced audit per year of the field data and sampling techniques employed. Additional audits can be conducted as deemed necessary when quality assurance objectives are in question. Systems audits will be based on a review and evaluation of an initial audit. Based on the findings from and response of this initial audit, corrective actions or consecutive audits may proceed. Periodic audits will monitor critical areas believed to need further emphasis.

Audits will be coordinated by the Quality Assurance Manager. Example checklists for performance audits of sample collection, field measurements, equipment decontamination, sample handling, and documentation are included in Exhibits 1, 2, 3,

and 4, respectively. Audit plans, completed checklists, and reports will be kept in the Environmental Department Filing System.

Audit results will be reviewed and consolidated into a brief audit report which is filed in the Environmental Department filing system. Depending on results a post-audit meeting can be held with the audited sampling personnel. The meeting can allow the discussion of findings and resolution of any misunderstandings. A plan and schedule for corrective actions will be established during the meeting, as well as a follow-up audit if deemed necessary by the Quality Assurance Manager.

SECTION 7
CORRECTIVE ACTION

If audit findings or quality control checks indicate that quality assurance objectives are not being met, corrective actions will be taken as deemed necessary by the Quality Assurance Manager or the Project Manager. Such actions may include, but not limited to, re-sampling, re-analysis, and procedure changes. The appropriate Program Manager will be notified of the problem to discuss possible solutions.

The Quality Assurance Manager will ensure all necessary corrective actions are implemented, verify the outcome of these actions, and verify the effect on data produced. Documentation generated from these efforts should be forwarded to the appropriate Project Manager and filed in the Environmental Department filing system.

SECTION 8
QUALITY ASSURANCE REPORTING

The Quality Assurance Manager will prepare a brief annual report that includes results of quality assurance monitoring activities and audits of monitoring data quality, sampling and laboratory activities and any results of corrective actions that has taken place throughout the year. This brief report will address issues concerning accuracy, precision, completeness, representativeness, and comparability (PARCC) using the results of QC sample analyses, monitoring and audit results along with other potential sources that may not be mentioned in this document. These reports, along with any reports of audits and corrective actions, will be filed in the Environmental Department filing system. Copies will be sent to appropriate Project and Quality Assurance Managers.

Precision and Accuracy Objectives

DUPLICATE SAMPLES

Indicator Parameters, Major Anions, Major Cations, Metals:
Within 20% RPD or 4 times the PQL, whichever is greater

Organics:
Within 30% RPD or 4 times the PQL, whichever is greater

SPIKED SAMPLES*

Major Anions and Cations, Metals:
75% to 125% of the spiked analyte

Organics:
70% to 130% of the spiked analyte

*The spike objectives are generally for clean waters with less than 2000 mg/l TDS

BLANK SAMPLES

Less than the PQL (Practical Quantitation Level)

MASS BALANCES

TDS: Measured and observed TDS within 15%

Ion Balance:

Anions sum as meq/L	*Acceptance*
0-3.0	±0.2 meq/L
3.0-10.0	±2 RPD
10 and greater	±5 RPD

DETECTION LIMITS

Target Detection for Metals and Organics:
Located on table QAQCP 2

NOTES:

RPD = Relative Percent Difference
MDL = Method Detection Limit
PQL = Practical Quantitation Level
MCL = Maximum Contaminant Level

Analytical Methods

Field

PARAMETER	ANALYTICAL METHOD	PRESERVATIVE	HOLDING TIME
pH	150.1	N/A	N/A
Temperature	170.1	N/A	N/A
Conductance	2510B	N/A	10 umho/cm
Depth to Water	N/A	N/A	0.01 ft

Laboratory

PARAMETER	ANALYTICAL METHOD	PRESERVATIVE	HOLDING TIME
TDS	SM 2540C/160.1	4°C	7 Days
TSS	160.2	4°C	7 Days
Total Coliform	SM9223B/9221D	4°C/$Na_2S_2O_3$	30 Hours
Fecal Coliform	SM 9222D	4°C/$Na_2S_2O_3$	6 Hours
Gross-Alpha	900.0, 9310	HNO_3 <2 pH	6 Months
Gross-Beta	900.0, 9310	HNO_3 <2 pH	6 Months
Radium 226	903.1	HNO_3 <2 pH	6 Months
Radium 228	904.0, 9320	HNO_3 <2 pH	6 Months
Uranium	200.8	HNO_3 <2 pH	6 Months
Chloride (Cl^-)	300.0, 325.2	4°C	28 Days
Cyanide	SM4500	4°C/ NaOH to >12 pH	14 Days
Fluoride (F^-)	SM 4500F	4°C	28 Days
Sulfate ($SO_4^=$)	300.0, 375	4°C	28 Days
Nitrate (NO_3^--N)	300.0, 352/353	4°C	48 Hours
Nitrite (NO_2^--N)	300.0, 354	4°C	48 Hours
Nitrogen - Nitrite + Nitrate	353	4°C /H_2SO_4 <2 pH	28 Days
Total Phosphorous	200.7	4°C /H_2SO_4 <2 pH	28 Days
Calcium (Ca)	200.7	HNO_3 <2 pH	6 Months
Magnesium (Mg)	200.7	HNO_3 <2 pH	6 Months
Potassium (K)	200.7	HNO_3 <2 pH	6 Months
Sodium (Na)	200.7	HNO_3 <2 pH	6 Months
Alkalinity (ALK)	SM 2320B	4°C	14 Days
Aluminum (Al)	200.7, 200.8	HNO_3 <2 pH	6 Months
Antimony (Sb)	200.7, 200.8	HNO_3 <2 pH	6 Months
Arsenic (As)	200.7, 200.8	HNO_3 <2 pH	6 Months
Barium (Ba)	200.7, 200.8	HNO_3 <2 pH	6 Months
Beryllium (Be)	200.7, 200.8	HNO_3 <2 pH	6 Months
Boron (B)	200.7		

Laboratory con't

PARAMETER	ANALYTICAL METHOD	PRESERVATIVE	HOLDING TIME
Cadmium (Cd)	200.7, 200.8	HNO_3 <2 pH	6 Months
Chromium (Cr)	200.7, 200.8	HNO_3 <2 pH	6 Months
Cobalt (Co)	200.7, 200.8	HNO_3 <2 pH	6 Months
Copper (Cu)	200.7, 200.8	HNO_3 <2 pH	6 Months
Iron (Fe)	200.7	HNO_3 <2 pH	6 Months
Lead (Pb)	200.7, 200.8	HNO_3 <2 pH	6 Months
Manganese (Mn)	200.7, 200.8	HNO_3 <2 pH	6 Months
Mercury (Hg)	200.7, 200.8, 245.1	HNO_3 <2 pH	6 Months
Molybdenum (Mo)	200.7, 200.8	HNO_3 <2 pH	6 Months
Nickel (Ni)	200.7, 200.8	HNO_3 <2 pH	6 Months
Selenium (Se)	200.7, 200.8	HNO_3 <2 pH	6 Months
Silver (Ag)	200.7, 200.8	HNO_3 <2 pH	6 Months
Thallium (Tl)	200.8	HNO_3 <2 pH	6 Months
Titanium (Ti)	200.7, 200.8	HNO_3 <2 pH	6 Months
Zinc (Zn)	200.7, 200.8	HNO_3 <2 pH	6 Months
Chemical Oxygen Demand	410.4	4°C /H_2SO_4 <2 pH	28 Days
Oil and Grease	413.2	4°C/HCl	28 Days
Biological Oxygen Demand	405.1	4°C	48 Hours
Benzene	524.2, 8021B	4°C/$C_6H_8O_6$ + HCl	14 Days
Toluene	524.2, 8021B	4°C/$C_6H_8O_6$ + HCl	14 Days
Ethylbenzene	524.2, 8021B	4°C/$C_6H_8O_6$ + HCl	14 Days
Naphthalene	524.2	4°C/$C_6H_8O_6$ + HCl	14 Days
Xylene	524.2, 8021B	4°C/$C_6H_8O_6$ + HCl	14 Days
Total Petroleum Hydrocarbons	SW8015, 418.1	4°C	28 Days
VOC	624/ SW 8260	4°C/$C_6H_8O_6$ + HCl	14 Days

Critical Values for T_n in the Test for Outliers

Number of Observations	Upper 5% Significance Level	Upper 0.1% Significance Level
3	1.133	1.155
4	1.463	1.499
5	1.672	1.78
6	1.822	2.011
7	1.938	2.201
8	2.032	2.358
9	2.11	2.492
10	2.176	2.606
11	2.234	2.705
12	2.285	2.791
13	2.331	2.867
14	2.371	2.935
15	2.409	2.997
16	2.443	3.042
17	2.475	3.103
18	2.504	3.149
19	2.532	3.191
20	2.557	3.23
21	2.58	3.266
22	2.603	3.3
23	2.624	3.332
24	2.644	3.362
25	2.663	3.389
26	2.681	3.415
27	2.698	3.44
28	2.714	3.464
29	2.73	3.486
30	2.745	3.507
31	2.759	3.528
32	2.773	3.546
33	2.786	3.565
34	2.799	3.582
35	2.811	3.599
36	2.823	3.616
37	2.835	3.631
38	2.846	3.646
39	2.857	3.66
40	2.866	3.673
41	2.877	3.687
42	2.887	3.7
43	2.896	3.712
44	2.905	3.724
45	2.914	3.736
46	2.923	3.747

Number of Observations	Upper 5% Significance Level	Upper 0.1% Significance Level
47	2.931	3.757
48	2.94	3.768
49	2.948	3.779
50	2.956	3.789
51	2.964	3.798
52	2.971	3.808
53	2.978	3.816
54	2.986	3.825
55	2.992	3.834
56	3	3.842
57	3.006	3.851
58	3.013	3.858
59	3.019	3.867
60	3.025	3.874
61	3.032	3.882
62	3.037	3.889
63	3.044	3.896
64	3.049	3.903
65	3.055	3.91
66	3.061	3.917
67	3.066	3.923
68	3.071	3.93
69	3.076	3.936
70	3.082	3.942
71	3.087	3.948
72	3.092	3.954
73	3.098	3.96
74	3.102	3.965
75	3.107	3.971
76	3.111	3.977
77	3.117	3.982
78	3.121	3.987
79	3.125	3.992
80	3.13	3.998
81	3.134	4.002
82	3.139	4.007
83	3.143	4.012
84	3.147	4.017
85	3.151	4.021
86	3.155	4.026
87	3.16	4.031
88	3.163	4.035
89	3.167	4.039
90	3.171	4.044

Number of Observations	Upper 5% Significance Level	Upper 0.1% Significance Level
91	3.174	4.049
92	3.179	4.053
93	3.182	4.057
94	3.186	4.06
95	3.189	4.064
96	3.193	4.069
97	3.196	4.073
98	3.201	4.076
99	3.204	4.08
100	3.207	4.084
101	3.21	4.088
102	3.214	4.092
103	3.217	4.095
104	3.22	4.098
105	3.224	4.102
106	3.227	4.105
107	3.23	4.109
108	3.233	4.112
109	3.236	4.116
110	3.239	4.119
111	3.242	4.122
112	3.245	4.125
113	3.248	4.129
114	3.251	4.132
115	3.254	4.135
116	3.257	4.138
117	3.259	4.141
118	3.262	4.144
119	3.265	4.148

Number of Observations	Upper 5% Significance Level	Upper 0.1% Significance Level
120	3.267	4.15
121	3.27	4.153
122	3.273	4.156
123	3.276	4.159
124	3.279	4.161
125	3.281	4.164
126	3.284	4.166
127	3.286	4.169
128	3.289	4.173
129	3.291	4.175
130	3.294	4.178
131	3.296	4.18
132	3.298	4.183
133	3.302	4.185
134	3.304	4.188
135	3.306	4.19
136	3.309	4.193
137	3.311	4.196
138	3.313	4.198
139	3.315	4.2
140	3.318	4.203
141	3.32	4.205
142	3.322	4.207
143	3.324	4.209
144	3.326	4.212
145	3.328	4.214
146	3.331	4.216
147	3.334	4.219

Standard Operating Procedures – Water and Environmental Sample Collection
Phelps Dodge Sierrita

March 2005

Standard operating procedures for environmental sample collection are specified in the following text. Procedures of this type allow the processes of data collection to be uniform. In turn the adherence to these procedures will permit proper analysis of data collected.

Table of Contents

Sample Documentation and Handling

This section contains standard operating procedures for proper documentation of sampling activities and proper sample handling as outlined in the sections listed below.

Procedure DH-A: Field Log Book

Record appropriate information in a Field Log Book for reconstruction of events associated with environmental sampling as they happened. Entries to Field Log Books will be made with blue or black indelible ink. Prepare and use Field Log Book as follows:

1. A weather/water resistant bound book should be used. Consecutively number the pages, if they are not already numbered.

2. Enter the following information on the cover of each book.

   - The name of the organization to which the book belongs (Phelps Dodge Sierrita).
   - The type of sampling the book will be used for. e.g. Groundwater Sampling
   - Start Date
   - End Date

3. Upon arriving at each sampling location, a new page should be started and contain the following information:

   - Sample location identification number if it exists (Well number, or sample location number).
   - Description of site. This must be done if no identification number is given.
   - Date and time of arrival at sampling location.
   - Personnel present at sampling location.
   - Ambient weather conditions (temperature, wind speed/direction, precipitation, etc)
   - Condition of sampling location (is well and cement pad in good condition, is sampling point damaged or in poor condition).
   - Equipment models and serial numbers. (e.g. mobile equipment)
   - Calibration results at site (if done daily, reference page number calibration results for the day are recorded on)
   - Equipment decontamination and/or maintenance conducted.
   - Equipment problems and actions taken to correct them.
   - Additional observations or conditions about the sampling event, which may affect sample integrity. (e.g. time to purge and flow rate)
   - If a duplicate is taken then the identification of the duplicate should be recorded.
   - Time/Date sampling conducted (If the same as arrival, date not required)
   - Time/Date sampling site was vacated.
   - Photograph location of file or film, a description of the contents for any photograph taken (if any) during event.

4. Enter any other information that may be pertinent to the sampling activity.

Procedure DH-B: Sample Identification

A sample coding system will be used to identify each sample location. The coding system will ensure all samples collected from an identified location will be able to be located and retrieved for tracking of parameters analyzed for each sampling event.

Sample locations may be identified by a sample identification number (All well locations are identified). Within this sample identification number is a unique coding of alphanumeric characters used for providing a delineation of area, medium, and/or location of the sample site.

For some existing sites sample identification numbers have already been assigned to them, using varying methods for identification.

The method of establishing sample location identifications can be done through designating an alphanumeric identification acronym, followed by unique numeric sample identification.

New sample locations can be designated as outlined:

Sample Identification for New Sites

— —	— — —
Area \ Type Designation	**Numeric Location Identifier**

Area \ Type Designation Acronym

The area \ type designation acronym consists of a one or two-letter code, which identifies the specific area or type of site at Phelps Dodge Sierrita and its surrounding areas. Approved area / type designation codes area identified in table DH-A. Other acronyms may be used, with the approval of the Environment, Land and Water (ELW) Department, if they are consistent with this procedure and will create less confusion.

Numeric Location Identifier

The numeric sample identification is unique to the location of each established sample site throughout the sampling network. It identifies a specific sampling location. This number must be obtained from the ELW Department. For instance, a replacement well will have an "A" following the numeric identifier of the original well.

The sample identification is a unique numbering system that delineates each location throughout the Phelps Dodge Sierrita property. Therefore, one group must manage the identification of the locations for proper management in the PDSI comprehensive environmental database. Identifications may be obtained for new sample locations through the ELW Department.

Procedure DH-C: Sample Container Preparation

Use certified clean, laboratory clean or properly decontaminated sample containers for all environmental samples. Have all sample containers prepared prior to sampling event.

1. If the sample containers are provided from the laboratory ensure they have already been cleaned and the preservatives are inside of the container. (Lab may put the preservatives in a small vial inside of the sample container.)

2. Select the proper containers and preservatives for each parameter to be analyzed as specified in Table DH-B for each sample.

3. If non-laboratory provided containers are used then prepare sample containers by rinsing three times with de-ionized water.

4. Add proper preservatives to appropriate containers while in lab to reduce further exposure to potential contaminants. Use proper personal protective equipment (i.e. safety glasses w/ side shields, chemical resistant gloves, chemical resistant clothing, etc.) while using care handling the preservatives.

5. Mark containers containing preservatives with what they are containing. (e.g. HNO_3)

6. Label containers as prescribed by Procedure DH-D.

Procedure DH-D: Sample Labeling

Labeling of sample containers should be done either directly on the sample container or on a water proof label. Whether the labeling is directly on the bottle or on a label, permanent indelible ink will be utilized to prevent any smearing or loss of sample container information. The following information must be included on each sample container. Some containers may have a sticker that can be placed on the sample container these can substitute for writing directly on the sample container.

1. Write the sample site identification as prescribed by Procedure DH-B (if not a duplicate, trip blank, or equipment blank.) Use procedures QC-A, B, C for duplicate, trip blank, or equipment blanks.

2. Analysis to be completed on each specific portion of sample (i.e. total metals, dissolved metals, etc).

3. Preservative added to sample container as specified in Procedure DH-F.

4. Date (mmddyy) and Time (hhmm) sample was collected (for a duplicate, trip blank, or equipment blank this information is contained in the sample identifier as described in procedures QC-A, B, C and is not required.)

5. Sampler Name

Procedure DH-E: Sample Analytical Request and Chain of Custody

Analytical requests and Sample Chain of Custody can be documented on the approved Chain of Custody sheet (Figure DH-A) or an equivalent sheet. The Analytical Request Sheet will be filled out by the sampler, prior to submitting the samples to the analytical laboratory and/or relinquishing custody to a courier. The form will be filled out as follows:

Sample ID:	Sample Identification (Alphanumeric location ID)
Time:	Time sample was collected.
Date:	Date sample was collected.
# of Containers:	Enter total number of containers in each sample set.
Field Data:	Final reading of field data recorded while sampling.
Preservative:	Indicate number of bottles in sample set preserved with specific preservative.
Analysis Requested:	Enter pre-determined suite of analyses or specific analytes to be completed.
Sample Submitted By:	Name of Sampler
Report Results To:	Name of Project Manager or person requesting the analysis results.
Surrendered By:	Signature of individual surrendering the sample to analytical laboratory or courier.
Received By:	Signature of laboratory staff member or courier receiving sample set.
Comments/ Special Instructions	Additional comments and/or instructions.

After collection, samples will be stored in a secure manner, which would prevent any tampering or potential damage to containers, until they can be delivered to the analytical laboratory conducting the analysis. Laboratory personnel will note any damaged containers, container number discrepancies, form or label discrepancies, and presence of ice in cooler (if required) at time of delivery. Laboratory Manager or Supervisor will contact Project Manager or person receiving data to resolve any discrepancies.

Procedure DH-F: Sample Preservation and Packaging

Proper sample preservation and packaging is essential in obtaining optimal quality assurance of the analysis being performed on a sample. Sample container, preservative, and holding time requirements must be met in order to ensure the integrity of the analysis being performed. Table DH-B specifies required containers, preservatives, and holding times for a variety of analytical parameters.

1. If required to keep sample chilled, place samples in cooler with sufficient ice to ensure sample will be delivered to the analytical laboratory with residual ice remaining.

2. Place "cooler temperature check" (1 oz bottle containing water) in cooler for laboratory to ensure temperature is adequate for proper preservation upon delivery.

3. Secure Chain of Custody/Analytical Request Sheet inside of cooler (in a Ziploc® plastic bag) for shipment to analytical laboratory.

4. Samples being submitted to external analytical laboratories may require some additional securing with tape and/or seals to prevent container breakage or tampering.

5. Ship the samples with respect for the holding time of each requested parameter.

Procedure DH-G: Collecting a sample

Environmental samples should be collected uniformly so that samples are representative of the actual conditions and data collected from analysis is precise.

- An overview inspection of the site location, considering site condition, security, weather, should be recorded into the log book as prescribed in procedure DH-A.
- Prepare sample containers as prescribed in procedure DH-C.
- Label all sample containers as prescribed in procedure DH-D.
- Wear PPE as needed for safety.
- Setup sample containers near the sample location so that samples can be taken quickly with minimal time between samples.

Filtered Sample:

1. Allow sampling point to flow if necessary as prescribed by procedure WS-A, or for several minutes to ensure a representative sample is being collected.
2. Install a new unused 0.45µg filter on the sample location.
3. Start flow if required. Once the initial flow has passed through the filter begin collecting samples one at a time into the proper container as specified in table DH-B.
4. Be sure not to introduce contaminates from the cap when closing the sample containers. Cap each sample container immediately after the sample is collected and place it in the shade if possible. Continue until all samples are collected.
5. Place samples into a cooler with ice to cool them as close to $4^{O}C$ as possible as specified in table DH-B.

Unfiltered Sample:

1. Allow sampling point to flow if necessary as prescribed by procedure WS-A, or for several minutes to ensure a representative sample is being collected.
2. Start flow if required, and then begin to collect samples one at a time into the proper containers as specified in table DH-B.

3. Be sure not to introduce contaminates from the cap when closing the sample containers. Cap each sample container immediately after the sample is collected and place it in the shade it possible. Continue until all samples are collected.

4. Place samples into a cooler with ice to cool them as close to $4^{O}C$ as possible as specified in table DH-B.

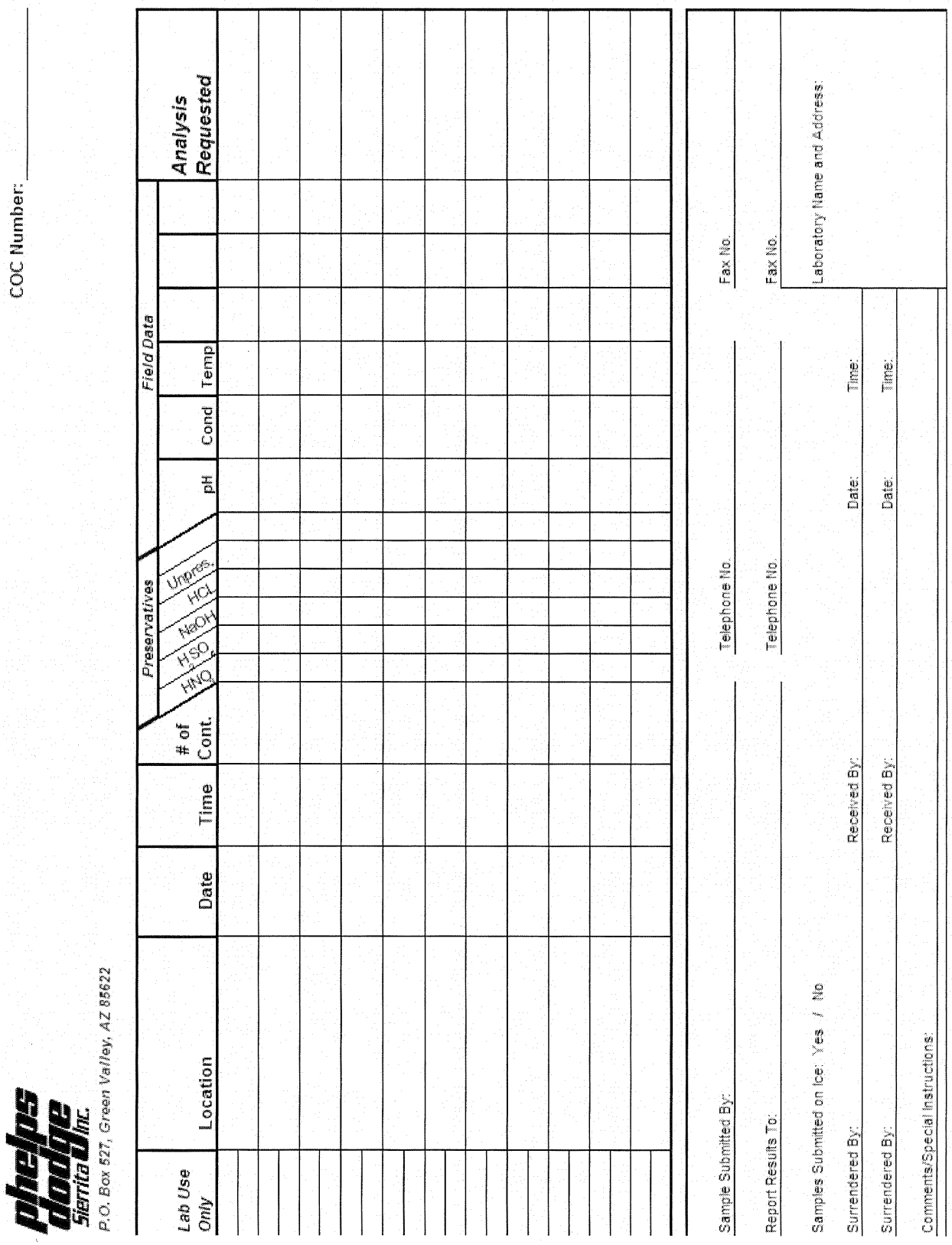
Table DH-A: Approved area / type designation codes

Code	Type of Site
BW	Monitor Well
I	TB Industrial Well
IW	Interceptor Well
M	TB Monitor Well
MH	Monitor Well
PZ	Piezometer
S	Production Well
ESP	Production Well

Table DH-B: Sample Containers, Preservation Techniques, and Holding Times

ANALYTE		CONTAINER [1]	PRESERVATION	MAXIMUM HOLDING TIME
Alkalinity		P, G	Store on Ice[2]	14 Days
BOD		P, G	Store on Ice[2]	48 Hours
Chloride		P, G	Store on Ice[2]	28 Days
Chromium		P	Store on Ice[2]	24 Hours
Coliform		P (Sterilyzed)	Store on Ice[2]	6 Hrs - NPDES 48 Hrs - Drinking
Corrosively		P		14 Days
Cyanide		P	Store on Ice[2], NaOH to pH > 12, Store in Dark.	48 Hours Non-preserved w/ NaOH, 14 Days Preserved.
Fluoride		P, G	Store on Ice[2]	28 Days
Hydrocarbons Chlorinated		G	Store on Ice[2]	7 Days
Hydrogen Ion (pH)		P, G	None	Analyze As Soon As Possible
Ignitability		G,M		14 Days
Mercury		P, G	HNO_3, to pH < 2	28 Days
Metals, except Mercury		P, G	HNO_3, to pH < 2	6 Months
Nitrate		P, G	Store on Ice[2]	48 Hours - Non Preserved
Nitrite		P, G	Store on Ice[2]	48 Hours
$NO_2 + NO_3$		P, G	Store on Ice[2]	48 Hours, 28 Days w/ H_2SO_4
Oil & Grease		G	Store on Ice[2], H_2SO_4 to pH < 2	28 Days
Organics				
	PCB	AG	Store on Ice[2], pH 5 - 9	7 Days
	Pesticides	VOA	Store on Ice[2], $Na_2S_2O_3$ If residual Cl^- present	7 Days
	PAH	AG	Store on Ice, $Na_2S_2O_3$ If residual Cl^- present	7 Days
	BTEX	VOA	Store on Ice[2]	14 Days
	TPH	G	Store on Ice[2], HCl	28 Days
	VOC	VOA	Store on Ice[2], HCl < 2, $Na_2S_2O_3$ If residual Cl^- present	7 Days
Phenolics		G	Store on Ice, H_2SO_4 to pH < 2	28 Days
Phosphate		P, G	Store on Ice[2]	48 Hours
Radionucleides		P, G	HNO^3, to pH < 2	6 Months
Silica		P	Store on Ice[2]	28 Days
Sulfate		P, G	Store on Ice[2], if pH is < than 4.5 preserve w/ HCl	28 Days
TCLP		AG	None unless specified by lab	7 Days
TDS		P, G	Store on Ice[2]	7 Days
TSS		P, G	Store on Ice[2]	7 Days
[1] Polyethylene (P), Glass (G), Amber Glass (AG), Volitile Organic Amber (VOA), Metal (M)				
[2] or Refrigerate				

Figure DH-A: Chain of Custody Sheet



Equipment Decontamination and Maintenance

This section contains standard operating procedures for proper decontamination and maintenance of sampling equipment and instruments as outlined in the sections listed below.

Procedure DM-A: Equipment Decontamination

Decontamination of environmental sampling equipment is essential in obtaining quality representative data from characterized and non-characterized sampling locations. All equipment used in collection should be decontaminated prior to each use. Decontamination of field sampling equipment such as; stainless steel buckets, bailers, pumps, dippers, scoops, Coliwasas, triers, and augers shall be conducted before and between every sampling event and at the end of each day. Materials needed for effective decontamination of equipment is listed below:

- Phosphate Free Cleaning Detergents (Liquinox®)
- Potable Water
- Deionized Water
- Water storage containers for large volumes of soapy, potable, and deionized water in transport.
- Buckets for use in washing and rinsing of equipment.
- Protective gloves.
- Proper personal protective equipment (i.e. safety glasses w/ side shields, chemical resistant gloves, chemical resistant clothing, etc.) while handling dangerous chemicals.
- Paper towels or cloth towels for cleaning all outside surfaces or surfaces that do not come in with the sample.
- Plastic garbage bags for storage of disposable items (gloves, paper towels, containers, etc.).

Decontaminate non-disposable sampling equipment such as stainless steel buckets, bailers, dippers, scoops, Coliwasas, triers, and augers as described below:

1. Use proper personal protective equipment (i.e. safety glasses w/ side shields, chemical resistant gloves, chemical resistant clothing, etc.) using care while handling detergents and other chemicals.

2. Manually scrub exterior with non-phosphate detergent/potable water mixture.

3. If there is an interior (bailers, Coliwasas, etc.), flush with non-phosphate detergent/potable water mixture

4. Rinse with potable water until all detergent and residue is removed.

5. Rinse with deionized water.

6. Air dry.

7. Place all disposable items in plastic bag and take to appropriate disposal receptacle.

Decontaminate mobile monitoring well pumps and non-disposable hoses as described below:

1. Use proper personal protective equipment (i.e. safety glasses w/ side shields, chemical resistant gloves, chemical resistant clothing, etc.) using care while handling detergents and other chemicals.

2. Manually scrub exterior portion of hose, which was immersed in the well water, with non-phosphate detergent/potable water mixture.

3. Pump non-phosphate detergent/potable water mixture through pump and tubing until it discharges from the discharge hose.

4. Rinse exterior portion of hose, which was immersed in the well, with potable water until all detergent and residue is removed.

5. Pump potable water through pump and tubing until all detergent and residue is removed from interior.

6. Rinse exterior portion of hose which was immersed in the well water with deionized water.

7. Pump deionized water through pump and tubing until sufficient rinsing has been achieved or at a minimum until it discharges from the discharge hose.

8. Air Dry exterior.

9. Place all disposable items in plastic bag and take to appropriate disposal receptacle.

If excessive amounts of grime or residue are present on the exterior of a pump and/or tubing, a pressure sprayer can periodically be used to remove any buildup.

Decontaminate meters and/or probes to meters used for general field measurements as described below:

1. Use proper personal protective equipment (i.e. safety glasses w/ side shields, chemical resistant gloves, chemical resistant clothing, etc.) using care while handling detergents and other chemicals.

2. Rinse meters and/or meters probes for several seconds with deionized water between each reading.

3. Periodically, glassware used for sample collection and/or field measurements should be immersed in a 10% hydrochloric acid solution, followed by manual scrubbing to remove any residual residue.

Procedure DM-B: Equipment Maintenance

Routine equipment and instrument maintenance is essential in ensuring efficient, accurate data is obtained in environmental sampling. Refer to equipment and instrument manuals for determination of proper scheduling and preventative maintenance for each piece of equipment and instrument. General routine preventative maintenance shall be conducted as follows:

1. Store equipment and instruments in secure, dry place, away from weather and dust.

2. Remove dirt and residual grime acquired in transport.

3. Keep sensitive parts (membranes, electrical, etc.) covered, to protect from weather, dust, and other hazards while in field.

4. Inspect all equipment for potential problems (cracked and clogged tubing, electrical wiring, pump impellers, etc.).

5. Keep battery packs for equipment charged and ready to use, replace as necessary.

Quality Assurance Quality Control Practices

This section contains standard operating procedures for proper quality control of samples and equipment as outlined in the sections listed below.

Procedure QC-A: Blind Duplicates

Duplicate samples will be collected by alternately filling pre-marked containers of the designated sample location and the duplicate. For example, if a container preserved for total metals for the designated sample location is being filled, the container preserved for total metals for the duplicate shall immediately follow. This method will be followed for each subsequent container of the sampling sets to ensure both sampling sets are representative of each other. Duplicate samples will consists of the exact same containers and analysis for which the original designated sampling location is being analyzed.

Duplicates will be collected at a rate of one in every ten samples collected from varying sample locations. The sample identification for duplicates will consist of the three-letter acronym DUP, followed by the date (mmddyy) and alpha identifier. (e.g. DUP091404D this would identify the fourth duplicate sample taken on September 14, 2004)

Selection of the specific locations for duplicate sample collection will be at the discretion of the sampler. However, sites should represent the general, overall water quality for the entire site. To ensure overall water quality control objectives are being met, sample location selection should be conducted by rotating designation areas according to the last area sampled. For example, if a groundwater sample was collected within the IW designation on the last duplicate round, the next duplicate would be collected from a location in another area designation.

Duplicate samples shall be recorded in the field logbook on the same page of the sample being duplicated as prescribed by procedure DH-A in this manual. Proper documentation is necessary to ensure proper quality control can be obtained through contrast analysis.

Procedure QC-B: Trip Blanks

Trip blank samples will be collected by filling pre-marked containers with de-ionized water and placing them in the same cooler as all subsequent samples collected for that day. Samples will be kept on ice and accompany the sampler(s) throughout the day of sampling to ensure contaminants are not affecting the integrity of the samples while in storage and transport. The exact same container will be used for Trip blanks along with an equivalent analysis to the original sample submitted to the lab.

Trip blanks will be collected every time an equipment blank sample is collected from any of the pieces of equipment. The sample identification for trip blanks is TB then the date (mmddyy) and an alpha identifier. (e.g. TB052805A would identify the first trip blank from May 28, 2005)

Trip blanks shall include all of the same procedures as a sample being collected from a designated sampling location, including container rinsing and preservation, and field measurements. All information regarding a trip blank will be recorded in the field log book on the same page as the equipment blank taken in conjunction with this sample. Proper documentation is necessary to ensure proper quality control can be obtained through contrast analysis.

Procedure QC-C: Equipment Blanks

Equipment blank samples will be collected by filling pre-marked containers with de-ionized water, which has been run through, on, or over equipment that has been decontaminated as prescribed in procedure DM-A. The sample will be collected from the final rinse of de-ionized water in the decontamination process. To ensure accuracy of QC efforts, decontamination of equipment should be done to no more or less extent than that which is done during normal decontamination between sampling events. The exact same container will be used for Equipment blanks along with an equivalent analysis to the original sample submitted to the lab.

Equipment blanks are to be performed on non-dedicated, non-disposable equipment such as; stainless steel buckets, bailers, pumps, dippers, scoops, Coliwasas, triers, and augers. Equipment like dedicated monitoring well pumps or disposable bailers do not require routine decontamination or equipment blank samples, as long as the disposable items are disposed of between each sampling site and not reused.

Equipment blanks will be collected at a rate of one in every twenty sample locations collected by each sampling device and in conjunction with a trip blank as prescribed in procedure QC-B. The sample identification for equipment blanks will consist of the three-letter acronym EQB, followed by the date (mmddyy) and an alpha identifier. (e.g. EQB030604A would identify the first equipment blank taken on March 6, 2004)

Equipment blanks shall include all of the same procedures as a sample being collected from a designated sampling location, including container rinsing and preservation, and field measurements. All information regarding an equipment blank will be recorded in the field log book on the same page as the trip blank taken in conjunction with this sample. Proper documentation is necessary to ensure proper quality control can be obtained through contrast analysis.

Well Specific Procedures

This section contains standard operating procedures for sites that are wells as outlined in the sections listed below.

Procedure WS-A: Depth to Water

Depth to water measurements should be taken at each well at a frequency specified in the PDSI sampling plan. The static water level is the level of the water in the well before pumping has taken place. It is a measurement of the water level in the target aquifer. The pumping water level is the level of the water at which the pumping and recharge rates are in equilibrium and the water level no longer varies. The depth to water should be measured from the predetermined measuring point. The measuring point is the north side of the top of the well casing. This point should be marked on the top of the casing. This measurement should be taken to within one hundredth of a foot using a depth to water sounder. Depth to water measurements should be done by following these procedures.

1. Proper decontamination should be done on the depth to water sounder as prescribed in procedure DM-A.

2. Locate the measuring point; if not marked then determine north.

3. Allow the sounder to go down the well until it indicates the probe is in water.

4. Obtain reading from tape to within one hundredth (1/100) of a foot.

5. Record reading in field notebook and electronically in the handheld or on the field data sheet.

6. Properly decontaminate the depth to water sounder as prescribed in procedure DM-A.

Static Water level

- Depth to water measurements should be taken before any pumping occurs to be sure that the static non-pumping water level is obtained.

Pumping Water level

- Depth to water measurements for a pumping well should be taken after the pump has been running for at least 3 purge volumes.

Procedure WS-B: Groundwater Well Evacuation

For wells of known construction, evacuate a minimum of three (3) standing well casings and sand pack porosity volumes to help ensure the collection of a sample which is representative of the target aquifer. The removal of at least three volumes is believed to achieve a representative sample of the water with in the target aquifer. Once three standing well casings have been purged stop pumping once the given indicator parameters have stabilized, limiting the evacuation to five volumes. This prevents the stressing of the well and introduction of ground water from another area within the aquifer. If the well goes dry during evacuation, allow the water level to recover and re-evacuate, if possible, until it is believed that a representative sample from the aquifer can be collected. The following steps should be followed to ensure a representative sample is collected during each sampling round.

6. Conduct an overview inspection of the site location. Consider well and concrete pad condition, security of well and weather conditions while at the site. Document information as prescribed by procedure DH-A.

7. Determine the static water level as described in procedure WS-A.

8. Calculate purge volume of well from the following procedure

   The purge volume is calculated as follows. All hand calculations should be done in the field log book. The handheld computer may do the calculations if provided all of the necessary information.

   a. Measure the inside diameter of the well casing if unknown.

   b. Determine the depth to the bottom of the casing.

   c. Determine the length of the screened interval.

   d. Determine the porosity of the sand pack. If the actual porosity is not available then assume that $\eta = 0.3$.

   e. Determine the Diameter of the borehole.

   f. Calculate the standing water volume as follows;

      - V = Volume of standing water (gallons)
      - L = Length of screened interval (ft)
      - η = Assumed porosity of sand pack
      - Z_W = depth to water (ft)
      - Z_C = depth to bottom of casing (ft)
      - D_B = Diameter of the borehole (ft)

- D_C = Diameter of the casing (ft)

$$V = 1.87\pi\left[(Z_C - Z_W)D_C^2 + \eta L\left(D_B^2 - D_C^2\right)\right]$$

g. Multiply the volume of standing water by (3) to obtain the minimum purge volume.

h. Multiply the volume of standing water by (5) to obtain the maximum purge volume.

9. If well has dedicated pump, install proper equipment (hoses, fittings, etc.) If well does not have a dedicated pump, install decontaminated portable pump in well, connect appropriate equipment and control devices. Ensure that the portable equipment has been decontaminated before use, as described in procedure DC-A.

10. Turn on pump, and adjust flow rate to maintain steady flow to minimize the chance of pumping well dry. Do not run the pump while the all the valves are closed, this may cause damage to the pump. When organic constituents are to be analyzed, do not pump or bail the well to dryness or cause recharge water to cascade vigorously down the sides of the screen or lower the water level below the level of the pump.

11. While evacuating record measurements of conductivity, pH, and water temperature after the removal of each well volume. This is done so that it can be known as to when a representative sample can be collected. Once these values have stabilized then collection of the sample can be done. If (5) standing well volumes have been purged then it is assumed that a representative sample from the correct location in the aquifer can be obtained. Record the interval reading values along with the total purged volume in the handheld computer and in the log book.

12. Collect sample(s) for predetermined analytes from pump discharge as prescribed in procedure DH-G.

13. Once sampling is completed turn off the pump and close the valves on the well. Disconnect all mobile equipment. Follow decontamination procedure DC-A as needed for portable reusable equipment.

14. Secure the well by replacing lock on protective casing.

APPENDIX B

BESST, INC. HYDROBOOSTER SYSTEM

Dye Tracer Flow Velocity Profiling and HydroBooster™ Groundwater Sampling

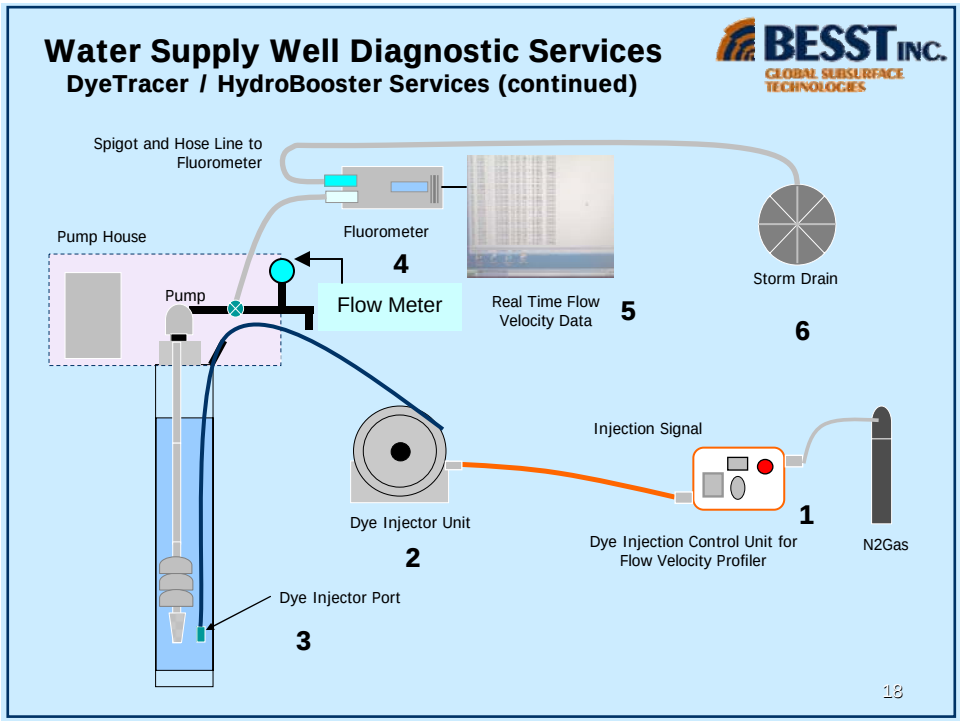
1. Dye Tracer Flow Velocity Profiling – General Description

The Dye Tracer Flow Velocity Profiling System (DT) is a USGS method and apparatus patented technology and was constructed and is operated by BESST, Inc. under exclusive license from the USGS. The technology has the ability to provide a dynamic flow velocity profile from virtually any type of production, remediation or monitoring well without first having to remove the pump from the well. The end result of the method produces a quantitative groundwater production profile of water influx along a well screen under dynamic flow pumping conditions along the entire well screen. The velocity and production profiles generated by this technology are comparable to profiles generated by spinner logging tools under dynamic flow conditions. The setup schematic for the Dye Tracer (DT) system is presented in Figure 1.

The DT system is composed of six main components:

a. Flexible Dye Injection Hose w/ Injection Nozzle
b. Motorized Hose Spool for deploying and retrieving the dye injection tubing w/ nozzle
c. Injection Pump / w/ Pneumatically Controlled Solenoid for the injection pump and Valve Switching Unit
d. Injection Control Unit
e. 10-AU Fluorometer from Turner Designs
f. Rhodamine Red Dye (NSF 60 Approved)

Figure 1: Schematic of Dye Tracer Flow Velocity Profiling System



50 Tiburon Street, Suite 7, San Rafael, CA 94901
Toll Free: 866.298.8701 / 415.453.2501 (fax: 2509)

1.1 Planning and Field Preparation

The first step in operation of the DT system is access to the well of interest. Preparation consists of communication between the consultant, water purveyor and BESST in order to determine the most suitable access points into the well – between the pump column and interior well casing wall. Schematics of the pump and pump house and multiple photos of the well head are typically reviewed before the start of any project. Once reviewed, a planned approach is agreed to before commencement of work.

The DT tubing and injection nozzle typically ranges between ½-inch to ¾-inch in diameter. The small diameter and flexibility of the tubing and nozzle assembly make it possible to bypass the pump column, down-hole impeller bowls and / or electric pump motors. A key factor in successfully inserting the injection tubing and nozzle is the attachment of a small diameter steel cable or weighted chain to a metal loop located and attached just below the injection nozzle. The weight attachment makes it possible to move the DT tubing up and down in the well without turning off the pump.

In typical applications, the DT tubing is lowered through a mechanical counter that indicates the depth of the injection nozzle. The injection process can be started near the top of the pump or impeller bowls or from the bottom of the well screen. Injection points are typically laid out on a 10- to 20-foot vertical grid in order to obtain enough data points to vertically profile production along the well screen.

Prior to well injection, 50 ml of Rhodamine Red (RR) (from Bright Dyes, Inc.) is injected into a 5-Gallon bottle of DI water. The solution from the RR bottle is then fed by the injection pump (IP) to the injection line until the line is completely filled with the RR solution. When released into a well, each second of injection by the Injection Control Unit (ICU) is equivalent to approximately 20 ml of RR released from the injection nozzle (IN). Figure 2 below shows a typical setup for the DT system at a production well location in northern Nevada.

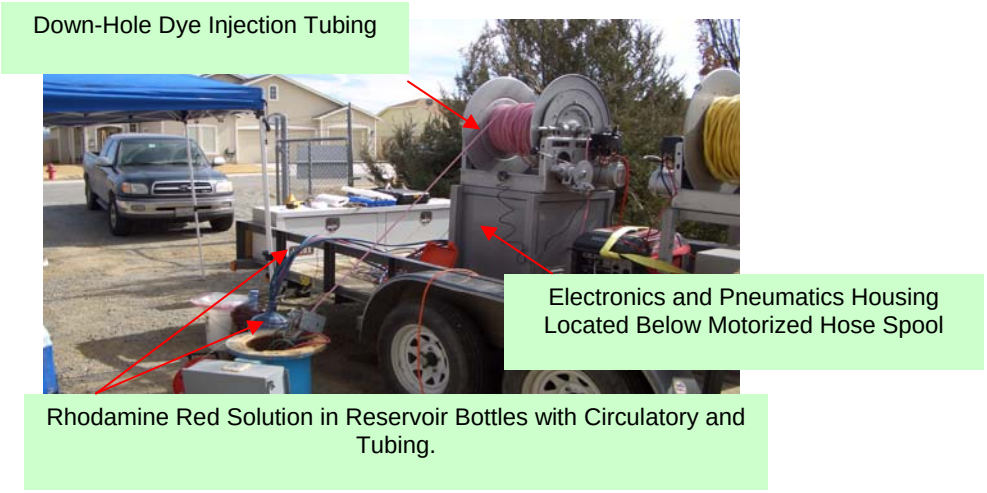


Figure 2: Typical trailer setup for Dye Tracer Flow Velocity Profiling System – at a location in northern, Nevada.

While the system is in non-injection mode and idling, the RR solution is circulated in the RR reservoir bottle to prevent air bubbles from entering the liquid and being injected into the well. Additionally, an electronic float sensor is placed within the RR reservoir bottle

to prevent air from being drawn into the injection line. As a result, when the RR solution is drawn down to the lower third of the RR bottle, the injection pump automatically shuts off. More RR solution is then added to the bottle before RR injection is continued. Introduction of air into the injection line is undesirable since air bubbles can cause delays in the return time of the RR to the fluorometer.

1.2 General Description of Equipment

The fluorometer used for the velocity profiling is a Model 10-AU from Turner Designs and is shown in Figure 3. The 10-AU Fluorometer measures the concentration of various analytes in samples of interest via fluorescence. In the case of dynamic flow velocity analysis for wells, the analyte of interest is artificially introduced in order to measure the peak concentration return times of rhodamine red from the release point to the fluorometer via the discharge path of the pumping well. The return concentrations are typically in the part per billion range. Light or exciting light from a light source within the fluorometer is passed through a color filter specific to rhodamine red, that transmits light of the chosen wavelength range (color). The wavelength of the exciting light that falls on the sample is set by the choice of the light source and the excitation filter. The emitted light radiates in a sphere from the light source and is directed towards the 10-AU detector through an emission filter. The purpose of the emission filter is to prevent any scattered exciting light from reaching the detector (photomultiplier tube) and to pass the emitted color that is specific to the analyte of interest. The concentration of the RR solution is directly proportional to the signal response received by the fluorescing light emitted by the rhodamine red that is received by the detector. The concentration is typically reported on an analog display panel located on the front of the 10-AU (Turner Designs, 1996).

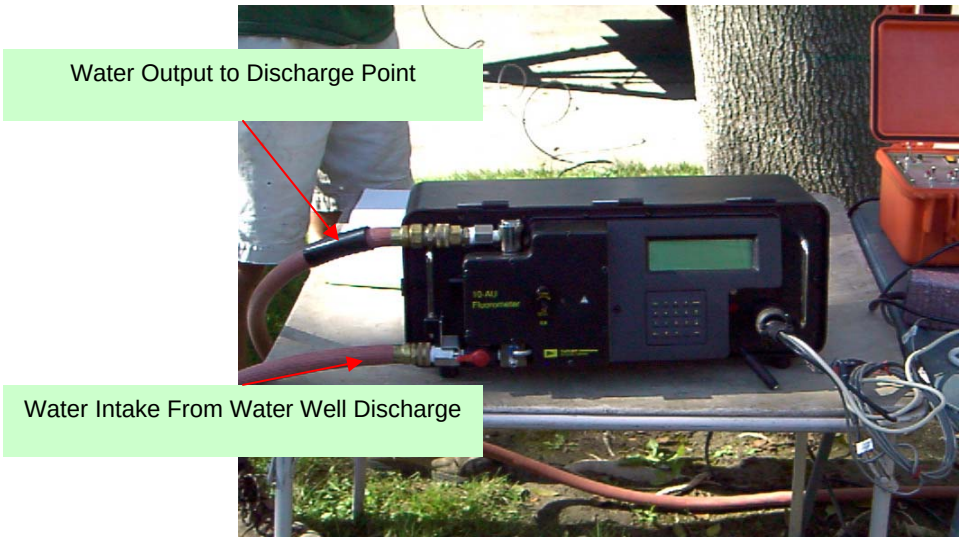


Figure 3: Model 10-AU fluorometer from Turner Designs.

To-the-second consistency of injection time, and bubble free RR injection solution is the key to establishing meaningful and reproducible results for defining dynamic flow velocity measurements in any well under study. Figure 4 shows a BESST, Inc. injection control unit for tightly regulating injection pulse times. Figures 5 and 6 provide a more detailed look of the circulatory system of the dye injector.

Figure 4: Dye Injection Control Unit for to-the-second regulation of dye injection pulses.

Figure 5: Electrical and Pneumatics components inside housing are controlled by the Dye Injection Control Unit (Figure 4). The housing contains injection pump, injection pressure regulator, pneumatically controlled valve switching solenoid, fuse box, electrical circuits and primary and secondary valve control units.

Figure 6: Bottle to right contains primary RR reservoir. When the large oval red button is depressed on the Dye Injection Control Unit (Figure 4), the RR solution is fed from the red tube, then to the injection pump, and finally through the injection nozzle and into the well. When the injection pump is idling, the RR solution circulates through the blue tube and red tube in the primary RR reservoir bottle. The secondary RR bottle receives excess RR that is not used during an injection pulse.

1.3 Injection Procedure

Prior to the first dye injection, the well of concern is typically pumped at the specified pumping rate for the flow velocity test until draw down stabilization inside the well has been reached. Periodic readings are recorded from a flow meter attached to the discharge line. Ideally, the flow meter is attached to the discharge line at a distance of at least 10 feet from the well head in order to minimize the effect of pipe fluid turbulence on the flow meter reading.

The first step in the dye injection process is to lower the injection tubing and nozzle through a mechanical counter to the first injection point in the well. Often times, the injection process starts from the well bottom – since the weighted end of the injection tubing is used to verify the actual well depth. Therefore, as a matter of convenience, the first injection point is typically near the bottom of the well. The injection points are then executed along a vertical ascending grid. At the point of dye injection, the release time is manually noted in a field log. Each release time is selected from a scrolling time and concentration log which appears on a laptop screen – the laptop being directly connected to the fluorometer. The communication of this information through the laptop is facilitated through the laptop's default communication software called Hyperlink. An example of the laptop display is shown in Figure 7 below.

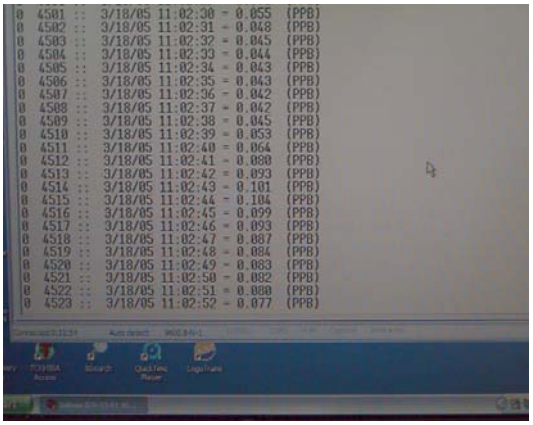


Figure 7: Streaming Laptop Hyperlink Communication Display from AU-10 Fluorometer. Date, time and concentration value are reported and stored in continuous scrolling format.

Figure 8: Laptop connected to 10-AU

1.4 Data Requirements

During the course of completing the vertical dye injection grid, some of the injection points are repeated in order to establish travel time and velocity reproducibility. Once all of the injection points are completed, the data is entered into an Excel spreadsheet with built-in data calculations that facilitate the generation of the flow profile – using the Excel chart function. The basic equation (Izbicki, 2000) used for calculating flow velocity is:

$Q= (V\pi r^2)$

where,

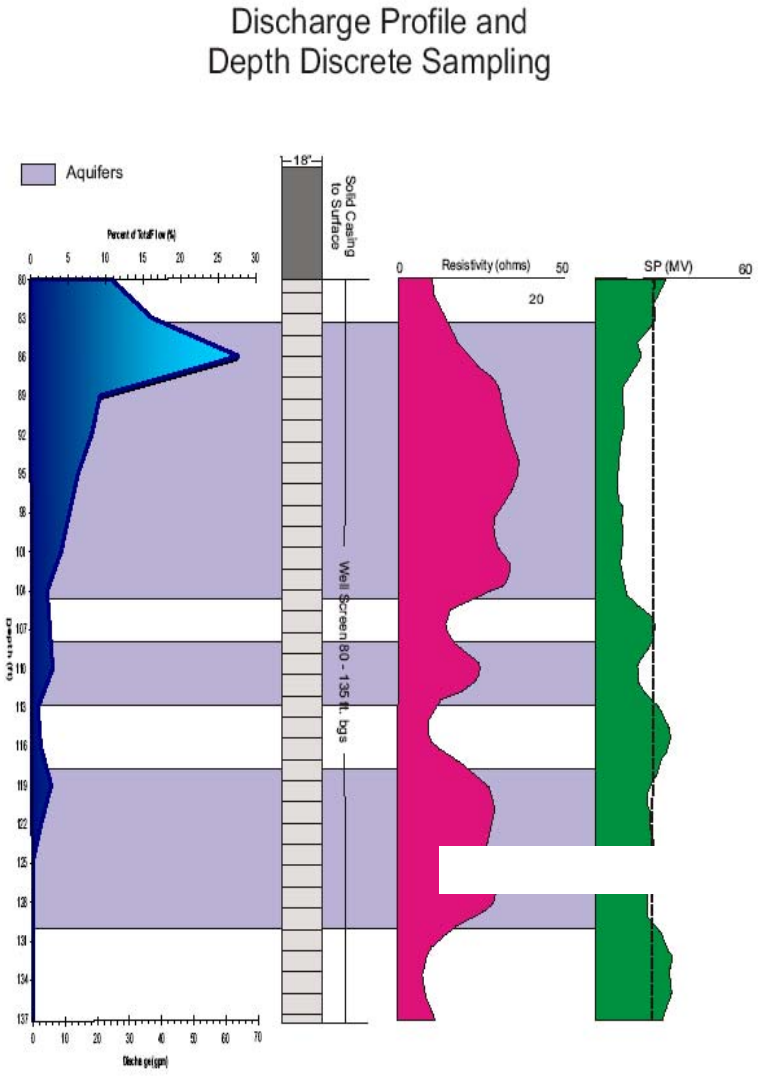
$V = (d_2-d_1) / (t_2-t_1)$

Q = flow in gallons per minute (gpm)
d = injection depth
d_2 = injection depth # 2
d_1 = injection depth # 1
t = travel time of peak tracer concentration from release point to detector
t_2 = return time for rhodamine red peak to fluorometer detector for d_2 injection point
t_1 = return time for rhodamine red peak to fluorometer detector for d_1 injection point

Other factors that are required for the solution and interpretation of the results are well diameter, pump diameter, pump column diameter and length, depth of pump intake, well screen interval(s), and length of well screen located above the pump. Other pieces of information that can play a role in the interpretation of the results are driller's logs from when the well bore was drilled and any geophysical logs such as resistivity short and long normal, spontaneous potential (SP), gamma ray, neutron, caliper, video surveys and others.

As far as data plotting, there are various types of valid presentation formats. One type of format (presented in Figure 9) plots depth on the y-axis, percent flow on the top x-axis and GPM discharge on the bottom x-axis. Additionally, lithologic and geophysical information are presented in co-plots to the right in order to correlate lithologic and geophysical properties to production.

Figure 9: Blue curve displays flow profile of production well – where injection depth points are shown along y-axis. Top x-axis shows percent contribution with depth and bottom x-axis shows discharge with depth in GPM. Magenta shaded curve displays resistivity in ohms and green-shaded curve shows spontaneous potential (SP) in millivolts (MV).



2. HydroBooster™ Groundwater Sampling – General Description

The HydroBooster™ pump is a high-lift gas displacement pump that was designed by BESST, Inc. for the USGS for collecting groundwater samples from active production wells without having to remove the pump (USGS, 2004). The HydroBooster™ pump spans from 6 to 18-inches in length (depending on model) and ranges in diameter from ½-inch to 7/8-inch. The pump can be connected to any type of tubing (i.e. Teflon, polyethylene, nylon, etc.). For high pressure applications, the tubing can consist of regular nylon, or even nylon reinforced with fiber glass or Kevlar for ultra high pressure applications to 3,000+ feet BGS. Figure 10 shows an example of a HydroBooster™ application at a site in the California Central Valley for a production well under study for vertical distribution of nitrate contamination.

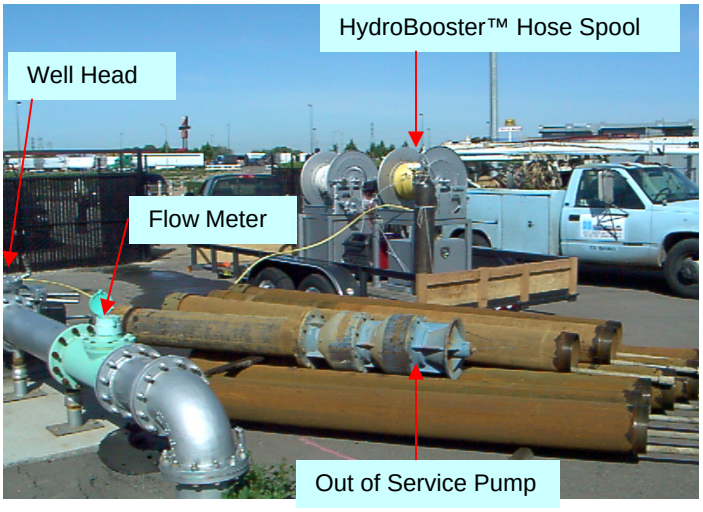


Figure 10: Setup of the HydroBooster system at a groundwater production well in the California Central Valley. Groundwater samples were collected in conjunction with running a smaller electric pump inside the well contemporaneously with the sampling process. The main production pump was removed sometime prior to the testing and is shown in foreground (blue housing). The production well was under study for vertical distribution of nitrate contamination. Note the flexibility of the HydroBooster system leading up to the well head.

As with the Dye Tracer Flow Velocity Unit, the tubing for the HydroBooster™ system is flexible, permitting access into various types of production well settings without having to remove the pump. The different types of BESST pump models used for groundwater sampling in production wells (as well as small diameter and Westbay Multi Port wells) is shown in Figure 11. The pneumatic lift formula used for the gas displacement pump is the following:

Minimum Pneumatic Lift Pressure = X'/[(2.31'/PSI) x 1.1]

where,

X= depth of pump below ground surface
2.31' / PSI = approximate linear gradient of water pressure at sea level and assuming a specific gravity of 1.

1.1 = Correction factor used for increasing lift pressure by 10% to compensate for friction loss of the water inside the sample return line.

Figure 11: Various models of BESSt miniaturized gas displacement pumps for HydroBooster system.

The gas displacement principle that operates the pumps utilizes a single valve located directly below a Y-tube junction between the gas-in and sample return lines. When the pump with bundle is submerged within the well water, the single valve cracks open at about 1/3-PSI water pressure. Groundwater from the well fills both the gas-in and sample return lines simultaneously through the bottom of the one-way valve. When the pump is lowered to its final destination inside the well, water rising inside the two lines eventually rises to a point of static equilibrium. The groundwater in the two lines is pumped from the system by releasing gas at the calculated minimum pneumatic lift pressure. As the groundwater dispenses from the sample return line, flow is continuous until all of the groundwater in the gas-in and sample return lines is discharged. During pressurization, the stainless steel poppet inside the pump's valve chamber is forced to seat against an o-ring located at the bottom of the chamber – and therefore preventing back flow back out through the bottom of the valve. As a result, the water in the sample return line is pushed by the water in the gas-in line in a "u-path", and ascends up the sample return line as a single slug. When all of the groundwater has exited the sample return line, the back end of the water slug is followed by the compressed gas that was pushing the entire slug. At this point, the end of the discharge line sputters – signaling the end of the purge cycle. The gas pressure is then turned off and released – allowing new water from the well to refill both the gas-in and sample return lines. The procedure is typically repeated three times and the sample collected on the fourth purge cycle. This technique allows for the two lines to be cleaned by the water at each sample collection depth.

APPENDIX C

ASTM 2488 – DESCRIPTION AND IDENTIFICATION OF SOILS

Designation: D 2488 – 00

Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)[1]

This standard is issued under the fixed designation D 2488; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope *

1.1 This practice covers procedures for the description of soils for engineering purposes.

1.2 This practice also describes a procedure for identifying soils, at the option of the user, based on the classification system described in Test Method D 2487. The identification is based on visual examination and manual tests. It must be clearly stated in reporting an identification that it is based on visual-manual procedures.

1.2.1 When precise classification of soils for engineering purposes is required, the procedures prescribed in Test Method D 2487 shall be used.

1.2.2 In this practice, the identification portion assigning a group symbol and name is limited to soil particles smaller than 3 in. (75 mm).

1.2.3 The identification portion of this practice is limited to naturally occurring soils (disturbed and undisturbed).

NOTE 1—This practice may be used as a descriptive system applied to such materials as shale, claystone, shells, crushed rock, etc. (see Appendix X2).

1.3 The descriptive information in this practice may be used with other soil classification systems or for materials other than naturally occurring soils.

1.4 The values stated in inch-pound units are to be regarded as the standard.

1.5 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For specific precautionary statements see Section 8.

1.6 *This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this practice may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 653 Terminology Relating to Soil, Rock, and Contained Fluids[2]

D 1452 Practice for Soil Investigation and Sampling by Auger Borings[2]

D 1586 Test Method for Penetration Test and Split-Barrel Sampling of Soils[2]

D 1587 Practice for Thin-Walled Tube Sampling of Soils[2]

D 2113 Practice for Diamond Core Drilling for Site Investigation[2]

D 2487 Classification of Soils for Engineering Purposes (Unified Soil Classification System)[2]

D 3740 Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and rock as Used in Engineering Design and Construction[3]

D 4083 Practice for Description of Frozen Soils (Visual-Manual Procedure)[2]

3. Terminology

3.1 *Definitions*—Except as listed below, all definitions are in accordance with Terminology D 653.

NOTE 2—For particles retained on a 3-in. (75-mm) US standard sieve, the following definitions are suggested:
Cobbles—particles of rock that will pass a 12-in. (300-mm) square opening and be retained on a 3-in. (75-mm) sieve, and
Boulders—particles of rock that will not pass a 12-in. (300-mm) square opening.

3.1.1 *clay*—soil passing a No. 200 (75-μm) sieve that can be made to exhibit plasticity (putty-like properties) within a range of water contents, and that exhibits considerable strength when air-dry. For classification, a clay is a fine-grained soil, or the

[1] This practice is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.07 on Identification and Classification of Soils.

Current edition approved Feb. 10, 2000. Published May 2000. Originally published as D 2488 – 66 T. Last previous edition D 2488 – 93[ε1].

[2] *Annual Book of ASTM Standards*, Vol 04.08.

[3] *Annual Book of ASTM Standards*, Vol 04.09.

***A Summary of Changes section appears at the end of this standard.**

fine-grained portion of a soil, with a plasticity index equal to or greater than 4, and the plot of plasticity index versus liquid limit falls on or above the "A" line (see Fig. 3 of Test Method D 2487).

3.1.2 *gravel*—particles of rock that will pass a 3-in. (75-mm) sieve and be retained on a No. 4 (4.75-mm) sieve with the following subdivisions:

coarse—passes a 3-in. (75-mm) sieve and is retained on a ¾-in. (19-mm) sieve.

fine—passes a ¾-in. (19-mm) sieve and is retained on a No. 4 (4.75-mm) sieve.

3.1.3 *organic clay*—a clay with sufficient organic content to influence the soil properties. For classification, an organic clay is a soil that would be classified as a clay, except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.4 *organic silt*—a silt with sufficient organic content to influence the soil properties. For classification, an organic silt is a soil that would be classified as a silt except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.5 *peat*—a soil composed primarily of vegetable tissue in various stages of decomposition usually with an organic odor, a dark brown to black color, a spongy consistency, and a texture ranging from fibrous to amorphous.

3.1.6 *sand*—particles of rock that will pass a No. 4 (4.75-mm) sieve and be retained on a No. 200 (75-μm) sieve with the following subdivisions:

coarse—passes a No. 4 (4.75-mm) sieve and is retained on a No. 10 (2.00-mm) sieve.

medium—passes a No. 10 (2.00-mm) sieve and is retained on a No. 40 (425-μm) sieve.

fine—passes a No. 40 (425-μm) sieve and is retained on a No. 200 (75-μm) sieve.

3.1.7 *silt*—soil passing a No. 200 (75-μm) sieve that is nonplastic or very slightly plastic and that exhibits little or no strength when air dry. For classification, a silt is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index less than 4, or the plot of plasticity index versus liquid limit falls below the "A" line (see Fig. 3 of Test Method D 2487).

4. Summary of Practice

4.1 Using visual examination and simple manual tests, this practice gives standardized criteria and procedures for describing and identifying soils.

4.2 The soil can be given an identification by assigning a group symbol(s) and name. The flow charts, Fig. 1a and Fig. 1b for fine-grained soils, and Fig. 2, for coarse-grained soils, can be used to assign the appropriate group symbol(s) and name. If the soil has properties which do not distinctly place it into a specific group, borderline symbols may be used, see Appendix X3.

NOTE 3—It is suggested that a distinction be made between *dual symbols* and *borderline symbols.*

Dual Symbol—A dual symbol is two symbols separated by a hyphen, for example, GP-GM, SW-SC, CL-ML used to indicate that the soil has been identified as having the properties of a classification in accordance with Test Method D 2487 where two symbols are required. Two symbols are required when the soil has between 5 and 12 % fines or when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart.

Borderline Symbol—A borderline symbol is two symbols separated by a slash, for example, CL/CH, GM/SM, CL/ML. A borderline symbol should be used to indicate that the soil has been identified as having properties that do not distinctly place the soil into a specific group (see Appendix X3).

5. Significance and Use

5.1 The descriptive information required in this practice can be used to describe a soil to aid in the evaluation of its significant properties for engineering use.

5.2 The descriptive information required in this practice should be used to supplement the classification of a soil as determined by Test Method D 2487.

5.3 This practice may be used in identifying soils using the classification group symbols and names as prescribed in Test Method D 2487. Since the names and symbols used in this practice to identify the soils are the same as those used in Test Method D 2487, it shall be clearly stated in reports and all other appropriate documents, that the classification symbol and name are based on visual-manual procedures.

5.4 This practice is to be used not only for identification of soils in the field, but also in the office, laboratory, or wherever soil samples are inspected and described.

5.5 This practice has particular value in grouping similar soil samples so that only a minimum number of laboratory tests need be run for positive soil classification.

NOTE 4—The ability to describe and identify soils correctly is learned more readily under the guidance of experienced personnel, but it may also be acquired systematically by comparing numerical laboratory test results for typical soils of each type with their visual and manual characteristics.

5.6 When describing and identifying soil samples from a given boring, test pit, or group of borings or pits, it is not necessary to follow all of the procedures in this practice for every sample. Soils which appear to be similar can be grouped together; one sample completely described and identified with the others referred to as similar based on performing only a few of the descriptive and identification procedures described in this practice.

5.7 This practice may be used in combination with Practice D 4083 when working with frozen soils.

NOTE 5—Notwithstanding the statements on precision and bias contained in this standard: The precision of this test method is dependent on the competence of the personnel performing it and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D 3740 are generally considered capable of competent and objective testing. Users of this test method are cautioned that compliance with Practice D 3740 does not in itself assure reliable testing. Reliable testing depends on several factors; Practice D 3740 provides a means for evaluating some of those factors.

6. Apparatus

6.1 *Required Apparatus*:

6.1.1 *Pocket Knife or Small Spatula.*

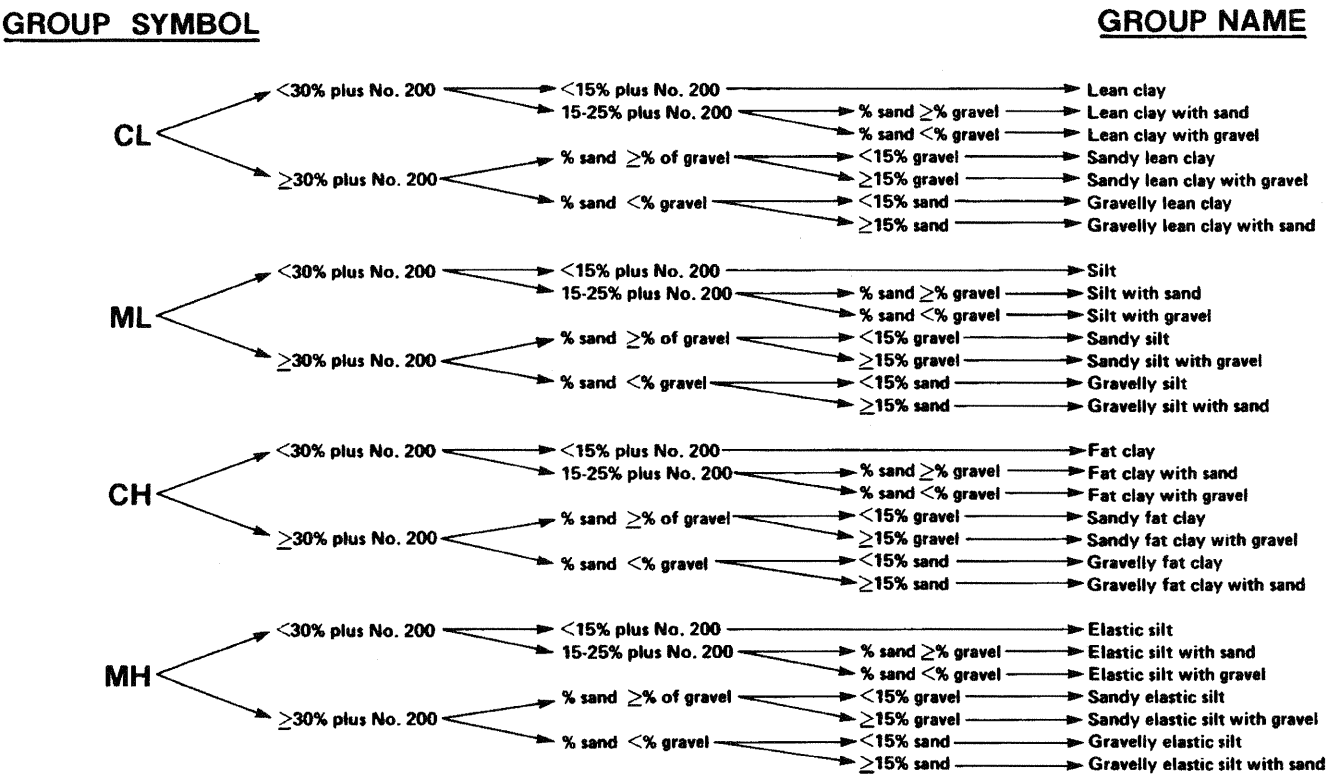
6.2 *Useful Auxiliary Apparatus*:

6.2.1 *Small Test Tube and Stopper* (or jar with a lid).

6.2.2 *Small Hand Lens.*

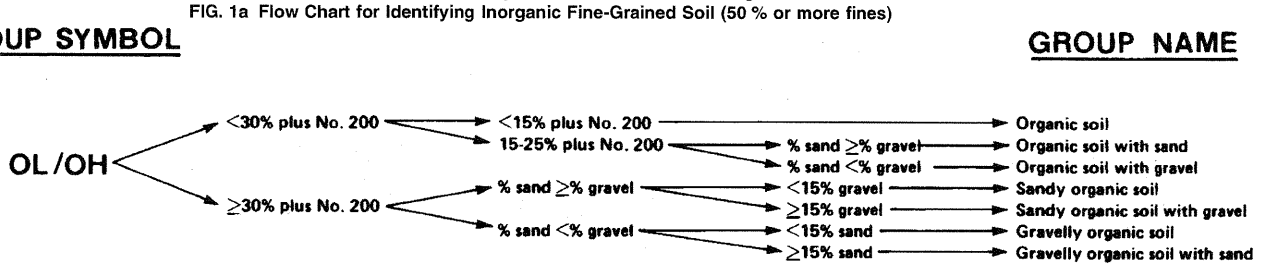
7. Reagents

7.1 *Purity of Water*—Unless otherwise indicated, references



NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1a Flow Chart for Identifying Inorganic Fine-Grained Soil (50 % or more fines)



NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1 b Flow Chart for Identifying Organic Fine-Grained Soil (50 % or more fines)

to water shall be understood to mean water from a city water supply or natural source, including non-potable water.

7.2 *Hydrochloric Acid*—A small bottle of dilute hydrochloric acid, HCl, one part HCl (10 *N*) to three parts water (This reagent is optional for use with this practice). See Section 8.

8. Safety Precautions

8.1 When preparing the dilute HCl solution of one part concentrated hydrochloric acid (10 *N*) to three parts of distilled water, slowly add acid into water following necessary safety precautions. Handle with caution and store safely. If solution comes into contact with the skin, rinse thoroughly with water.

8.2 **Caution**—Do not add water to acid.

9. Sampling

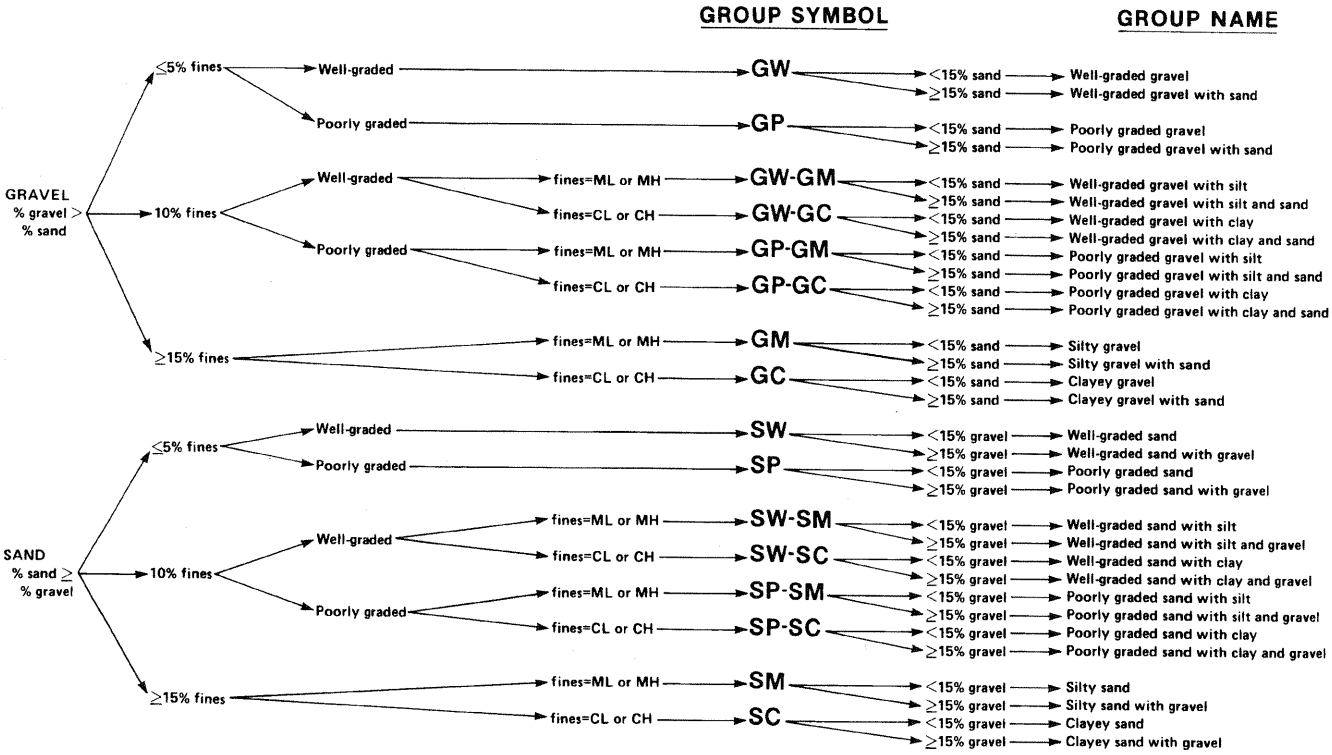
9.1 The sample shall be considered to be representative of the stratum from which it was obtained by an appropriate, accepted, or standard procedure.

NOTE 6—Preferably, the sampling procedure should be identified as having been conducted in accordance with Practices D 1452, D 1587, or D 2113, or Test Method D 1586.

9.2 The sample shall be carefully identified as to origin.

NOTE 7—Remarks as to the origin may take the form of a boring number and sample number in conjunction with a job number, a geologic stratum, a pedologic horizon or a location description with respect to a permanent monument, a grid system or a station number and offset with respect to a stated centerline and a depth or elevation.

9.3 For accurate description and identification, the minimum amount of the specimen to be examined shall be in accordance with the following schedule:



NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 2 Flow Chart for Identifying Coarse-Grained Soils (less than 50 % fines)

Maximum Particle Size, Sieve Opening	Minimum Specimen Size, Dry Weight
4.75 mm (No. 4)	100 g (0.25 lb)
9.5 mm (⅜ in.)	200 g (0.5 lb)
19.0 mm (¾ in.)	1.0 kg (2.2 lb)
38.1 mm (1½ in.)	8.0 kg (18 lb)
75.0 mm (3 in.)	60.0 kg (132 lb)

NOTE 8—If random isolated particles are encountered that are significantly larger than the particles in the soil matrix, the soil matrix can be accurately described and identified in accordance with the preceeding schedule.

9.4 If the field sample or specimen being examined is smaller than the minimum recommended amount, the report shall include an appropriate remark.

10. Descriptive Information for Soils

10.1 *Angularity*—Describe the angularity of the sand (coarse sizes only), gravel, cobbles, and boulders, as angular, subangular, subrounded, or rounded in accordance with the criteria in Table 1 and Fig. 3. A range of angularity may be stated, such as: subrounded to rounded.

10.2 *Shape*—Describe the shape of the gravel, cobbles, and boulders as flat, elongated, or flat and elongated if they meet the criteria in Table 2 and Fig. 4. Otherwise, do not mention the shape. Indicate the fraction of the particles that have the shape, such as: one-third of the gravel particles are flat.

10.3 *Color*—Describe the color. Color is an important property in identifying organic soils, and within a given locality it may also be useful in identifying materials of similar geologic origin. If the sample contains layers or patches of varying colors, this shall be noted and all representative colors shall be described. The color shall be described for moist samples. If the color represents a dry condition, this shall be stated in the report.

TABLE 1 Criteria for Describing Angularity of Coarse-Grained Particles (see Fig. 3)

Description	Criteria
Angular	Particles have sharp edges and relatively plane sides with unpolished surfaces
Subangular	Particles are similar to angular description but have rounded edges
Subrounded	Particles have nearly plane sides but have well-rounded corners and edges
Rounded	Particles have smoothly curved sides and no edges

10.4 *Odor*—Describe the odor if organic or unusual. Soils containing a significant amount of organic material usually have a distinctive odor of decaying vegetation. This is especially apparent in fresh samples, but if the samples are dried, the odor may often be revived by heating a moistened sample. If the odor is unusual (petroleum product, chemical, and the like), it shall be described.

10.5 *Moisture Condition*—Describe the moisture condition as dry, moist, or wet, in accordance with the criteria in Table 3.

10.6 *HCl Reaction*—Describe the reaction with HCl as none, weak, or strong, in accordance with the critera in Table 4. Since calcium carbonate is a common cementing agent, a report of its presence on the basis of the reaction with dilute hydrochloric acid is important.

10.7 *Consistency*—For intact fine-grained soil, describe the

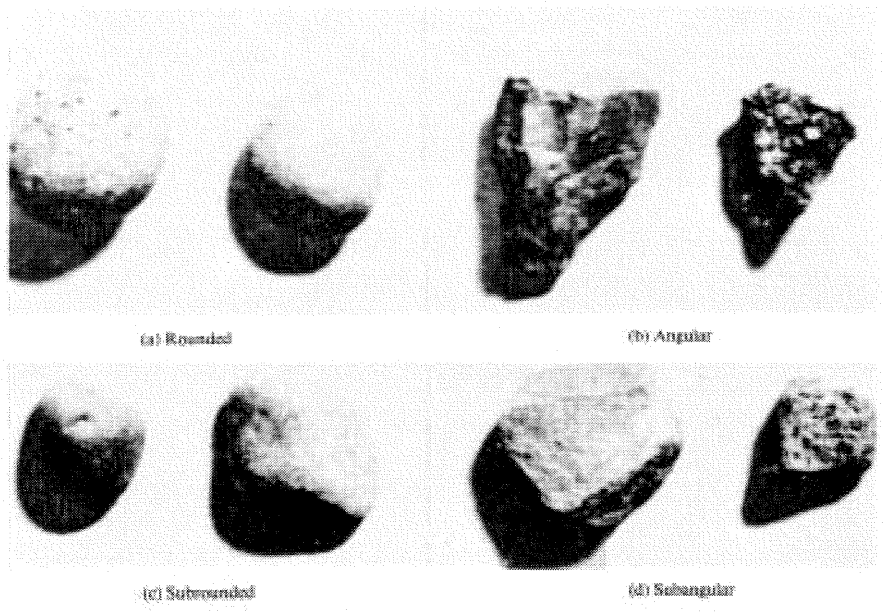


FIG. 3 Typical Angularity of Bulky Grains

TABLE 2 Criteria for Describing Particle Shape (see Fig. 4)

The particle shape shall be described as follows where length, width, and thickness refer to the greatest, intermediate, and least dimensions of a particle, respectively.	
Flat	Particles with width/thickness > 3
Elongated	Particles with length/width > 3
Flat and elongated	Particles meet criteria for both flat and elongated

consistency as very soft, soft, firm, hard, or very hard, in accordance with the criteria in Table 5. This observation is inappropriate for soils with significant amounts of gravel.

10.8 *Cementation*—Describe the cementation of intact coarse-grained soils as weak, moderate, or strong, in accordance with the criteria in Table 6.

10.9 *Structure*—Describe the structure of intact soils in accordance with the criteria in Table 7.

10.10 *Range of Particle Sizes*—For gravel and sand components, describe the range of particle sizes within each component as defined in 3.1.2 and 3.1.6. For example, about 20 % fine to coarse gravel, about 40 % fine to coarse sand.

10.11 *Maximum Particle Size*—Describe the maximum particle size found in the sample in accordance with the following information:

10.11.1 *Sand Size*—If the maximum particle size is a sand size, describe as fine, medium, or coarse as defined in 3.1.6. For example: maximum particle size, medium sand.

10.11.2 *Gravel Size*—If the maximum particle size is a gravel size, describe the maximum particle size as the smallest sieve opening that the particle will pass. For example, maximum particle size, 1½ in. (will pass a 1½-in. square opening but not a ¾-in. square opening).

10.11.3 *Cobble or Boulder Size*—If the maximum particle size is a cobble or boulder size, describe the maximum dimension of the largest particle. For example: maximum dimension, 18 in. (450 mm).

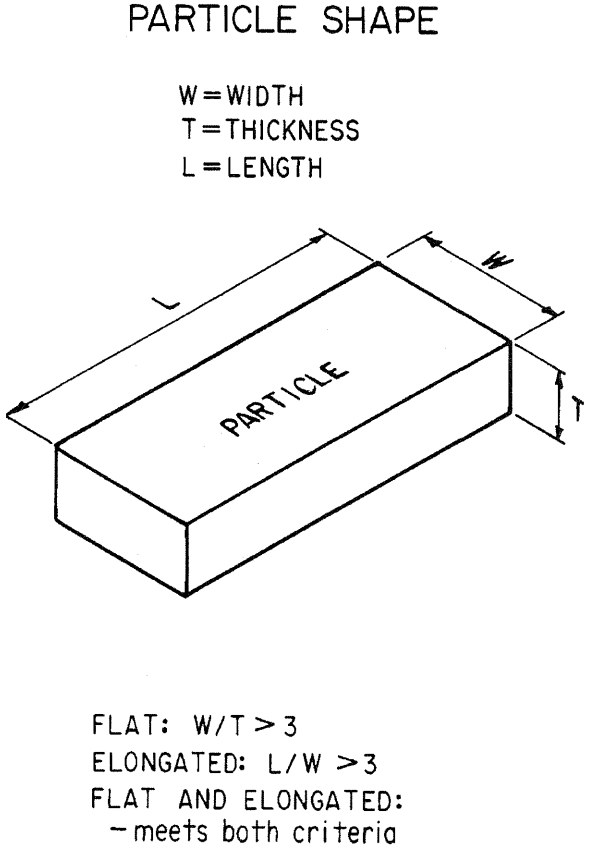


FIG. 4 Criteria for Particle Shape

10.12 *Hardness*—Describe the hardness of coarse sand and larger particles as hard, or state what happens when the

TABLE 3 Criteria for Describing Moisture Condition

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

TABLE 4 Criteria for Describing the Reaction With HCl

Description	Criteria
None	No visible reaction
Weak	Some reaction, with bubbles forming slowly
Strong	Violent reaction, with bubbles forming immediately

TABLE 5 Criteria for Describing Consistency

Description	Criteria
Very soft	Thumb will penetrate soil more than 1 in. (25 mm)
Soft	Thumb will penetrate soil about 1 in. (25 mm)
Firm	Thumb will indent soil about ¼in. (6 mm)
Hard	Thumb will not indent soil but readily indented with thumbnail
Very hard	Thumbnail will not indent soil

TABLE 6 Criteria for Describing Cementation

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure
Moderate	Crumbles or breaks with considerable finger pressure
Strong	Will not crumble or break with finger pressure

TABLE 7 Criteria for Describing Structure

Description	Criteria
Stratified	Alternating layers of varying material or color with layers at least 6 mm thick; note thickness
Laminated	Alternating layers of varying material or color with the layers less than 6 mm thick; note thickness
Fissured	Breaks along definite planes of fracture with little resistance to fracturing
Slickensided	Fracture planes appear polished or glossy, sometimes striated
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay; note thickness
Homogeneous	Same color and appearance throughout

particles are hit by a hammer, for example, gravel-size particles fracture with considerable hammer blow, some gravel-size particles crumble with hammer blow. "Hard" means particles do not crack, fracture, or crumble under a hammer blow.

10.13 Additional comments shall be noted, such as the presence of roots or root holes, difficulty in drilling or augering hole, caving of trench or hole, or the presence of mica.

10.14 A local or commercial name or a geologic interpretation of the soil, or both, may be added if identified as such.

10.15 A classification or identification of the soil in accordance with other classification systems may be added if identified as such.

11. Identification of Peat

11.1 A sample composed primarily of vegetable tissue in various stages of decomposition that has a fibrous to amorphous texture, usually a dark brown to black color, and an organic odor, shall be designated as a highly organic soil and shall be identified as peat, PT, and not subjected to the identification procedures described hereafter.

12. Preparation for Identification

12.1 The soil identification portion of this practice is based on the portion of the soil sample that will pass a 3-in. (75-mm) sieve. The larger than 3-in. (75-mm) particles must be removed, manually, for a loose sample, or mentally, for an intact sample before classifying the soil.

12.2 Estimate and note the percentage of cobbles and the percentage of boulders. Performed visually, these estimates will be on the basis of volume percentage.

NOTE 9—Since the percentages of the particle-size distribution in Test Method D 2487 are by dry weight, and the estimates of percentages for gravel, sand, and fines in this practice are by dry weight, it is recommended that the report state that the percentages of cobbles and boulders are by volume.

12.3 Of the fraction of the soil smaller than 3 in. (75 mm), estimate and note the percentage, by dry weight, of the gravel, sand, and fines (see Appendix X4 for suggested procedures).

NOTE 10—Since the particle-size components appear visually on the basis of volume, considerable experience is required to estimate the percentages on the basis of dry weight. Frequent comparisons with laboratory particle-size analyses should be made.

12.3.1 The percentages shall be estimated to the closest 5 %. The percentages of gravel, sand, and fines must add up to 100 %.

12.3.2 If one of the components is present but not in sufficient quantity to be considered 5 % of the smaller than 3-in. (75-mm) portion, indicate its presence by the term *trace*, for example, trace of fines. A trace is not to be considered in the total of 100 % for the components.

13. Preliminary Identification

13.1 The soil is *fine grained* if it contains 50 % or more fines. Follow the procedures for identifying fine-grained soils of Section 14.

13.2 The soil is *coarse grained* if it contains less than 50 % fines. Follow the procedures for identifying coarse-grained soils of Section 15.

14. Procedure for Identifying Fine-Grained Soils

14.1 Select a representative sample of the material for examination. Remove particles larger than the No. 40 sieve (medium sand and larger) until a specimen equivalent to about a handful of material is available. Use this specimen for performing the dry strength, dilatancy, and toughness tests.

14.2 *Dry Strength*:

14.2.1 From the specimen, select enough material to mold into a ball about 1 in. (25 mm) in diameter. Mold the material until it has the consistency of putty, adding water if necessary.

14.2.2 From the molded material, make at least three test specimens. A test specimen shall be a ball of material about ½ in. (12 mm) in diameter. Allow the test specimens to dry in air, or sun, or by artificial means, as long as the temperature does not exceed 60°C.

14.2.3 If the test specimen contains natural dry lumps, those that are about ½ in. (12 mm) in diameter may be used in place of the molded balls.

NOTE 11—The process of molding and drying usually produces higher strengths than are found in natural dry lumps of soil.

14.2.4 Test the strength of the dry balls or lumps by crushing between the fingers. Note the strength as none, low, medium, high, or very high in accorance with the criteria in Table 8. If natural dry lumps are used, do not use the results of any of the lumps that are found to contain particles of coarse sand.

14.2.5 The presence of high-strength water-soluble cementing materials, such as calcium carbonate, may cause exceptionally high dry strengths. The presence of calcium carbonate can usually be detected from the intensity of the reaction with dilute hydrochloric acid (see 10.6).

14.3 *Dilatancy*:

14.3.1 From the specimen, select enough material to mold into a ball about ½ in. (12 mm) in diameter. Mold the material, adding water if necessary, until it has a soft, but not sticky, consistency.

14.3.2 Smooth the soil ball in the palm of one hand with the blade of a knife or small spatula. Shake horizontally, striking the side of the hand vigorously against the other hand several times. Note the reaction of water appearing on the surface of the soil. Squeeze the sample by closing the hand or pinching the soil between the fingers, and note the reaction as none, slow, or rapid in accordance with the criteria in Table 9. The reaction is the speed with which water appears while shaking, and disappears while squeezing.

14.4 *Toughness*:

14.4.1 Following the completion of the dilatancy test, the test specimen is shaped into an elongated pat and rolled by hand on a smooth surface or between the palms into a thread about ⅛ in. (3 mm) in diameter. (If the sample is too wet to roll easily, it should be spread into a thin layer and allowed to lose some water by evaporation.) Fold the sample threads and reroll repeatedly until the thread crumbles at a diameter of about ⅛ in. The thread will crumble at a diameter of ⅛ in. when the soil is near the plastic limit. Note the pressure required to roll the thread near the plastic limit. Also, note the strength of the thread. After the thread crumbles, the pieces should be lumped together and kneaded until the lump crumbles. Note the toughness of the material during kneading.

14.4.2 Describe the toughness of the thread and lump as low, medium, or high in accordance with the criteria in Table 10.

TABLE 8 Criteria for Describing Dry Strength

Description	Criteria
None	The dry specimen crumbles into powder with mere pressure of handling
Low	The dry specimen crumbles into powder with some finger pressure
Medium	The dry specimen breaks into pieces or crumbles with considerable finger pressure
High	The dry specimen cannot be broken with finger pressure. Specimen will break into pieces between thumb and a hard surface
Very high	The dry specimen cannot be broken between the thumb and a hard surface

TABLE 9 Criteria for Describing Dilatancy

Description	Criteria
None	No visible change in the specimen
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing

14.5 *Plasticity*—On the basis of observations made during the toughness test, describe the plasticity of the material in accordance with the criteria given in Table 11.

14.6 Decide whether the soil is an *inorganic* or an *organic* fine-grained soil (see 14.8). If inorganic, follow the steps given in 14.7.

14.7 *Identification of Inorganic Fine-Grained Soils*:

14.7.1 Identify the soil as a *lean clay*, CL, if the soil has medium to high dry strength, no or slow dilatancy, and medium toughness and plasticity (see Table 12).

14.7.2 Identify the soil as a *fat clay*, CH, if the soil has high to very high dry strength, no dilatancy, and high toughness and plasticity (see Table 12).

14.7.3 Identify the soil as a *silt*, ML, if the soil has no to low dry strength, slow to rapid dilatancy, and low toughness and plasticity, or is nonplastic (see Table 12).

14.7.4 Identify the soil as an *elastic silt*, MH, if the soil has low to medium dry strength, no to slow dilatancy, and low to medium toughness and plasticity (see Table 12).

NOTE 12—These properties are similar to those for a lean clay. However, the silt will dry quickly on the hand and have a smooth, silky feel when dry. Some soils that would classify as MH in accordance with the criteria in Test Method D 2487 are visually difficult to distinguish from lean clays, CL. It may be necessary to perform laboratory testing for proper identification.

14.8 *Identification of Organic Fine-Grained Soils*:

14.8.1 Identify the soil as an *organic soil*, OL/OH, if the soil contains enough organic particles to influence the soil properties. Organic soils usually have a dark brown to black color and may have an organic odor. Often, organic soils will change color, for example, black to brown, when exposed to the air. Some organic soils will lighten in color significantly when air dried. Organic soils normally will not have a high toughness or plasticity. The thread for the toughness test will be spongy.

NOTE 13—In some cases, through practice and experience, it may be possible to further identify the organic soils as organic silts or organic clays, OL or OH. Correlations between the dilatancy, dry strength, toughness tests, and laboratory tests can be made to identify organic soils in certain deposits of similar materials of known geologic origin.

TABLE 10 Criteria for Describing Toughness

Description	Criteria
Low	Only slight pressure is required to roll the thread near the plastic limit. The thread and the lump are weak and soft
Medium	Medium pressure is required to roll the thread to near the plastic limit. The thread and the lump have medium stiffness
High	Considerable pressure is required to roll the thread to near the plastic limit. The thread and the lump have very high stiffness

TABLE 11 Criteria for Describing Plasticity

Description	Criteria
Nonplastic	A 1/8-in. (3-mm) thread cannot be rolled at any water content
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit

TABLE 12 Identification of Inorganic Fine-Grained Soils from Manual Tests

Soil Symbol	Dry Strength	Dilatancy	Toughness
ML	None to low	Slow to rapid	Low or thread cannot be formed
CL	Medium to high	None to slow	Medium
MH	Low to medium	None to slow	Low to medium
CH	High to very high	None	High

14.9 If the soil is estimated to have 15 to 25 % sand or gravel, or both, the words "with sand" or "with gravel" (whichever is more predominant) shall be added to the group name. For example: "lean clay with sand, CL" or "silt with gravel, ML" (see Fig. 1a and Fig. 1b). If the percentage of sand is equal to the percentage of gravel, use "with sand."

14.10 If the soil is estimated to have 30 % or more sand or gravel, or both, the words "sandy" or "gravelly" shall be added to the group name. Add the word "sandy" if there appears to be more sand than gravel. Add the word "gravelly" if there appears to be more gravel than sand. For example: "sandy lean clay, CL", "gravelly fat clay, CH", or "sandy silt, ML" (see Fig. 1a and Fig. 1b). If the percentage of sand is equal to the percent of gravel, use "sandy."

15. Procedure for Identifying Coarse-Grained Soils

(Contains less than 50 % fines)

15.1 The soil is a *gravel* if the percentage of gravel is estimated to be more than the percentage of sand.

15.2 The soil is a *sand* if the percentage of gravel is estimated to be equal to or less than the percentage of sand.

15.3 The soil is a *clean gravel* or *clean sand* if the percentage of fines is estimated to be 5 % or less.

15.3.1 Identify the soil as a *well-graded gravel*, GW, or as a *well-graded sand*, SW, if it has a wide range of particle sizes and substantial amounts of the intermediate particle sizes.

15.3.2 Identify the soil as a *poorly graded gravel*, GP, or as a *poorly graded sand*, SP, if it consists predominantly of one size (uniformly graded), or it has a wide range of sizes with some intermediate sizes obviously missing (gap or skip graded).

15.4 The soil is either a *gravel with fines* or a *sand with fines* if the percentage of fines is estimated to be 15 % or more.

15.4.1 Identify the soil as a *clayey gravel*, GC, or a *clayey sand*, SC, if the fines are clayey as determined by the procedures in Section 14.

15.4.2 Identify the soil as a *silty gravel*, GM, or a *silty sand*, SM, if the fines are silty as determined by the procedures in Section 14.

15.5 If the soil is estimated to contain 10 % fines, give the soil a dual identification using two group symbols.

15.5.1 The first group symbol shall correspond to a clean gravel or sand (GW, GP, SW, SP) and the second symbol shall correspond to a gravel or sand with fines (GC, GM, SC, SM).

15.5.2 The group name shall correspond to the first group symbol plus the words "with clay" or "with silt" to indicate the plasticity characteristics of the fines. For example: "well-graded gravel with clay, GW-GC" or "poorly graded sand with silt, SP-SM" (see Fig. 2).

15.6 If the specimen is predominantly sand or gravel but contains an estimated 15 % or more of the other coarse-grained constituent, the words "with gravel" or "with sand" shall be added to the group name. For example: "poorly graded gravel with sand, GP" or "clayey sand with gravel, SC" (see Fig. 2).

15.7 If the field sample contains any cobbles or boulders, or both, the words "with cobbles" or "with cobbles and boulders" shall be added to the group name. For example: "silty gravel with cobbles, GM."

16. Report

16.1 The report shall include the information as to origin, and the items indicated in Table 13.

NOTE 14—*Example: Clayey Gravel with Sand and Cobbles, GC*—About 50 % fine to coarse, subrounded to subangular gravel; about 30 % fine to coarse, subrounded sand; about 20 % fines with medium plasticity, high dry strength, no dilatancy, medium toughness; weak reaction with HCl; original field sample had about 5 % (by volume) subrounded cobbles, maximum dimension, 150 mm.

In-Place Conditions—Firm, homogeneous, dry, brown

Geologic Interpretation—Alluvial fan

TABLE 13 Checklist for Description of Soils

1. Group name
2. Group symbol
3. Percent of cobbles or boulders, or both (by volume)
4. Percent of gravel, sand, or fines, or all three (by dry weight)
5. Particle-size range:
   Gravel—fine, coarse
   Sand—fine, medium, coarse
6. Particle angularity: angular, subangular, subrounded, rounded
7. Particle shape: (if appropriate) flat, elongated, flat and elongated
8. Maximum particle size or dimension
9. Hardness of coarse sand and larger particles
10. Plasticity of fines: nonplastic, low, medium, high
11. Dry strength: none, low, medium, high, very high
12. Dilatancy: none, slow, rapid
13. Toughness: low, medium, high
14. Color (in moist condition)
15. Odor (mention only if organic or unusual)
16. Moisture: dry, moist, wet
17. Reaction with HCl: none, weak, strong

For intact samples:

18. Consistency (fine-grained soils only): very soft, soft, firm, hard, very hard
19. Structure: stratified, laminated, fissured, slickensided, lensed, homogeneous
20. Cementation: weak, moderate, strong
21. Local name
22. Geologic interpretation
23. Additional comments: presence of roots or root holes, presence of mica, gypsum, etc., surface coatings on coarse-grained particles, caving or sloughing of auger hole or trench sides, difficulty in augering or excavating, etc.

NOTE 15—Other examples of soil descriptions and identification are given in Appendix X1 and Appendix X2.

NOTE 16—If desired, the percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages, as follows:

Trace—Particles are present but estimated to be less than 5 %
Few—5 to 10 %
Little—15 to 25 %
Some—30 to 45 %
Mostly—50 to 100 %

16.2 If, in the soil description, the soil is identified using a classification group symbol and name as described in Test Method D 2487, it must be distinctly and clearly stated in log forms, summary tables, reports, and the like, that the symbol and name are based on visual-manual procedures.

17. Precision and Bias

17.1 This practice provides qualitative information only, therefore, a precision and bias statement is not applicable.

18. Keywords

18.1 classification; clay; gravel; organic soils; sand; silt; soil classification; soil description; visual classification

APPENDIXES

(Nonmandatory Information)

X1. EXAMPLES OF VISUAL SOIL DESCRIPTIONS

X1.1 The following examples show how the information required in 16.1 can be reported. The information that is included in descriptions should be based on individual circumstances and need.

X1.1.1 *Well-Graded Gravel with Sand (GW)*—About 75 % fine to coarse, hard, subangular gravel; about 25 % fine to coarse, hard, subangular sand; trace of fines; maximum size, 75 mm, brown, dry; no reaction with HCl.

X1.1.2 *Silty Sand with Gravel (SM)*—About 60 % predominantly fine sand; about 25 % silty fines with low plasticity, low dry strength, rapid dilatancy, and low toughness; about 15 % fine, hard, subrounded gravel, a few gravel-size particles fractured with hammer blow; maximum size, 25 mm; no reaction with HCl (Note—Field sample size smaller than recommended).

In-Place Conditions—Firm, stratified and contains lenses of silt 1 to 2 in. (25 to 50 mm) thick, moist, brown to gray; in-place density 106 lb/ft^3; in-place moisture 9 %.

X1.1.3 *Organic Soil (OL/OH)*—About 100 % fines with low plasticity, slow dilatancy, low dry strength, and low toughness; wet, dark brown, organic odor; weak reaction with HCl.

X1.1.4 *Silty Sand with Organic Fines (SM)*—About 75 % fine to coarse, hard, subangular reddish sand; about 25 % organic and silty dark brown nonplastic fines with no dry strength and slow dilatancy; wet; maximum size, coarse sand; weak reaction with HCl.

X1.1.5 *Poorly Graded Gravel with Silt, Sand, Cobbles and Boulders (GP-GM)*—About 75 % fine to coarse, hard, subrounded to subangular gravel; about 15 % fine, hard, subrounded to subangular sand; about 10 % silty nonplastic fines; moist, brown; no reaction with HCl; original field sample had about 5 % (by volume) hard, subrounded cobbles and a trace of hard, subrounded boulders, with a maximum dimension of 18 in. (450 mm).

X2. USING THE IDENTIFICATION PROCEDURE AS A DESCRIPTIVE SYSTEM FOR SHALE, CLAYSTONE, SHELLS, SLAG, CRUSHED ROCK, AND THE LIKE

X2.1 The identification procedure may be used as a descriptive system applied to materials that exist in-situ as shale, claystone, sandstone, siltstone, mudstone, etc., but convert to soils after field or laboratory processing (crushing, slaking, and the like).

X2.2 Materials such as shells, crushed rock, slag, and the like, should be identified as such. However, the procedures used in this practice for describing the particle size and plasticity characteristics may be used in the description of the material. If desired, an identification using a group name and symbol according to this practice may be assigned to aid in describing the material.

X2.3 The group symbol(s) and group names should be placed in quotation marks or noted with some type of distinguishing symbol. See examples.

X2.4 Examples of how group names and symbols can be incororated into a descriptive system for materials that are not naturally occurring soils are as follows:

X2.4.1 *Shale Chunks*—Retrieved as 2 to 4-in. (50 to 100-mm) pieces of shale from power auger hole, dry, brown, no reaction with HCl. After slaking in water for 24 h, material identified as "Sandy Lean Clay (CL)"; about 60 % fines with medium plasticity, high dry strength, no dilatancy, and medium toughness; about 35 % fine to medium, hard sand; about 5 % gravel-size pieces of shale.

X2.4.2 *Crushed Sandstone*—Product of commercial crushing operation; "Poorly Graded Sand with Silt (SP-SM)"; about 90 % fine to medium sand; about 10 % nonplastic fines; dry, reddish-brown, strong reaction with HCl.

X2.4.3 *Broken Shells*—About 60 % gravel-size broken

shells; about 30 % sand and sand-size shell pieces; about 10 % fines; "Poorly Graded Gravel with Sand (GP)."

X2.4.4 *Crushed Rock*—Processed from gravel and cobbles in Pit No. 7; "Poorly Graded Gravel (GP)"; about 90 % fine, hard, angular gravel-size particles; about 10 % coarse, hard, angular sand-size particles; dry, tan; no reaction with HCl.

X3. SUGGESTED PROCEDURE FOR USING A BORDERLINE SYMBOL FOR SOILS WITH TWO POSSIBLE IDENTIFICATIONS.

X3.1 Since this practice is based on estimates of particle size distribution and plasticity characteristics, it may be difficult to clearly identify the soil as belonging to one category. To indicate that the soil may fall into one of two possible basic groups, a borderline symbol may be used with the two symbols separated by a slash. For example: SC/CL or CL/CH.

X3.1.1 A borderline symbol may be used when the percentage of fines is estimated to be between 45 and 55 %. One symbol should be for a coarse-grained soil with fines and the other for a fine-grained soil. For example: GM/ML or CL/SC.

X3.1.2 A borderline symbol may be used when the percentage of sand and the percentage of gravel are estimated to be about the same. For example: GP/SP, SC/GC, GM/SM. It is practically impossible to have a soil that would have a borderline symbol of GW/SW.

X3.1.3 A borderline symbol may be used when the soil could be either well graded or poorly graded. For example: GW/GP, SW/SP.

X3.1.4 A borderline symbol may be used when the soil could either be a silt or a clay. For example: CL/ML, CH/MH, SC/SM.

X3.1.5 A borderline symbol may be used when a fine-grained soil has properties that indicate that it is at the boundary between a soil of low compressibility and a soil of high compressibility. For example: CL/CH, MH/ML.

X3.2 The order of the borderline symbols should reflect similarity to surrounding or adjacent soils. For example: soils in a borrow area have been identified as CH. One sample is considered to have a borderline symbol of CL and CH. To show similarity, the borderline symbol should be CH/CL.

X3.3 The group name for a soil with a borderline symbol should be the group name for the first symbol, except for:

CL/CH lean to fat clay
ML/CL clayey silt
CL/ML silty clay

X3.4 The use of a borderline symbol should not be used indiscriminately. Every effort shall be made to first place the soil into a single group.

X4. SUGGESTED PROCEDURES FOR ESTIMATING THE PERCENTAGES OF GRAVEL, SAND, AND FINES IN A SOIL SAMPLE

X4.1 *Jar Method*—The relative percentage of coarse- and fine-grained material may be estimated by thoroughly shaking a mixture of soil and water in a test tube or jar, and then allowing the mixture to settle. The coarse particles will fall to the bottom and successively finer particles will be deposited with increasing time; the sand sizes will fall out of suspension in 20 to 30 s. The relative proportions can be estimated from the relative volume of each size separate. This method should be correlated to particle-size laboratory determinations.

X4.2 *Visual Method*—Mentally visualize the gravel size particles placed in a sack (or other container) or sacks. Then, do the same with the sand size particles and the fines. Then, mentally compare the number of sacks to estimate the percentage of plus No. 4 sieve size and minus No. 4 sieve size present. The percentages of sand and fines in the minus sieve size No. 4 material can then be estimated from the wash test (X4.3).

X4.3 *Wash Test (for relative percentages of sand and fines)*—Select and moisten enough minus No. 4 sieve size material to form a 1-in (25-mm) cube of soil. Cut the cube in half, set one-half to the side, and place the other half in a small dish. Wash and decant the fines out of the material in the dish until the wash water is clear and then compare the two samples and estimate the percentage of sand and fines. Remember that the percentage is based on weight, not volume. However, the volume comparison will provide a reasonable indication of grain size percentages.

X4.3.1 While washing, it may be necessary to break down lumps of fines with the finger to get the correct percentages.

X5. ABBREVIATED SOIL CLASSIFICATION SYMBOLS

X5.1 In some cases, because of lack of space, an abbreviated system may be useful to indicate the soil classification symbol and name. Examples of such cases would be graphical logs, databases, tables, etc.

X5.2 This abbreviated system is not a substitute for the full name and descriptive information but can be used in supplementary presentations when the complete description is referenced.

X5.3 The abbreviated system should consist of the soil classification symbol based on this standard with appropriate lower case letter prefixes and suffixes as:

Prefix:	Suffix:
s = sandy	s = with sand
g = gravelly	g = with gravel
	c = with cobbles
	b = with boulders

X5.4 The soil classification symbol is to be enclosed in parenthesis. Some examples would be:

Group Symbol and Full Name	Abbreviated
CL, Sandy lean clay	s(CL)
SP-SM, Poorly graded sand with silt and gravel	(SP-SM)g
GP, poorly graded gravel with sand, cobbles, and boulders	(GP)scb
ML, gravelly silt with sand and cobbles	g(ML)sc

SUMMARY OF CHANGES

In accordance with Committee D18 policy, this section identifies the location of changes to this standard since the last edition (1993$^{\epsilon 1}$) that may impact the use of this standard.

(1) Added Practice D 3740 to Section 2.

(2) Added Note 5 under 5.7 and renumbered subsequent notes.

APPENDIX D

ADEQ DATA QUALIFIERS

Arizona Laboratory Data Qualifiers

Revision 1.0
03/20/2002

(Developed by the Technical Subcommittee of the Arizona Environmental Laboratory Advisory Committee. This is a revised list with additional qualifiers added to the original list dated 12/11/2000)

Microbiology:

A1 = Too numerous to count.

A2 = Sample incubation period exceeded method requirement.

A3 = Sample incubation period was shorter than method requirement.

A4 = Target organism detected in associated method blank.

A5 = Incubator/water bath temperature was outside method requirements.

A6 = Target organism not detected in associated positive control.

A7 = Micro sample received without adequate headspace.

Method blank:

B1 = Target analyte detected in method blank at or above the method reporting limit.

B2 = Non-target analyte detected in method blank and sample, producing interference.

B3 = Target analyte detected in calibration blank at or above the method reporting limit.

B4 = Target analyte detected in blank at/above method acceptance criteria.

B5 = Target analyte detected in method blank at or above the method reporting limit, but below trigger level or MCL.

B6 = Target analyte detected in calibration blank at or above the method reporting limit, but below trigger level or MCL.

B7 = Target analyte detected in method blank at or above the method reporting limit. Concentration found in the sample was 10 times above the concentration found in the method blank.

Confirmation:

C1 = Confirmatory analysis not performed as required by the method.

C2 = Confirmatory analysis not performed. Confirmation of analyte presence established by site historical data.

C3 = Qualitative confirmation performed. See case narrative.

C4 = Confirmatory analysis was past holding time.

C5 = Confirmatory analysis was past holding time. Original result not confirmed.

Dilution:

D1 = Sample required dilution due to matrix interference. See case narrative.

D2 = Sample required dilution due to high concentration of target analyte.

D3 = Sample dilution required due to insufficient sample.

D4 = Minimum reporting level (MRL) adjusted to reflect sample amount received and analyzed.

Estimated concentration:

E1 = Concentration estimated. Analyte exceeded calibration range. Reanalysis not possible due to insufficient sample.

E2 = Concentration estimated. Analyte exceeded calibration range. Reanalysis not performed due to sample matrix.

E3 = Concentration estimated. Analyte exceeded calibration range. Reanalysis not performed due to holding time requirements.

E4 = Concentration estimated. Analyte was detected below laboratory minimum reporting level (MRL).

E5 = Concentration estimated. Analyte was detected below laboratory minimum reporting level (MRL), but not confirmed by alternate analysis.

E6 = Concentration estimated. Internal standard recoveries did not meet method acceptance criteria.

E7 = Concentration estimated. Internal standard recoveries did not meet laboratory acceptance criteria.

Hold time:

H1 = Sample analysis performed past holding time. See case narrative.

H2 = Initial analysis within holding time. Reanalysis for the required dilution was past holding time.

H3 = Sample was received and analyzed past holding time.

H4 = Sample was extracted past required extraction holding time, but analyzed within analysis holding time. See case narrative.

BOD:

K1 = The sample dilutions set-up for the BOD analysis did not meet the oxygen depletion criteria of at least 2 mg/L. Any reported result is an estimated value.

K2 = The sample dilutions set up for the BOD analysis did not meet the criteria of a residual dissolved oxygen of at least 1 mg/L. Any reported result is an estimated value.

K3 = The seed depletion was outside the method acceptance limits.

K4 = The seed depletion was outside the method and laboratory acceptance limits. The reported result is an estimated value.

K5 = The dilution water D.O. depletion was > 0.2 mg/L.

K6 = Glucose/glutamic acid BOD was below method acceptance criteria.

K7 = A discrepancy between the BOD and COD results has been verified by reanalysis of the sample for COD.

K8 = Glucose/glutamic acid BOD was above method acceptance levels.

Laboratory fortified blank/blank spike:

L1 = The associated blank spike recovery was above laboratory acceptance limits. See case narrative.

L2 = The associated blank spike recovery was below laboratory acceptance limits. See case narrative.

L3 = The associated blank spike recovery was above method acceptance limits. See case narrative.

L4 = The associated blank spike recovery was below method acceptance limits. See case narrative.

Note: The L1, L2, L3 & L4 footnotes need to be added to all corresponding analytes for a sample.

Matrix spike:

M1 = Matrix spike recovery was high, the method control sample recovery was acceptable.

M2 = Matrix spike recovery was low, the method control sample recovery was acceptable.

M3 = The accuracy of the spike recovery value is reduced since the analyte concentration in the sample is disproportionate to spike level. The method control sample recovery was acceptable.

M4 = The analysis of the spiked sample required a dilution such that the spike concentration was diluted below the reporting limit. The method control sample recovery was acceptable.

M5 = Analyte concentration was determined by the method of standard addition (MSA).

M6 = Matrix spike recovery was high. Data reported per ADEQ policy 0154.000.

M7 = Matrix spike recovery was low. Data reported per ADEQ policy 0154.000.

General:

N1 = See case narrative.

N2 = See corrective action report.

Sample quality:

Q1 = Sample integrity was not maintained. See case narrative.

Q2 = Sample received with head space.

Q3 = Sample received with improper chemical preservation.

Q4 = Sample received and analyzed without chemical preservation.

Q5 = Sample received with inadequate chemical preservation, but preserved by the laboratory.

Q6 = Sample was received above recommended temperature.

Q7 = Sample inadequately dechlorinated.

Q8 = Insufficient sample received to meet method QC requirements. QC requirements satisfy ADEQ policies 0154 and 0155.

Q9 = Insufficient sample received to meet method QC requirements.

Q10= Sample received in inappropriate sample container.

Q11= Sample is heterogeneous. Sample homogeneity could not be readily achieved using routine laboratory practices.

Duplicates:

R1 = RPD exceeded the method control limit. See case narrative.

R2 = RPD exceeded the laboratory control limit. See case narrative.

R3 = Sample RPD between the primary and confirmatory analysis exceeded 40%. Per EPA Method 8000B, the higher value was reported.

R4 = MS/MSD RPD exceeded the method control limit. Recovery met acceptance criteria.

R5 = MS/MSD RPD exceeded the laboratory control limit. Recovery met acceptance criteria.

R6 = LFB/LFBD RPD exceeded the method control limit. Recovery met acceptance criteria.

R7 = LFB/LFBD RPD exceeded the laboratory control limit. Recovery met acceptance criteria.

R8 = Sample RPD exceeded the method control limit.

R9 = Sample RPD exceeded the laboratory control limit.

Surrogate:

S1 = Surrogate recovery was above laboratory acceptance limits, but within method acceptance limits.

S2 = Surrogate recovery was above laboratory and method acceptance limits.

S3 = Surrogate recovery was above laboratory acceptance limits, but within method acceptance limits. No target analytes were detected in the sample.

S4 = Surrogate recovery was above laboratory and method acceptance limits. No target analytes were detected in the sample.

S5 = Surrogate recovery was below laboratory acceptance limits, but within method acceptance limits.

S6 = Surrogate recovery was below laboratory and method acceptance limits. Reextraction and/or reanalysis confirms low recovery caused by matrix effect.

S7 = Surrogate recovery was below laboratory and method acceptance limits. Unable to confirm matrix effect.

S8 = The analysis of the sample required a dilution such that the surrogate concentration was diluted below the method acceptance criteria. The method control sample recovery was acceptable.

S9 = The analysis of the sample required a dilution such that the surrogate concentration was diluted below the laboratory acceptance criteria. The method control sample recovery was acceptable.

S10 = Surrogate recovery was above laboratory and method acceptance limits. See Case narrative.

S11 = Surrogate recovery was high. Data reported per ADEQ policy 0154.000.

S12 = Surrogate recovery was low. Data reported per ADEQ policy 0154.000.

Method/analyte discrepancies:

T1 = Method promulgated by EPA, but not by ADHS at this time.

T2 = Cited ADHS licensed method does not contain this analyte as part of method compound list.

T3 = Method not promulgated either by EPA or ADHS.

T4 = Tentatively identified compound. Concentration is estimated and based on the closest internal standard.

Calibration verification:

V1 = CCV recovery was above method acceptance limits. This target analyte was not detected in the sample.

V2 = CCV recovery was above method acceptance limits. This target analyte was detected in the sample. The sample could not be reanalyzed due to insufficient sample.

V3 = CCV recovery was above method acceptance limits. This target analyte was detected in the sample, but the sample was not reanalyzed. See case narrative.

V4 = CCV recovery was below method acceptance limits. The sample could not be reanalyzed due to insufficient sample.

V5 = CCV recovery after a group of samples was above acceptance limits. This target analyte was not detected in the sample. Acceptable per EPA Method 8000B.

V6 = Data reported from one-pont calibration criteria per ADEQ policy 0155.000.

V7 = Calibration verification recovery was above the method control limit for this analyte, however the average % difference or % drift for all the analytes met method criteria.

V8 = Calibration verification recovery was below the method control limit for this analyte, however the average % difference or % drift for all the analytes met method criteria.

Calibration:

W1 = The % RSD for this compound was above 15%. The average % RSD for all compounds in the calibration met the 15% criteria as specified in EPA method 8000B.

APPENDIX B

URS FIELD SOPS

1.0 PURPOSE

The purpose of this Standard Operating Procedure is to describe procedures to reduce the risk of contact with buried or above ground utility service lines.

2.0 SCOPE

This Standard Operating Procedure applies to all work involving field activities where there is possible contact with subsurface utilities or above ground utilities.

3.0 METHOD

3.1 General

Buried utilities of concern are typically electrical, water, gas, sewer, storm drains, industrial waste lines, and fiber-optic communication lines. Several types of geophysical methods may be used to locate buried utilities, including ground-penetrating radar, pipe and cable locator, electromagnetic survey, and magnetometry.

3.2 Procedures

The following procedures apply to determining the locations of buried and above ground utility lines, and for associated recordkeeping.

3.2.1 Buried Utilities

Any available property maps, as-built drawings, and utility maps will be reviewed before beginning activities on site. During a site inspection, any discrepancies or new information regarding utilities will be added to the work site maps.

3.2.1.1 Public Utilities

Arizona Blue Stake (800-STAKEIT) will be contacted for a utility markout prior to initiating intrusive sampling activity other than surface soil sampling. A utility clearance form (Form 103) will be completed and approved for all sampling locations. As a general rule, utilities are marked using the following color code:

- White - work location;
- Red - electrical;
- Yellow - gas or oil;
- Orange – telephone, communication, cable, and fiber optic;
- Blue - water; and
- Green - sewer.

All uncovered utilities must be supported. Any repairs or modifications to existing utility lines require the line to be locked-out/tagged-out by the utility company prior to work.

For borings located in areas of dense utility distribution or in areas where specific utility locations are uncertain or unknown, a hand auger pilot hole will be advanced to a minimum depth of 7 feet (or refusal, whichever comes first) for utility presence verification.

3.2.1.2 Private Utilities

A private utility locator will be subcontracted to locate using geophysical methods and mark subsurface private utilities at each soil boring location where such utilities may exist. Private utilities may include some or all of the utilities listed in 3.2.1.1 that were not installed by public utilities.

3.2.2 Above Ground Power Lines

The minimum clearances for working near overhead power lines are as follows:

Normal Voltage	Minimum Clearances
0 - 50 kilovolts (kV)	20 feet or one mast length, whichever is greater
50 kV +	20 feet plus four inches for every ten kV over 50 kV; or 1.5 mast lengths, whichever is greater

If it is necessary to work without the minimum clearance, the overhead line must be re-routed or de-energized by the utility company or authorized contractor.

A Utility Clearance Permit will be completed to document utility location(s).

4.0 REFERENCES

Occupational Safety and Health Act (OSHA) 1910.333 - *Selection and Use of Work Practices in Subpart S - Electrical*.

OSHA 1926.650 through 1926.652 - *Excavations*.

OSHA 1926.955 - *Provisions for Preventing Accidents Due to Proximity to Overhead Lines*.

5.0 RECORDS

The Field Manager/Task Leader must complete the Utility Clearance Permit. The Site Manager/Field Task Leader, in collaboration with the SSO, must approve any deviations from this Standard Operating Procedure.

6.0 ATTACHMENTS

Utility Clearance Form.

Attachment 1 Utility Clearance Permit

Project: _____ Completed by: _____

Site Location: _____ Date: _____

Reason for Clearance: _____

Description of Activity	Yes	No	N/A	Date	INT
1. Review of Existing Maps					
2. Interviewed Personnel Familiar With Area?					
3. Above Ground Utilities					
a) marked on site maps					
b) necessary to lockout					
c) document procedures used to lockout or re-route					
4. Underground Utilities					
a) State Agency called: (specify)					
Ticket number:					
b) Additional Utility Company(s) called: (specify)					
Ticket number:					
c) Geophysical clearance method(s) used: (specify)					
By:					
d) Utility locations marked with appropriate color code:					
By:					
e) Utilities marked on site map (attached)					
By:					
5. Hand augering completed to:					
By:					
6. Trench/Excavation probed:					
By:					
a) Hand Clearance required:					
7. Clearance Approval: Site Manager: _____ Date: _____ Client Representative:					
8. Deviations Approval: Project Manager: _____ Date: _____ HSSO or Safety Manager:					

Describe Deviations: _____

Justification: _____

1.0 PURPOSE

The purpose of this Standard Operating Procedure is to ensure that borings, monitoring wells, and piezometers are properly installed.

2.0 SCOPE

This Standard Operating Procedure applies to all contractor personnel and subcontractors installing borings, monitoring wells, and piezometers for environmental investigations and monitoring programs.

3.0 METHOD

3.1 General

Drilling techniques to be used for borehole and monitoring well installation will be either sonic, air rotary, direct push technology (DPT) or hollow-stem auger (HSA).

Boreholes that are not converted to monitoring wells will be abandoned per SOP-007, *Well Abandonment/Borehole Plugging* and *ADWR Well Abandonment Handbook* (Appendix D).

3.2 Procedures

The following procedures apply to borehole drilling and monitoring well installation.

3.2.1 Borehole Drilling

Each of the borehole drilling methods and their usage are described below:

- Sonic involves the advancement of sampling tools into the subsurface by hydraulic pressure combined with high frequency vibration. The sonic sampling tool is typically advanced in 10-foot or other various increments. After the sampling tool has advanced to the required depth, the tool is retrieved from the subsurface and the sample is extruded in various foot lengths into plastic bags. The bags are cut open by the Field Geologist and the soil sample screened, logged, and collected for chemical analysis. Samples may be collected continuously or at specific depths.

  The sonic drill head is a technologically advanced, hydraulically activated unit that imparts high frequency sinusoidal wave vibrations into a drill string to effectuate a cutting action at the bit face. The resultant cutting action forces a circular continuous core of the formation up into the drilling string. Due to the high forces developed by the Sonic head and the external flush nature of the drill string, excess formation material generated by the cutting face of the bit is forced into the borehole wall thus resulting in the generation of no cuttings during the drilling process other than the generated core sample. Using telescopic Sonic casing advancement, wells or borings can be installed through multiple or connected water bearing units without risking cross contamination by casing off those zones while drilling. Depth discrete water sampling is possible.

If necessary due to unanticipated subsurface conditions that limit sonic penetration, HSA drilling with split-spoon sampling may be used as an alternative technique for soil borings. DPT or air rotary could be alternative techniques.

- Air rotary has the advantage of advancing the borehole without the need for introduction of drilling fluids. Air rotary drilling is similar to direct mud rotary drilling except that compressed air is used to transport the cuttings to the surface. An air-operated downhole casing advancement system is sometimes used. This casing advancement system consists of an air-operated down-the-hole hammer drill that is fitted with a specialized bit that has an eccentric reamer that cuts the hole large enough for the casing to follow. The hammer drill is designed to be used inside and at the bottom of the drill casing so that the bit and eccentric reamer are below the casing. Using compressed air, the hammer pulverizes the material below the casing, then blows it back through the casing to the top of the hole. As the hammer drives through material it also reacts against an interior shoulder bevelled on the drill casing shoe, which pulls the casing down the hole as the hammer drill is advanced. This method is well suited for drilling through difficult material such as rock fill. The major drawback is the high air pressure and large air volume required for operation.

- HSA drilling is commonly used for soil boring and monitoring well installation at relatively shallow depths (<100 ft). The drill rig will be mounted on a heavy-duty truck or an all terrain vehicle. Soil samples will be collected with a split-spoon sampler. At boring locations where monitoring wells will be installed, hollow stem augers of sufficient outer diameter (OD) should be used to ensure 2 inches annular space between the outside of the well casing and the borehole (i.e., 8 ¼ inch OD augers or larger for a 4-inch diameter well).

- DPT is a technique that uses both static force and percussion to advance sampling and logging tools into the subsurface. The DPT machine is typically mounted on a truck or a track-mounted terrain vehicle. Soil samples are usually collected with an acetate-lined core barrel. Specific procedures for soil sampling with DPT are described in SOP-013, *Soil Sampling*. DPT equipment can seldom reach depths greater than 50 feet bgs and, therefore, are limited to shallow deposits.

3.2.2 Monitoring Well Construction

All monitoring wells will be constructed in accordance to state and local regulations and shall be supervised by a competent geologist. The contractor shall obtain all permits, applications, and other documents required by state and local authorities. Drill rigs and sampling devices shall be decontaminated according to the guidelines in SOP-021, *Equipment Decontamination Procedures*. Ensuring a successful well installation requires that the procedures used for installing each component of the well are followed and well documented.

3.2.2.1 Well Casing Requirements

Wells will be constructed in accordance to state and local regulations. The casing requirements that will be followed are the following:

- All casing will be new, unused, and decontaminated according to the decontamination procedures provided in SOP-021, *Equipment Decontamination Procedures*. Certifications of cleanliness for manufacturer's pre-cleaned materials must be documented in project files. The pre-calculated and actual quantities of materials used in the well installation must be documented in the field logbook.

- All casings will be flush threaded, and no solvents or glues will be allowed to join casing, and casings shall be joined only with compatible welds or coupling that shall not interfere with the planned use of the well.

- All monitoring wells will be constructed using PVC or stainless steel riser. All PVC shall conform to the ASTM Standard F-480-88A or the National Sanitation Foundation Standard 14 (Plastic Pipe System).

- The casing will be sufficiently straight and plumb within the tolerance stated for the borehole and to allow passage of pumps or sampling devices and the driller will cut a “V” notch in the top of the casing on the north side of the well casing to be used as a permanent reference mark for measuring water levels.

- The drilling subcontractor will make provisions to prevent PVC shavings from entering the well during cutting of the casing for stick-up height and for the water level measurement point notch.

3.2.2.2 Well Screen Requirements

Well screen requirements are the following:

- All requirements that apply to casing will also apply to well screen, except for strength requirements.

- Monitor wells shall not be screened across more than one water-bearing unit.

- All monitoring wells will be constructed using PVC or stainless steel sumps and PVC, stainless steel machine-slotted, or continuous wrapped wire-wound well screen. The cap will be joined to the screen by threads or stainless steel screws.

- Screens shall be factory slotted or wrapped.

- The standard screen to be used is number 10 slot (0.010-inch slot) and/or shall be sized to prevent 90% of the filter pack from entering the well. The standard filter pack may be 20 to 40 mesh size or other size to allow unrestricted flow of

groundwater through the well screen while minimizing inflow of fine sediment material.

3.2.2.3 Well Casing and Screen Installation Procedures

The following procedures will be used when installing well casings and well screens:

- All well casing and screen material will be assembled and installed with sufficient care to prevent damage to the sections and joints.
- Sections of well casing and screen must be connected by flush threading.
- Prior to installing the section(s) of well screen into the well boring, an end cap must be placed at the bottom of the well screen.
- During installation of the well pipe, the drill depth must be periodically measured to ensure that the well boring remains clean of sloughed sidewall material.
- The casing must be suspended to provide a minimum of six inches of filter pack below the end cap. Casing will remain suspended until placement of filter pack and transition seal has been completed and has set.
- Prior to the addition of the filter pack and annular seals, a cap will be placed on top of the casing to avoid well materials from entering the well casing.

3.2.2.4 Filter Pack

The standard filter pack will be 20 to 40 mesh size paired with 10 slot well screen to allow unrestricted flow of groundwater through the well screen while minimizing inflow of fine sediment material. Other acceptable well screen/filter pack sizes are to be sized to prevent 90% of the filter pack from entering the well. Filter pack materials must be poorly graded (well sorted) to ensure good permeability and hydraulic conductivity of the materials near the screen. The materials used should be chemically inert, well rounded, and slightly coarser than the surrounding formation.

Filter pack material will be obtained from known clean sources and should be washed and properly packaged for handling, delivery, and storage. Filter pack will meet the National Science Foundation (NSF) standards and be packaged in properly sealed and marked packages.

3.2.2.5 Filter Pack Installation Procedures

The following procedures will be used during installation of the filter pack:

- The well boring should allow for placement of filter pack around the well screen and approximately six inches of filter pack below the well end cap.
- The chemical composition and manufacturer's contaminant-free certifications for the filter pack materials will be readily available and documented.

- The volume of the well annulus (i.e., filter pack required) must be pre-calculated and documented in the field logbook, and the volume of filter pack installed must be monitored and documented to ensure that the filter pack placement is complete. All discrepancies must be explained and reported to the Site Manager/Field Task Leader.

- For all shallow wells, the filter pack will be dropped directly down the annulus of the well with care taken to ensure that bridging of material does not occur. In deeper wells a tremie pipe will be used to emplace the filter pack.

- The depth to top of the filter pack must be periodically monitored using a sounder or weighted measuring tape, and noted to ensure uniform placement.

- Filter pack must be allowed to settle for approximately five to ten minutes prior to final top-off. Additional filter pack will be placed as required to return the level of the pack to a minimum of two feet above the screen. The depth to the top of the filter pack will be measured to verify its thickness.

3.2.2.6 Bentonite Seal

A bentonite seal is used to prevent communication between the filter pack and the natural cave-in material above the screen. The permeability of the seal should be one to two orders of magnitude less than the surrounding formation. The seal must be chemically compatible with the anticipated contaminants and chemically inert so it does not offset the quality of groundwater samples.

Powdered, granular, pelletized, or chipped bentonite and pre-formed bentonite “doughnuts” are acceptable as an annular sealant.

The bentonite seal requirements that will be followed are the following:

- The bentonite seal will consist of 3 feet of bentonite between top of the filter pack and the casing grout.

- Bentonite will be dropped directly down the annulus of the well or installed by tremie pipe, and a tamping device will be used to prevent bridging.

- The bentonite seal will be allowed to cure for a minimum of 2 hours prior to installing the grout seal.

- Only 100 percent sodium bentonite will be used.

3.2.2.7 Bentonite Seal Installation Procedures

The following procedures will be employed for placement of the bentonite seal:

- The depth to the seal will be measured using a sounder or weighted measuring tape to ensure that the thickness of the transition seal meets the design requirements.

- The amount of water added to the bentonite will be consistent with the manufacturer's specifications. If there is no groundwater present in the borehole, potable water will be added in a sufficient quantity to properly hydrate the bentonite.

- The water added to the bentonite for hydration will be from an approved source that has undergone quality control laboratory analyses, and the volume of water added will be documented in the field logbook.

- Care must be taken to ensure that augers if applicable (or formation support casing) are removed as the bentonite is hydrated. Failure to do so in a timely manner may result in the bentonite expanding inside the augers (or formation support casing) and jacking the well casing out when removed.

- The bentonite seal will be allowed to hydrate for a minimum of 2 hours before well completion activities continue.

- The quantities used will be documented in the field logbook.

3.2.2.8 Annular Seal

The annulus between the well casing and the wall of the well boring must be effectively sealed to prevent it from constituting a preferential pathway for the vertical movement of pollution and contaminants in groundwater or from surface water recharge. The material used for an annular seal must be:

- Placed around the well casing from the top of the bentonite seal to the ground surface;

- Able to hydrate or develop sufficient set strength within a reasonably short time;

- Able to provide a positive seal between the casing and the adjacent formation(s);

- Chemically inert to formations or fluids with which it may come in contact;

- Permanent and stable, and able to resist chemical or physical deterioration;

- Sufficiently impermeable to fluids to ensure that the vertical permeability of the casing borehole system is lower than that of surrounding formation(s); and

- Able to prevent interformational flow between different groundwater-bearing units.

The annular seal requirements are the following:

- The annular seal will be mixed in the following proportions: the casing grout shall extend from the top of the bentonite seal to ground surface.
- The grout shall be mixed in the following proportions: 94 pounds of neat Type I Portland or American Petroleum Institute Class A cement, not more than 4 pounds of 100% sodium bentonite powder, and not more than 8 gallons of potable water.
- The annular seal will be pumped in using a side-discharge tremie pipe, and pumping will continue until 20 percent of the annular seal has been returned to the surface. In wells where the bentonite seal is within 30 feet of the land surface, the 20 percent return is not necessary.
- For borings in which augers have traveled, resulting in a slightly larger diameter borehole than planned, an additional 30 percent grout volume will be added to the calculated amount required to fill the annular space.

3.2.2.9 Annular Seal Installation Procedures

The following tasks must be performed to achieve a positive annular space seal:

- The expected volume of the annular seal material will be pre-calculated for each well and included in field notes. The calculation will be the volume of the borehole minus the volume of the well casing for the depth interval of annular seal placement.
- The annular seal mixture should be properly mixed according to the manufacturer's specifications (or other acceptable and documented criteria).
- The water added to the annular seal material will be documented in the field logbook.
- The annular seal should be mixed prior to placement ensuring a thorough mixture without balls, clods, etc.
- The bentonite seal must be set according to manufacturer’s instructions and allowed to cure a minimum of 2 hours prior to placing the annular seal.
- The annular seal will be emplaced by a side-discharge tremie pipe inserted within five feet of the top of the bentonite seal. A side-discharge tremie pipe must be used to lessen the possibility that the transition seal may be cavitated and grout introduced into the filter pack. The pipe must remain submerged in the sealing material while the grout is being emplaced.

- The augers must be withdrawn during grouting to provide a positive seal to the well boring. To prevent borehole caving, a minimum of two feet of annular seal must be maintained in the augers during removal.

- In wells where the bentonite seal is visible and within 30 feet of the land surface, the 20 percent return is not necessary as long as the tremie pipe is pulled back as the annular seal is emplaced. Excess annular seal that has been returned to the surface will be removed prior to installing the surface pad.

3.2.3 Surface Completions for Monitoring Wells

The following procedures will be used for both aboveground and flush-mount surface completions for monitoring wells.

3.2.3.1 Aboveground Surface Completions

The surface completion will begin after completing the annular seal. Note that an above-ground completion is the standard well completion; a flush-mounted completion should be used in wells installed in traffic areas.

- Well casing will extend two to three feet above the top of the well pad with a vented end plug or casing cap provided for each well.

- A steel protective casing will be installed around the well casing by placing the protective casing into the cement/bentonite surface seal while still wet and uncured. The protective casing will be positioned and installed in a plumb position.

- The protective casing must be vented to allow for the escape of possible gas buildups and to allow the water levels to respond naturally to barometric pressure changes. Additionally, a drain hole should be placed above the concrete level to allow for draining of any trapped water from installation and sampling of the well. The casing will be painted yellow or a client-directed color to be easily observable.

- A weatherproof locking cap will be installed on the protective casing, ensuring adequate clearance between the top of the well casing and bottom of the locking cap.

- A concrete surface pad (3 feet by 3 feet by 4 inches) will be placed surrounding the well protective casing. The pad will be sloped away from the protective casing to provide sufficient drainage away from the well.

- Well protection posts will be placed around wells in any area where vehicular traffic may occur. Posts will be concrete-filled and should be placed approximately two feet below ground surface and three feet above the top of the

pad (flush with the top of the well casing). The posts should not be placed in the concrete well pad. Posts will be painted yellow or a client-directed color to be easily observable.

3.2.3.2 Flush-Mounted Surface Completions

Flush-mounted surface completions may be used and will be installed similar to aboveground completions. Flush-mounted wells will include a well box set in the concrete pad. The well casing must be cut off below grade leaving enough space for the placement of a lockable expanding well cap. The surface seal will then be set to 2 inches above ground surface around the outside of the well box and up to 12 inches below ground surface on the inside of the well box. The concrete pad will be constructed with an outward slope to provide sufficient drainage of precipitation away from the well.

In circumstances where flush-mount completions are installed in paved areas where existing pavement is in excess of 4 inches thick, concrete or asphalt will be sawcut to a depth of 4" around the perimeter of a 4.5-foot by 4.5-foot square centered on the well casing and the concrete within the 2-foot by 2-foot area will be removed to a depth of 4 inches by jackhammer or other suitable means. New concrete will be placed to secure the well box, and new concrete will be sloped so as to provide positive drainage away from the well box.

The well box for flush mounted surface completions will be outfitted with a steel lid or manhole cover that has a rubber seal or gasket to prevent water from entering the vault. No flush-mount wells will be completed in areas known to be subject to surface water accumulation.

3.2.4 Well Security

All wells will be secured as soon as possible after drilling. Vented well caps will be placed on all completed wells. Corrosion-resistant locks for both flush and aboveground surface completions will be utilized. The locks must either have identical keys or be keyed for opening with one master key. The lock keys should be delivered to the appropriate Air Force personnel following completion of the field effort.

3.2.5 Borehole Backfilling Prior to Well Completion

In some instances, it may be necessary to backfill a borehole to achieve the required depth for the well screen interval. This usually is the result of intentionally overdrilling the depth of the well to verify the lithology of the underlying material. For example, a borehole is drilled to a depth of 25 feet but the depth of the bottom well screen to be installed is determined to be 20 feet. This means that there is five feet of open borehole below the planned bottom of the screen. It is unacceptable to fill this excess borehole depth with sand or other permeable material, as it will act as a vertical migration pathway. Therefore, the bottom five feet of the borehole must be abandoned.

Backfilling of an overdrilled borehole will be accomplished by the installation of a bentonite grout via tremie pipe as discussed in SOP-007, *Well Abandonment/Borehole Plugging* and *ADWR Well Abandonment Handbook (Appendix D).* The backfill material will be placed into the borehole to a depth of 6 inches below the bottom of the proposed well screen. This will

allow for the placement of 6 inches of filter pack sand between the grout and the well screen. Once the bentonite grout is installed into the borehole, it will be allowed to cure for a minimum of 2 hours. The level of the grout will be checked and additional grout added, if necessary, prior to initiation well installation activities.

4.0 REFERENCES

Aller, L., et al., 1989. *Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells*: National Water Well Association, U.S. Environmental Protection Agency (USEPA), USEPA 600/4-89/034.

American Society for Testing and Materials (ASTM), 1995. *Standard Practice for Design and Installation of Ground Water Monitoring Wells in Aquifers.* ASTM D5092 - 90, 2nd Edition, Volume 04.09, ASTM, Philadelphia, PA, pp. 70-85.

Barcelona, M.J., J.P. Gibb, J.A. Helfrich, and E.E. Garske, 1985. *Practical Guide for Ground-Water Sampling*, USEPA/600/2-85/104, pp. 47-72.

Driscoll, F.G., 1986. *Groundwater and Wells*, 2nd Edition, Johnson Division, St. Paul, MN, pp. 395-463.

Arizona Department of Water Resources (ADWR), 2002. *ADWR Well Abandonment Handbook*

Nielsen, D.M., 1991. *Practical Handbook of Ground-Water Monitoring*, Lewis Publishers, p. 717.

Todd, D.K., 1980. *Ground-Water Hydrology*, 2nd Edition, pp. 164-193.

USEPA, 1992. *RCRA Ground-Water Monitoring Draft Technical Guidance.*

USEPA, 1991. *Groundwater Volume II: Methodology*, USEPA/625/6-90/016b, pp. 1-21.

USEPA, 1986. *RCRA Ground-Water Monitoring Technical Enforcement Guidance Document*, Office of Solid Waste and Emergency Response Directive 9950.1, pp. 71-94.

5.0 RECORDS

All materials and procedures used during installation of the well will be documented in field logbooks as detailed in SOP-019, *Field Activity Records*.

6.0 ATTACHMENTS

Attachment 1 – Well Construction Form, Stick-Up Well Completion
Attachment 2 - Well Construction Form, Flush Mount Well Completion

1.0 PURPOSE

The purpose of this Standard Operating Procedure is to provide details, specifications, and requirements for establishing the horizontal and vertical position of sampling points and monitoring locations.

2.0 SCOPE

This Standard Operating Procedure applies to all professional land-surveying activities in support of environmental investigation.

3.0 METHOD

3.1 General

Land surveying services will be required to establish coordinates for sampling points and monitoring locations. These locations will include monitoring wells, soil borings, surface water/sediment sample locations, surface soil sample locations, and reference points used for stream gauging.

3.2 Procedures

To be provided by surveying subcontractor.

1.0 PURPOSE

The purpose of this Standard Operating Procedure is to describe the preferred methodology for collecting groundwater samples in the field using the low-flow purge/sample method and the conventional three well volume purge method.

2.0 SCOPE

This Standard Operating Procedure applies to all personnel who purge groundwater monitoring wells and collect groundwater samples.

3.0 METHOD

3.1 General

Every effort will be made during well construction to minimize the amount of silt and clay that enters the well casing by choosing appropriate screen and filter pack material. However, it should be anticipated that turbidity in groundwater monitoring wells may be a concern. To obtain representative groundwater samples, disturbances of the water in the well should be kept to a minimum. The reasoning behind the use of low-flow sampling techniques to sample monitoring wells is to minimize physical disturbance (turbulence) at the sampling point and chemical changes (aeration) in the medium. Another benefit of low-flow sampling techniques is the total volume of water purged is minimized. For the purposes of this procedure, "low-flow pumps" are defined as dedicated bladder pumps, or variable speed submersible pumps. Practical operational flow rates for these sampling devices range from 0.1 liters per minute (L/min) to greater than 1 L/min. If low-flow procedures are not possible or practical or a project specific need requires the standard three-well volume purge and sampling procedures may be used.

3.2 Supplies and Equipment

3.2.1 Major Equipment Items

- Variable-rate, submersible pump/hose assembly with control unit, electrical generator if required, and extension cord, air compressor or other air supply if required, and/or
- Gasoline and oil (for generator, if used);
- Soapy water mixture containers;
- Potable water containers;
- Deionized water containers; and
- Purge water drums or purge water tank.

3.2.2 Equipment Support Items

- Drum liners;
- Trash bags;
- Decontamination tub;
- Low phosphate detergent, such as Liquinox;
- Gloves (nitrile rubber);
- Graduated five-gallon buckets and/or graduated cylinder;
- Folding table;
- Folding chairs;
- Paper towels;
- Calculator; and
- Digital watch with stopwatch function.

3.2.3 Sampling Supplies

- Written description of wells including identification (ID) numbers, maps, well locations, elevations, well construction details, and (if available) records of previous development and/or purging and sampling;
- Well keys;
- Sample containers and applicable preservative;
- Chain-of-custody forms;
- Sample labels;
- Field data forms;
- Ice chest;
- Ice for sample preservation;
- Ziploc® bags;

- Field logbook; and
- Pen and waterproof permanent marker.

3.2.4 Monitoring Equipment

- Electronic water level indicator and, when necessary, oil/water interface probe;
- Water quality sampling field instrumentation (e.g., pH, temperature, specific conductance [conductivity], turbidity, dissolved oxygen [DO], oxidation/reduction potential [ORP] probes); and
- Photoionization detector (PID) or flame ionization detector (FID), if required.

3.2.5 Health and Safety Items

- First aid kit and emergency eye-wash kit;
- Fire extinguisher;
- Material Safety Data Sheet/emergency information packet (route to hospital, phone contacts); and
- Field radio or cell phone.

3.3 Procedures

3.3.1 General Equipment Decontamination

Before purging or sampling, all pumps and hoses, water level measurement devices, and any other sampling equipment that may come in contact with the sample will be decontaminated. If new dedicated equipment is used, it should be thoroughly decontaminated and rinsed with distilled water before placement in the well. While decontamination of the pump/hose assembly may generally be performed at a central decontamination area, mobile decontamination supplies will be made available so that some accessory equipment (e.g., electronic water level indicators) can be decontaminated in the field. Each piece of purging or sampling equipment will be decontaminated prior to and between sampling operations and wells. Depending on site conditions, the decontamination solutions may be replaced with clean solutions between wells. Purge water and decontamination solutions will be handled and disposed of as outlined in SOP-020, *Investigation-Derived Waste*. The procedures specified in SOP-021, *Equipment Decontamination Procedures,* will be followed for decontamination of field equipment and for personnel decontamination.

3.3.2 Measurement of Water Quality Parameters and Instrument Calibration

Electronic equipment used during purging and sampling may include a PID, FID, Multi-Gas Meter, a water level indicator, an oil/water interface probe, water quality measurement devices for temperature and pH, conductivity, turbidity, DO, and ORP. Before going into the field, the Field Task Leader will verify that these instruments are operating properly. Each probe of the water quality-measuring device must be calibrated prior to its use and checked at the beginning and end of each day for maintenance of calibration. Calibration procedures will follow the manufacturer's instructions. The PID or FID will be calibrated daily using standard calibration gas as specified by the manufacturer. If instrument readings become erratic during normal operations, recalibration will be conducted. Operating instructions for the PID and FID are detailed in SOP-022, *Organic Vapor Measurement*.

Person(s) responsible for calibrating equipment will complete the equipment specific calibration form, which includes identifying calibration standards and affixing a signature to the form.

Field measurements for temperature, pH, turbidity, conductivity, DO, and ORP will be made in accordance with procedures outlined in SOP-024, *Water Quality Measurements Using a Multiple Parameter Water Quality Meter*, along with the manufacturer's instructions.

3.3.3 Well Purging

The purpose of well purging is to remove stagnant water from the well and obtain a representative water sample from the geologic formation being sampled while minimizing disturbance of the water column during sample collection.

3.3.3.1 Low-Flow Purge Methodology

Using the low-flow purging methodology, the well will be purged until field parameters (pH, temperature, turbidity, DO, ORP, and conductivity) have stabilized. Readings will be taken at a rate commensurate for the flow involved, but no sooner than every three minutes. Low-flow purging rates on the order of 0.1 - 1.0 L/min will be used depending on the site-specific hydrogeology. The maximum allowable drawdown during low-flow purging is 0.3 feet. If the maximum allowable drawdown limit of 0.3 feet is exceeded and cannot be achieved, then the Total Volume Purge Method described in Section 4.3.4.2 will be followed. Background wells being sampled for metals must attain a turbidity of 10 Nephelometric Turbidity Units (NTUs) or less before sample collection unless a written variance (on a well-specific basis) is acquired. The turbidity goal for non-background samples is 15 NTU, but samples with higher turbidity are acceptable if turbidity readings are stabilized and the other conditions of low-flow purging have been met. See *EPA/540/S-95/504, Low-Flow (Minimal Drawdown) Ground-water Sampling Procedures (April 1996).*

Purge water will be managed as outlined in SOP-020, *Investigation-Derived Waste*. Necessary precautions will be taken to prevent spilling of potentially contaminated water. The water will need to be containerized and appropriately disposed or treated prior to discharge.

For standard low-flow well purging, the following procedures will be performed at each well:

- The condition of the well completion (outer well casing, concrete well pad, protective posts, well label) and any unusual conditions of the area around the well will be noted in the field logbook. The well may also be photographed. Any deficiencies encountered will be reported to the Site Manager on the same working day.

- Set up and establish the exclusion zone around the work area, using traffic cones and caution tape where necessary.

- Don personal protective equipment (PPE) as specified in the Health and Safety Plan (HSP).

- Note if the reference point (measuring point) on the well is present. This is usually an indelible mark or V-notch cut in the top of the well casing. If this point is missing, make one on the north side of the well casing.

- The depth of the static water level will be measured with a water level indicator (to the nearest 0.01 foot) in accordance with SOP-006, *Static Water Level and Total Depth Measurement*. If a high concentration of organic vapors are detected in the well, an oil/water interface probe will be used to determine the presence of an immiscible phase light non-aqueous phase liquids (LNAPL) or dense non-aqueous phase liquids (DNAPL).

- The total depth of well will be measured from the same measuring point on the casing with a water level indicator and recorded. It is critical that the distance between the water sensor (zero point) and the end of the water level indicator probe be measured independently and added to each total depth measurement.

- Slowly lower the pump or pump tubing into the well casing to a point in the middle of the screened interval: 5 feet below the water table or, in instances where the well screen is submerged, 5 feet below the top of the screen. Reinsert the water level indicator to monitor water levels during purging.

- Start the pump. As soon as water is discharging, adjust the pump speed to a rate suitable to create minimal drawdown. During purging and sampling, the maximum allowable drawdown is 0.3 feet.

- Using a stopwatch and some type of graduated cylinder, measure the pumping rate. Monitor the water level, pumping rate, cumulative volume withdrawn, and field parameters (temperature, pH, turbidity, conductivity, DO, and ORP) approximately every three to five minutes.

Low-flow purging is complete only when all required field parameters have stabilized (temperature, pH, turbidity, conductivity, DO, and ORP). Stabilization is achieved when two consecutive readings show temperature is within ± one degree Celsius, pH values are within ± 0.1 pH unit, turbidity is less than or equal to 10 NTUs or within ± ten %, conductivity is within ± 5 %, DO is within ± 10 %, and ORP is is within ± 10 millivolts (mV). The Site Manager/Field Task Leader has the responsibility of determining if redevelopment of any monitoring well is necessary and appropriate.

3.3.3.2 Total Well Volume Purge Methodology

If a water level drawdown greater that 0.3 feet occurs at a purge rate of 0.1 L/min or less, or if it is deemed necessary, the total well volume purge methodology will be used. Using the total well volume purging methodology, the well will be purged until a minimum of three total well casing volumes (WCV) have been removed and field parameters (pH, temperature, turbidity, conductivity, DO, and ORP) have stabilized. A pumping rate should be established to minimize drawdown and will not exceed 2 L/min. When purging by this methodology, if parameters have not stabilized after six WCVs, then purging will cease and samples will be collected. Background wells being sampled for metals must attain 10 or less NTUs before sample collection unless a written variance (on a well-specific basis) is acquired. The turbidity goal for non-background samples is 15 NTU, but samples with higher turbidity are acceptable if turbidity readings are stabilized and the other conditions of total well volume purging have been met.

The volume of water in the well will be calculated based on the length of the saturated thickness in the well and the screen diameter (see below for calculation of volumes).

The well volume can be calculated in gallons using the following equation:

Well Volume V (in gallons) = H x F

where V = one well volume
H = the difference between the depth of the well and depth of water (ft)
F = factor for volume of one foot section of casing (gallons) from the table below.

Diameter of Casing (inches)	F Factor (gallons)
1.5	0.09
2.0	0.16
3.0	0.37
4.0	0.65
6.0	1.47

F can also be calculated from the following equation:

$$F = II\ (D/2)^2\ X\ 7.48\ gal/ft^3$$

where D = the inside diameter of the well casing (ft)

The well will be sampled immediately following purging without moving or adjusting the position of the pump. Evacuated well water will be managed as outlined in SOP-020, *Investigation-Derived Waste.* Necessary precautions will be taken to prevent spilling potentially contaminated water. The water will need to be containerized and appropriately disposed of or treated prior to discharge.

If the well is purged dry with a flow rate of less than 2 L/min, it will be sampled as soon as possible after the minimum sample volume of groundwater has recharged the well. The requirements of a minimum of three well volumes purged and stabilization of field parameters will not be applied to sampling a well that has been purged dry if the pumping rate was less than 2 L/min.

For total well volume purging, the following procedures will be performed at each well:

- The condition of the well completion (outer well casing, concrete well pad, protective posts, well label) and any unusual conditions of the area around the well will be noted in the field logbook. The well may also be photographed. Any deficiencies encountered will be reported to the Site Manager on the same working day.

- Set up and establish the exclusion zone around the work area, using traffic cones and caution tape where necessary.

- Don PPE as specified in the HSP.

- Note if the reference point (measuring point) on the well is present. This is usually an indelible mark or V-notch cut in the top of the well casing. If this point is missing, make one on the north side of the well casing.

- The depth of the static water level will be measured with a water level indicator (to the nearest 0.01 foot) in accordance with SOP-006, *Static Water Level and Total Depth Measurement*. If a high concentration of organic vapors are detected in the well, an oil/water interface probe will be used to determine the presence of an immiscible phase (LNAPL or DNAPL).

- The total depth of well will be measured from the same measuring point on the casing with a water level indicator and recorded. It is critical that the

distance between the water sensor (zero point) and the end of the water level indicator probe be measured independently and added to each total depth measurement.

- Slowly lower the pump or pump tubing into the well casing to a point in the middle of the screened interval. Reinsert the water level indicator to monitor water levels during purging.

- Start the pump. As soon as water is discharging, adjust the pump speed. The pumping rate should never exceed 2 L/min.

- Using a stopwatch and some type of graduated cylinder, measure the pumping rate. Monitor the water level, pumping rate, cumulative withdrawal, and field parameters every ten minutes and/or per well volume. Field parameters including temperature, pH, turbidity, conductivity, DO, and/or ORP will be monitored.

- At a minimum, three total volumes must be purged for this method if the well is not purged dry with a pumping rate less than 2 L/min. If the well is purged dry with a pumping rate less than 2 L/min then the sample will be collected after a sufficient volume of water has recharged the well regardless of total volume purged and field parameter stabilization.

Purging is complete only when all required field parameters have stabilized (temperature, pH, turbidity, conductivity, DO, and ORP) or six WCVs have been removed, whichever comes first. Water parameters will be measured after removal of each volume and approximately every five minutes after the first 2 WCVs. Stabilization is achieved when two consecutive readings show temperature is within $\pm$ one degree Celsius, pH values are within $\pm$ 0.1 pH unit, turbidity is less than or equal to 10 NTUs or within $\pm$ 10 %, conductivity is within $\pm$ 5 %, DO is within $\pm$ 10 %, and ORP is is within $\pm$ 10 millivolts (mV). The Site Manager/Field Task Leader has the responsibility of determining if redevelopment of any monitoring well is necessary and appropriate.

3.3.4 Sample Collection (Low Flow & Total Well Volume)

Using low-flow or total well volume sampling procedures, samples for chemical analysis will be collected immediately following purging. For wells that were purged dry, samples will be collected as soon as possible after a sufficient volume of groundwater is available in the well. The water quality samples will be taken from within the well screen interval. The following sampling procedure will be used at each well:

- Immediately following purging, the pump will be used to collect the groundwater sample. The pump should not be moved between purging and sampling, unless a peristaltic pump is used.

- Identification labels for sample bottles will be filled out for each well.

- The individual sample bottles should be filled in the order given below:
  - Volatile organic compounds (VOCs),
  - Semi-volatiles organic compounds (SVOCs),
  - Other organic parameters,
  - Metals (inorganics),
  - Inorganic anions,
  - Other parameters, and
  - Field test parameters (e.g., pH, conductivity, and temperature).
- VOC sample vials should be completely filled so the water forms a convex meniscus at the top, then capped so that no air space exists in the vial. Turn the vial over and tap it to check for bubbles in the vial. If air bubbles are observed in the sample vial, discard the vial and collect another sample.
- Fill containers for SVOCs, inorganics, inorganic anions, and other parameter analyses until almost full. Samples will be preserved and managed as detailed in the Quality Assurance Project Plan (QAPP). The time of sampling will be recorded. When collecting samples using preservatives, the pH should be periodically checked. For non-VOC samples, a small amount of the preserved sample should be poured from the sample container directly onto the pH strip (rather than dipping the strip into the sample container, which can contaminate the sample). For VOCs, the pH check is best accomplished by filling an extra vial during collection, ensuring it is not overfilled, then dipping a pH strip into the sample vial to check that the sample is at or below the maximum pH allowed. This vial would then be disposed of as investigation-derived waste (IDW).
- After the samples have been collected, they should immediately be placed in an ice-filled cooler until relinquished to the on-site laboratory or shipped to the appropriate laboratory for analysis.
- After removing the pump and equipment from the well, replace and lock the well cap.

3.4 Quality Assurance/Quality Control (QA/QC) Procedures and Samples

The well sampling order will be dependent on expected levels of contamination in each well, if known, and will be estimated prior to sampling. To the extent practicable, sampling will progress from the least contaminated well to the most contaminated. QA/QC samples will be collected during groundwater sampling according to the QAPP.

QA/QC samples may be labeled with QA/QC identification numbers (or fictitious identification numbers if blind submittal is desired), and sent to the laboratory with the other samples for analyses.

3.5 Sample Identification, Handling, and Documentation

Samples will be identified, handled, and recorded as described in this Standard Operating Procedure and in accordance with standard sample handling protocols indicated in the QAPP.

4.0 REFERENCES

Ground Water Issue, Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures, April 1996 (EPA/540/S-95/504).

5.0 RECORDS

Field notes will be kept in a bound field logbook or Monitoring Well Purging Form (Attachment 1) as required by SOP-019, *Field Activity Records*. The following information will be recorded using waterproof ink:

- Names of sampling personnel;
- Weather conditions;
- Project title;
- Location and well number;
- Date and time of sampling;
- Condition of the well;
- Decontamination information;
- Initial and final static water level, total well depth;
- Equipment calibration information;
- Method of purging;

- Volume of water purged before sampling;
- Purge start/stop times;
- Pumping rate, if applicable;
- Field parameter measurements during purging;
- Method of sample collection;
- Sample identification numbers;
- Photo documentation, if applicable;
- QA/QC samples collected; and
- Irregularities or problems.

In addition to the logbook, the Monitoring Well Purging Form located in Attachment 1 will be completed.

6.0 ATTACHMENTS

Attachment 1 – Monitoring Well Purging Form.

1.0 PURPOSE

The purpose of this Standard Operating Procedure is to describe the equipment and methods used to accurately determine static water level and total depth in a groundwater monitoring well, pumping well, or piezometer.

2.0 SCOPE

This Standard Operating Procedure applies to all personnel who measure water levels and total depths in wells. The 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.

3.0 METHOD

3.1 General

This procedure requires the use of an electronic water level device that employs a battery-powered probe assembly attached to a cable marked in 0.01-foot increments. When the probe makes contact with the water surface, a circuit is closed and energy is transmitted through the cable to sound an audible alarm. This equipment will have a sensitivity adjustment switch that enables the operator to distinguish between actual and false readings. The manufacturer's operating manual should be consulted for instructions on use of the sensitivity adjustment.

3.2 Procedures

3.2.1 Equipment

- Water level indicator with an audible alarm and a cable marked in 0.01-foot increments. The point on the probe that triggers the alarm corresponds to the zero point.

- If free-phase product is present on the water surface, then an interface probe capable of distinguishing between product and water will be used.

3.2.2 Calibration

The water level indicator or interface probe should be calibrated before use. The end of a probe should be placed in a bucket of water to ensure that the audible alarm is in working condition and responds when the electrical contacts encounter water. The marked length units on the probe line should be verified for accuracy by comparing to a standard steel tape measure. If there is any noted discrepancy between the water level indicator and the measuring tape, the difference in length will be noted on the field log and identified on the water level indicator. All subsequent water level measurements will be corrected as necessary.

3.2.3 Static Water Level Measurement

Before water level measurements are collected, all equipment will be thoroughly decontaminated as detailed in SOP-021, *Equipment Decontamination Procedures.* The static water level will be measured each time a well is sampled. This must be done before any fluids are withdrawn and before any purging or sampling equipment enters a well.

The measurements of static water level and total depth must be taken at an established reference point, generally from the top of the well casing at the surveyor's mark. The mark should be permanent, such as a notch or mark on the top of the casing. If the surveyor's point is not marked at the time of water level measurement, the north side of the casing should be used and marked. All equipment will be decontaminated before and after introduction of the equipment to the well following procedures in SOP-021, *Equipment Decontamination Procedures.*

If the well is sealed with an air-tight cap, allow time for equilibration of pressures after the cap is removed before water level measurement. Air-tight caps should be replaced by ventilated caps or a hole drilled in the well casing, where feasible, to allow the water to equilibrate to barometric changes.

With the water level indicator switched on, slowly lower the probe until it contacts the water surface as indicated by the audible alarm. Raise the probe out of the water until the alarm turns off. Three or more measurements will be taken on three minute intervals at each well until two measurements agree to within +/- 0.01 feet. Record the reading on the cable at the established reference point to the nearest 0.01 foot.

3.2.4 Total Depth Measurement

Slowly lower the water level indicator, with weight attached if necessary, until the cable goes slack. Raise and lower the probe until the precise location of the bottom is determined. Record the reading on the cable at the established reference point to the nearest 0.01 foot. Depending on the type of instrument used, the total depth measurement may need to be adjusted for the offset between the bottom of the probe and the water level sensor. Some instruments have the sensor at the bottom of the probe so the depth reading is accurate without an adjustment. However, the water indicator sensor on some probes is not located at the bottom of the probe. To get a true total depth reading, the distance from the water indicator sensors to the bottom of the probe housing must be added to the depth reading.

If it is not possible to measure the depth of a well in which pumping equipment is installed, then the as-built well construction diagram will provide the total depth.

3.2.5 Interface Probe Measurement

If there is the potential for free-phase product to be present on the surface of the water table in a well, then an oil-water interface probe will be used to collect water level measurements. Interface probes are used in the same manner as a water level indicator. The difference is that the interface probes have two different audible signals to differentiate between water and oil. If a layer of free-phase product is present, the probe will emit a different signal than for water. Most probes emit an intermittent beep when product is encountered, as opposed to a constant

tone for water. The alarm codes for individual probes are marked on the reel casing. If product is encountered, continue to raise and lower the probe until a precise level (within 0.01 foot) is determined. Record the measurement in the field log and identify it as a product measurement.

Next, slowly lower the probe until the water interface is encountered. Repeat the level measurement process and record the depth to water in the field logbook. Care should be taken during the measurement process to minimize disturbance of the product layer.

4.0 REFERENCES

Driscoll, F.G., 1986. *Groundwater and Wells*, 2nd Edition, Johnson Division, St. Paul, MN, pp. 1089.

Thornhill, J.T., 1989. *Accuracy of Depth to Ground Water Measurements*, from U.S. Environmental Protection Agency (USEPA) Superfund Ground Water Issue, USEPA/540/4-89/002.

U.S. Department of the Interior, 1981. *Groundwater Manual, A Water Resource Technical Publication*, Water and Power Resources Services, U.S. Government Printing Office, Denver, CO, pp. 480.

5.0 RECORDS

All field notes for water level and well depth measurements will be recorded in accordance with SOP-019, *Field Activity Records*.

1.0 PURPOSE

The purpose of this Standard Operating Procedure is to describe the general methodology for collecting soil samples in order to document the horizontal and vertical extent of contaminated soils at a site and to determine the geotechnical, hydrogeological, physical, and chemical properties of site soils.

2.0 SCOPE

This Standard Operating Procedure applies to all personnel who collect and/or handle samples of surficial and/or subsurface soil.

3.0 METHOD

3.1 General

Collecting soil samples is an important site characterization activity. Soil samples are used to determine the nature and extent of contamination, to identify hazardous substance source areas, and to determine the geotechnical, hydrogeologic, physical, and chemical properties of site soils. Field conditions at the site (e.g., direct push technology [DPT] or drilling refusal) may preclude collection at one or more predetermined sample locations. Additional soil sampling may be required, if unexpected subsurface conditions are observed during the course of the sampling activity. Proper sampling techniques, proper selection of sampling equipment, and proper decontamination procedures will eliminate cross-contamination and introduction of contaminants from external sources.

Soil conditions can vary widely at a site. These variations can affect the rate of contaminant migration through the soil. Therefore, it is important that detailed records be maintained during sampling activities, particularly with respect to location, depth, color, odor, lithology, hydrogeologic characteristics, and readings derived from field monitoring equipment. All soils will be classified in the field by a geologist, hydrogeologist, or soil scientist using the Unified Soil Classification System (USCS). All soils removed from borings that are not collected as samples will be disposed of according to the procedures in SOP-020, *Investigation-Derived Waste.*

3.2 Procedures

3.2.1 Equipment

Equipment that will be used to collect surficial and/or subsurface soil samples includes, but is not limited to, the following items:

- Stainless steel spoons/trowels;
- Stainless steel hand auger;
- Stainless steel split-spoon, split-barrel, or continuous sampler;

- Stainless steel closed-piston type soil sampler;
- T-handled sampler with disposable plastic syringes for VOC sampling;
- Stainless steel bowls/pans;
- Nitrile rubber gloves;
- Field notebook/logbook/boring log;
- Waterproof/permanent marker;
- Paper towels;
- Teflon® film in 3-inch squares;
- Aluminum foil;
- Appropriate decontamination equipment;
- Appropriate health and safety equipment;
- Sample cooler with ice;
- Sample jars and labels;
- Chain-of-custody forms;
- Munsell Soil Color Charts;
- Grain size charts;
- Hand lens; and
- Ziploc® freezer bags.

3.2.2 Decontamination

Before collecting any soil samples, all sampling devices shall be decontaminated. Decontamination supplies will be available so that small equipment can be decontaminated on site. Each piece of sampling equipment shall be decontaminated before initiation of sampling operations and between each sample location or interval. Decontamination solutions may be replenished between each site as needed. Spent decontamination fluids will be containerized and handled according to SOP-020, *Investigation-Derived Waste*. All procedures presented in

SOP-021, *Equipment Decontamination Procedures*, will be followed for decontamination of field equipment and for personnel decontamination.

3.2.3 Volatile Organic Compounds

If volatile organic compounds (VOCs) are among the contaminants expected at a particular site, soil samples submitted for laboratory VOC analysis will be collected and preserved as discussed in Attachment 1.

3.2.4 Surface Soil Sampling

Surface soil is considered to be the top six inches of a soil horizon profile (i.e., soil from zero to six inches below ground surface [bgs]). All personnel who collect or handle the soil samples will wear disposable nitrile gloves to prevent cross-contamination and provide personal protection. New gloves will be donned between each soil sample, or whenever gloves are torn or otherwise compromised.

Any surface vegetation will be removed before sample collection with a decontaminated shovel or sampling spoon. Surface soil samples not analyzed for VOCs may be collected as either discrete or composite samples. Each surface soil sample will be collected using either a stainless steel spoon or trowel. The sampler, while wearing clean disposable nitrile gloves, will remove pebbles, roots, etc. from the mixture as the sample is collected. Except for VOCs, each sample will be collected by thoroughly homogenizing material from the zero to six-inch depth interval (unless stated otherwise in project-specific documents) from the respective soil sample location. The homogenized material will then be divided equally among the appropriate sample containers. The sample containers will then be sealed tightly, and handled according to SOP-018.

Each soil sample collected for analysis of VOCs by Method SW8260 will be collected and preserved in accordance with Method SW5035A as described in Attachment 1. The sample container will be sealed tightly and handled according to SOP-018, *Packing and Shipping of Environmental Samples.*

Upon completion of sampling, if the sample is located in a residential yard setting, the hole will be filled with stockpiled soil or commercial topsoil to achieve the original grade. Sod will be replaced.

Each composite sample will be collected by placing equal amounts (or aliquots) of soil collected from multiple locations into a decontaminated collection container. The aliquots will then be homogenized using a spoon or trowel. The homogenized material will then be divided equally among the appropriate sample containers. The sample containers will then be sealed tightly and handled according to SOP-018. Composite samples will not be collected for VOCs.

3.2.5 Subsurface Soil Sampling

3.2.5.1 Shallow Subsurface Soil Sampling

Shallow subsurface soil samples not analyzed for VOCs may be collected as either discrete

(grab) or composite samples. Each subsurface soil sample location should be checked and cleared before intrusive activities according to SOP-001, *Utility Clearance for Intensive Activities*. Subsurface soil samples can be collected using a wide variety of sampling equipment and devices. Common equipment used to collect shallow subsurface soil samples include thin-wall tube samplers and various types of hand augers, including bucket-type hand augers, continuous-flight hand augers, and posthole hand augers. Of these sampling methods, only the thin-wall tube sampler collects an undisturbed soil sample. Depending on field conditions or sampling objectives, several types of sample collection equipment can be used to collect a soil sample at a single location.

Using a decontaminated hand auger or powered drill rigs, the soil borehole will be advanced to the depth immediately above the sampling interval, and all cuttings will be removed from the borehole. During advancement of the auger, cuttings from in and around the borehole will be periodically removed and placed on a plastic sheet or in a plastic bucket or tub. If the sample is to be collected using the same hand auger, the auger bucket will be decontaminated (or replaced with a decontaminated bucket) before collecting the sample. The discrete sample will then be collected by advancing the sampling equipment (e.g., hand auger bucket or thin-wall tube sampler) to the appropriate depth and retrieving the soil sample. Any sample collected for analysis of VOCs will follow the method presented in Attachment 1. The remaining soil in the sampling equipment will be placed in a decontaminated stainless steel, glass, plastic, or disposable collection container, and thoroughly homogenized using a decontaminated stainless steel spoon or trowel. The homogenized material will then be divided equally among the appropriate sample containers. Depending on the number of sample containers to be filled at each sample location, additional sample material may be required from the soil boring. The sample containers will then be sealed tightly, and handled according to SOP-018.

3.2.5.2 Deep Subsurface Soil Sampling

Equipment commonly used to collect deep subsurface samples includes, but is not limited to, split-spoon samplers, continuous core samplers, Shelby tubes, and ring-lined barrel samplers. These types of sampling equipment are used in conjunction with a drill or DPT rig, and are usually either hammered, drilled, or pushed into the interval to be sampled. The interval(s) to be sampled may be either predetermined as specified in the project-specific plans, or determined according to criteria observed during advancement of the drilling equipment (which will also be specified in the project-specific work plans).

3.2.5.2.1 Direct Push Technology (DPT) Drilling

DPT soil sampling equipment will be a hydraulically powered soil-probing machine that utilizes static force and percussion to advance small diameter sampling tools into the subsurface for collecting soil cores. This equipment is typically mounted on a truck or all-terrain vehicle capable of traversing rough and possibly muddy terrain.

Prior to initiation of the DPT borings concrete or asphalt surface at the selected sample locations will be removed (if necessary) by coring. Geoprobe® or other equivalent DPT sampling method will be used to collect soils by utilizing either the Macro-core® sampler (i.e., 48 inches long and 2 inches in diameter), or the Large-bore® sampler (i.e., 24 inches long and 1 inch in diameter).

Each Geoprobe® soil sampler will be equipped with a clear plastic liner and a closed-piston tip. The sampler will be driven down to the top of the desired sampling interval and the piston tip unlocked, then driven to the bottom of the desired interval (either 24 or 48 inches). Macro-core® catchers or an equivalent will be used in sandy intervals to minimize the potential for loss of sample recovery. The Field Geologist will collect the necessary samples for logging, field photoionization detector/flame ionization detector (PID/FID) screening, and laboratory analyses. Any sample collected for analysis of VOCs will be collected and preserved according to Attachment 1. The remaining soil in the sampler will be placed in a decontaminated stainless steel, glass, plastic, or disposable collection container, and thoroughly homogenized using a decontaminated stainless steel spoon or trowel. The homogenized material will then be divided among the appropriate sample containers. Sample containers will be sealed tightly, and handled per the Basewide FSP. Following sampling, soil boreholes will be abandoned per specifications in SOP-007, *Well Abandonment/Borehole Plugging*. The boreholes will be logged in accordance with the specific procedures provided in SOP-012, *Boring Log Development.* All equipment associated with collection of the soil samples will be decontaminated in accordance with the procedures provided in SOP-021, *Equipment Decontamination Procedures.*

3.2.5.2.2 Hollow-Stem Auger Drilling

Using the drilling equipment (e.g., hollow-stem augers and auger bit), the soil borehole should be advanced to the depth immediately above the sampling interval in accordance with American Society for Testing and Materials (ASTM) Method D-1586. During advancement of the auger, cuttings from around the augers will periodically be removed and placed on a plastic sheet or in appropriately labeled drums. The sampler will be inserted into the hollow-stem augers and lowered to the bottom of the borehole. The sampler will then be driven ahead of the augers by hammering into the undisturbed sampling interval. Blow counts for that sample will be recorded on the boring log, as well as the interval in which the sample was obtained. The sampler will be retrieved and split open. Any samples for analysis of VOCs will be immediately collected and preserved according to Attachment 1. The remaining soil in the sampler will be placed in a decontaminated stainless steel, glass, plastic, or disposable collection container, and thoroughly homogenized using a decontaminated stainless steel spoon or trowel. The homogenized material will then be divided among the appropriate sample containers. Sample containers will be sealed tightly, and handled per the Basewide FSP. Following sampling, boreholes will be abandoned per specifications in SOP-007, *Well Abandonment/Borehole Plugging.*

3.2.5.2.3 Sonic Drilling

With sonic drilling, the core barrel is vibrated into the ground 10 or 20 feet ahead of the outer drill casing. The outer drill casing is then advanced to the bottom of the core barrel and the core barrel is then removed from the hole and the core is extruded into a plastic sleeve. Any samples collected for analysis of VOCs will be collected and preserved as outlined in Attachment 1. The core is measured for recovery and recorded on the soil boring log. The sample will be inspected for changes in lithology, color, moisture, and density and recorded on the soil boring log. A stainless steel or plastic catcher should be used once the water table has been reached. The catcher prevents finer, wetter material from falling out of the core barrel and will improve recovery of the sample. The stainless steel catcher is usually welded into the bit to prevent material from being pushed up into the core barrel.

3.2.5.2.4 Air Rotary Drilling

Dual rotary soil samples will be collected directly from the air/cuttings discharge point. These samples may only be analyzed for geotechnical parameters. The depth of the sample will be determined by the Rig Geologist due to the travel time for the cuttings to move from the bottom of the borehole through the annulus to the cyclone. The driller shall be consulted for the time when penetration is initiated to measure the travel time.

4.0 REFERENCES

Barth, D.S. and B.J. Mason, 1984. *Soil Sampling Quality Assurance User's Guide*, U.S. Environmental Protection Agency (USEPA)-600/4-84-043.

Mason, B.J., 1983. *Preparation of Soil Sampling Protocol: Techniques and Strategies*, USEPA-600/4-83-020.

Penetration Test and Split Barrel Sampling of Soils, Method D-1586, Volume 04.08, ASTM, Philadelphia, PA, pp.216-219.

U.S. Environmental Protection Agency (USEPA), July 2002. SW-846 Final Update III A Method 5035A. Closed-system purge-and-trap and extraction for volatile organics in soil and waste samples.

USEPA, 1984. *Characterization of Hazardous Waste Sites - A Methods Manual, Available Sampling Methods*, Vol. II, 2nd Edition, USEPA-600/4-84-076.

5.0 RECORDS

All records shall be documented in a bound field logbook in accordance with SOP-019, *Field Activity Records.*

6.0 ATTACHMENTS

Attachment 1 - Soil Volatile Organic Compounds Sampling Procedure by USEPA Extraction Method 5035A.

Attachment 1 – Soil Volatile Organic Compounds Sampling Procedure by USEPA Extraction Method 5035A

This attachment presents the US EPA Extraction Method 5035A for the collection of volatile organic compound (VOC) samples of soils in the field. In summary, this method involves the collection of a fixed volume of soil using a specially designed disposable sampler, containerizing the sample in a prepared sample vial, and freezing the sample for delivery to the analytical laboratory. The advantage of this extraction method over previous methods is the resulting 14-day holding time, which allows more time for shipment and laboratory preparation over the 48-hour holding time required by the previous methods.

Sample Collection

The method requires that a fixed amount of soil be collected, usually as 5 gram or 10 gram samples. To achieve this, a specialized sampling tool has been developed that approximates these quantities at the time of collection depending on soil texture. The tool consists of a T-bar handled sampling device that is affixed with a disposable plastic soil syringe. To collect a sample, the Field Geologist sets the sampling device to the desired sample volume (5 or 10 grams) and inserts a new disposable plastic syringe. The Field Geologist then inserts the syringe portion of the sampler into the selected undisturbed soil sample. The soil is forced into the plastic syringe, pushing the syringe plunger out until it reaches the predetermined volume set on the sampling device handle. Immediately after the syringe has been filled with the soil sample, the Field Geologist will remove the syringe from the soil and place the open end of the syringe over a labeled pre-weighed sample vial containing a stir-bar and regent grade water. The soil sample will then be extruded into the vial by pushing down on the sampler T-handle, depressing the plunger. Once the sample is extruded, the vial is capped and placed on ice. The used plastic soil syringe is removed from the sampler and discarded, a new syringe is placed in the sampler to collect the next sample.

The collected sample vials are taken to a prearranged location and weighed to the nearest 0.01 gram using a calibrated scale. The location used for weighing the samples should have a stable surface for the scale, a relatively constant temperature, and no wind or other significant disturbances, preferably indoors. The measured weight is recorded on the sample vial label and in the log book. The sample vials are then placed in a cooler on ice. The samples are then packed in coolers and shipped according to SOP-018, *Packing and Shipping of Environmental Samples*. All samples will be packed on ice for shipment to the laboratory.

Additional Equipment Needed

- T-bar sampler with 5 and 10 gram graduations;
- Disposable plastic soil syringes (equivalent to the AnalSys soil sampling device);
- 40-ml glass pre-prepared sample vials – the vials must include label, and magnetic stir bar and have been pre-weighed.
- Cooler with wet ice, capable of maintaining 4 ± 2°C;

- Scale capable of measuring to the nearest 0.01 gram; and
- Scale calibration weights.

1.0 PURPOSE

The purpose of this Standard Operating Procedure is to assure representative environmental sample data by documenting the management of samples from time of collection through analysis and final disposition.

2.0 SCOPE

This Standard Operating Procedure applies to all personnel who collect and/or handle environmental samples.

3.0 METHOD

3.1 General

An essential part of the sampling/analytical portion of any environmental project is assuring the integrity of the sample from collection to data reporting. Projects where analytical data or conclusions based upon analytical data may be used in litigation demand that accountability of the history of a sample be available to demonstrate that the data are a true representation of the environment. The chain of custody (COC) form is used as evidence in legal proceedings to demonstrate that a sample was not tampered with or altered in any way that may skew the analytical accuracy of the laboratory results. Therefore, it is extremely important that COC forms be complete, accurate, and consistent.

Assuring sample integrity and accountability requires strict adherence to the proper use of the following six essential sampling components:

- Field Sampling Plans (FSPs);
- Sample labels;
- Sample logs;
- Sample custody seals;
- Field logbooks; and
- COC forms.

Successful implementation of these components requires a thorough understanding of sample custody requirements. A sample is under an organization's custody if:

- It is in an employee's physical possession;
- It is in view of an employee, after being in their physical possession;

- It was in an employee's physical possession and then locked up so no one could tamper with it; and

- It is in a designated and identified secure area, controlled and restricted to authorized personnel (or individuals accompanied by authorized personnel) only.

A sample remains in an organization's custody until relinquished in writing to another person or organization that is authorized to take custody of the sample.

3.2 Procedures

3.2.1 Sample Labels

Sample labels are required to prevent misidentification of samples. Sample labels will generally be pre-printed by a database technician and taken to the field.

The sample label will be affixed to the proper sample container at the time of the sampling event by the field sampler. The labels will contain the following pre-printed information:

- Sample identification number (ID);

- Site ID;

- Event ID (if applicable);

- Location ID;

- Analyses requested;

- Receiving laboratory;

- Type of sample container;

- Preservatives used;

- Sample matrix; and

- Matrix spike/matrix spike duplicate (MS/MSD) if required.

During a sampling event, the field sampler will write the following information on the label:

- Field sampler's initials;

- Date (mm/dd/yy or m/d/yy, i.e., 04/03/98 or 4/3/98 is April 3, 1998); and

- Time of sample collection (military format).

Custody seals are narrow strips of adhesive paper used to document that no sample tampering has occurred during transport from the time of collection to laboratory receipt. Custody seals will be signed, dated, and attached to all coolers so they tear if the cooler is opened.

3.2.2 Field Logbooks

All samples collected will be documented in field logbooks. All field documentation will follow SOP-019, *Field Activity Records.*

3.2.3 Chain-of-Custody Form

Every person involved with sample collection and handling will know and understand the COC form, discussed in detail in SOP-017, *Chain-of-Custody Form*. These procedures will be made available to all field personnel.

The sample shipper will complete the COC form while preparing the samples for shipment. This individual or other authorized person will sign the "Relinquished By" box and enter the shipper's name in the "Received By" box prior to sealing a sample shipping container for courier pickup after ensuring that samples and COC forms match (in other words, only samples identified on the enclosed COC(s) are in the container and all samples enclosed are listed on the COC(s) enclosed). The "Received By" box will be signed by the laboratory sample receipt staff. As long as COC forms are sealed inside the sample shipping container, commercial carriers are not required to sign the COC form.

Distribution of the COC form will be:

- Original and one copy - sealed in plastic bag and taped inside the top of the shipping container;
- One copy - file in appropriate Field Office project file; and
- One copy - submit to Data Management staff.

All changes to a COC form will be made by striking the incorrect information with a single line, initialing and dating the strike, and inserting the correct information. If changes are made to a COC form after the original distribution, the following steps will be taken:

- Make the change by striking the incorrect information with a single line, initialing and dating the strike, and inserting the correct information (in black or blue indelible ink). Add a comment as to why the change was made, as appropriate.
- Distribute copies of the corrected COC form as specified above.

Whenever a sample is split with a second party (e.g., client, agency) a separate COC form must

be prepared for those samples.

4.0 REFERENCES

US Environmental Protection Agency (US EPA), December 1984, *Characterization of Hazardous Waste Sites - A Methods Manual*: Vol. II. Available Sampling Methods, 2nd Edition, USEPA-600/4-84-076, p. D1-D11.

US EPA/NEIC, *User's Guide to the EPA Contract Laboratory Program*.

US EPA/NEIC, 1982. *Policies and Procedures*, 330/9/78/001-R.

5.0 RECORDS

Procedures for maintaining COC forms are described in SOP-017, *Chain-of-Custody Form*

1.0 PURPOSE

The purpose of this Standard Operating Procedure is to ensure that the chemical integrity of a sample is maintained from time of collection until chemical analysis.

2.0 SCOPE

This Standard Operating Procedure applies to all personnel involved with the collection, shipping and chemical analysis of environmental samples. The Standard Operating Procedure documents the protocols and chemicals to be used for the preservation of field samples. The environmental media addressed in this Standard Operating Procedure include soils, sediments, IDW, and aqueous samples.

3.0 METHOD

3.1 General

Most chemical and biological reactions and many physical processes are slowed by lowering the temperature. Therefore all samples except solids samples for volatile organic compound (VOC) analysis need to be cooled at the time of collection and maintained slightly above freezing until preparation for final analysis. Solid VOC samples are extracted within 48 hours of collection and the extracts are kept chilled.

Non VOC soil samples and other solid samples, including sediments, sludges and solid waste, will be preserved by cooling to ≤ 6°C. Soil and solid samples require no other preservatives, except for volatiles in soil and sediments, which are discussed in Attachment 1 of SOP-013, *Soil Sampling*. However, analysis must be performed within the method-specific holding time requirements.

Aqueous samples may be presumed to be homogenous and amenable to chemical preservation as applicable. In addition to keeping such samples cold, the following general approaches are employed depending on the analyte(s):

- Volatile acids (hydrogen cyanide, hydrogen sulfide) are rendered involatile in the presence of strong base (sodium hydroxide (NaOH), pH > 12).
- Volatile bases (ammonia) are rendered involatile in the presence of strong acid (sulfuric acid [H_2SO_4], pH < 2).
- Biodegradation of organic compounds is retarded under strongly acidic conditions (hydrochloric acid [HCl] or H_2SO_4, pH < 2).
- Dehydrohalogenation (loss of HCl) of chlorinated solvents is counteracted in the presence of acid (HCl, pH $\leq$ 2).

- Oxidation of target analytes by the chlorine found in drinking water is eliminated by destroying the chlorine with a reducing agent such as sodium thiosulfate.

- Many soluble metal salts tend to plate out on the walls of the container or form precipitates with time. This can be prevented by the addition of nitric acid to a pH of < 2, which maintains the metals as soluble nitrate salts.

3.2 Procedures

3.2.1 General

All sample containers and disposable soil syringes for VOC sample collection will be supplied in advance by the subcontracting laboratories.

The required chemical preservatives for aqueous samples will normally be added to the appropriate containers by the subcontracting laboratories prior to delivery to the field. Pre-preserved sample containers are preferable so that the laboratory scheduled to do the analysis maintains control over sample integrity and container cleanliness. Sample preservatives should be identified on the sample label and the sample log form.

3.2.2 Soil, Sediment and Solid IDW

Following collection, solid samples, except for volatiles in any type of container, will be labeled and then immediately placed in an ice chest containing sufficient ice to maintain a temperature range of 0 - ≤ 6°C throughout the day. Ice chests with samples collected at the sampling site will be transported to the field sample control area in a timely fashion.

Samples are maintained in ice or in refrigerators, within a range of 0 - ≤ 6°C, from the time they are collected until the samples are packed for shipment and relinquished to the shipper or other transport agent.

All soil and sediment samples are shipped in ice chests packed with sufficient ice to maintain a temperature range of ≤ 6°C for at least 24 hours (refer to Standard Operating Procedure SOP 018, *Packing and Shipping of Environmental Samples*). The receiving laboratory will measure the temperature within the ice chest and then place the VOC samples in a freezer with a temperature between –7°C and –20°C immediately upon assuming custody of a shipment of samples. The temperature of all ice chests will be noted on the chain-of-custody form or addenda to the form.

Temperatures in excess of 6°C will be reported immediately to the Project Chemist. After consultation with the Project Chemist and QA Manager, the Project Manager will determine if resampling is necessary.

3.2.3 Aqueous Samples

With respect to procedures for maintaining a temperature range of 0 - ≤ 6°C, aqueous samples will be treated the same as solid samples as described in Section 3.2.2.

The amount of acid preservative provided by the laboratory may not suffice to lower the pH to ≤ 2 in the case of highly buffered waters. The pH of such samples should be monitored on a regular basis (see SOP-005, *Groundwater Purging and Sampling*). A small amount should be poured from each container with preservative (except zero headspace samples) directly onto the pH strip. For volatile organic compounds, this is best accomplished by filling an extra vial during collection, ensuring it is not overfilled, then using pH strips or probe to check that the sample is at or below the maximum pH allowed. This vial would then be disposed of as Investigation-Derived Waste (IDW). Similar remarks apply to aqueous samples preserved with NaOH where the pH should be > 12. With the exception of VOCs, if the pH of a sample is not at the required level, the appropriate chemical preservative will be added in the field until the required level is achieved. For VOCs, the sample containers cannot be reopened once the sample has been collected; therefore, the laboratory will be notified of all VOC samples which do not meet the target preservation pH. Those VOC samples will be prioritized by the laboratory so that the analyses are completed within the unpreserved holding time limits.

3.2.4 Reagents

Reagent-grade inorganic chemicals conforming to specifications of the Committee on Analytical Reagents of the American Chemical Society (ACS) will be used as preservatives, including:

- Analyte-free reagent water, prepared per page 26 of Chapter One of *Standard Methods for the Examination of Water and Wastewater* (American Public Health Association, 1985) or purchased high pressure liquid chromatography-grade water;
- Nitric Acid, ACS grade, 16N;
- NaOH, ACS grade, pellets;
- H_2SO_4, ACS grade, 37N;
- HCl, ACS grade, 12N;
- Sodium Thiosulfate, ACS grade crystals; and
- Zinc Acetate.

4.0 REFERENCES

American Public Health Association, 1985. *Standard Methods for the Examination of Water and Wastewater*, 16th Edition.

Code of Federal Regulations (CFR), 1990, 40 CFR 136.

State of California, 1989. *Leaking Underground Fuel Tank Field Manual: Guidelines for Site Assessment, Cleanup, and Underground Storage Tank Closure*, Leaking Underground Fuel Tank Task Force.

U.S. Environmental Protection Agency (EPA), June 1991. *Statement of Work for Organics Analysis*, Document No. OLMO1.0, Contract Laboratory Program.

EPA, November 1990. *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*, SW-846, 3rd Edition, Final Update I, Office of Solid Waste and Emergency Response, Washington, D.C.

EPA, March 1990. *Statement of Work for Inorganics Analysis*, Document No. ILMO1.0, Contract Laboratory Program.

EPA, December 1982. *Methods for Chemical Analysis of Water and Wastes*, USEPA-600/4-82-055.

5.0 RECORDS

A record of reagents used with corresponding lot control numbers will be maintained in the sample control area by the Sample Shipper/Controller.

6.0 ATTACHMENTS

Requirements for containers, preservation techniques, sample volumes, and holding times are provided in Table 5-1 of the Work Plan.

1.0 PURPOSE

The purpose of this Standard Operating Procedure is to delineate protocols for use of the chain-of-custody (COC) form.

2.0 SCOPE

This Standard Operating Procedure applies to all personnel responsible for collecting, shipping and analyzing environmental samples.

3.0 METHOD

3.1 General

COC forms are used to legally track samples from time of collection through completion of laboratory analysis.

3.2 Procedures

The following information will be preprinted on the COC form when possible:

- Project name;
- Name and address of laboratory; and
- Potential analysis and method numbers.

The following information will be written on the COC form by the sample controller/shipper:

- Site name;
- Name of receiving laboratory;
- Sample IDs for all samples in a particular cooler/shipping container;
- Sample matrix or matrix code (e.g., SO for soil);
- Sample type (environmental, trip blank, equipment blank, etc.), which is encrypted in the sample ID code;
- Analysis requested by method number unless other arrangements are made with the receiving laboratory;
- Number of containers;
- Quality Control (QC) required (to indicate the sample is to be used for matrix spike/matrix spike duplicate analyses);

- Date of collection (mm/dd/yy or m/dd/yy: 04/03/98 or 4/3/98 is April 3, 1998);
- Time of collection (military format);
- Signature of individual who prepares the COC form;
- Cooler identification (ID);
- Carrier service and airbill number; and
- Signature of individual relinquishing samples along with the date and time of relinquishment.

Upon completion of the form, retain two copies and affix the original and one copy to the inside of the sample cooler (in a Ziploc® bag to protect from moisture), to be sent to the designated laboratory.

4.0 REFERENCES

U.S. Environmental Protection Agency (EPA), December 1990. *Sampler's Guide to the Contract Laboratory Program*, USEPA/540/P-90/006, Directive 9240.0-06, Office of Emergency and Remedial Response, Washington, D.C.

EPA, January 1991. *User's Guide to the Contract Laboratory Program*, USEPA/540/0-91/002, Directive 9240.0-01D, Office of Emergency and Remedial Response, Washington, D.C.

EPA, *Guidelines and Specifications for Preparing Quality Assurance Project Plans.*

5.0 RECORDS

Distribution of the COC record will be:

- Original and one copy - sealed in plastic bag with a custody seal (initialed and dated) and taped inside the top of the shipping container;
- One copy - file in Project File; and
- One copy - submit to URS Database Manager.

6.0 ATTACHMENTS

A sample of a chain-of-custody form is attached.

1.0 PURPOSE

The purpose of this Standard Operating Procedure is to provide guidance for the packing and shipping of environmental samples with the appropriate chain-of-custody (COC) forms. This is in accordance with all applicable transportation regulations, analytical requirements, and proper COC forms.

2.0 SCOPE

This Standard Operating Procedure applies to all personnel involved in the packing and shipping of environmental samples. Samples determined to be hazardous will be managed in accordance with the requirements of the U.S. Department of Transportation (DOT) and the International Air Transportation Association (IATA) for shipping hazardous/dangerous goods by land or air.

3.0 METHOD

3.1 General

Environmental samples and quality control samples are collected, labeled, and sealed in the field, and COC is maintained, as defined in SOP-015, *Field Sample Management.*

40 Code of Federal Regulations (CFR) Part 261.4 describes sample shipping requirements. It states that:

> "... a sample of solid waste or a sample of water, soil, or air, which is collected for the sole purpose of testing its characteristics or composition, is not subject to any requirements of this part (hazardous materials shipping requirements)... when:
>
> (i) The sample is being transported to a laboratory for the purpose of testing; or
>
> (ii) The sample is being transported back to the sample collector after testing.
>
> In order to qualify for the(se) exemption(s)..., a sample collector shipping samples to a laboratory and a laboratory returning samples to a sample collector must:
>
> (i) Comply with DOT, U.S. Postal Service (USPS), or any other applicable shipping requirements; or
>
> (ii) Comply with the following requirements if the sample collector determines that DOT, USPS, or other shipping requirements do not apply to the shipment of the sample:
>
> (A) Assure that the following information accompanies the sample:
>
> (1) The sample collector's name, mailing address, and telephone number;

(2) The laboratory's name, mailing address, and telephone number;

(3) The quantity of the sample;

(4) The date of shipment; and

(5) A description of the sample.

(B) Package the sample so that it does not leak, spill, or vaporize from its packaging. The URS Hazardous Materials Shipping Hotline can be reached at 1.800.381.0664. Shipping experts are available via the hotline to answer any shipping questions you may have.

Samples will be assessed to determine potential hazard. Potentially hazardous samples are required by law to be properly handled and labeled.

PID readings greater than 1,000 parts per million will be used to identify a sample as hazardous. These measurements should be made on the sample headspace or directly over the sample as it is being collected. Good judgement on the part of the sample coordinator is also necessary to identify hazardous samples. Samples collected from chemical or fuel drums and tanks, stained or otherwise obviously contaminated soil, free product from a well, leachates, sludges, and samples with headspace readings noted above are all hazardous samples. Hazardous waste samples will be shipped according to DOT and IATA regulations.

Samples determined to be non-hazardous by the Sample Coordinator are environmental samples. They are to be labeled, packaged, documented, and shipped as described in Section 4.3.

3.2 Procedures

Determine the maximum allowable weight of each cooler (Federal Express limit for Priority Overnight shipping is 150 pounds).

Place each container in a Ziploc® bag and seal, squeezing as much air as possible from the bag before closing. Glass bottles and jars will be wrapped in bubble wrap.

Tape the cooler's drain plug shut on the inside and the outside, unless using dry ice in shipment.

Place a large size plastic bag (trash bag) in the cooler to contain samples.

Place the bottles upright in the plastic bag, with enough room for ice bags to be placed among and around the containers, and insulate with enough bubble wrap to deter breakage.

Place ice (double-bagged) among the containers along the walls and top of each cooler in a manner to ensure uniform cooling. When shipping soil samples, place one bag of ice along the bottom of the cooler as well. For water samples, it is possible to place the bottles upright in

absorbent material to provide additional stability. Do not use Blue Ice, as its heat capacity is lower than regular ice. If the Sample Shipper/Controller is informed by the laboratory that the samples are not being chilled sufficiently, additional ice may be required. Note that in summer months, more ice may be needed to ensure the samples arrive cold at the laboratory.

If shipping via commercial carrier (e.g., Federal Express), write the carrier's airbill number on the COC form, place the appropriate pages of the COC form inside a Ziploc® bag, and seal the bag with a signed, dated custody seal. The COC form has three pages. The original and one copy are sealed inside the Ziploc® bag and placed inside the cooler. One copy goes to project data management, and one copy (made by the Field Manager) is placed in field files. The COC form sent to the laboratory must be completed with all designated information, the pages must be originals (not photocopies), and the COC must be unique to the samples contained in the cooler.

If a courier from the laboratory is collecting the samples and delivering them to the laboratory, have the courier confirm that all samples listed are present and then sign the COC form.

Tape the Ziploc® bag with the COC form to the inside lid of the cooler, and close and latch the cooler.

Wrap strapping tape completely around the cooler on both sides of the latch.

Affix the shipping label with the address and telephone number of the laboratory and the contractor.

Affix signed custody seals on the front right and back left of the cooler across the lid, so as to tear if the cooler is opened during shipping.

The laboratory should be notified if the samples are being delivered via courier. They should be prepared to receive and check the samples and sign the COC form as the sample receiver.

4.0 REFERENCES

40 CFR 261.4, July 1990, Identification and Listing of Hazardous Waste, Federal Register, Chapter 1, p. 35.

Environmental Resource Center, 1992. *Hazardous Waste Management Compliance Handbook*, Van Nostrand Reinhold, New York.

EPA, 1987. *A Compendium of Superfund Field Operation Methods*, Office of Solid Waste and Emergency Response, Directive 9355.0-14.

EPA, 1986. *RCRA Groundwater Monitoring Technical Enforcement Guidance Document*.

EPA, 1985. *Characterization of Hazardous Waste Sites: A Method Manual*, Vol. I, Site

Investigation.

5.0 RECORDS

Completed COC form.

1.0 PURPOSE

The purpose of this Standard Operating Procedure is to set site-wide criteria for content entry and form of field logbooks, and to document procedures employed in recording site activities photographically or using a video camera.

2.0 SCOPE

This Standard Operating Procedure applies to all personnel who record information in field logbooks, or employ photographic or video techniques to document site activities.

3.0 METHOD

3.1 General

An essential part of the sampling/analytical portion of any environmental project is assuring that proper documentation of all activities is accomplished. The primary document used to record site data is the field logbook. Tasks where analytical data or conclusions based upon analytical data may be used in litigation demand that accountability of the history of a sample be available to demonstrate that the data are a true representation of the environment. The field logbook may be used as evidence in legal proceedings to defend procedures and techniques employed during site investigations. Therefore, it is extremely important that field logbook documentation be factual, complete, accurate and consistent.

Likewise, when photographic or videographic techniques are used to document site activities, the goal of the records is a true representation of field activities that accurately portrays site conditions or procedures.

3.2 Procedures

3.2.1 Preparation

New field logbooks will be obtained as needed from the Field Manager/Task Leader. The individual using the field logbook will be responsible for its care and maintenance throughout the field task.

Field logbooks will be bound with lined, consecutively numbered pages. All pages must be numbered prior to initial use of the logbook. The following information will be recorded on the cover, binding, or inside the front cover of the logbook:

- Field document control number;
- Activity;
- Contractor's name;
- Phone number; and

- Site contact (Field Manager/Task Leader).

3.2.2 Operation

The following requirements must be followed when using a logbook:

- The date must be recorded at the top of each page.
- If data collection forms are specified by an activity-specific plan or procedure, the information need not be duplicated in the logbook.
- All changes must be made with a single line through the deletion. Changes must be initialed and dated.
- A diagonal line must be drawn through any space left at the bottom of each page.
- The bottom of each page will be signed by the author.
- Do not remove any pages from the logbook.

Entries into the field logbook will be preceded with the time of the observation. The time should be recorded frequently and at the point of events or measurements that are critical to the activity being logged.

At each station where a sample is collected or an observation made, a detailed description of the location is required. If a map is not already available that shows the sample location, a sketch of the location is required. The sketch or diagram should be detailed enough for other individuals to locate the points at future times. A direction indicator or compass direction should be located on the sketch. It is preferred that maps and sketches be oriented so that north is towards the top of each page.

Events and observations that should be recorded include, but are not limited to:

- Changes in weather that may impact field activities;
- Deviations from procedures outlined in any governing documents. Also record the reason for any noted deviation;
- Problems, downtime, or delays;
- Upgrade or downgrade of personal protective equipment;
- All task members and visitors;

- Actual and background readings of health and safety monitoring equipment;
- Identification of equipment used, including model numbers and/or serial identification numbers;
- Start and end times of sample locations; and
- Decontamination times and methods.

When samples are collected, the following should be recorded:

- Sample location;
- Sample number;
- Sample methodology;
- Sample description;
- Sample collector;
- Sample depth;
- Sample type;
- Sample analyses requested;
- Sample preservation and confirmation; and
- Quality control (QC) sample numbers and types.

3.2.3 Visual Recordings

When visual recordings (photographs or video recordings) are made, they will be documented in the associated field logbook. At the start of the day, the weather conditions should be recorded; the weather should also be noted if site conditions change (e.g., weather goes from clear to overcast) throughout the day. For each photograph, the following information must be recorded:

- Location;
- Date and time;
- Photographer;

- Detailed description of subject of photograph;
- Direction of photograph (e.g., "taken facing northwest");
- Identification of individuals in the photograph and their affiliation;
- Photograph number;
- Mechanical difficulties (if encountered) and corrective actions taken (and results).

A figure, map, or sketch of the site indicating the locations where photographs were taken is useful, especially if before and after photographs are to be taken at different times (potentially by different photographers, although using the same photographer is highly recommended).

For video recordings, the same information should be noted, along with the start and stop times on the recording. If the camera is capable of captioning with date, time, and text information to the recorded image, this is recommended. Such a captioning capability aids in later labeling and identifying the photographs or video recordings.

Photographs and/or video recordings should be taken with a camera-lens system having a perspective similar to that afforded by the naked eye. Telephoto or wide-angle shots are to be avoided unless previously approved by the client.

Most video cameras offer the cameraperson, or an accompanying field technician, audio recording capability that can be used to provide a running commentary on the activities recorded. This information is not a substitute for hard-copy documentation in a logbook (wind blowing across the microphone or technical difficulties may render the sound inaudible). Commentary should be pertinent and succinct.

3.2.4 Post-Operation

At the conclusion of a task or when a logbook has been completed, it will be submitted to the Field Manager/Task Leader for filing in the Project File.

Cameras will be returned to the location designated by the field task leader in the field office (the camera and film must be kept in a temperature and humidity controlled environment when not in use; camera batteries may need to be recharged overnight). Film and developed photographs should be protected from unnecessary exposure to light (to avoid fading), and video recordings must be protected from magnetic fields. The video cartridge must be labeled.

After the first day of work and on a regular basis thereafter, the Field Manager/Task Leader will perform a QC content check for compliance with this Standard Operating Procedure.

4.0 REFERENCES

U.S. Environmental Protection Agency (USEPA), December 1984. *Characterization of Hazardous Waste Sites - A Methods Manual: Volume II. Available Sampling Methods*, 2nd Edition, USEPA-600/4-84-076, pp. D1-D11.

USEPA/NEIC, 1982. *Policies and Procedures*, 330/9/78/011-R.

USEPA/National Enforcement Investigations Center (NEIC), *User's Guide to the USEPA Contract Laboratory Program*.

5.0 RECORDS

Documentation will follow all guidelines contained in this Standard Operating Procedure.

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to ensure that Investigation-Derived Waste (IDW) generated as the result of environmental investigations is managed:

- In a manner consistent with the federal and state applicable or relevant and appropriate requirements (ARARs) to the extent practical;
- To ensure that the potential of further contamination to the site from IDW is eliminated;
- To ensure the quantity of generated IDW is minimized;
- To provide labeling, tracking, and inventory of IDW; and
- To reduce health and safety concerns by reducing the potential for exposure.

2.0 SCOPE

This SOP applies to all contractor personnel and subcontractors generating, transporting, and handling IDW during environmental investigations and monitoring programs at Sierrita Mine. This SOP describes the minimum acceptable practices.

3.0 METHOD

3.1 General

The IDW generated should be considered part of the site that is being investigated and should be managed with other wastes from the site. The IDW should be managed in a protective manner and should comply with Arizona Department of Environmental Quality (ADEQ) and Resource Conservation Recovery Act (RCRA) requirements.

3.2 Procedures

3.2.1 Materials

The following materials may be used to comply with this Standard Operating Procedure:

- Ring-top 55-gallon drums (DOT-17-H);
- 20-yard (or similar capacity) roll-off boxes with tarps to cover;
- Roll-off liners;
- Drum labels;
- Field supplies such as pallets, Visqueen, rope, drum liners, paint pens, tape, and hand tools;

- Sampling and shipping supplies such as bottles, coolers, plastic bags, vermiculite, self-closing plastic bags, labels, tapes, and bubble wrap;
- Health and safety equipment such as PPE, first aid supplies from sites and vehicles, and eye wash stations;
- 250-gallon truck tank(s);
- Submersible pump(s);
- Hoses and clamps; and
- Spill kit that contains absorb booms or pads, vermiculite, hand tools, spill-related PPE.

3.2.2 Equipment

The following equipment will be needed to comply with this Standard Operating Procedure:

- Boom truck;
- Flat bed truck;
- Soil sampling equipment such as hand auger, trowels, bowls, sieves, drum thieves, disposable bailers, funnels, and bottles;
- Drum forks or clamps;
- Health and safety equipment and monitoring equipment (photoionization detector [PID], flame ionization detector [FID]);
- First aid supplies, eye wash station, splash protection PPE;
- Water polishing system, if applicable (Project-Specific Basewide sampling analysis plan [SAP] should contain the plans, designs, and equipment list for this system);
- Bulk tank(s); and
- Roll-off boxes.

3.2.3 Solid Investigation-Derived Waste

All waste that is generated, stored, processed, transported or disposed of in the state must be classified according to the provisions of Arizona Administrative Code Title 18, Article 2.

Non-indigenous Solid IDW such as disposable sampling equipment or tools will be disposed at a licensed landfill. Used PPE such as Tyvek® or Saranac® suits; latex, nitrile, or rubber gloves or booties; and spent respirator filters will be disposed as hazardous, non-hazardous, or radioactive waste in an appropriate designated drum/container/dumpster based on its generation. PPE generated from coming into contact with listed or characteristic hazardous waste, will be disposed in a separate drum/container/dumpster designated for hazardous waste and shipped to a TSD facility. However, PPE generated during the investigation from non-hazardous waste areas will be placed in a separate container and will be managed as non-hazardous waste.

Grossly contaminated PPE will be put into a ring-top 55-gallon drum lined with plastic bag drum liner. When the drum is full, the liner bag will be sealed, the lid closed, and the drum will be numbered, labeled, and moved to the secured site drum holding area.

Indigenous Solid IDW Any solids generated during an investigation will be collected and placed in appropriate designated drums/containers/dumpsters and manifested off-site for disposal based on its nature and characteristics as either hazardous waste, non-hazardous waste, or a radioactive waste. For solids where nature of contamination is not known, the contractor must first determine whether the waste is hazardous or non-hazardous using either historical information or sampling. Waste such as drill cuttings, and excess soil samples or other solid media that may be generated, will be stored at the sampling location and/or a designated location at Sierrita Mine. As the IDW is generated, it will be placed into clean ring-top 55-gallon drums or lined roll-off boxes. The drums to be used for the collection of wastes will be placed in new or reconditioned containers carrying the Department of Transportation (DOT) United Nations "performance oriented packaging standard" symbol. Containers storing hazardous waste must be marked using a yellow "Hazardous Waste" label with the name, address, city, state, zip code, EPA ID number, EPA waste number, accumulation start date, manifest document number and DOT proper shipping name.

3.2.3.1 Solid Waste Sampling and Characterization

Generators who characterize waste using analytical methods to classify their waste must follow all state requirements. Where required by the disposal facilities, additional samples from each drum/container may be required. The solid samples will be collected using either a trier or an auger (SW-846, Chapter 9, Sampling Plans, 1986). For each drum/container, the analytical data associated with the samples collected for characterization of the waste will be evaluated to determine if the IDW is hazardous waste. To determine the characteristic of the IDW, the analytical results will be compared to the TCLP regulatory limit (40 CFR 261.24).

The field sampler will accurately record field-screening data on the waste accumulation log. IDW at each site will be containerized, managed, and sampled as a single waste stream. The

non-segregated IDW may be bulk containerized with other non-hazardous solid IDW as necessary for efficient management of the waste.

Grossly contaminated non-indigenous IDW will be characterized as special or hazardous waste. The drums will be labeled, manifested, transported, and disposed of at a licensed RCRA hazardous/special waste landfill.

Indigenous solid IDW will be classified after analytical data are available. If soil is determined to be suitably free of contamination and can be classified as a Class 3 waste, it may be used as clean fill on site or taken out of the drums and put onto the ground at the location it was generated. The disposition of this investigation-derived waste and the container will be recorded on the IDW Inventory Table.

If the IDW is found to be either a special waste or a hazardous waste, then the container will be labeled, manifested, transported, and disposed of at a licensed RCRA hazardous/special waste landfill, or a municipal solid waste (MSW) landfill that can accept Special Wastes. The landfill will be certified according to 40 CFR 300.440, also known as the off site rule.

3.2.3.2 Analytical Methods

The hazardous waste characteristics are defined in 40 CFR 261 Subpart C. Those characteristics include ignitability, corrosivity, reactivity, and Toxicity Characteristic Leaching Procedure (TCLP) levels. In the TCLP procedure, samples are extracted by Method 1311, further analyzed for TCLP metals, TCLP volatile and semivolatile organic compounds. All waste streams shipped off-site for disposal will be analyzed for RCRA characteristics in accordance with 40 CFR 261 Subpart C. For purposes of determining accurate waste classification, any commercial laboratory capable of performing SW-846 analytical method, using internally derived quality control limits, are adequate to meet the DQOs for off-site disposal. Typically, the laboratory will be associated with the disposal company and will provide relevant information such as bottle sizes, holding times and sample preparation.

All samples analyzed for IDW characterization will be performed in compliance with the project-specific plans.

3.2.4 Liquid Investigation-Derived Waste

It is expected that during sampling activities, liquids will be generated. The liquid IDW generated at each location, such as groundwater from the purging and development of monitoring wells and wastewaters from the decontamination of equipment will be characterized to determine types of contaminants present and management process required to handle the waste. Liquid IDW may at the Project Manager and Air Force direction be combined from several sites if the IDW is determined to be non-hazardous. Historical results may be used to make this determination. The disposal options for liquids include disposal by discharge into the sanitary sewer upon an appropriate modification into the NPDES permit, if necessary and approval from the City of Mesa. Any liquids that cannot be discharged into the sanitary sewers will be containerized and disposed properly as liquid wastes

Section 5.5 provides direction on the drum numbering scheme, labeling, and management of the IDW.

3.2.4.1 Liquid Waste Characterization

Before any data gathering activity occurs, the presence of a water-immiscible phase will be determined visually or using an oil/water interface probe. If a water-immiscible phase is present, then the IDW generated from that location will be pumped into 55-gallon drums. The drums, which will be sealed, numbered, labeled, and recorded on log sheets, will be left on pallets at the location. A composite sample will be taken and analyzed for hazardous waste characteristics. Before sampling, the drums of water with an immiscible layer will be inspected.

If the IDW is found to be a special or hazardous waste as defined in 30 TAC Chapter 335, or 40 CFR 261, Subpart D, or 30 TAC, Chapter 330.3 Subchapter A, then the container will be labeled, manifested, stored in a secured area with temporary berms, until it can transported for disposal at a licensed RCRA hazardous/special waste disposal facility.

If analytical results from liquid samples demonstrate the IDW is non-hazardous but contains constituents at levels above City of Mesa guidelines, the wastes must be containerized and disposed at an offsite facility.

If the analytical results from liquid samples show the IDW to be hazardous the drummed IDW will be managed and disposed of as a hazardous waste.

Empty drums will be decontaminated and if structurally sound, will be reused. If the drum is not structurally sound, the drum will be decontaminated, crushed, and recycled as scrap.

3.2.4.2 Sampling Liquid IDW

Representative composite samples will be collected and analyzed to characterize the liquid IDW generated at each site and accumulated in bulk storage tanks, drums or other containers using a Coliwasa tube. The samples will be labeled, sealed, recorded on the chain of custody, packaged, and shipped to the laboratory for analysis.

3.2.4.3 Analytical Methods

The hazardous waste characteristics are defined in 40 CFR 261 Subpart C. Those characteristics include: Toxicity, ignitability, corrosivity, reactivity, and Toxicity Characteristic Leaching Procedure (TCLP) levels by Method 1311, further analyzed for TCLP metals, TCLP volatile and semivolatile organic compounds. For purposes of determining accurate waste classification, any commercial laboratory capable of performing SW-846 analytical method, using internally derived QC control limits, are adequate to meet the DQOs for offsite disposal. Typically, the laboratory will be associated with the disposal company and will provide relevant information such as bottle sizes, holding times and sample preparation.

3.2.5 IDW Management Procedures

3.2.5.1 Drum Specifications

The drums to be used for the collection of wastes will be placed in new or reconditioned containers carrying the DOT UN "performance oriented packaging standard" symbol. Drums should be selected on their ability to hold hazardous, radioactive, and non-hazardous liquids and solids without damage to drum integrity. Special care should be taken in the selection of drums in areas where wastes will be collected and that are known to be reactive, corrosive, or contain organic solvents. The drums will be marked with weather proof indelible ink showing the sampling location (associated with the waste), and an identification number which will represent the location in the storage building where the drum is housed. These markings will be located on the top and side of the drum. Each drum will be stored in a manner so that the drum and attached labels can be inspected without moving the drum or surrounding drums.

3.2.5.2 Waste Tracking Labels

Container labels will be placed on the side and top of each container and will include the following information: Waste tracking number; generator; contents; the estimated depth collected (if solid); date the waste was first put in the container; date the container was closed; estimated quantity; and the name, address, and phone number of an emergency Point of Contact for additional information concerning the containers, and the words "Waste Solids or Waste Liquids". The drums will comply with DOT regulations outlined in 40 CFR.

3.2.5.3 Transport of Drums and Rolloff Boxes

All drums will be placed on a flat bed truck or trailer using a forklift or Bobcat and transported to the designated central IDW staging area. Roll-off boxes will be transported on a flatbed trailer to the central IDW staging area when $2/3^{rds}$ full or after the roll-off box is no longer needed. Straps will be used to secure the drums when they are placed on the flat bed and while being transported to the central IDW staging area.

3.2.5.4 Drum Inspections

The drums will be stored at the sampling location and/or designated location at Sierrita. The drums will rest directly on a gravel/soil substrate with a secondary containment. Any spills will be reported immediately to the Field Manager and the Project Manager. If drum integrity is compromised, it will be immediately corrected. All drums will remain closed at all times except during accumulation or when waste is being sampled or removed.

Drums will be inspected at least monthly by the Field Manager or his designee who will document in the field logbook or on a checklist the condition of each drum. Initiation of any necessary corrective actions will be the responsibility of Field Manager and coordinated with the Air Force. Any corrective actions will be discussed with the Air Force and it contractor's project management personnel.

3.2.5.5 Storage Time Limitations

Potential RCRA hazardous IDW generated at each site(s) will be temporarily stored for no longer than 90 days from beginning date of collection. According to 40 CFR 262.34(a), a generator may accumulate hazardous waste on-site for 90 days or less without a permit or without having interim status provided that the requirements in 40 CFR 262.34(a) are met. The storage unit will conform to 40 CFR 262.34(a), having a secondary containment system lined with 10-mil plastic. All non-hazardous waste will be stored at the central IDW staging area no longer than one year.

4.0 REFERENCES

- 40 Code of Federal Regulations (CFR) 261, Subpart D;

5.0 RECORDS

The following records will be maintained by the Field Administrator and retained as project documents and included as appropriate in the Waste Management Report for client deliverables.

- Hazardous Waste Weekly Inspection Forms;
- IDW Inventory Sheet;
- Field log books;
- Certificates of Disposal;
- Water treatment logs, sample collection data sheets, and discharge records; and
- Receipts for material being recycled.

1.0 PURPOSE

The purpose of this Standard Operating Procedure is to provide the step-by-step procedures for field decontamination of equipment. Decontamination of equipment and personal protective equipment (PPE) is designed to ensure that the introduction and transfer of contamination is minimized.

2.0 SCOPE

This Standard Operating Procedure applies to all personnel collecting environmental samples or operating in environments in which hazardous or contaminating substances are expected to be present.

3.0 METHOD

3.1 General

Decontamination consists of physically removing contaminants. To prevent the transfer of harmful materials and unwanted cross contamination, decontamination procedures continue throughout site operations.

A decontamination plan should be based on the worst-case scenario (if information about the site is limited). The plan can be modified if justified by supplemental information obtained as the field program evolves. Initially, the decontamination plan assumes all protective clothing and equipment that leave the exclusion zone are contaminated. Based on this assumption, a system is established to wash and rinse all non-disposable equipment. This Standard Operating Procedure will serve as the site decontamination plan.

The type of decontamination procedures and solutions needed at each site should be determined after considering the following project-specific conditions:

- The type of equipment to be decontaminated;
- The type of contaminant(s) present; and
- Extent of contamination.

3.2 Procedures

All sampling equipment used at the site must be decontaminated both before activities begin and after each sample is collected. All drilling equipment must be decontaminated both before activities begin and between each location.

3.2.1 Decontamination Site

Central decontamination areas for drill rigs and other large equipment will be located within Sierrita Mine Operations Area. A decontamination area will be chosen so that decontamination fluids and soil wastes can be easily discarded or discharged into controlled areas of

accumulation. A full-scale decontamination pad will be constructed. At a minimum, the pad must consist of a bermed liner large enough for equipment, have a nearby source of potable water, have a containment system for rinse water, and be equipped with a steam cleaner. After completion of drilling at a site, signs of gross contamination (if any) will be removed from the drill rig prior to moving the rig.

Smaller decontamination tasks, such as for groundwater, soil, and surface water/sediment sampling equipment, may take place at the sampling locations. In this case all required decontamination supplies and equipment will be mobilized to the site and all decontamination wastes containerized. Decontamination fluids will be disposed of according to WI-020, *Investigation-Derived Wastes.*

3.2.2 Decontamination Equipment

The following is a list of equipment that may be needed to perform decontamination:

- Bermed concrete or synthetic material-lined decontamination pad;
- Brushes (including long-handled brushes), garden-type water sprayers (without oil-lubricated moving parts), rinse bottles, flat-bladed scrapers;
- Portable steam cleaner;
- Sump or collection system for contaminated liquid;
- Wash tubs and buckets;
- Drums or tanks for containing decontamination fluids and solids; and
- Non-phosphate detergent,
- American Society for Testing and Materials (ASTM) Type II reagent grade water, isopropanol, methanol, hexane, or nitric acid.

3.2.3 Decontamination Procedure

3.2.3.1 Sample Bottles and Jars

At the completion of each sampling activity the outside of each sample bottle or jar must be decontaminated as follows:

- Be sure that the bottle or jar lids are snug.
- Wipe the outside of the bottle with a paper towel, if necessary to remove visible sample material from the bottle or jar.

3.2.3.2 Personnel and Personal Protective Equipment

Review the project HSP for appropriate personnel decontamination requirements.

3.2.3.3 Sampling Equipment

The following steps will be used to decontaminate small sampling equipment:

- Decontamination personnel will wear the appropriate personal protective equipment as required by the contractor specific HASP.
- The sequence of actual decontamination will be as follows:
  - Gross contamination on equipment will be scraped off at the sampling site.
  - Water-resistant equipment is placed in a wash tub containing Liquinox, or equivalent laboratory-grade detergent with potable water, and scrubbed with a bristle brush or similar utensil.
  - Equipment will be thoroughly rinsed with potable water in a second wash tub, and then rinsed using an ASTM Type II reagent grade water.
  - Rinse with pesticide-grade methanol if visible oil is present.
  - Rinse with pesticide-grade hexane if visible oil is present.
  - If methanol and hexane are used, rinse twice again with tap water and then rinse again using an ASTM Type II reagent grade water.
- Depending on site conditions and the number of samples collected at each location, rinse and detergent water may be replaced with new solutions between boreholes or sample locations.
- Following decontamination, equipment will be placed in a clean area to prevent contact with contaminated soil. All equipment should be allowed time to dry before re-use. If the equipment is not used immediately, it will be covered or wrapped in aluminum foil after drying to minimize potential airborne contamination.

3.2.3.4 Measurement Devices/Monitoring Equipment

Any delicate instrument that cannot be decontaminated easily should be protected while it is being used. These instruments can be covered with plastic sheeting, plastic bags, or aluminum foil to minimize contamination of the instrument. Openings can be made in the wrapping for sample intake.

3.2.3.5 Bailers

3.2.3.6 Groundwater Sampling Pumps

Proper pump decontamination between wells is essential for the integrity of samples. The following steps will be adhered to during decontamination:

- Potable water with a non-phosphate detergent such as Liquinox will be flushed through the pump and over the outside of the hoses. A minimum of three pump tubing volumes of soapy water will be purged through the pump.

- Potable water will then be flushed through the pump and over the outside of the hoses. A minimum of three pump tubing volumes of potable water will be purged through the pump to assure that all of the detergent solution has been removed.

- At least two pump tubing volumes of ASTM Type II reagent grade water will then be flushed through the pump. When applicable, the pump may then be used for the collection of an equipment blank.

- The pump is then allowed to dry and stored in the equipment area.

3.2.3.7 Drilling and Subsurface Soil Sampling Equipment

Drilling equipment, including the rig, augers, drill rods, and split-spoon samplers will be decontaminated by the drilling contractor prior to any drilling operations and between borings. Decontamination will take place at the fixed decontamination pad. All external surfaces of all drilling equipment, rigs, tools, drill bits, drilling stem, hoses, and all other appurtenant equipment will be thoroughly cleaned after each hole is completed. All tools used for soil sampling (i.e., split-spoon, split-barrel, Hydropunch samplers) will be decontaminated as specified in Section 4.3.3.3 prior to the collection of each sample. When collecting samples for geotechnical analysis only, soil sampling equipment will be decontaminated in the same manner as other drilling tools.

All drilling rigs and tools will be steam cleaned prior to commencement of drilling activities. All fluids will be contained and managed. Decontamination begins by completely removing all soil and visible contamination (i.e., soil, mud, hydraulic fluid) from the equipment with a high pressure steam cleaner, and thoroughly flushing the interior and exterior of all downhole tools, including drill pipes, collars, bits and tremie pipe with fresh, clean, potable water. Decontamination will take place at the decontamination pad where all rinse water will be containerized for disposition.

3.2.3.8 Decontamination of Heavy Equipment

Heavy equipment (e.g., drill rigs, bulldozers, backhoes, and trucks) is generally washed with water under pressure, if possible. Portable steam cleaners and handwashing with a brush and detergent, followed by a potable water rinse, can also be used. Decontamination of heavy equipment will be conducted at the decontamination pad where all rinse water can be containerized for treatment. Particular care must be given to the components in direct contact with contaminants, such as tires and buckets. Wipe sampling may be utilized to establish effectiveness of decontamination procedures.

3.3 Investigative Derived Material

All materials and wastes generated during decontamination will be managed as described in SOP-020, *Investigation-Derived Waste*.

4.0 REFERENCES

U.S. Environmental Protection Agency (EPA). *A Compendium of Superfund Field Operations Methods*, Vols. I and II, USEPA/540/P 87/001a&b.

5.0 RECORDS

Sampling personnel will be responsible for documenting the decontamination of sampling and drilling equipment. The documentation will be recorded in the field logbooks as per SOP-019, *Field Activity Records*. The information entered in the field logbook concerning decontamination should include the following:

- Date, start and end times;
- Decontamination personnel;
- Decontamination solutions used;
- Equipment identification numbers; and
- General decontamination methods and observations.

6.0 ATTACHMENTS

Not applicable.

1.0 PURPOSE

The purpose of this Standard Operating Procedure is to ensure that monitoring wells and other wells are properly developed after installation and prior to their designated use.

2.0 SCOPE

This Standard Operating Procedure applies to all personnel who develop or re-develop monitoring and other wells.

3.0 METHODS

3.1 General

Well development involves a reciprocating surge action causing inward water movement through the well screen, followed by pumping the well with the pump intake at various depths throughout the screen. Mechanical surging facilitates the removal of fine particles lodged in the well screen and filter pack. However, any number of techniques (e.g., jetting, airlifting) may be used in combination to help dislodge and remove sediment and achieve the well development objectives (detailed in section 4.3.3). Well development restores the aquifer properties disturbed during the drilling process, and improves the hydraulic characteristics of the filter pack and hydraulic communication between the well and the hydrologic unit adjacent to the well screen.

3.2 Procedures

The equipment needed for well development and the development procedures are discussed below. All newly installed wells will be developed no sooner than 24 hours after installation. All downhole development equipment will be decontaminated to prevent any cross contamination prior to developing each well. Decontamination procedures are detailed in SOP-021, *Equipment Decontamination Procedures*.

3.2.1 Equipment

The following equipment may be required to perform well development:

- Water level indicators;
- Equipment (e.g., surge blocks, work-over rig) capable of reciprocating surge action;
- Flow metering equipment (which could include graduated buckets or tanks and a digital watch with stopwatch function);
- Pump capable of flows up to 150 percent of the maximum planned well yield;
- Decontamination equipment;

- Logbook;
- Well development log form;
- Well construction log or information;
- In-line discharge valve or control;
- Pump electrical control system;
- Discharge settlement tank;
- Equipment for measuring water quality parameters (i.e., turbidity, temperature, pH, specific conductance);
- Leather work gloves;
- Nitrile rubber gloves;
- Hand-held radios and/or cellular telephones; and
- Photoionization detector (PID) to monitor the wellhead area.

3.2.2 Site Preparation

- Set up caution tape around work area (where necessary)
- If generator is used, place on plastic to contain fuel leaks and/or spills.
- Remove well cap and place it in a in clean area. Take initial PID headspace reading.
- The depth of the static water level and total depth of the well will be measured with a water level indicator (to the nearest 0.01 foot) as described in SOP-006, *Static Water Level and Total Depth Measurement.*
- Calculate well volume and record on well development log form.

3.2.3 Development Activities

- If no water level measurement reference point has been made in the top of the well casing, create a small but visible notch in the casing with a small saw, file, or similar tool. Use proper hand protection (leather gloves) while making the mark, and take care to avoid getting PVC shavings into the well. Create the notch on the north side of the well casing if it is practical to do so.

- Prior to setting development equipment in the well, the water level and total depth of the well will be measured and noted in the field logbook.

- If there is an appreciable amount of sediment noted in the bottom of the well, it should be removed (preferably with a bailer or by pumping) prior to well surging.

- The well will then be pumped or bailed without surging for a minimum of ten minutes or until dry. Water level readings, flow rate and water quality parameters (turbidity, temperature, pH, and specific conductance) will be measured and logged.

- Assemble equipment to locate surge tool(s) within the screened interval. The surge tool(s) will be placed such that surge action will be performed over the entire length of the screen. Surging may be performed on one section of the screen at a time, striving for equal time devoted to each portion of the screen.

- After removing at least well borehole volume from the well either during or following surging, measure and record water quality parameters. Surge the well again, removing at least another well volume of water. Measure water quality parameters (temperature, pH, specific conductance [conductivity], and turbidity at a minimum) after each volume of water has been removed.

- Well development is complete when water parameters have stabilized for two consecutive readings (such as those collected after the second and third well volume of water has been removed). Stabilization is defined as follows:

  - Conductivity, temperature, and pH have stabilized to $\pm$ ten percent conductivity, $\pm$ one degree Celsius, and $\pm$ 10% pH, over two consecutive readings, and;

  - The water is “relatively free of suspended solids.”

- Acceptable water quality parameters indicate that the well’s screened zone is properly developed. Once the water quality parameters have stabilized, the downhole development equipment (e.g., pumps, surge tools) will be removed, completing well development.

In some instances, low turbidity samples are difficult to obtain. This occurs primarily when the well is screened in a formation that contains a high level of fine material (silt and clay). Silt and clay can occasionally travel through the filter pack of a properly constructed well, resulting in turbid water. While selection of proper filter pack and screen materials minimizes turbidity, fine-grained particles can still flow through. In order for samples to meet turbidity criteria, additional development activities (e.g., pumping, surging) may be required. If the well is pumped dry, it will be allowed to recharge and the development process will be repeated as much as practical to reduce turbidity. If turbidity has not decreased to 10 or less NTU after 8 hours of development activities, development will cease provided conductivity, temperature, and pH have stabilized. The Field Manager/Task Leader will be notified. The possibility of additional development can be addressed on a well-specific basis.

3.2.4 Purge Water Treatment

All development and purge water generated will be contained and disposed of as described in SOP-020, *Investigation-Derived Waste.*

4.0 REFERENCES

American Society for Testing and Materials (ASTM), 1995. *Standard Practice for Design and Installation of Groundwater Monitoring Wells in Aquifers*, D5092-90, Vol. 04.09, ASTM, Philadelphia, PA, pp. 70-85.

Driscoll, F.G., 1986. *Groundwater and Wells*, 2nd Edition, Johnson Division, St. Paul, MN, 1089 pp.

Nielsen, D.M., 1991. *Practical Handbook of Ground-Water Monitoring*, Lewis Publishers, pp. 334-343.

U.S. Department of the Interior, 1981. *Groundwater Manual, A Water Resource Technical Publication*, Water and Power Resources Services, U.S. Government Printing Office, Denver, CO, 480 pp.

5.0 RECORDS

The Well Development Record is intended for use by contractor personnel and subcontractors for tracking and recording development method, purging information, water level(s) and water quality parameters.

6.0 ATTACHMENTS

Well Development Log

APPENDIX C

URS FIELD FORMS

URS Site Control Log

Date	Name	Signature	Affiliation	Time In	Time Out

Tailgate Safety Meeting Form

Date:	Time:	Job Number:
Client:		
Site Location:		
Task:		
SAFETY TOPICS PRESENTED		
Protective Clothing/Equipment:		
Chemical Hazards:		
Physical Hazards:		
Special Equipment:		
Other:		
Emergency Procedures:		
Hospital:	Phone:	Ambulance Phone:
Hospital Address and Route:		
ATTENDEES		
Printed Name:	Signature:	

Meeting Conducted By: _____

Signature: _____

WELL BORING:

Total Depth . . . . . .
Casing Diameter . . . . . .
Depth Interval . . . . . .
Casing Diameter . . . . . .
Depth Interval . . . . . .
Drilling Method . . . . . .

WELL CONSTRUCTION:

Casing length . . . . . .
Material . . . . . .
Diameter . . . . . .

Surface Seal . . . . . .
Seal Material . . . . . .

Backfill . . . . . .
Backfill Material . . . . . .
Placement Method . . . . . .

Seal Interval . . . . . .
Seal Material . . . . . .
Placement Method . . . . . .

Transition Interval . . . . . .
Transition Material . . . . . .
Placement Method . . . . . .

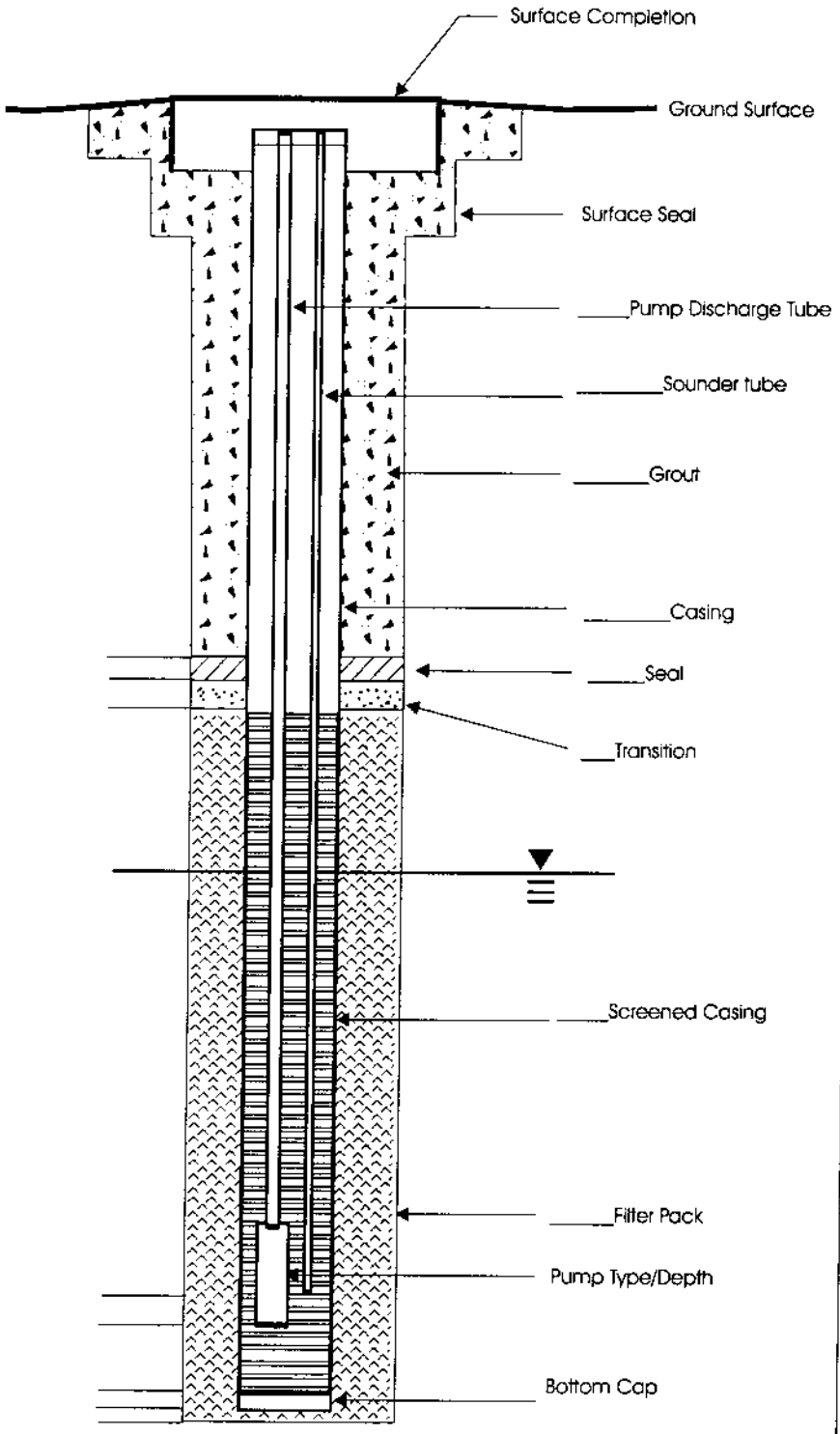
Gravel Pack Interval . . . . . .
Gravel Pack Material . . . . . .
Placement Method . . . . . .

Depth to Top of Perforation Zone . . .

Screened Interval . . . . . .
Perforated Type . . . . . .
Perforation Size . . . . . .

SURFACE CONSTRUCTION:

Surface Completion. . . . . .
Surface Casing Length . . . . . .
Material . . . . . .
Diameter . . . . . .



NOT TO SCALE

D:\Forms\Drilling Log Book\well schem.cdt 5/01

Generalized Monitor Well Schematic
Standard Well Completion

Well Materials Tally

BLANK CASING

Type:	Diameters	Total Length Required:	Delivery
Manufacturer:	I.D.:		Date:
	O.D.:		Time:
Vendor:	Thickness:		

WELL NO.:

Job No.:

Client:

Project:

Driller:

AS-BUILT DIAGRAM

Actual Length	Diameter Checked	Installed Date/Time	Connection Checked	Comments

SCREENED CASING

Type:	Diameters	Total Length Required:	Delivery
Manufacturer:	I.D.:		Date:
	O.D.:		Time:
Vendor:	Thickness:		

Actual Length	Diameter Checked	Installed Date/Time	Connection Checked	Comments

WELL DEVELOPMENT RECORD

SITE _____ DATE _____

LOCATION _____ WELL NO. _____

_____

MEASUREMENT OF WATER LEVEL AND WELL VOLUME

- Prior to sampling, the static water level and total depth of the well will be measured with a calibrated weighted line. Care will be taken to decontaminate equipment between each use to avoid cross contamination of wells.
- The number of linear feet of static water (difference between static water level and total depth of well) will be calculated.
- The static volume will be calculated using the formula:

$$V = Tr^2(0.163)$$

Where:
V = Static volume of well in gallons;
T = Depth of water in the well, measured in feet;
r = Inside radius of well casing in inches;
and 0.163 = A constant conversion factor which compensates for r^2h factor for the conversion of the casing radius from inches to feet, the conversion of cubic feet to gallons, and (pi).
1 well volume (v) = _____ gallons.

Volume of Water in Casing or Hole

Diameter of Casing or Hole (in)	Gallons per Foot of Depth	Cubic Feet per Foot of Depth	Liter per Meter of Depth	Cubic Meters per Meter of Depth
1	0.041	0.0055	0.509	0.509×10^{-3}
11/2	0.092	0.0123	1.142	1.142×10^{-3}
2	0.163	0.0218	2.024	2.024×10^{-3}
21/2	0.255	0.0341	3.167	3.167×10^{-3}
3	0.367	0.0491	4.558	4.558×10^{-3}
31/2	0.500	0.0668	6.209	6.209×10^{-3}
4	0.653	0.0873	8.110	8.110×10^{-3}
41/2	0.826	0.1104	10.260	10.260×10^{-3}
5	1.020	0.1364	12.670	12.670×10^{-3}
51/2	1.234	0.1650	15.330	15.330×10^{-3}
6	1.469	0.1963	18.240	18.240×10^{-3}
7	2.000	0.2673	24.840	24.840×10^{-3}
8	2.611	0.3491	32.430	32.430×10^{-3}
9	3.305	0.4418	41.040	41.040×10^{-3}
10	4.080	0.5454	50.670	50.670×10^{-3}
11	4.937	0.6600	61.310	61.310×10^{-3}
12	5.875	0.7854	72.960	72.960×10^{-3}
14	8.000	1.0690	99.350	99.350×10^{-3}
16	10.440	1.3960	129.650	129.650×10^{-3}
18	13.220	1.7670	164.180	164.180×10^{-3}
20	16.320	2.1820	202.680	202.680×10^{-3}
22	19.750	2.6400	245.280	245.280×10^{-3}
24	23.500	3.1420	291.850	291.850×10^{-3}
26	27.580	3.6870	342.520	342.520×10^{-3}
28	32.000	4.2760	397.410	397.410×10^{-3}
30	36.720	4.9090	456.020	456.020×10^{-3}
32	41.780	5.5850	518.870	518.870×10^{-3}
34	47.160	6.3050	585.680	585.680×10^{-3}
36	52.880	7.0690	656.720	656.720×10^{-3}

1 Gallon = 3.785 liters
1 Meter = 3.281 feet
1 Gallon water weighs 8.33 lbs. = 3.779 kilograms
1 Liter water weighs 1 kilogram = 2.205 pounds
1 Gallon per foot of depth = 12.419 liters per foot of depth
1 Gallon per meter of depth = 12.419×10^{-3} cubic meters per meter of depth

INITIAL DEVELOPMENT WATER

WATER LEVEL (TOIC) _____
WELL DEPTH (TD) _____
COLOR _____
ODOR _____
CLARITY _____

FINAL DEVELOPMENT WATER

WATER LEVEL (TOIC) _____
WELL DEPTH (TD) _____
COLOR _____
ODOR _____
CLARITY _____

DESCRIPTION OF DEVELOPMENT TECHNIQUE _____

_____

_____

WELL DEVELOPMENT – PARAMETER MEASUREMENTS

TIME	TOTAL VOL. WITHDRAWN		pH	COND. (µmhos/cm)	TEMP. (°C/°F)	TURB. (NTU)	COMMENTS
	GALS.	BORE VOL.					

DEVELOPED BY:

DATE_____

_____

SAMPLING DATA SHEET

Sierrita VRP

Well ID:	Screen Interval:	Depth to Water:	
Project Name:	Well Diameter:	Date Measured:	
Project Number:	Total Well Depth:	Measured From:	Page_____ of _____
Task Code:	Dedicated Pump:	Well Volume	
		3/8" - 0.0025 gal/ft. 1/4" - 0.0014 gal./ft.	

FIELD INSTRUMENT CALIBRATION

Ph: pH: 4.00=_____at_____°C pH: 7.0=_____at_____°C pH: 10.00=_____at_____°C

Turbidity: NTU: 0 = Reading_____ NTU: 10 = Reading_____ NTU: 1 = Reading_____ Other: NTU:_____= Reading_____

Conductivity: Standard_____umhos/cm at 25 °C Reading_____umhos/cm at _____°C

Dissolved Oxygen: Meter_____mg/L at _____°C PID: Calibration Gas Type_____PPM_____Span_____Reading_____

Date / Time of Calibration(s):

Instrument Model and Serial Number(s):

WELL PURGING

Time	Discharge Rate	Dissolved Oxygen (mg/L)	Temp °C	Eh/ORP (mV)	pH	Spec. Cond (uS/cm)	Turbidity (NTU)	Gallons Purged	Casing Vol.	Depth to Water
Stabilization		(+/- 10%)	(+/- 1 deg.)	(+/- 10 mV)	(+/- 1)	(+/- 5%)	(+/- 10%)			(+/- 0.3 ft.)

SAMPLING INFORMATION

Sampling Method: _____Dedicated Pump _____Non-Dedicated Pump _____Hand Bailer _____Low Flow/Micropurge

Sample ID	Date	Time	Container Type	Number of Containers	Preservative	Filtered Yes/No	Analysis	Comments

Samplers Signature(s):_____

Instrument Calibration Log

PROJECT NAME:	**INSTRUMENTS (Brand, Model, S/N):**
PROJECT NUMBER:	
SITE LOCATION/WELL ID:	**FIELD PERSONNEL(Name):**

DATE	TIME	TEMP		pH		SC (uS/cm)		TURBIDITY (NTU)	
		°C	°F	STANDARD	READING	STANDARD	READING	STANDARD	READING

Notes: _____

_____

_____

INVESTIGATION-DERIVED WASTE INVENTORY SHEET

Site:_____ No. of Drums:_____

Inventory Date:_____

Waste Source	Drum/Container ID Number	Date Generated	Contents (Solid, Liquids, etc.)	Approximate Volume	Drum Location/Comments

URS	Health and Safety Program INCIDENT REPORT FORM	Attachment 49-1 Revised: 5/08/01

ADMINISTRATIVE INFORMATION:

URS Division/Company: _____

Project Office: _____

Project Number: _____

Date/Time of Incident: _____ _____

Location/Client: _____ _____

FOR INJURIES / ILLNESSES:

Name of Injured Employee _____

Job Title _____

Phone Number _____ Age _____

Sex ○ Male ○ Female

See a Doctor? ○ Yes ○ No
If yes, attach a doctor's report.

Describe Injury:

TYPE OF INCIDENT
(Check all applicable items)

☐ Illness ☐ Injury ☐ Fire, Explosion, Flash ☐ Unexpected Exposure
☐ Property Damage ☐ Vehicular Accident ☐ Other (describe):

DESCRIPTION OF INCIDENT: (Describe the facts contributing to the incident. Identify individuals involved, witnesses, and their affiliations. Attach additional sheets, drawings, or photographs as needed.)

APPENDIX D

ACZ LABORATORY QAP

A C Z Laboratories, Inc.

QUALITY ASSURANCE PLAN

v. 12

Effective Date: August 10, 2007

UNCONTROLLED COPY

Authorization Signatures and Dates:

_____

Audrey Stover, President/CEO

_____

Matt Sowards, Production Manager

_____

Kristen Russell, QA/QC Officer

2773 Downhill Drive
Steamboat Springs, CO 80487

(970)-879-6590
www.acz.com

TABLE OF CONTENTS

1 INTRODUCTION

ACZ Laboratories, Inc. is an environmental testing laboratory that provides data to clients primarily for regulatory purposes. Samples are analyzed for compliance with federal programs including the Resource Conservation Recovery Act (RCRA), Safe Drinking Water Act (SDWA), and Clean Water Act (CWA). Environmental compliance and management decisions are based on the analytical data provided, which are critical to the expenditure of large amounts of money; are important to public health safety; are important in evaluating, monitoring, and protecting the environment; and are often essential in litigation. To this effect, analytical data must always be technically sound, accurate, and legally defensible or it is useless to the end user.

An effective Quality Assurance and Quality Control program is the cornerstone of the generation of reliable analytical data. ACZ's Quality Assurance Plan (QAP) outlines the quality assurance and quality control objectives, policies, and procedures determined to be necessary to meet the requirements of the EPA, federal government entities, state agencies, other regulatory authorities, and our clients. This document provides the necessary guidelines to ensure all ACZ employees have sufficient knowledge and training to perform their job responsibilities in a manner that guarantees all data reported to all of our clients is accurate, reliable, technically sound, legally defensible, and impartial.

For data to be accurate, it must be of known and documented quality. The word "quality" has many different meanings, but for the purposes of environmental testing activities can be stated simply as "conformance to requirements." Conforming to requirements allows objective measurements to be applied, rather than subjective opinions, to determine when work is of good quality. *Quality control* refers to all activities that ensure accuracy (i.e. good quality) of the data. It requires action(s) to be taken and is typically included as part of the procedure. *Quality assurance* provides the records of the results obtained from the required action(s) and refers to the ability of the laboratory to demonstrate or prove to an outside party that the quality of the data is what the laboratory states it is. Quality assurance relies heavily on documentation, and to be effective, the documentation must (1) assure the quality control procedures are being implemented as required (2) assure the reported data reflect the sample as it was received, meaning sample mix-up was avoided, the sample was properly preserved prior to analysis, etc. (3) facilitate traceability of an analytical result and (4) be subjected to reasonable precautions to protect data from loss, damage, theft, and internal or external tampering.

Quality Policy Statement: To maintain an effective QA/QC program, continually improve the quality of our environmental testing services, and consistently provide clients with technically sound and legally defensible data, in a timely manner, the management of ACZ recognizes the importance of its commitment to:

- Ensuring good professional practice by well-trained and qualified employees with the necessary experience and skills to carry out their organizational functions and to meet or exceed ACZ's standards for the quality and reliability of its testing services.
- Ensuring the data provided to our clients is of known and documented quality, accurate, and impartial.
- Ensuring that all quality assurance and quality control policies and procedures are communicated to and understood by all employees, and that they are implemented by all employees in their work.
- Ensuring that all aspects of the business operations are conducted in a manner that adheres to the NELAC Standards and all of ACZ's policies and procedures documented in the QAP, SOPs, emails, memos, etc.
- Upholding the spirit and intent of ACZ's Ethics Program and implementing the requirements of the program.

2 QUALITY SYSTEM OBJECTIVES & COMPONENTS

ACZ's QAP provides a framework that guides all technical staff and administrative personnel. The information presented is necessary to ensure all employees perform their duties in a manner that allows the company to achieve its objectives, thereby ensuring the precision, accuracy, completeness, and consistency of the analytical data reported to our clients. This framework is referred to as the Quality System. The Quality System encompasses every documented quality assurance (QA) and quality control (QC) policy and procedure and guides all business functions and laboratory operations by specifying standardized protocols to control both the short-term and long-term activities that influence the quality and defensibility of our testing services.

The Quality System is designed to be appropriate to the type, range and volume of the environmental testing undertaken. The Quality System is not a static entity and must function in a manner that allows for continuous evolution of all aspects of ACZ's business when improvements have been identified and have been determined to be necessary or beneficial. ACZ management recognizes that the staff is comprised of people who possess varied experience and knowledge and can contribute valuable insight and suggestions regarding these improvements. All employees are encouraged to be involved in this process. The following six (6) key elements form the foundation of ACZ's Quality System:

- Documents & Records
- SOPs
- Training
- Audits
- Corrective Actions
- Management Review of the Quality System

2.1 Documents & Records

The entire history of any sample must be readily understood through the associated documentation. To this extent, a formal and systematic control of documents and records is necessary for accurately reconstructing all events pertaining to any sample and for guaranteeing the quality and defensibility of the data. All information relating to the laboratory facilities equipment, analytical test methods, and related laboratory activities (such as sample receipt, sample preparation, data verification and data reporting) must be documented, and all records, including those pertaining to calibration and test equipment, certificates and reports, must be maintained. Documents and records must be safely stored (protected against fire, theft, loss, deterioration, and vermin), and must be held secure and in confidence to the client for a minimum of five (5) years. Refer to section 10.0 for details regarding the storage and control of ACZ's documents and records.

2.1.1 Documents

A document is a writing that contains information. All documents are reviewed for accuracy, approved for release by authorized personnel, and properly distributed. A document control system subsequently ensures that employees use only the correct and effective version of any form, Standard Operating Procedure (SOP), or other document, which are maintained through ACZ's LabWeb intranet. LabWeb is a computerized document control system based in HTML that can be accessed from any network computer within the facility. Documents can be queried by department and then organized in several ways by clicking the appropriate header. Click on the title of the document to view it as an Adobe Acrobat (*.pdf) file. The PDF has a "read only" qualifier and does not allow changes. Users may view SOPs but the documents may not be saved to another network drive and may not be printed. Forms may be viewed and printed but may not be saved to another network drive.

All documents are categorized by department and are assigned a unique document ID that is printed in either the header or footer section. The ID nomenclature starts with either SOP (procedure) or FRM (form), followed by the 2-letter department code, the unique document number, the month and year of issue, and the revision. The effective date for any SOP or other document is included on the title page and header section of each subsequent page and indicates the implementation date.

The QA/QC Officer has full responsibility of the Document Control System. Documents can be changed, overwritten, or saved as a different document only by employees with Domain Administer computer rights (primarily IT and QA/QC staff). A new or revised document is reviewed, and following approval, the document control number is updated and the SOP or form is uploaded to Labweb. When a new version of an SOP is added to Labweb, the previous version is removed from the active list, date-stamped and electronically archived in a designated location on the network. This automatic process guarantees that ACZ can retrieve the version that was in effect at any given time. Controlled forms are not currently archived.

2.1.2 Records

A record is any information or data on a particular subject that is collected and preserved. Records are produced on a daily basis and contain original, factual information from an activity or study. For ACZ's purpose, this information may be recorded by the following means: LIMS database, logbooks, raw instrument data, worksheets, and notes (or exact copies thereof) that are necessary for the reconstruction and evaluation of the report of the activity or study. The record management system provides control of records for data reduction, validation, reporting and storage, and also provides control of all laboratory notebooks and logbooks. The system must allow for historical reconstruction of all laboratory activities that produced analytical data, must document the identity of personnel involved in sample receipt, preparation, calibration or testing, and must facilitate the retrieval of all working files and archived records for inspection and verification purposes. At a minimum, the following criteria for records must be met:

1) Instrument logbooks must be kept up-to-date on a daily basis. In general, document all relevant activities when the event occurs.

2) Dilution factors and observations must be recorded at the time they are made, and notes regarding the sample(s) or analysis must be identifiable to the specific task.

3) A detailed description of any departure from a documented procedure, and the reason for the departure, must be provided at the time it is performed.

4) All generated data must be recorded either by an automated data collection system or must be recorded directly, promptly and legibly in permanent ink (blue or black is preferred).

5) Erroneous entries (hard copy or electronic) cannot be destroyed by methods such as erasures, overwritten files or markings. Refer to section 16 for ACZ's error correction protocol.

6) Any change(s) to hard copy records must be clearly initialed and dated by the responsible staff. Changes to electronic records must also be traceable to the individual who made the change, and the reason for the change must be provided.

7) Records generated by computers must have hard copy or write-protected backup copies.

2.2 Standard Operating Procedures

A documented procedure is required for all phases of ACZ's business operations, from sample log-in through sample disposal. A Standard Operating Procedure (SOP) is a written document that details the manner in which an operation, analysis, or action is performed and thoroughly prescribes the techniques and procedures, which are the accepted process for performing certain routine or repetitive tasks. Analytical SOPs must be written with adequate detail to allow someone similarly qualified, other than the analyst(s) who routinely performs the procedure, to reproduce the procedure used to generate the test result. To the extent possible, administrative SOPs [non-technical] must include specific requirements pertaining to the process; however, the procedure itself may be a more general description so as to lend a degree of necessary flexibility to account for client requests and other circumstances, which may be outside of ACZ's control.

Proposed revisions to any test SOP must be noted on the SOP Revision Form (FRMQA030). Proper use of FRMQA030 ensures the SOP continues to include all requirements of the procedure. All procedural revisions must be reviewed and approved by QA/QC prior to implementation. Changes to provide additional clarification, correct typographical errors, etc. do not need to be approved but need to be noted on the revision form to ensure the changes are included during the next revision. Analytical SOPs must be reviewed annually using the SOP Review Form (FRMQA035), and Administrative SOPs must be reviewed regularly and revised if necessary to ensure the information is accurate and reflects current practice. Documenting changes in the controlled copy of any SOP is not permitted. Refer to section 10.5.1 for additional information on SOPs.

SOPs are proprietary documents and ACZ does not distribute them freely. Any copy sent electronically or otherwise to an outside party is considered uncontrolled, and the recipient understands that additional changes can be made without prior notification. The use of uncontrolled copies of SOPs is not permitted on site unless approved by QA/QC, and such documents will be initialed and dated by QA/QC personnel when issued.

Before a new procedure, application, or instrument can be implemented, an SOP must be developed. Following QA/QC review, an effective "working draft" will be issued to allow the user(s) to "fine-tune" the document. If a client requests a procedure for which there is not a published method or an existing SOP, ACZ will utilize the process described in the SOP *Client Service Policies and Procedures* (SOPAD043). Analytical SOPs are written in accordance with the NELAC Standards and must include or reference the following items, where applicable:

1) identification of the test method
2) summary, scope & application of the test method, including matrices & components to be analyzed
3) references, including documents provided by instrument / equipment manufacturer
4) sample collection, preservation, & storage
5) equipment & supplies
6) reagents & standards, including storage conditions & shelf-life for each
7) safety
8) interferences
9) complete procedure, including details and acceptance criteria for initial & continuing calibration
10) data review & assessment, including protocols for handling out-of-control or unacceptable data
11) quality control, including acceptance criteria & corrective action for handling failed quality control
12) calculation equations (dilution factors, RPD, % recovery, etc.) & calibration formulas
13) method detection limit & reporting limit
14) method performance, including Demonstration of Capability and Method Detection Limit procedures
15) pollution prevention & waste management
16) definitions
17) tables, diagrams, flowcharts

2.3 Training

It is the responsibility of ACZ's management to ensure the competence of all employees who perform environmental tests and other specific duties, operate equipment or instrumentation, give opinions and interpretations, evaluate results, and sign test reports. Additionally, ACZ management is responsible for formulating the goals and policies with respect to the necessary education, training, and skills of all personnel and for providing training that is relevant to the company's present and anticipated tasks.

Employees must possess the appropriate combination of education, experience, and skills to adequately demonstrate a specific knowledge of their particular functions and to carryout those functions in a manner that meets or exceeds ACZ's standards and expectations. Additionally, each staff member must demonstrate an understanding of laboratory operations, test methods, related quality assurance and quality control procedures, and management of records and documents to the extent necessary to successfully perform their job duties.

All full-time and part-time personnel must complete a formal training process for Safety, Ethics, Quality Assurance / Quality Control, and Sexual Harassment on the first day of hire and are subsequently responsible for complying with all requirements that pertain to their organizational functions. For all technical staff, training for analytical procedures must be completed prior to independent generation of client data, including Proficiency Testing samples. In general, any staff member who is undergoing training must be provided with appropriate supervision. It is the responsibility of each supervisor or manager to ensure personnel within his or her department is supervised, competent, and is working in accordance with ACZ's Quality System.

2.3.1 Safety Training

Safety training is scheduled with ACZ's Chemical Hygiene Officer and includes viewing a video of general laboratory safety, a complete review of ACZ's Chemical Hygiene Plan, and a building tour to identify the location of Material Safety Data Sheets, emergency showers, eye wash stations, and emergency exits. Following completion of the training, the employee takes an exam, which allows the CHO to evaluate his/her understanding of the material covered.

2.3.2 Ethics Training

ACZ is committed to fostering and enforcing an ethically sound work environment that encourages the conscientious production of accurate, technically sound and legally defensible data. Initial and follow-up ethics training is required for all full-time and part-time employees (permanent or temporary) as described in ACZ's SOP *Ethics and Proactive Prevention Program* (SOPAD039). Initial training provides a general introduction to ACZ's Ethics program, ACZ's Code of Conduct, Code of Ethics, and zero-tolerance policy. Each new employee is also introduced to the company's Ombudsman. Follow-up training is provided within 30 – 60 days and includes a more in-depth review of unacceptable practices. The employee is required to read SOPAD039 prior to attending the session. On an annual basis, a review of SOPAD039 and exercises in making ethical decisions, as well as other relevant information, are presented to all employees.

2.3.3 QA/QC Training

2.3.3.1 All full-time and part-time employees attend an initial orientation session, which is based on the most current version of ACZ's Quality Assurance Plan [QAP] and focuses on the relationship between quality control, quality assurance, environmental testing, and environmental monitoring.

2.3.3.2 Follow-up training is completed within 30 – 60 days and includes a more detailed review and discussion of QA/QC policies and procedures. By this time, employees are expected to be familiar with their responsibilities and have a general understanding of ACZ's operations. The employee must read ACZ's QAP and any pertinent supporting SOPs prior to attending the training, and should prepare questions in advance, as material in each document will be reviewed and an opportunity to seek clarification will be provided. The supervisor must schedule sufficient time for the employee to read all pertinent documents prior to follow-up training.

2.3.3.3 A performance review will be conducted for a new employee after 90 days from the hire date. The review is conducted by the supervisor and is based on general work performance, supervisor observations, and feedback from the QA/QC department.

2.3.4 Sexual Harassment Training

Sexual Harassment training is required for each new employee and includes viewing a video that demonstrates the identification, reporting, and remediation of harassment issues in the work place.

2.3.5 Technical personnel must be thoroughly trained in the analytical techniques and operating principles for all pertinent method procedures. Under no circumstances may any analyst independently generate or review client data for a test procedure before completing the required training and receiving the explicit approval of the QA/QC department. Section 5 provides details of ACZ's technical training program.

2.3.6 An employee performing only data AREV or SREV functions must be appropriately trained regarding QC requirements, corrective action(s), and data qualification criteria stated in the effective version of the test SOP. The trainee must first read the SOP, and then review all pertinent information with the department supervisor. Items covered during training must be documented using the appropriate form, and both the supervisor and the trainee must sign the form. Thereafter, the effective version of the test SOP must always be used for data review.

2.3.7 Continuing training must be documented and at a minimum, the documentation must certify that the employee has read, understands, and agrees to follow the effective version of a revised SOP or other in-house document. The department manager is required to meet with their staff to review the change(s) and to ensure each employee fully understands the change(s). Training is documented using either FRMQA023 or FRMQA030, whichever is most appropriate.

2.3.8 Training is required for all employees whose activities are affected by any procedural change(s) to an SOP and is considered to be complete once the department supervisor has reviewed the change(s) with all staff members and each employee has subsequently initialed and dated the changed item(s) on the SOP Revision form (FRMQA030). Alternatively, if the revisions have been incorporated into a new effective version of the SOP then training is documented using FRMQA023.

2.3.9 ACZ recognizes the benefit of continuing education and encourages employee participation in advanced training courses, seminars, and professional organizations and meetings.

2.4 Audits

The purpose of any audit is to verify performance and compliance to documented Quality Assurance and Quality Control policies and procedures, and to identify discrepancies when they exist. In the latter case, any problems must be addressed and resolved in an appropriate manner in order to assure the Quality System is continuously improved on all levels.

2.4.1 External Audits

External audits are conducted to ascertain compliance with rules, regulations, and additional criteria for certification, and will have a higher degree of formality than internal audits. Where mandatory records are required, compliance with such will be critically evaluated. The search for any corrective actions and the correction of problems identified in a previous audit will also be an important activity. The ease with which important records and information can be retrieved is a criterion for judgment of the management practices of a laboratory and may dictate the depth of the audit. Individual state agencies, its NELAC Primary Accrediting Authority, and current and potential clients typically audit ACZ.

The on-site assessment is generally a two to four day process during which the regulating agency conducts an entrance interview and tours the facility before performing an in-depth review of documents, workgroups, reports, electronic data files, etc. A critical aspect of the on-site assessment is review and verification of bench-level documentation and analyst interviews to determine actual laboratory practices. It is ACZ's policy to always have QA/QC personnel present during an interview. If necessary, the President or Production Manager may attend the interview. An exit interview is conducted upon completion of all on-site assessment activates, during which observations and findings are reviewed. The agency will submit a final report to ACZ, generally within 30 days, detailing all pertinent findings and recommendations.

Upon receipt and review of the agency's report, the QA/QC department will meet with each department manager to develop a corrective action plan, which must be submitted to the agency by the date indicated in their report. Each finding is addressed as a major corrective action as described in section 2.5.2. Employees may not make changes to any laboratory or other practice based on comments or opinions expressed by the regulating agency during an interview or any other stage of the on-site assessment. ACZ will revise polices and procedures as necessary upon completion of the major corrective action process. The audit report and all subsequent corrective actions are thoroughly documented, and all documentation is retained for at least five (5) years.

2.4.2 Internal Audits

ACZ is responsible for the quality of its data and must take reasonable efforts to assure itself and all interested parties of the confidence that can be placed in it. To this extent, internal audits of its activities must be conducted to verify continued compliance with the Quality System. It is the responsibility of the QA/QC Officer to plan, direct, and organize internal audits; however, a trained and qualified individual, independent from the area or system being audited, may be designated by the QA/QC Officer to conduct an internal audit. The area of activity audited, the audit findings, and subsequent corrective actions must be documented, and all documentation must be retained for at least five (5) years.

Whenever any internal audit finding casts doubt on the effectiveness of the operations or on the correctness or validity of the test results, timely corrective action must be taken, and the client(s) must be notified in writing, as soon as the extent of the problem can be determined, if investigations show that the laboratory results may have been affected.

At a minimum, internal audits are conducted for the following departments. Method audits performed for all analytical departments listed below encompass both qualitative evaluation of the operational details of the QA/QC program and quantitative evaluation of the accuracy of data generated by the laboratory staff. These evaluations do not include the real-time review of laboratory raw data or final reports for routine quality control sample verification.

- Log-In
- Reporting
- Wet Chemistry Manual
- Wet Chemistry Instrument (Prep and Analytical)
- Inorganic Instrument
- Inorganic Metals Prep
- Soils
- Radiochemistry (Prep and Analytical)
- Organics (Prep and Analytical)

More frequent internal audits may be scheduled depending on the following criteria:

- Number and type of corrective actions filed for a method or activity
- Client complaints
- Continued failure to achieve acceptable results for a Proficiency Testing sample
- Findings from an external audit
- Request from management

All findings from internal audits are directed through ACZ's corrective action system. Each finding is assigned a corrective action number (similar findings may be combined). A general description of the process is as follows:

1) Findings and observations are summarized in a memo.

2) The memo is distributed to the department supervisor, Production Manager, and President.

3) The supervisor reviews the memo with their staff and develops a response for each finding.

4) The supervisor informs the QA/QC Officer of all resolutions and expected implementation date(s) within two (2) weeks from the date indicated in the memo.

Additionally, an in-depth review will be conducted if there is any evidence of inappropriate actions or vulnerabilities related to data integrity. This review shall be handled in a confidential manner until a follow up evaluation, full investigation, or other appropriate actions have been completed and the issue(s) clarified. Refer to ACZ's SOP *Ethics and Proactive Prevention Program* (SOPAD039). All documentation related to the investigation must be maintained for at least five (5) years.

2.4.3 Electronic Data Audits

Periodically ACZ hires a third party auditing firm to perform a full level audit of analytical data, either on-site or off-site. The auditing firm provides ACZ management with a report citing the deficiencies and recommendations. After review of these findings by management, the QA/QC Officer, and the production supervisor, corrective actions are initiated to ensure that any deficiencies are rectified.

2.4.4 Proficiency Testing [PT] Program

ACZ is required to participate in a formal Proficiency Testing Program at the frequency stipulated by regulating agencies. These "performance audits" are facilitated through the introduction of blind samples, purchased from approved vendors. ACZ analyzes PT samples for most accredited parameters twice in a calendar year, with each study being approximately six (6) months apart. These tests are analyte, matrix, and technology specific, but are not method specific, and provide useful information regarding the accuracy of the analytical data being produced. ACZ participates in the Water Supply (WS) study for SDWA, the Water Pollution (WP) study for CWA, the Soil and Underground Storage Tank studies for RCRA, and Radiochemistry PT study for Drinking Water.

Following log-in, the PT sample is prepared by the analyst according to the vendor's instructions and is then analyzed in the same manner as client samples as described by the test SOP. **NOTE:** Analysts must record the date of preparation (and time of preparation if the holding time is $\leq$ 72 hours) on the subsample container and on the associated workgroup bench sheet(s). Analysis must be performed as soon as possible after diluting the concentrate, as indicated in the vendor's instruction pamphlet. Metals analyses must be completed within 48 hours of diluting the concentrate, as indicated in ACZ CAR519.

Data is compiled by the QA/QC department and reported to the vendor no later than the study close date. The vendor evaluates the data as "acceptable," "not acceptable," or "check for error" by comparing the reported values to statistically derived acceptance criteria and issues a report within 21 days from the study close date. Upon receipt of the report, the QA/QC department initiates a major corrective action for the PT study if any "not acceptable" results were reported. Each production supervisor must investigate all "not acceptable" results for their department, indicate possible causes and determine the appropriate corrective action(s) by the designated due date. If necessary, the QA/QC department will order follow-up samples to confirm the system deficiency has been corrected. Refer to ACZ's SOP *Proficiency Testing Program* (SOPAD011) for additional information.

Strict rules apply regarding the exchange of information for any PT sample:

- ACZ shall not send any PT sample, or a portion of a PT sample for accrediting purposes to another laboratory for any analysis.
- ACZ shall not knowingly accept any PT sample or a portion of a PT sample for accrediting purposes from any other laboratory.
- Employees of ACZ shall not discuss PT data results with any other person outside of the laboratory, in particular any person associated with another laboratory.
- Employees of ACZ shall not attempt to obtain the results or assigned values of any PT sample from our PT Provider prior to the close of the study.

2.5 Corrective Action

When any problem, deviation or failure is identified within the Quality System or when any change is made to a previously documented company-wide protocol, a corrective action must be initiated. Corrective actions are a fundamental element of ACZ's QA/QC Program, as a successful Quality System requires the identification of deficiencies and depends on the development, implementation, and documentation of effective contingency plans and resolutions to effectively address the deficiencies.

Problems can ordinarily be classified two ways: 1) undesirable but not critical or 2) critical and requiring immediate action. To this extent, ACZ utilizes two types of corrective actions: Minor and Major. A minor corrective action pertains to any temporary deviation from a policy or procedure and may be initiated by any employee in order to resolve an immediate problem that is isolated or may impact only one workgroup or several related workgroups. Minor corrective actions do not require QA/QC follow-up. Major corrective actions address system-wide errors or failures and require the root cause(s) of the error or failure to be determined and the resolution to be documented and implemented.

2.5.1 Minor Corrective Action

The minor corrective action report (FRMQA001) allows for complete documentation of any temporary deviation from the SOP or other protocol. The employee who initiates the corrective action will complete Section 1 of the report. Documentation must be accurate and must provide a complete detailed explanation of the situation for future reference. The department supervisor should always be informed of the need for a minor corrective action and may provide additional information in the appropriate section. The project manager may also provide additional information in the appropriate section if necessary. QA/QC does not need to close a minor corrective action; however, the employee may review the report with QA/QC personnel and request their signature in the appropriate section.

Complete documentation may be provided either on the workgroup bench sheet or on the data review checklist in lieu of using FRMQA001 if the deviation applies to a limited number of workgroups. Use FRMQA001 if the deviation applies to many workgroups and attach a copy of the completed form to each workgroup before the workgroup is scanned. If the report is generated after the workgroups have been scanned, then the workgroup must be retrieved and rescanned with the report include as part of the data package. In this case, a note is made on the front page of the workgroup package indicating the reason the workgroup was rescanned (i.e. "CAR attached, WG rescanned"). If appropriate, a minor corrective action will be addressed in the case narrative of the client report.

2.5.2 Major Corrective Action

It is the responsibility of the QA/QC Officer to notify laboratory management in writing of departures from the Quality System, and it is the responsibility of the laboratory management to ensure that any corrective action that arises is discharged within the time frame indicated on the corrective action report, or additional communication must be provided to the QA/QC Officer (see item 3 below).

A major corrective action is initiated whenever a system failure has been identified or whenever an audit finding or other circumstance casts doubt on the correctness or validity of the analysis result(s). The client must be notified in writing if their work is affected. The QA/QC department will work with the Project Manager to determine if a revised report must be issued to the client. See ACZ's SOP *Client Service Policies and Procedure* (SOPAD043) for details. A major corrective action may also be initiated when the need for preventive action has been identified (refer to section 2.5.4).

Only QA/QC department personnel may open and close a major corrective action. When opened, the corrective action will be assigned a unique tracking number (referred to as the CAR number) to ensure that ACZ maintains a complete and accessible record of all Quality System deviations or failures, root cause determinations and subsequent resolutions, and preventive actions. All associated documentation must be retained for at least five (5) years as described in Section 10.

Other examples of circumstances requiring a major corrective action include, but are not limited to:

- Contamination trends as indicated by blanks routinely above acceptable levels
- Spikes, surrogates and lab control samples continually outside acceptance limits
- Change to the MDL and/or PQL (RL) for a procedure
- Client inquiries about data anomalies
- "Not Acceptable" Proficiency Testing results
- Results of internal or external audits
- Discrepancies observed at any stage of data review or reporting
- Using expired receivables
- Hold times or deadlines routinely missed
- Evidence of insufficient or inadequate training

Following initiation, the procedure for a major corrective action proceeds to an investigation by the assigned individual to determine the root cause of the problem and to identify possible resolutions to rectify the problem. The action(s) most likely to eliminate the problem and prevent recurrence of the problem must be selected, documented and implemented, and pertinent staff members must be trained, if necessary. Changes resulting from the corrective action will be monitored, if necessary, to ensure the resolution(s) are shown to be effective. A general outline of the procedure is as follows:

1) Initiation: Any employee may initiate a corrective action by notifying QA/QC. The department manager should always be notified first of any problem and then inform QA/QC. If determined to be necessary, QA/QC personnel will open a corrective action and assign a unique tracking number.

2) Assignment: QA/QC assigns the corrective action to the person(s) responsible for performing the "root cause" determination.

3) Investigation and Action: Must be completed within two (2) weeks from the date the corrective action was initiated. The need for an extension must be communicated to the QA/QC department.

    a. The assigned individual(s) perform a "root cause" determination to identify the suspected cause(s) of the problem.

    b. A resolution to correct the problem and prevent its reoccurrence must be determined, and the estimated date by which the resolution will be completed and implemented must be indicated in the appropriate section of the form. Resolution may be done solely by the person(s) who investigated the root cause or it may require input from one or more additional departments.

4) Project Manager Review: If necessary, the PM will determine whether affected data will be accepted or rejected, contact the client, and reissue a revised report if necessary. Project Manager review may not be required for every major corrective action.

5) Conduct additional training if necessary. Training must be documented using the appropriate form and must include a description provided by the person who conducts the training. All trainees are required to sign and date the form to acknowledge he/she has received training, understands the change(s) and agrees to adhere to any change(s) in a policy or procedure.

6) Revise SOP(s). Proposed revisions must be documented on the SOP Revision form (FRMQA030) and approved by QA/QC before trained personnel initial / date and implement the changes. Use FRMQA023 if the changes are incorporated into the SOP and a new effective version is issued.

7) Submit all supporting documentation to QA/QC to be attached to the hard copy of the report.

8) QA/QC reviews the corrective action. If satisfactory, the corrective action is closed and the implementation date is documented in the space provided.

9) If necessary, QA/QC conducts follow-up within two (2) weeks from the implementation date. If the corrective action is determined to be ineffective, then a new major corrective action will be initiated and the process repeated.

2.5.3 Technical Corrective Actions

Technical corrective actions apply to departures or deviations from the quality control parameters stated in individual test SOPs. Each test SOP must include all required quality control that applies to the procedure (as stipulated by the method and other regulatory agencies) as well as the performance frequency, acceptance criteria and corrective action for handling failed quality control measurements. Each SOP must describe the procedures to be followed for reviewing and assessing data, including corrective action for handling out-of-control or unacceptable data. The required protocol for technical corrective actions is summarized below. ACZ's protocols are included within the [ ].

1) identify the individual responsible for assessing each nonconformance and initiating or recommending corrective action [analyst who performs AREV]

2) define how the analyst must treat data if associated quality control measurements are unacceptable [section 12 of SOP]

3) specify how non-conformance and subsequent corrective actions are to be documented [data review checklist]

4) specify how management reviews the corrective actions [reviewed during SREV]

To the extent possible, samples shall be reported only if all quality control measures are acceptable. If a quality control measure is found to be out of control then the corrective action described in the SOP must be performed. Alternatively, report data with the appropriate qualifier if reprocessing and reanalysis is not possible. The qualifier must be assigned to any sample(s) associated with the failed quality control measure. A current list of all extended qualifiers is available in the LIMS database and may be accessed by all employees.

2.5.4 Preventive Action

Preventive action is a pro-active process to identify opportunities for improvement rather than reacting to the identification of problems or complaints. Needed improvements and potential source(s) of any nonconformance, either technical or concerning the Quality System, must be identified and addressed. Examples of preventive action include but are not limited to: maintaining a cross-trained staff; maintaining a supply of spare consumable parts; monitoring the performance of support equipment; performing routine maintenance on instruments; maintaining an adequate supply of standards/reagents; ordering supplies before running out; completing log-in review in a timely manner; ensuring ACZ can perform work before samples are accepted; correcting quotes before samples are logged in; and analyzing samples by the appropriate method.

2.6 Management Review of the Quality System

At least once per calendar year, ACZ's management conducts a review of its Quality System and all activities related to its environmental testing services to ensure their continuing suitability and effectiveness, and to introduce necessary changes or improvements. At a minimum, the review must take the following into account:

- Status, review, and discussion of major corrective actions
- Results of recent PT studies and corrective actions initiated / completed
- Review of recent external audits
- Review of internal audits
- Presentation of ideas to improve efficiency and productivity
- Presentation of ideas to improve service and data quality
- Status of state certifications
- Feedback from clients
- Feedback from employees
- Ethics Program
- Ombudsman
- Changes in the volume and type of work undertaken
- Other pertinent issues

2.6.1 Department Reports

Each department manager completes a Department Report (FRMQA041) prior to the Management Review meeting. Each item on the report is to be evaluated as it pertains to the individual department. FRMQA041 is provided in Appendix D.

2.6.2 Management Review Report

The completed department reports are submitted to ACZ's President by the specified due date, and the information from each report is reviewed and compiled to complete the Management Review Report (FRMQA042). A copy of the completed report is issued to each manager in advance of the Management Review meeting. At a date / time specified by the President, all managers meet as a group to discuss the report. Other formats may be utilized at the President's discretion. All reviews will be appropriately documented and all documentation retained for at least five (5) years as described in section 10 (Control & Storage of Records & Documents). FRMQA042 is provided in Appendix D.

3 ETHICAL AND LEGAL RESPONSIBILITY

All ACZ employees have an ethical and legal responsibility to produce data that is accurate, reliable, and legally defensible. ACZ's proactive program for the prevention and detection of improper, unethical or illegal actions includes the implementation in 2002 of an Ombudsman who acts as a neutral party and serves as a confidential liaison between ACZ employees and upper management regarding questions, problems, complaints, suggestions, or ethical dilemmas.

All employees are educated with regards to ACZ's Code of Conduct and Code of Ethics as well as ACZ's zero-tolerance policy, which is strictly enforced. Additionally, employees are informed about the processes in place to ensure employees are free from any undue internal or external commercial, financial or other pressures that may adversely effect the quality of an employee's work, endanger the trust in the independence of ACZ's judgment, or compromise the integrity of ACZ's environmental testing activities. A more detailed description of all aspects of the ethics program is provided in ACZ's SOP *Ethics and Proactive Prevention Program* (SOPAD039).

ACZ will not tolerate any unethical or improper activities or behavior. Violation of company policies may lead to repercussions ranging from a severe reprimand to termination, and possible criminal prosecution if warranted by the situation. ACZ has access to many resources that may be utilized at any time to help clarify any situation determined to be a "gray area." Employees are strongly encouraged to seek further guidance from a supervisor, ACZ's Ombudsman, President or QA/QC staff whenever doubt is raised. Activities that will not be tolerated include, but are not limited to:

- **Misrepresentation of a procedure or documentation** – Intentionally performing a job duty in a manner that does not comply with a documented procedure, including but not limited to a test SOP or method used for sample analysis; providing inaccurate and misleading documentation associated with a data package or failing to provide the necessary documentation as part of a data package.

- **Falsifying Records** – Providing false information on personal credentials, resumes or educational transcripts, logbooks, raw data and client reports, or creating data without performing the procedure (also known as dry labbing).

- **Improper peak integration** – Intentionally performing improper integration of data chromatograms so quality control samples meet acceptance criteria. This is also known as peak shaving or peak enhancing.

- **Improper clock setting** – Readjusting the computer clock so that it appears samples were analyzed within hold times.

- **Improper representation of Quality Control samples** – Failing to treat batch quality control samples in the same manner as client samples (including Proficiency Testing samples) or misrepresenting any type of quality control sample associated with the preparation batch and/or analytical batch.

- **Improper calibration** – Intentionally performing improper manipulation of calibration data or forging tune data so that it meets acceptance criteria.

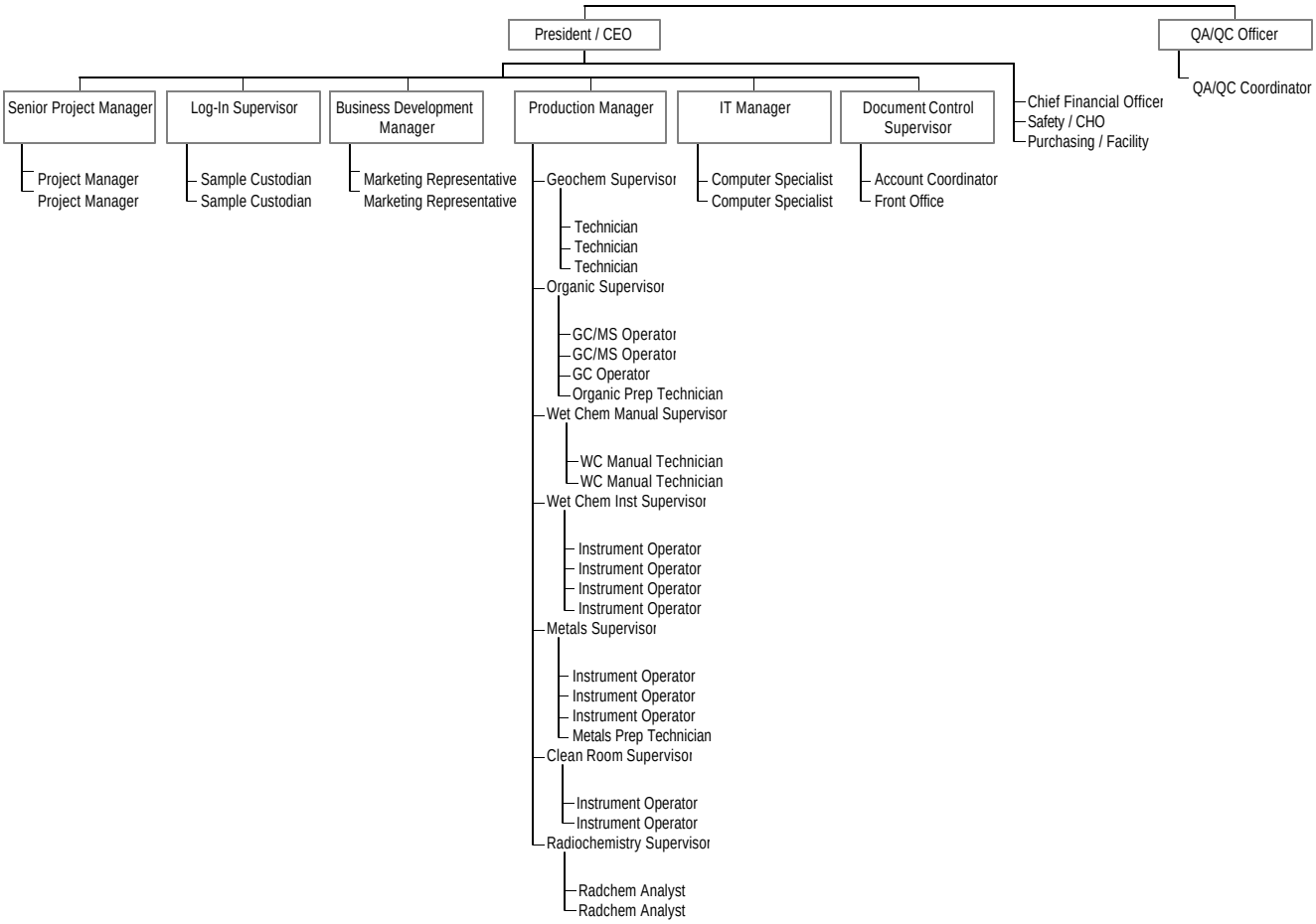
- **File Substitution** – Replacing invalid data with valid data from a different time so the analysis appears to be successful.

4 PERSONNEL AND RESPONSIBILITIES

Due to the nature of regulatory oversight and the increasing demands of the environmental lab industry, QA/QC issues permeate all aspects of our business, the largest and most critical of which are operations (production). On a daily basis, QA/QC and Production must efficiently function together to consistently provide our clients with technically sound and legally defensible data and to ensure the Quality System remains an integral part of all areas within ACZ. The President must rely on regular input and feedback from ACZ's QA/QC Officer and Production Manager, and to this effect, upper management is defined as ACZ's President, QA/QC Officer and Production Manager. It is the responsibility of upper management to document company policies, objectives, systems, programs, procedures, and instructions to the extent necessary to assure the quality and defensibility of all data.

ACZ is organized such that the President also works directly with and relies on input and feedback from the Senior Project Manager, Business Development Manager, Production Supervisors, Document Control Supervisor, IT Manager, Chief Financial Officer, and Chemical Hygiene Officer. These individuals are responsible for managing both the day-to-day operations and long-term goals within their respective areas. It is the responsibility of all managers to ensure that all documented ACZ policies and procedures, including those in the QAP and associated SOPs, are communicated to, understood by, made available to, and implemented by ACZ personnel.

Figure 4-1. Employee Organizational Chart



4.1 President/CEO

The President is ultimately responsible for all analytical and operational activities of the laboratory and must ensure that 1) the laboratory carries out all environmental activities in such a way as to meet the requirements of the NELAC Standards and 2) the laboratory satisfies the needs of the client and the regulatory authorities. General duties involve budgeting for all departments, making decisions on capital equipment and automation; developing company policies and benefits; addressing personnel issues such as hiring, firing, and promotions; and working with clients on various matters. Day-to-day responsibilities include providing direction to all laboratory departments including laboratory operations, accounting, marketing, QA/QC, and client services. Additional responsibilities are as follows:

- Work directly with ACZ's Ombudsman to provide and maintain a mechanism for confidential reporting of ethical/data integrity issues as well as issues that may directly affect current ACZ policies.
- Define the minimal level of qualification, experience, and skills necessary for all laboratory positions.
- Provide the QA/QC Officer with defined responsibility and authority for ensuring the successful development, implementation, and management of ACZ's Quality System.
- Provide the Production Manager with defined responsibility and authority for ensuring the technical operations and provision of resources needed to maintain the required quality of laboratory operations.
- Provide adequate supervision of environmental staff by persons familiar with methods and procedures, purpose of each test, and assessment of the test results.
- Ensure all technical staff has demonstrated capability in the activities for which they are responsible and ensure that the training of each member of the technical staff is kept up-to-date.
- Ensure the QA/QC Officer has access to the highest level of management at which decisions are made on laboratory policy or resources.
- Provide managerial staff the authority and resources needed to discharge their duties.
- Provide technical personnel the resources needed to discharge their duties.
- Specify and document the responsibility, authority, and interrelationship of all personnel who manage, perform or verify work affecting the quality of calibrations and tests.
- Implement appropriate and current guidelines for all lab methods and procedures to ensure data quality and efficiency of analyses. Ensure all method protocols utilized by ACZ meet the QC requirements as established by EPA or other governing agency.
- Document all policies and procedures related to the analytical and operational activities of the laboratory.
- Provide support to technical staff to ensure timely completion of all laboratory work, and develop contingency plans to ensure workflow progresses as planned.
- Meet quarterly (or more often) with the QA/QC Officer and Production Manager.

4.2 QA/QC Officer

The QA/QC Officer reports directly to the President; however, the QA/QC department is considered a separate entity from operations in order to assure data is evaluated objectively and assessments are performed without outside (i.e. managerial) influence. The QA/QC Officer has direct access to the President, and is therefore able to discuss and/or resolve all concerns, policies, etc. related to quality assurance or quality control. The primary responsibility of the QA/QC Officer is to develop, implement, and manage all aspects of ACZ's Quality System, and he/she may take any action necessary to ensure all ACZ employees adhere to all policies, procedures, and objectives documented in ACZ's QAP, SOPs, memorandums, emails, etc. If warranted, the QA/QC Officer has the authority to halt the performance of a single method or the production of a department, and if necessary, the operations of the entire laboratory, and will grant permission to resume when satisfied that the issue(s) have been resolved. Additional responsibilities include but are not limited to those stated in FRMAD060 and the following:

- Review and revise ACZ's QAP and provide training for all employees following approval of a new version.
- Provide QA/QC orientation to new employees.
- Meet quarterly (or more often) with the President and Production Manager.
- Work with department managers to develop and improve training protocols.
- Conduct department training sessions as needed to address specific problems and questions.
- Arrange for or conduct internal audits; notify management of deficiencies; and track corrective actions.
- Organize all external audits; notify management of deficiencies; and assign and track corrective actions.
- Review and approve SOPs (may designate responsibilities to QA/QC Coordinator).
- Meet at least quarterly with Production Supervisors to provide information, respond to questions, etc.
- Manage Proficiency Testing (PT) program (may designate responsibilities to QA/QC Coordinator).
- Coordinate and maintain all regulatory and client certification programs.
- Review and validate a determined percentage of all data packages from Log-in to Reporting.
- Work with marketing/client service representatives on QA/QC aspects of proposals.
- Work with Project Managers and the Production Manager to resolve client feedback regarding data quality.
- Review and maintain records and documentation for audits, certifications and all other QA/QC issues.
- Schedule electronic data audits with third-party.

Qualifications:

- General knowledge of the analytical test methods
- Documented training and/or experience in QA/QC procedures
- Knowledge of the Quality System as defined under NELAC

4.3 QA/QC Coordinator

The QA/QC Coordinator reports directly to the QA/QC Officer and assists the QA/QC Officer with the development, implementation, and management of the Quality System. Primary job responsibilities are as follows:

- Review and maintain records/documentation for employee training including DOCs, MDLs, etc.
- Provide initial QA/QC orientation to new employees.
- Provide follow-up QA/QC training to new employees.
- Schedule analyses and compile and report data for Proficiency Testing (PT) program, including DMRQA.
- Initiate and track corrective actions related to PT samples and manage all documentation associated with analyses.
- Review and approve SOPs.
- Conduct internal audits, notify management of deficiencies; and track corrective actions.
- Conduct department training sessions as needed to address specific problems and questions.
- Update control chart-generated QC limits in the LIMS database as needed.

Qualifications:

- General knowledge of the analytical test methods
- Documented training and/or experience in QA/QC procedures
- Knowledge of the Quality System as defined under NELAC

4.4 Production Manager

The Production Manager reports directly to the President. General duties involve working with analytical department supervisors on a daily basis to prioritize client projects and QA/QC deadlines and to track sample analyses in order to maintain acceptable turn-around-times for project completion. The Production Manager also addresses personnel, instrumentation, and reagent/supply issues that may affect the completion of the scheduled work and works directly with the QA/QC department to ensure all Quality System requirements pertaining to production are successfully completed in a timely manner. Additional responsibilities are described in FRMAD060.

- Conduct weekly meeting with Production Supervisors to discuss current and upcoming workload, scheduling, priority projects, QC requirements, instrument / equipment issues, personnel, etc.
- Schedule QA/QC work (MDL studies, DOCs, PT sample analysis, SOP revisions, etc.) with department supervisors in order to ensure QA/QC requirements are kept up-to-date.
- Meet at least quarterly with the President and QA/QC Officer.
- Communicate with Project Managers regarding project/instrument status. Notify PMs if problems exist that may affect the project completion date.
- Work with marketing/client service representatives on production aspects of proposals.
- Work with Project Managers and the QA/QC Officer to resolve client feedback regarding data quality.
- Perform checks of sample status using LIMS database to help the laboratory staff meet all established hold times and to determine that analyses can proceed as scheduled to meet required turn around times.
- Provide hands-on support to analysts when necessary to ensure timely completion of all laboratory work, and develop contingency plans to ensure workflow progresses as planned.
- Work with QA/QC Officer to develop and improve training protocols, conduct department work sessions to address specific problems and questions.

Qualifications:

- General knowledge of the analytical test methods
- Minimum four (4) years of laboratory experience
- Minimum two (2) years of supervisory experience
- General knowledge of lab-wide systems (including but not limited to log-in and reporting)

4.5 Production Supervisor

Each Production Supervisor is a full-time employee who reports to the Production Manager and exercises day-to-day oversight of laboratory operations for their specific area(s) of expertise. Each supervisor must be familiar with the test methods and related theory and instrumentation, as well as the assessment of results. In addition to monitoring the standards of performance, validity of all analyses, and quality of all data generated in their respective department(s), each supervisor is also responsible for ensuring that a new analyst has successfully completed all training requirements and is adequately prepared to commence work on client samples. Additional responsibilities are described in FRMAD060. If any supervisor is absent for more than 15 consecutive calendar days then another full-time staff member meeting the required qualifications will be assigned to perform the supervisor's duties.

Required Qualifications for a Production Supervisor:

1) Chemical analyses (Organics & Metals): BS or BA in chemical, environmental, biological sciences, physical sciences or engineering, with a minimum of 24 college semester credit hours in chemistry and at least two (2) years of experience in the environmental analysis of representative inorganic and organic analytes for the which the laboratory seeks or maintains accreditation. A masters or doctoral degree in one of the above disciplines may be substituted for one (1) year of experience.

2) Inorganic Chemical analyses (other than Metals): At least an earned associate's degree in the chemical, physical, or environmental sciences, or two (2) years of equivalent and successful college education, with a minimum of 16 college semester credit hours in chemistry and at least two (2) years of experience performing such analyses.

3) Radiological analyses: BS or BA in chemistry, physics, or engineering, with at least 24 college semester credit hours in chemistry and at least two (2) years of experience in the radiological analyses of environmental samples. A masters or doctoral degree may be substituted for one (1) year of experience.

4.6 Business Development Manager

ACZ's Business Development Manager reports directly to the President and supervises all Client Service Representatives, each of who conducts marketing and sales efforts on behalf of ACZ with potential, new and existing clientele, and develops and maintains long-term relationships with customers by working with Project Managers when necessary. Additional responsibilities of the Business Development Manager are described in FRMAD060. ACZ's Client Service staff is authorized to review all contractual agreements with clients, review all proposals and develop price quotations for routine and non-routine analytical projects.

4.7 Project Manager (PM)

The Senior Project Manager reports directly to the President and is responsible for overseeing the PM department. Additional responsibilities of the Senior PM are described in FRMAD060. Each Project Manager serves as the primary laboratory contact for each ACZ client, handles all client service requests, and investigates and resolves any problem brought to ACZ's attention by the customer. In order to provide consistency, each PM is assigned a list of clients, and it is the primary responsibility of each PM to ensure all of their client project needs are managed on a day-to-day basis and met in a timely manner and that all data submitted to the client is of high quality. All PMs work directly with the Production Manager and Production Supervisors regarding client data issues (due dates, hold times, retests, data quality, etc.), with Document Control regarding client reports and with the QA/QC department regarding data quality questions or concerns.

4.8 Instrument Operator

Instrument operators report directly to the respective Production Supervisor. The position involves the analysis of various matrices for trace level contaminants using specialized and technical instrumentation, and each operator must be capable of performing all job duties in an accurate and proficient manner. Education will be verified by providing a copy of a college transcript or diploma, which is maintained in the employee's personnel file. Experience is verified by ACZ's CFO prior to completing the hiring process (verbal or documented verification provided by each reference listed on a resume or application is acceptable). The operator must demonstrate understanding of related theory, mathematics, analytical instrumentation and data interpretation. This work is predominantly intellectual and involves the continuous use of professional and sound judgment. The employee must meet or exceed all requirements for generation of litigation-quality data and must also continue to demonstrate increased proficiency regarding the interpretation of the data as well as the operation and troubleshooting of the assigned instrument(s). These improvements should be attainable through ongoing efforts in-house as well as through specialized instruction at off-site locations. Prerequisites regarding education and experience, as well as job responsibilities and performance expectations are described in FRMAD059. Exceptions pertaining to experience or education will be made on a case-by-case basis.

Qualifications:

- BA or BS in Chemistry or related science or a minimum of 3 years of relevant experience in lieu of degree
- Prior laboratory experience is preferred but is not required.
- Successful completion of training by supervisor or proficient instrument operator

4.8.1 Laboratory Analyst [Technician]

The laboratory technician reports directly to the respective Production Supervisor. The position involves analysis of various matrices using appropriate analytical techniques and support equipment as well as preparation of samples for instrument analyses. Each technician must be capable of performing all job duties in an accurate and proficient manner. Education will be verified by providing a copy of a college transcript or diploma, which is maintained in the employee's personnel file. Experience is verified by ACZ's CFO prior to completing the hiring process (verbal or documented verification provided by each reference listed on a resume or application is acceptable). The technician must demonstrate understanding of related principles and mathematics, must possess common sense and mechanical skills, and must seek professional judgment from the supervisor as necessary. The employee must meet or exceed all requirements for generation of litigation-quality data as well as sample preparation tasks and routine analyses, and must also continue to demonstrate continuous improvements. These improvements should be attainable through ongoing training efforts in-house as well as through training opportunities at off-site locations. Prerequisites regarding education and experience, as well as job responsibilities and performance expectations are described in FRMAD058. Exceptions pertaining to experience or education will be made on a case-by-case basis.

Qualifications:

- BA or BS in Chemistry or related science is preferred but is not required
- Prior laboratory experience is preferred but is not required
- Successful completion of training period by supervisor or proficient technician

4.9 Information Technology (IT) Manager

The Information Systems Manager reports directly to the President and is responsible for the oversight of the IT department regarding the installation and maintenance of ACZ's computer network and all hardware and software and related equipment deployed on the premise. Additional responsibilities are described in FRMAD060. The department is also responsible for developing, maintaining, and improving custom written applications for laboratory automation and efficiency as well as for ACZ's Oracle database, Intranet (Labweb), Internet and electronic diskette deliverables (EDDs).

4.10 Log-In Supervisor

The Log-In Supervisor reports directly to the President and is responsible for the oversight and management of all department personnel and operations. Primary responsibilities include fulfillment and shipment of bottle orders to the client's destination in a timely manner, receipt of all incoming samples, evaluation of all incoming samples against ACZ's Sample Acceptance Policy, entering samples into the LIMS database, and performing timely review of all logged samples. Additional responsibilities are described in FRMAD060.

4.11 Document Control Supervisor

The Document Control Supervisor reports directly to the President and is responsible for the oversight of the Document Control department. Primary responsibilities include the generation of client reports and EDDs and the maintenance, organization and control of all hard copy data and records, including workgroup data, client reports, CCOCs, QA/QC records and documents. Additional responsibilities are described in FRMAD060.

4.12 Chemical Hygiene Officer

The Chemical Hygiene Officer (CHO) is primarily responsibilities for oversight of ACZ's documented Chemical Hygiene Plan, conducting initial and refresher safety training for all employees, monitoring exposures, and maintaining records for Material Safety Data Sheets, injury reports, chemical exposure reports, etc. Additional responsibilities include as working with management to develop and implement policies to improve the program. The person designated as CHO must have completed at least one basic laboratory safety course and has one year's experience performing laboratory work, preferably with responsibility for at least one area of laboratory safety.

4.13 Chief Financial Officer

ACZ's Chief Financial Officer (CFO) is primarily responsible for all financial matters including payroll, accounts receivable, accounts payable and financial statements; monthly and annual balance and profit and loss statements; and assisting with annual budget preparation. In addition, the CFO maintains and monitors the security system and electronic time clock, invoices client projects from the database, updates customer account information, acts as the administrator for 401k/Profit Sharing Plan, maintains and executes the Employee Benefits Manual and assists in hiring process by posting job openings, scheduling qualified candidates for interviews, checking references, and ensuring a new employee provides proof of education.

4.14 Purchasing Agent

Primary responsibilities include generating material requisitions and tracking all subsequent purchase orders; inspecting all incoming goods; generating PCNs for all incoming standards, reagents, and chemicals; tracking and maintaining an adequate supply of laboratory consumables.

5 TECHNICAL TRAINING

Prior to the independent generation or review of data for client samples (including PT samples), all analysts must undergo a formal, documented training process. Technical personnel must be thoroughly trained in the analytical techniques and operating principles and procedures for the methods utilized by ACZ. This process includes but is not limited to: reading the associated published method, reading all related SOPs, improving laboratory skills, learning troubleshooting, maintenance, and operating procedures for pertinent equipment and instruments, and creating workgroups and reviewing data through the LIMS database.

It is the responsibility of the department supervisor to determine that a new analyst is properly trained, has successfully completed all initial training requirements and is prepared to commence work on client samples. Under no circumstances may any analyst independently generate client data before receiving the explicit approval of the QA/QC department.

5.1 The effective version of the test SOP provides the framework for training for all sample preparation and analysis. The SOP is typically based on published approved methodologies (EPA or other) and incorporates any necessary activities and protocols not included in the published method(s) as well as requirements stipulated by other regulatory agencies.

5.2 Training for data AREV or SREV only must be documented as specified in section 2.3.6.

5.3 Each employee must be trained either by the department supervisor or by an analyst within the department who is proficient in the area of testing and has been designated by the supervisor. Anyone performing training must meet the following requirements:

1) Documentation of training on the effective version of the test SOP.
2) Documented approval for the analysis.
3) A current IDOC or CDOC.

5.4 Initial training is documented using the Initial Method Training form (FRMQA004). Once training has been completed, the trainee and the instructor fill out the form together to ensure all pertinent information has been addressed and to ensure the trainee comprehends the material and is provided an opportunity to ask questions or request additional training. The trainee's signature is an attestation that he/she has read, understands, and agrees to always follow the effective version of the SOP.

5.5 To demonstrate an aptitude for the procedure, the analyst must perform a successful Initial Demonstration of Capability (IDOC) prior to independent preparation and/or analysis of client samples. Performance is documented using FRMAD023. The data is reviewed initially by the department supervisor and the analyst (AREV), and both individuals must initial and date the review checklist.

5.6 SREV for any preparation workgroup is performed by the department supervisor or a qualified analyst, and SREV for any analytical workgroup is performed by QA/QC.

5.7 Prior to performing an IDOC, a new analyst should be provided sufficient opportunity to practice the procedure. This confirms the analyst understands the procedure and feels comfortable performing the procedure independently. Data associated with any practice is not submitted to QA/QC.

5.8 It is not necessary for the first IDOC attempt to pass; however, the supervisor needs to review the analyst's techniques if multiple attempts do not pass.

5.9 A thorough review of the raw data is performed as part of initial method training and should include particular attention to details not presented in LIMS or on the final report, such as generating final sample concentration from the instrument response provided in the raw data (if applicable) and verifying correct standard and reagent traceability.

5.10 Where specified by the method or a regulating entity, and as stated in the test SOP, successful demonstration of performance such as Linear Calibration Range determination (LCR) or Method Detection Limit (MDL) study must be completed prior to independent analysis of client samples.

5.11 All initial training documentation must be submitted to the QA/QC department as a complete package. At a minimum, the package must include:

1) Initial Method Training form (FRMQA004), signed by the trainee and instructor (or department supervisor).

2) IDOC documentation:

- ✓ Completed and signed certification statement (FRMAD023)
- ✓ Workgroup bench sheet, raw data, and all supporting documentation

3) If applicable, MDL study for each instrument. Complete FRMAD031 and attach all related raw data and supporting documentation.

4) If applicable, calibration range study for each instrument. Complete FRMQA029 and attach all related raw data and supporting documentation.

5.12 Following review of all pertinent training documentation, QA/QC will issue procedure-specific clearance for the trainee to independently generate and review data for client samples. This permission is tracked and may be viewed on a designated location on the public network drive.

1) Approval for preparation procedures is granted after the instrument data has been reviewed and approved.

2) An unapproved analyst who is "shadowing" the trainer (observing, learning the organization of the lab, reagent room, etc.) may not assisting with the procedure, and the workgroup documentation must bear only the initials of the trainer, who is fully responsible for the data.

3) If the analyst has completed training for a procedure and generates client data or reviews client data prior to QA/QC approval, then any workgroup(s) or data review checklist must also bear the initials of a proficient analyst, with current approval for the method, who oversees the analyst's work for the procedure and assumes full responsibility for the data. The primary analyst must always be aware that he/she is responsible for the workgroup. The use of another employee's initials without their explicit approval is not permitted.

5.13 The supervisor is responsible for ensuring the training of each analyst is kept up-to-date. Each analyst must read, understand, and agree to follow the effective version of the SOP and continued proficiency must be demonstrated and documented annually for each analyst.

5.14 Each production supervisor routinely conducts department meetings to discuss procedures, work schedules, resources, questions and concerns, problems, QA/QC, etc.

6 SAMPLE COLLECTION & HOLDING TIMES

Sample collection procedures are well documented by the EPA and other agencies, and ACZ's clients are instructed to provide representative samples whenever possible. ACZ supplies its clients with the containers and other materials necessary to maintain sample integrity (to the extent possible) from the time of collection through analysis. Although ACZ does not perform sample collection activities, each project manager or client service representative will assist a client with specific sampling requirements as needed, or when necessary, will direct a client to other resources. The following sections include general information on sample containers, preservatives and holding times, which are essential components in maintaining the chemical and physical properties possessed by the sample at the time of collection.

6.1 Sampling Containers and Preservatives

The EPA outlines the requirements for sample container types, sample volume and preservation. ACZ inventory includes various sizes of plastic and glass containers that range from pre-sterilized to certified-clean by the supplier. Amber bottles are used when specified by the method. Glass containers are obtained from vendors that specialize in the sales of environmental sample containers, and all non-certified bottles are purchased from reputable lab/industry vendors. Refer to FRMAD045 and FRMAD046 for bottles types and preservation techniques for specific analyses. Refer also to Appendix A for additional information regarding EPA requirements container types and preservation.

All sample containers shipped to our clients are new, contain the appropriate preservative(s), and are color-coded to identify preservation and storage. Out-going containers are packed in clean coolers with a copy of ACZ's Sample Acceptance Policy, general directions for sample collection, bottle labels, ice packs, sampling information, blank chain of custody, return shipping labels, and custody seals. Trip blanks and rinsette water are included when requested by the client or when mandated by a specific analytical method. After samples have been collected they are cooled to a temperature > 0 °C and < 6 °C. Samples that require thermal preservation must be maintained within this temperature range until all analyses have been completed.

6.2 Holding Times

The EPA has conducted lengthy studies of sample degradation versus time to establish a maximum holding time for each method, and the results of these studies are compiled into holding-time tables to provide guidelines for litigation purposes. Data for a sample prepared / analyzed outside of the established holding time are the most difficult to defend in court. Holding times will vary slightly from regulation to regulation, thus further emphasizing the need for a client to consult with their Project Manager prior to sample collection. The holding time begins from the time or date of collection in the field. Appendix A outlines holding times (a hold time stated in 40CFR supersedes the published method). **NOTE**: The sampling date for PT samples is the preparation date, which must be documented on the workgroup and the container of prepared sample.

If ACZ Laboratories, Inc. receives samples past holding times or near the expiration of the holding time, sample analysis will proceed unless the client has indicated on the CCOC that an attempt to contact the client must first be made. Analyses performed outside of holding time will be appropriately qualified on the final report. Holding times $\leq$ 72 hours are calculated based on the hour of the sample date/time. Holding times > 72 hours are calculated based on the day of the sample date/time.

In general, and unless otherwise noted in the test SOP, sample preparation and analysis must be completed within the stated holding time. For analyses that extend beyond the intended scope of the method for an analyte or matrix, the hold time stated in the SOP must be met, or samples must be appropriately qualified.

7 SAMPLE CUSTODY & SAMPLE HANDLING

Sample custody begins with the receipt of sample containers from the client and continues beyond preparation and analysis to the proper disposal of primary and secondary sub-samples. Complete and accurate documentation must be provided at all stages of custody. There are many key elements to sample custody including laboratory security, chain of custody records, sample storage, internal custody logs, sample tracking within the laboratory, control of subcontracted work, and sample disposal.

7.1 Laboratory Security

A secure facility is essential to maintaining sample and data integrity and to providing safety to employees and visitors. ACZ has an electronic security system based on anti-pass back protocols, which controls and limits access to only authorized personnel. The following steps have been taken to ensure this security:

- All entryways are armed and a proximity reader at the east entrance and west shipping entrance allows access to an employee only after he/she passes their card.
- Employees may enter/exit only through the west door at Log-In and the east door next to the lunchroom.
- During normal business hours, public access into the building can be made at the front entrance and the west shipping entrance. Both doors are equipped with a buzzer.
- The outside doors at the west shipping entrance remain unlocked; however, the doors between the vestibule area and sample receiving area are equipped with an anti-pass back system.
- Building access is limited to specific hours of the employee's shifts.
- All employees are required to use their access cards to enter and exit the building.
- If any employee does not have their access card, they must notify ACZ's CFO as soon as possible and must sign in and out during the day using the visitor's register at the front desk. This ensures a record is maintained of which personnel were in the building at any time.
- If employees fail to use their card, the anti-pass back system denies access for that card the next time it is used. The employee must report to ACZ's CFO if this occurs.
- Visitors must enter and exit through the main entrance and must sign the register at the front desk upon arrival and before departure.
- Lab personnel must escort visitors as long as they remain on the premises.
- Emergency Exit doors are to be used only for emergency purposes. If a door is opened, a siren alarm will sound.
- It is against company security policy to loan or transfer access cards to anyone, including other ACZ employees. Employees may not allow a non-shift employee to enter the building.
- Vendors and delivery services enter the building via the west shipping entrance.

7.2 Sample Receipt and Log-in

Upon delivery of samples to ACZ, Log-In personnel evaluate the condition of the cooler and custody seals. The custody seals are then broken to retrieve the Chain of Custody (COC), which must be signed by the sample custodian to document the transfer of possession of the samples to ACZ. Once a cooler is opened, the pH of each sample is checked, if necessary, to verify the method preservation requirements have been met. The pH check is documented along with cooler temperature, radioactivity screen and other pertinent sample information.

Any problems, such as expired hold times, lack of preservative or improper cooler temperature, are noted and the Project Manager must contact the client as soon as possible so that a contingency plan can be initiated if necessary. Samples are logged-in as outlined in the SOP *Sample Receipt & Log-In Procedure / Maintenance of Sample Integrity* (SOPAD016) and are delivered to the assigned storage areas. Following log-in, every project is reviewed by the assigned PM, and upon completion of the review, the client receives an electronic summary, referred to as the "Login Review Report" that details the project information. This summary allows the client an opportunity to make changes to the project before samples are analyzed. Refer to ACZ's SOP *Client Service Policies and Procedures* (SOPAD043) for additional information.

7.3 Internal Custody Logs

Some clients may specify additional custody tracking of the samples once they have been logged in. Internal custody may require that samples are stored in a manner that ensures limited access. The internal custody log (FRMQA015) shall accompany the samples from log-in through completed analysis. The person responsible for the work signs and dates each entry and/or page in the logbook. When all data from a sample set is compiled, copies of all logbook entries shall be included in the final report package. For projects requiring internal custody, ACZ will adhere to the procedure described in the SOP *Client Service Policies and Procedures* (SOPAD043).

7.4 Sample Tracking

Sample flow through the laboratory is facilitated by the use of an Oracle-based LIMS database (Laboratory Information Management System). Every product (requested analysis) logged into the LIMS for a sample has a specific, pre-determined department path. All products have default paths of at least Login Review and Reporting. Between these two departments, a product may go through, for example, Soil Prep and Metal Analysis or Soil Prep, Organic Prep and GC Analysis. At each department step in a product's path, the status can be updated and viewed at any time. Analytical product statuses are defined below. Additional information regarding sample tracking is available in the SOP *Client Service Policies and Procedures* (SOPAD043).

NEED	Prep or Analysis has not been started
WIP	Prep or Analysis has been started (Work In Progress)
PREP	Sample preparation is complete and sample is ready for analysis
UPLD	Analytical data has been uploaded into LIMS
AREV	Analyst has reviewed and accepted analytical data
SREV	Supervisor has reviewed and accepted analytical data
DONE	Analysis or task has been completed
REDO	Sample requires reanalysis
REDX	Sample requires re-digestion/extraction
CANT	Sample preparation or analysis cannot be performed

8 PROCUREMENT, INVENTORY & TRACEABILITY OF SUPPLIES

8.1 Procurement / Inventory

All consumable supplies are purchased from reputable vendors that have been evaluated for service, quality, and price. To the extent possible, materials traceable to national or international standards of measurement are purchased for use in technical operations. Supplies are purchased using ACZ's purchase order (PO) and inventory system database. The Purchasing Agent is not permitted to make a substitution for any material(s) specifically requested unless the department supervisor approves the substitution. Upon receipt, reagents, chemicals, standards, and other laboratory consumables are stored in the Chemical & Supply Room, which has limited access, or are delivered to the laboratory. Refer to ACZ's SOP *Purchase, Receipt, and Storage of Consumable Materials for Technical Operations* (SOPAD037) for additional information.

8.2 Glassware

ACZ uses only laboratory grade glassware. Prior to use, glassware is cleaned using Alconox® or Chemsolve® (or other appropriate detergent) and then rinsed with Type I water. Glassware for trace metals is subsequently rinsed with 50% Nitric Acid and rinse again with Type I water. Glassware for nutrients is subsequently rinsed with 10% Hydrochloric Acid and then with Type I water. All glassware for organic analyses is washed with Alconox® then rinsed with de-ionized water and kiln-baked. Glassware for radiochemistry analyses is washed first with Contrad70® and then with 50% Nitric Acid and is rinsed with Type I water. Clean glassware must be stored in an enclosed cabinet or other suitable container and/or covered with Parafilm or foil.

8.3 Other Supplies

Routine consumables (centrifuge tubes, autosampler tubes, pipette tips, etc.) are purchased through an automatic system managed by Fisher (RIMS). All other supplies are purchased on an as-needed basis through ACZ's Purchase Order and inventory system database. Refer to SOPAD037 for additional information.

8.4 Traceability of Standards and Reagents

To provide complete traceability, each data package must reference every standard and reagent used for sample preparation or analysis, including but not limited to acids, bases, preservatives, color reagents, pH indicators, buffers, instrument reagents. Each PCN and/or SCN must be documented either on the workgroup bench sheet, data review checklist, or a current standard/reagent form. The open date for all original containers is not tracked in LIMS; however, good laboratory practice dictates that the open date always be noted on the sample container.

8.4.1 Primary Control Number (PCN)

Upon receipt, all stock chemicals, standards, and reagents are assigned a unique PCN in LIMS for tracking and traceability purposes. A label with the PCN and the expiration date is affixed to both the container and the Certificate of Analysis (if applicable). Document Control enters the data for each PCN using the certified value(s) supplied by the vendor, as indicated on the Certificate of Analysis. Because the certified value is entered, the final concentrations for prepared standards may vary slightly from the theoretical value indicated in the test SOP. Non-certified values are not entered and are not used for quality control purposes. Document Control maintains certificates of Analysis, and a copy of the PCN report is generated and maintained. If data for any PCN is to be edited, then complete documentation must be provided as a major corrective action (FRMQA001).

NOTE: Only Document Control and QA/QC personnel are authorized to enter or edit PCN data.

8.4.2 Secondary Control Number (SCN)

To ensure complete traceability, a unique SCN must be created when any intermediate or working standard is prepared from one or more stock solutions, stock chemicals, or intermediate solutions. A standardized format is used for creating the SCN: a two-letter code indicates the lab section and is followed by the prep date and then by a daily sequential number. For example, the SCN **II051128-2** denotes the second standard prepared on November 28, 2005 in the Inorganic Instrument lab. An acceptable alternative is to let LIMS assign a unique number when prompted.

A SCN for any working standard subjected to a LIMS calculation must be created electronically in LIMS. The initial volume and concentration of each constituent and the final volume of the prepared solution are entered in the SCN Wizard program to calculate the final concentration(s) of each analyte using the formula $C_1V_1 = C_2V_2$. The preparation date, expiration date, and preparer's initials are included as part of this electronic record. A hard copy of the SCN report may be affixed to the standard/reagent logbook, depending on individual department practice; however, it is not required.

Prepared reagents do not require a SCN to be created electronically in LIMS; however, preparation must be recorded in the department's designated logbook. At a minimum, the logbook entry must clearly identify what reagent was prepared, its subcomponents, the preparer's initials, the preparation date, and the expiration date. This information is sufficient for color reagents, buffer solutions, instrument reagents, etc. because details of the preparation are stated in the test SOP.

8.5 Preparation and Expiration of Standards and Reagents

8.5.1 Preparation of Standards and Reagents

Refer to individual test SOPs for detailed information regarding standard and reagent preparation. In general, either Class A pipettes or mechanical pipettes are used to measure and dispense aliquots of any solution used to prepare a standard or reagent. Accurate delivery of mechanical pipettes must first be verified as described in ACZ's SOP *Control, Calibration, and Maintenance of Measuring and Test Equipment* (SOPAD013).

The term QS referenced in many test SOPs is the acronym for *Quantity Sufficient* and refers to the addition of appropriate diluent to the solution to achieve the final volume. All containers of prepared reagents and standards stored for more than one day must be properly labeled with the SCN (or other unique identifier), preparation date, and expiration date. Preparation of reagents and standards must be documented as described in 8.4.2.

8.5.2 Expiration of Purchased Standards and Chemicals (PCNs)

In general, purchased liquid standards or reagents are assigned a default expiration date of one year from receipt. When provided, the manufacturer's expiration date will be assigned in lieu of the default expiration date. Solid materials are assigned a default expiration date of five (5) years from receipt.

An expired stock material may continue to be used only if its reliability can be verified. For the purpose of ensuring transparency, the reason for extending the expiration date of a PCN must be documented as a QA/QC Issue Wizard assigned to QA/QC or the Document Control supervisor. Unusable materials must be replaced and the standard or reagent remade as soon as possible. Remove the container from the lab or the supply room and dispose of properly. Contact ACZ's CHO for assistance.

8.5.3 Expiration of Prepared Standards

Storage conditions and shelf life for prepared standards are provided in the individual test SOPs. The following guidelines may be used to determine the shelf life for a prepared standard:

1) A standard that has been prepared in-house may continue to be used after its assigned expiration date for as long as its reliability can been verified. For applicable procedures, instrument response should be considered when determining whether or not a solution is still reliable.

   - In cases where reliability has been verified, the expiration date of the SCN must be updated in LIMS or the standard/reagent logbook.

   - In the event the solution was used prior to updating the SCN then documentation must be provided as part of the workgroup to indicate the solution was used past the shelf life stated in the SOP (a minor corrective action may be used if more than one workgroup is affected). The expired standard must be remade as soon as its reliability becomes questionable – it is the responsibility of the analyst to use their best judgment.

2) The shelf life of any prepared standard with any analyte concentration < 10 mg/L is 90 days from the preparation date. This is a general guideline – if any constituent does not remain in solution for 90 days, then the standard must be prepared more often. If the manufacturer's expiration date for any stock standard is sooner, then the expiration date of the SCN is the manufacturer's expiration date for a single analyte solution or the earliest manufacturer's expiration date for a multiple analyte solution.

3) The shelf life of any prepared standard with analyte concentration $\geq$ 10 mg/L is one year from the preparation date. This is a general guideline – if any constituent does not remain in solution for one year, then the standard must be prepared more often. If the manufacturer's expiration date for any stock standard is sooner, then the expiration date of the SCN is the manufacturer's expiration date for a single analyte solution or the earliest manufacturer's expiration date for a multiple analyte solution.

4) In general there are no manufacturer expiration dates for Radiological isotopes. If provided, these will be used; otherwise, the default expiration date of one year from receipt will be assigned when the material is received and can be subsequently updated at yearly intervals as needed for as long as the material remains useable. Because the shelf life of a radiological isotope is dependent on the half-life, the isotope will be deemed expired when it falls within 3 times the detection limit of the method.

5) In general, prepared Radiochemistry standards expire one year from the preparation date. The solution may be re-evaluated using control charts or other criteria and the expiration date extended by year intervals if the solution is still deemed usable. Refer to the specific test SOP for details.

8.5.4 Expiration of Reagents

In general, a reagent is a solution, other than a surrogate or internal standard, which is used for any step of sample preparation or analysis but does not contain the target analyte(s). Storage conditions and shelf life are stated in the individual test SOPs. The expiration date can be extended for a prepared reagent provided the criteria stated in 8.5.3.1) are met.

9 MAINTENANCE & CALIBRATION OF INSTRUMENTATION & EQUIPMENT

9.1 Maintenance of Instruments and Support Equipment

The best protocol for producing quality work is to prevent errors and non-conformances rather than to react to and correct problems after they occur. An essential part of this protocol is ensuring that all laboratory instrumentation and equipment used for the generation of data has been optimized and is functioning properly before commencing work on client samples. Performing routine maintenance and optimizing instrument-operating conditions prior to sample analysis minimizes instrument downtime, thereby improving productivity and ensuring quality of the data. It is the responsibility of the designated analyst(s) to perform and properly document daily and routine maintenance, instrument optimization, troubleshooting, any instrument servicing or repair, and any repair or replacement of parts.

All manufacturer-prescribed inspection and maintenance must be performed according to the schedule indicated in the operator's manual (or similar) provided by the manufacturer and must be documented either in the instrument logbook or a separate maintenance logbook or on the instrument maintenance checklist (available in LabWeb). ACZ management recognizes that performing all maintenance procedures at the frequency indicated by the manufacturer may not be economically feasible or a significant increase in workload may require the maintenance be performed at a later time if instrument performance is deemed to be acceptable; therefore, at a minimum, the instrument part(s) must be inspected regularly according to the schedule. The analyst must use their professional judgment to determine if maintenance or replacement is necessary at that time. Refer to ACZ's SOP *Control, Calibration and Maintenance of Measuring and Test Equipment* (SOPAD013) for details for each specific instrument or instrument type.

Additionally, all support equipment (any device that may not be the actual test instrument, but is necessary to support laboratory operations) must be monitored regularly to confirm proper functioning. The temperature of all drying ovens, refrigerators, freezers, and incubators must be checked each working day (except Sundays or holidays) and each check recorded on the associated Temperature Logsheet. Refer to SOPAD013 for more detail.

Equipment that has been subjected to overloading or mishandling, gives suspect results or has been shown to be defective or outside specified limits must be taken out of service and FRMAD029 attached to indicate the instrument or equipment is waiting for repair and cannot be used. During this downtime the department supervisor, Production Manager, and Project Manager may collectively determine it is necessary to sub-contract samples until correct performance of the repaired instrument or equipment has been demonstrated by a successful calibration or other suitable test. Document all contact with the manufacturer, as well as all repairs and other services, in the instrument or maintenance logbook to be used as a reference for solving future instrument problems. Additionally, when instrumentation or equipment goes outside of the direct control of the laboratory, the functioning and calibration status must be checked and shown to be satisfactory before it is returned to service. Refer to SOPAD013 for additional information.

To minimize downtime, each laboratory should maintain an adequate inventory of reagents, stock standards, glassware, etc. and should keep a sufficient supply of extra "critical" parts in-house rather than possibly delay sample analysis while waiting for parts to arrive. Keep in mind that parts from a vendor may be back-ordered and will not be available for immediate shipment. Additionally, an MDL study, MDL verification, calibration range determination, etc. must be performed for all methods on each instrument used to analyze client samples. This ensures any "backup" instrument can be utilized for analysis of client samples as soon as needed, rather than delaying production to first successfully complete any QC requirement(s).

9.2 Instrument Calibration

The accuracy of all instrument-generated data is ultimately dependent upon the proper initial calibration of the instrumentation used for any particular analysis. In order to perform quantitative measurements, the initial calibration must be established and verified, at the frequency required by the method or by the manufacturer (whichever is more stringent), before samples are analyzed. In general, calibration or standardization involves defining the relationship between instrument response and the amount or concentration of analyte introduced into the instrument. The graphical depiction of this relationship is referred to as the calibration curve. Calibration frequency must be performed in accordance with the manufacturer's guidelines, test method or other regulatory requirements, or client contract stipulations, whichever is most stringent. Every calibration or standardization must meet the acceptance criteria stated in the SOP and must be subsequently verified by analyzing an initial calibration verification standard (ICV) or other control standard (if specified in the SOP) that contains all target analytes and has been prepared or obtained from a different source than the one used to prepare the calibration standards.[1] Whenever possible, calibration standards and the second-source verification standard should be prepared on different days. If they are prepared concurrently, then another qualified analyst should prepare the second-source verification standard. This eliminates the possibility of the same analyst preparing both solutions incorrectly, an error difficult to detect.

A continuing calibration verification standard (CCV) containing all analytes of interest must be analyzed at the frequency stated in the test SOP to ensure the stability of the initial calibration curve has not varied over time due to any change in the analytical instrument and its detection system, such as instability of standards, instrument cleanliness, column performance, matrix effects, flow changes, and changes within the laboratory environment.

For applicable methods, all initial and continuing calibration steps must be clearly detailed in the test SOP. Additionally, each test SOP must specify the frequency and acceptance limits for the calibration and subsequent verification (ICV and CCV). In general, acceptance criteria are method-specific; however, the SOP may also include requirements of other regulatory agencies. Prior to resuming sample analysis, immediate corrective action must be taken if the calibration, ICV, or CCV is outside of the acceptance criteria. Technical corrective actions are described in the individual test SOPs. Refer also to section 11.2 for additional information.

General calibration guidelines are listed below and detailed information is provided in ACZ's SOP *Maintenance and Control of Calibration and Test Equipment* (SOPAD013).

- Understand the method requirements for calibration (minimum number of standards, etc.)
- Use the correct calibration model (linear, second-order, etc.)
- Include all target analytes in the calibration standards and second-source standard
- Analyze a calibration standard with a concentration less than or equal to the reporting limit.[2]
- Do not remove points from the middle of the calibration (only high or low standard may be dropped).
- Calibration is a single-event process. A retest of a calibration standard must be performed immediately.
- Documentation and resolution of calibration abnormalities is absolutely critical

[1] If a second source standard is not available then a different lot(s) of the same standard(s) may be used. If a different lot is not available then an analyst who did not prepare the calibration standards may prepare the calibration verification standard. The latter is an exception, and an attempt must first be made to purchase a different lot from the same vendor whenever a second-source standard is not commercially available.

[2] In general, the concentration of the low calibration standard is equal to the reporting limit, because lesser values are qualified as estimated; however, actual lab practice may differ and must be stated in the test SOP.

10 CONTROL & STORAGE OF RECORDS & DOCUMENTS

A formal and systematic control of records and documents is necessary for accurately reconstructing the entire history of any sample as well as to guarantee the quality and defensibility of the data. All information pertaining to instrumentation and equipment, analytical test methods, and related laboratory activities, such as sample receipt, sample preparation, data verification and data reporting must be documented, must identify all personnel involved, and must be readily understood. All records, including those pertaining to calibration and test equipment, certificates and reports, must be maintained, and the management system must facilitate the retrieval of all working files and archived records for inspection and validation purposes. Documents and records must be safely stored (protected against fire, theft, loss, environmental deterioration, and vermin) and must be held secure and in confidence to the client for a minimum of five (5) years. The hard copy of all records and documents must be maintained in a designated storage area with limited access. To the extent possible, hard copies for the most recent two (2) years are stored on-site, and if necessary, may be moved to off-site storage after two years. Off-site storage conditions must meet the same criteria that apply to on-site storage.

10.1 Workgroups

10.1.1 Changes made to any workgroup record (hardcopy or text file) must be documented.

1) If a workgroup is "dissolved" to change the status then all data must first be deleted, and the workgroup is then either re-reviewed or re-uploaded. In either case, the analyst is prompted in LIMS to provide an explanation of why he/she is performing the task.

2) Changes to text files must be documented in LIMS and on the hard copy of the workgroup.

10.1.2 Workgroup data that is re-uploaded *for any reason* must first be deleted. Use one of the following options in LIMS\Sx Analysis.

1) Choose "Delete workgroup data and set to WIP."

2) In either the AREV or SREV function choose "Errors" and then "Reupload."

If any of the data changes then a new Run Approval report must be printed and attached to the hard copy of the workgroup, and the workgroup must be rescanned.

10.1.3 Document Control or other administrative personnel use a multi-page scanner with its own PDF scanning software to scan all workgroups.

1) Before the workgroup is scanned, the top page is reviewed to make sure it has both the AREV and SREV initials and dates, and that errors have been properly corrected.

2) The person scanning the must initial and date in the lower right hand corner of the front page by the person. This provides a record of the scan date.

3) The workgroup is scanned to the designated network directory and is then moved through an automated process to the appropriate read-only LabWeb directory, which is accessible to all employees. When a workgroup is rescanned, the previous file is maintained. A copy will be automatically created so as not to overwrite any files and will have a letter appended; starting with "A" the first time the workgroup is rescanned. The most current file will not have a letter appended.

10.1.4 The hard copy is filed by workgroup number in a storage box. The front of the full storage box is labeled with the year and the workgroups contained in the box. The first box of each new calendar year is "1." Full boxes are consecutively numbered, transferred to a designated location and stored in numerical order. The storage room is locked at all times. Access is limited and is tracked through an access logbook.

10.1.5 Workgroups moved to storage may be accessed; however, a checkout card must hold the place of the workgroup in the file and must indicate who removed the workgroup, the workgroup number, and the date the workgroup was removed. When the workgroup is returned, then the checkout card is removed.

10.2 Electronic File Retention & Storage

All electronic records, stored either on instrument computers or on the network, are systematically backed up to tape. These records include Oracle data, instrument raw data, workgroups, client reports, instrument upload files, SOPs and other controlled documents, telephone records/voice mails, and department data. Tape backups are performed incrementally nightly Monday through Thursday, and a complete backup is performed each Friday. The tape from the first Friday of the month is pulled from service and placed in a secure, data-rated, 4-hour fireproof, safe that is located in the CFO's office. On a regular basis, the monthly tapes are moved to ACZ's safety deposit box at a local bank.

10.3 Instrument Data Files

Instrument raw data files are backed up by two different procedures: ACZ's Instrument Data Backup Application (IDBA) and StorActive. IDBA is a mandatory program that accesses local directories from instrument computers. Each night the program retrieves and backs up individual data files from the specified directory on each instrument computer. Refer to ACZ's SOP *Backup and Archive of Instrument Data Files* (SOPAD044) for details. StorActive LiveBackup is a third party program located on its own server that stores any saved version of all files located on any computer that employs LiveBackup (including files with the same name). This program is helpful in case a full restore is necessary or if multiple files overwritten by a saved version need to be retrieved. This program works for any computer utilizing Windows XP as its operating system.

10.4 Client Reports

10.4.1 Client reports are generated and signed electronically and are automatically stored as a PDF at a designated location on the network that has limited access. If a copy of any report exists on the network, and a new report is generated, then the existing copy will be renamed so that it is not overwritten. This way ACZ maintains a copy of all reports generated for a client.

10.4.2 Hardcopy documentation associated with a client project (CCOC, invoice, Login Review Form, etc) is filed by project number and stored in the document storage location.

10.4.3 Electronic Diskette Deliverables (EDD) are stored on the network at a designated location.

10.4.4 Changes to data may be necessary due to reporting requirements. These changes are made after the routine workgroup approval step and may include changes to reporting qualifiers, QC Summary qualifiers, report notes, etc. A record of the change must be made in the project

"Change Log." Access the Change Log from the LIMS2000 menu/Reporting/Report Approval form. Refer to ACZ's SOP *Client Service Policies and Procedures* (SOPAD043) for additional information.

10.4.5 The Change Log must be used when a reported parameter is moved from one workgroup to another. The preferred way to do this is for a PM to either document the necessary changes in the Change Log and then notify the reporting department of the required changes or notify the reporting department immediately that a change is necessary. In the case of the latter, the reporting department makes the changes and then logs this action in the Change Log. Refer also to ACZ's SOP *Client Service Policies and Procedures* (SOPAD043).

10.4.6 Once a project has been invoiced, the directory on P:\Client is moved to the designated network location as a read-only PDF. If a project is un-invoiced, the project folder is copied to P:\Client where changes can take place.

10.4.7 In general, changes are not allowed to projects (including compilation) if the project has been invoiced. If a change needs to be made, the project must first be un-invoiced. At the time of un-invoicing, the user must provide a reason in LIMS to explain why the project was un-invoiced. This information is then stored in the Oracle database.

10.5 Documents

10.5.1 Standard Operating Procedures

10.5.1.1 Refer to section 2.2 for additional information pertaining to SOPs.

10.5.1.2 The original master copy of each SOP is maintained through a combined effort of QA/QC and Document Control. Master copies are organized in three-ring binders, which are kept in the Document Control office. An SOP Control Form (FRMQA003) is kept with each master copy and indicates each controlled copy of the SOP that was issued as well as the date and to which lab(s) the copies were distributed.

10.5.1.3 When a new version of any SOP becomes effective, the master copy of the previous version is retained and filed in the Document Control office. All controlled copies of the previous version are collected and disposed of. The collect date is documented on the SOP Control Form, which is maintained with the associated master copy SOP.

10.5.1.4 A controlled copy of the SOP is kept in each location the procedure is performed.

1) Each lab or department is issued one controlled copy of all relevant SOPs. The controlled copy must not be removed from the assigned area for an extended period of time and may not be photocopied. An additional controlled copy of any SOP or individual replacement pages of any SOP will be distributed upon request.

2) A SOP Revision Form (FRMQA030) is issued with each controlled copy. Any revision to a procedure must be noted on the form and must be approved by QA/QC before changes may be implemented. The revision form is kept in the laboratory SOP binder until the SOP is reviewed and revised. Once the next revision of the SOP becomes effective, the original revision form(s) are maintained with the master copy of the new version.

3) To ensure outdated information is not inadvertently used as a reference, an uncontrolled copy of any SOP is not allowed unless issued by QA/QC. Additionally, an electronic copy of any SOP becomes obsolete and must be deleted from a network drive or email once the effective version has been uploaded to LabWeb.

10.5.2 When documents are found to contain conflicting policies or procedures, the more recent document will be followed.

10.5.3 All controlled forms must be printed from LabWeb and may not be stored on a separate network drive. If photocopies are used then any unused copies of the expired version must be disposed of as soon as a new version is uploaded to LabWeb. This ensures that the effective version of any controlled form is in use at all times.

10.5.4 Any controlled SOP(s) issued to an employee must collected upon resignation or termination.

10.5.5 Employees utilize an uncontrolled copy of the Ethics SOP or QAP for initial or continuing training purposes. All copies are collected following completion of the training session.

10.5.6 Only Document Control and QA/QC personnel are authorized to enter or edit data for a PCN.

10.5.7 The hard copy of each PCN report generated in LIMS is stored in a three-ring binder that is maintained by the Document Control department.

10.5.8 The original certificate of analysis for any stock material, if provided, is attached to the hard copy PCN report.

10.5.9 Accreditation certificates are scanned as a PDF to a designated network location. The original copy is maintained by Document Control. Certificates are also posted to ACZ's website.

10.5.10 Original calibration certificates and related documentation for support equipment (including but not limited to pipettes, thermometers, and glass micro liter syringes) are maintained by Document Control.

10.5.11 LIMS and other problems pertaining to IT are documented and managed by the electronic system called Issue Wizard. If an employee encounters a problem that requires attention, then that employee will submit a request through Issue Wizard. The request requires a priority to be assigned to the appropriate employee(s) for resolution. This system allows ACZ to track all changes made to computer systems. Reports are routinely generated to evaluate the status and eventual resolution of computer issues.

10.6 Records

10.6.1 Records include, but are not limited to: all logbooks; phone logs; raw data, derived data, and calibration data; training documentation (training forms, MDL studies, DOCs, etc.); proficiency testing results; calibration and certification records; internal audit reports; external audit reports; corrective action reports; management reports; and regulatory correspondence.

10.6.2 Records related to sample log-in are maintained as described in SOPAD016.

10.6.3 Raw data may include photography, microfilm or microfiche copies, computer printouts, magnetic media, dictated observations, and recorded data from automated instruments.

10.6.4 Original copies of records, except those pertaining to analytical data, are maintained by the QA/QC department or Document Control, and access is limited.

10.6.5 Relevant qualifications, training skills, and experience of technical personnel are maintained in the employee's training file.

10.6.6 Records such as transcripts, applications for employment, performance evaluations, etc. are maintained in the personnel files, which are stored in the secured office of the CFO.

10.6.7 The DOC certification statement (FRMAD023) and initial method training form (FRMQA004) are filed with the workgroup if the DOC was logged-in; otherwise, the training form is maintained in the employee's training file and the DOC form is filed with the data package.

10.6.8 Each employee's legal name, legal signature, and initials are documented on the New Employee Checklist (FRMAD043). The form is maintained in the employee's personnel file, which is stored in the Controller's office. A master signature/initial log is maintained for anyone employed at ACZ prior to the implementation of FRMAD043.

10.6.9 Each Organic Instrument ICAL data package is scanned to the designated network directory as a read-only PDF and the hard copy stored in labeled boxes. ICAL information that needs to be attached to any subsequent workgroup(s) must be printed from the PDF.

10.6.10 Logbooks must be maintained and controlled as described in SOPAD013.

10.6.11 Project Managers are responsible for maintaining all emails pertaining to a client and/or project. Refer to ACZ's SOP *Client Service Policies and Procedures* (SOPAD043).

10.6.12 Procedural change(s) made to a SOP must be noted on the SOP Revision Form (FRMQA030) and approved by QA/QC prior to implementation. The date of the QA/QC approval denotes the effective date for the change.

10.6.13 Any correction to a hard copy record must be made by crossing through the error with a single line, and the correction must be clearly initialed and dated by the responsible staff. Erroneous entries cannot be destroyed by erasures, other markings or use of Whiteout®.

10.6.14 Changes to electronic records must be traceable to the individual who made the correction, and the reason for the change must be provided. Erroneous entries cannot be destroyed by methods such as overwritten files.

10.6.15 Record Storage and Retention

10.6.15.1 The minimum retention period of five (5) years may be increased dependent upon client request, regulatory requirement, or civil action order.

10.6.15.2 Records stored by a computer must have hard copy or write-protected backup copies.

10.6.15.3 Records stored only on electronic media must be supported by the hardware and software necessary for their retrieval and utilization in the proper format.

10.6.15.4 Records stored on electronic media must be stored in a way to provide protection from electronic or magnetic sources.

10.6.15.5 Scanned workgroups and client reports are backed up to an off-site data vault, which is secure, fireproof, and equipped with electronic data redundancy. Data backups occur daily (including Saturday and Sunday) after 12:00 am. After one year of storage off-site, data is transferred to a DVD, which is stored in a bank safety deposit box until all data on the DVD is at least five (5) years old. Obsolete DVDs are permanently destroyed.

NOTE: Data files that precede June 1, 2005 are stored to tape and/or DVD, which are kept in a bank safety deposit box.

10.6.15.6 If there is a change in ownership and/or a change in location, all records and documents will be made available to all accrediting authorities for five (5) years. Under no circumstances shall any records or documents be destroyed – all records and analyses performed that pertain to NELAC accreditation are subject to inspection by the NELAC accrediting authorities during this five (5) year period. A new owner of ACZ will assume possession of all records and documents.

10.6.15.7 If ACZ goes out of business, all records and documents will be stored and maintained according to protocol in a location to be determined at the time of closure. All records will be maintained for at least five (5) years and will be made available to all accrediting authorities.

10.6.16 Access to Archived Records

10.6.16.1 Access to archived information must be documented with an access log. A log is kept in each storage location, and any person entering a storage location must provide the required information in the log.

10.6.16.2 Hard copy records are stored in a locked environment with limited access. When a record is removed from its location, a "checkout card" must be filled out to indicate who removed the record, the date the record was taken, and a description of the record. The card marks the place in the storage box, and when the record is returned the card is pulled from the box.

10.6.16.3 Any changes to be made to archived data will require assistance from IT to do so.

10.6.16.4 Electronic data that has been archived to a more permanent media (such as tape, CD, or DVD) is stored in a bank safety deposit box. Access is limited and must be documented in the logbook maintained by Document Control.

10.6.17 Record Disposal

10.6.17.1 Records are disposed of in a manner to ensure client confidentiality.

10.6.17.2 Stored records will be reviewed to determine which ones can be destroyed. Any record older than five (5) years from the current date will be destroyed, unless client request, regulatory requirement, or civil action order dictates otherwise.

10.7 Computer Data and Records

10.7.1 Network File Server

Computer files pertaining to all aspects of ACZ's business are stored on a file/print server. To gain access, an employee logs on to the "LAB" domain. Each employee has a unique network user name so that security rules may be enforced. No "guest" logon is permitted. Every employee belongs to a specific "group" and directory security is enforced through privileges granted to these groups. Typically, an employee is granted access to files that pertain to their job functions; otherwise, read-only access or no access is granted.

Data generated and reported by ACZ is extremely confidential and the company may be liable for the consequences of the release of this data to any unauthorized person. The implementation of password security is not arbitrary and ensures data is protected and cannot be disclosed to outside parties. Weak, unchanging passwords make this scenario more likely.

In general, the network will prompt employees to change their password every 30 days. The password must be at least five (5) characters. Numeric characters are optional. Passwords may not be shared with other employees. The use of another employee's password (with the exception of common passwords for shared computers) is grounds for disciplinary action.

10.7.2 LIMS Server

1) Information stored on the LIMS server consists of all sample and client information needed for day-to-day production activities. The information is stored using an Oracle database application. Access is controlled through membership in "groups." Employees may update and change database records according to their job responsibilities. Otherwise, information is restricted to read-only access or no access.

2) No modifications to data can be made through applications not authorized by ACZ's IT department unless a CAR or Issue Wizard is submitted or documentation is provided on the hardcopy of the workgroup. Unauthorized applications include Attached Tables.

3) All tables that track changes (TrackInvoice, TrackWorkgroup, etc.) will be audited on a regular basis by a member of the IT department to ensure sufficient information is being supplied as to why changes occur. The explanations must be professional and specific.

10.7.3 Docs Server

Access to the docs server is read-only and is permitted through Internet Information Services (IIS) authentication and is logged in IIS log files. The server is updated on a regular basis by automated scripts.

11 ELEMENTS OF QUALITY CONTROL

A critical focus of ACZ's quality control policies and protocols involves monitoring sample preparation and measurement processes to determine matrix effects and to evaluate laboratory performance. Quality control samples are typically analyzed with every batch of environmental samples. Each test SOP provides detailed information regarding quality control sample types, acceptance criteria, and corrective actions, if applicable to the procedure, and reflects the requirements of the method and/or other regulatory authorities.

Performance control samples demonstrate precision or accuracy and expose out-of-control events. Matrix-specific control samples indicate possible effects of the matrix on method performance and may also identify data as in-control or out-of-control. Data that is out-of-control dictates corrective action ranging from re-extraction / re-analysis to reporting data with qualifiers. In general, the corrective action specified in the SOP must be performed if any quality control sample does not meet the acceptance criteria. Data associated with failed quality control cannot be qualified after the initial analysis without acceptable justification.

To the extent possible, client samples are reported only if all quality control measures are acceptable. If any measure is outside of the acceptance criteria, and the data will be accepted and reported to the client, then the appropriate data qualifier(s) must be assigned to all associated samples. The list of current extended qualifiers is maintained in the LIMS database.

11.1 Method Performance

11.1.1 Negative Control – Prep Blank (Method Blank)

The prep blank is used to assess possible contamination introduced during sample processing steps. A prep blank is prepared using Type I water or other similar matrix similar that is free of the target analyte(s) and contains all reagents in the same volumes used to prepare the client samples. The prep blank must be prepared, processed and analyzed in the same manner as the associated client samples. Unless specified in the test SOP, sample concentration may not be corrected for the prep blank value.

While the goal is to have no detectable contaminants, each prep blank must be carefully evaluated as to the nature of the interference and the effect on the analysis of each sample in the batch. Contamination in the prep blank results from four principle sources: the environment the analysis is performed in; the reagents used; the supplies and apparatus used; and the analyst performing the analysis. Contamination sources vary and the test SOP must be referenced to determine the appropriate corrective action(s).

When contamination is suspected, the source(s) must be investigated and measures taken to correct, minimize or eliminate the problem, and associated client samples must be reprocessed and reanalyzed. Alternatively, report data with the appropriate qualifier if reprocessing and reanalysis is not possible or if one of the following criteria applies:

i) The concentration of a target analyte in the blank is at or above the acceptance limit and the measured concentration of the analyte in an associated sample is greater than 10 times the measured concentration of analyte in the blank.

ii) The concentration of a target analyte in any associated sample is less than the MDL.

iii) Corrective actions could not be performed or are ineffective. Thoroughly document any corrective action taken and the outcome.

11.1.2 Positive Control

11.1.2.1 Laboratory Fortified Blank (LFB)

An LFB is required for methods that do not include a Laboratory Control Sample but include a fortified matrix (spike). The LFB is an aliquot of reagent water to which a known quantity of each target analyte is added. It is treated exactly like a client sample, and its purpose is to determine whether the methodology is in control, and whether the laboratory is capable of making accurate and precise measurements. When the acceptance criteria for the LFB are exceeded (i.e. high bias) then any associated client sample with a measured concentration less than the MDL may be accepted and reported with the appropriate qualification.

11.1.2.2 Laboratory Control Sample [LCSW (Water) or LCSS (Soil)]

The performance of both sample preparation and analysis of each sample batch may be monitored by an LCS. The LCS is a matrix-specific standard (whenever possible) of known analyte concentration(s) that may be prepared by the laboratory or purchased pre-made. The LCS must be carried through the entire preparation and analytical schemes with the client samples. Analysis and evaluation of the LCS allows for confirmation of the applicability of the preparation procedure to the analytes. Evaluate data using the following guidelines:

1) When only an LCSW is analyzed, the results must be within the acceptance limits or the entire batch of samples must be re-prepped and retested.

2) An LCSW duplicate (LCSWD) may be prepared and analyzed with the batch, typically in lieu of a matrix duplicate or spike duplicate. Data is acceptable if the LCSW and/or LCSWD is within the acceptance limits and the RPD passes. Associated samples must be re-prepped and reanalyzed if either of the following occurs:

   - LCSW/D RPD fails the acceptance criteria specified in the SOP.
   - % R of both the LCSW and LCSWD is outside the acceptance limits.

3) For a solid or semi-solid matrix, an LCSS and LCSSD are prepared and analyzed.[3] The data is acceptable if the LCSS and/or LCSSD is within the acceptance limits and the RPD passes. Associated samples must be re-prepped and reanalyzed if any of the following occurs:

   - LCSS/D RPD fails the acceptance criteria specified in the SOP.
   - % R of both the LCSS and LCSSD is outside the acceptance limits.
   - MS/D RPD fails the acceptance criteria specified in the SOP (if applicable).

4) When the acceptance criteria for the LCS are exceeded [i.e. high bias] then any associated client sample with a measured concentration less than the MDL may be accepted and reported with the appropriate qualifier.

5) Refer to section 11.1.3.3 for additional information regarding data assessment for solid-matrix workgroups prepared with both LCSS/LCSSD and MS/MSD.

[3] Corrective action for Recommendation #5 cited in the 2002 ADHS audit report.

11.1.2.3 Radiological Tracers

Radiological tracers are used for Thorium and Uranium analyses. The tracer reacts in the same manner as the target isotope and is used to asses analyte recovery. The tracer is added to client samples, controls, and blanks in accordance with the requirements stipulated in the test SOP. Because the tracer recovery has a direct impact on the LLD, the recovery must be high enough to yield LLDs that are within the scope of the project or meet ACZ's acceptance criteria. Refer to the test SOP for evaluation criteria and corrective action(s) for out-of-control tracer recovery.

11.1.3 Sample Specific Controls

The effect of different sample matrices on the performance of any method can be profound; therefore, matrix spikes, duplicates, and surrogate compounds are analyzed to evaluate matrix effects on data quality. Each SOP includes specific information regarding the usage and evaluation of matrix-specific QC samples and also states the required corrective action to take if any matrix QC fails.

ACZ provides analytical services to numerous and varied clients; therefore, the possibility of routinely favoring one client is highly unlikely. Over the course of time, no single matrix type will always be spiked or duplicated, and no one client will be selected for a high percentage of spiked or duplicated samples. If either of these occurs, it is due entirely to chance. Samples are selected for a workgroup by due date or priority – not by client – and are presented in the workgroup in increasing numerical order according to project number. A client's samples will be grouped together within the batch – in this way, a single client cannot be selected for a spike or duplicate, unless all of the client samples in the batch are from the same project. ACZ recommends that the analyst, to the extent possible, select samples to spike or duplicate that are representative of the workgroup. Analysts are not to associate QC with a client sample known to be or believed to be any type of blank or Proficiency Testing sample. Several exceptions exist for selecting samples for spiking or duplicating:

1) A sample is not spiked or duplicated if the volume is inadequate, and the client sample and QC sample(s) would require dilution; however, if no other option is available then the client sample and QC sample should be prepared and analyzed on the same dilution whenever possible.

2) Use the same weights (or as similar as possible) to prepare duplicates of solid matrix samples.

3) A client may request that one or more of their samples be spiked or duplicated. A "RUN QC" comment is added when the sample is logged in to notify the analyst that QC must be performed for a specific sample or project. If a client requests that their sample(s) be spiked or duplicated then ACZ is obliged to accommodate the client.

4) If TDS data indicates a sample would require dilution, then the sample should not be selected for spiking. Performing dilutions increases the likelihood of introducing error due to pipetting, and it is possible that spike recoveries may be incorrectly influenced by this error. A high TDS value will not influence whether or not a sample is duplicated.

5) A reactive sample is unpredictable and is a poor choice for spiking or duplicating.

6) A PT sample is not a real-world sample and is a poor choice for spiking or duplicating, because the data does not provide any useful information about possible matrix effects. Spike or duplicate a PT sample only when there are no client samples in the workgroup.

11.1.3.1 Surrogates

Surrogates are organic compounds that are similar to the target analyte(s) in chemical composition and behavior in the analytical process, but are not normally found in environmental samples. Surrogates are included in the scope of Organic methods and are used to evaluate accuracy, method performance and extraction efficiency and shall be added to environmental samples, controls, and blanks, in accordance with the method requirements.

Whenever a surrogate recovery is outside the acceptance limits, the corrective action(s) stated in the test SOP must be performed. If corrective actions could not be performed or are ineffective, then the appropriate qualifier is applied to the sample results and reported to the client.

11.1.3.2 Matrix Spike Samples

A matrix spike sample (however named) is used to determine the level of bias (accuracy) associated with a particular matrix. For the purposes of this document, "MS" designates a matrix spike, and "MSD" designates a matrix spike duplicate. Spikes are prepared by adding a known and appropriate quantity of each target analyte to a replicate aliquot of client sample.

The required analytical frequency is specified by the method or other regulating entity and is indicated in the test SOP. Each result is evaluated against the acceptance criteria, and matrix effects are determined and reported to the client. The following evaluation criteria apply to spikes that are subjected to processing steps and post-digestion spikes (analytical spikes).

- Percent Recovery (%R) is considered for all spikes.
- %R is evaluated only if the theoretical concentration in the spiked aliquot is greater than or equal to the reporting limit; otherwise, each associated client sample must be reported with the appropriate qualifier, regardless of %R.
- If %R for the MS and/or the MSD is outside of the acceptance limits, the RPD passes, and all other pertinent prep and instrument QC passes, then each associated client sample may be accepted and reported with the appropriate qualification.

11.1.3.3 Matrix Duplicates and Matrix Spike Duplicates

The matrix-specific precision associated with an analysis is determined through the use of a matrix duplicate (DUP) or spike duplicate (MSD), which are performed at a frequency specified by the method or other regulating entity (refer to the specific test SOP). The results are evaluated, and the matrix effect on precision are determined and reported to the client.

- Relative Percent Difference (RPD) is considered for all duplicates except non-drinking water samples for radiochemical analyses (see 12.4.4).
- RPD for a spike duplicate is evaluated only if the observed concentration is greater than or equal to the reporting limit; otherwise each associated client sample must be reported with the appropriate qualifier.

- RPD for a matrix duplicate is evaluated only if the observed concentration is greater than 10 times the MDL; otherwise each associated client sample must be reported with the appropriate qualifier, regardless of RPD.

- In the absence of other contributing factors, a DUP failure for a solid or semi-solid matrix is attributed to non-homogeneity of the sample, and each associated client sample may be reported with the appropriate qualifier.

- For an aqueous matrix, if the DUP fails then all associated samples and the DUP must be retested. If permitted by the instrument software the sample and DUP can be reanalyzed at the end of the analysis in lieu of retesting all associated samples.

- For an aqueous matrix, if the MS/MSD RPD fails then the associated samples must be reanalyzed. If permitted by the instrument software the sample and MS/MSD can be reanalyzed at the end of the analysis in lieu of retesting all associated samples.

- If applicable, evaluate the LCS/LCSD if the RPD fails for a matrix duplicate or spike duplicate. Each associated client sample may be reported with the appropriate qualifier if the LCS/LCSD meets the criteria stated in 11.1.2.2.

- For a solid or semi-solid matrix, if both the LCSS and LCSSD recoveries pass but the RPD fails, then acceptable precision may be demonstrated by a passing RPD for the MS/MSD, and each associated client sample may be reported with the appropriate qualifier.

11.2 Instrument Specific Controls

All data must be associated with a passing instrument calibration and initial calibration verification. To the extent possible, all data must be associated with passing continuing calibration verification. If the initial calibration verification results (ICV/ICB) are outside of the acceptance criteria, then the source(s) of the failure must be identified, corrective action(s) performed if necessary, and the instrument recalibrated before proceeding with sample analysis.

If the continuing calibration verification results (CCV/CCB) do not meet the acceptance criteria then the source(s) of the failure must be identified and corrective action(s) performed, including recalibration if necessary, before continuing with sample analysis. If reanalysis of any sample(s) associated with failing calibration verification is not possible then the associated data must be reported with the appropriate qualification.

For instruments that permit the analysis of subsequent workgroups using the most recent calibration, two (2) consecutive attempts of the opening CCV/CCB are allowed. If both attempts fail to produce acceptable results then the source(s) of the failure must be identified and corrective action(s) performed, including recalibration if necessary, before commencing sample analysis.

Unless stated otherwise by the test SOP, passing calibration verification must always bracket all batch quality control samples, and results for additional instrument check standards, if applicable, must be within the acceptance criteria stated in the SOP. However, when the acceptance criteria for a CCV or CCB are exceeded (i.e. high bias) any associated client sample with a measured concentration less than the MDL may be accepted and reported with the appropriate qualification.

11.3 Other Control Indicators

11.3.1 Internal Standards

Internal Standards (IS) are measured amounts of certain compounds added after preparation or extraction of a sample to be analyzed by GC/MS or ICPMS. The IS is an analyte not likely to be found in the environment and is used in a calibration method to correct sample results affected by column injection losses, purging losses or viscosity effects. The IS is added to client samples, controls and blanks in accordance with the method requirements. When the results are outside of the acceptance limits for applicable quality control samples, corrective actions shall be performed. Once system control has been reestablished, all samples analyzed while the system was malfunctioning shall be reanalyzed. If corrective actions could not be performed or are ineffective then the data for each client sample must be appropriately qualified on the final report.

11.3.2 Trip Blank

The trip blank is a sample container filled in the laboratory with Type I water that is shipped to the collection site in the sample cooler, returned to the laboratory, logged-in, and analyzed in the same manner as the client samples. With the exception of Hg-1631, trip blanks are not opened in the field. If a target analyte is detected in the trip blank then the appropriate data qualifier is applied to pertinent results from those samples returned to ACZ in the same cooler as the trip blank. Trip blanks are typically prepared for Hg-1631, Cyanide, and VOA samples.

11.3.3 Instrument Blank

The instrument blank is an aliquot of Type I water processed only through the instrument steps of sample analysis and is used to determine presence of instrument contamination. For Organic instrument methods, neither surrogate nor IS standards are added.

11.3.4 Equipment Blank

An equipment blank is provided by the client and is used to assess the effectiveness of equipment decontamination procedures. Type I water is poured into (or over) or pumped through the sampling device, collected in a sample container and transported to the lab to be analyzed for all parameters requested for the environmental samples collected at the site. If any target analyte is detected then all associated sample results must be qualified on the final report.

11.3.5 Ambient Blank

The ambient blank consists of Type I water poured into a VOA vial at the sampling site (in the same vicinity as the associated samples). It is handled like an environmental sample and transported to the laboratory for analysis. Ambient blanks are prepared when samples are to be analyzed for VOA analytes and are used to assess the potential introduction of contaminants from ambient sources (e.g., active runways, engine test cells, gasoline motors in operation, etc.) to the samples during sample collection. The frequency of collection for ambient blanks is specified in the client's field-sampling plan and are not required for all projects.

12 EVALUATING QUALITY CONTROL SAMPLES

In general, acceptance criteria for quality control samples are method-specific; however, requirements of clients and regulatory or other accrediting agencies must also be included. Immediate corrective action must be taken if any quality control is outside of the acceptance criteria. Appropriate corrective actions are described in the test SOP. To the extent possible, client samples are reported only if all quality control measurements are acceptable. If a quality control measure is outside of acceptance criteria, and the data must be reported, then all samples associated with the failed QC must be reported to the client with the appropriate data qualifier(s). Clients will occasionally request limits different from those in a published method. If a client has data quality objectives that require modification of our guidelines then we may deviate from those guidelines only if more stringent controls are requested. ACZ's policy is to adhere to the strictest limits as a means of meeting all agency and client requirements.

For methods that do not specify acceptance criteria for any type of quality control measurement, limits may be generated by plotting historical data in a control chart once a minimum of 20 data points is available. A control chart application may be accessed through LIMS and allows the user to create limits, either from a specified number of data points or for a specific time period, that are set at $\pm$ 3 times the standard deviation from the mean percent recovery. Current control limits are also plotted to provide a direct comparison of the two sets of data. New limits developed from a control chart must be documented on FRMQA039 and must be reviewed by the QA/QC department prior to implementation. If the new limits are approved, then QA/QC personnel will update LIMS. Refer to ACZ's SOP *Control Charting Application and Procedure* (SOPAD041) for further details. Default acceptance criteria established by the Arizona Department of Health Services (ADHS) may be used in lieu of generating a control chart to establish limits; however the SOP must specify which limits are in use. [4] **NOTE:** For all data evaluation, final results ending with 1 – 4 are rounded down and results ending with 5 – 9 are rounded up.

12.1 Accuracy

Accuracy is defined as "the degree of agreement of a measured value with the true or expected value of the quantity of concern."[*] Control samples (LCS or LFB) and spiked samples are analyzed with every batch of samples or as stipulated by the specific test SOP to assess accuracy and matrix effects.

- Percent Recovery (%R) for a control sample is calculated as follows:

$$\%R = \frac{M}{S_p} \times 100$$

Where: M = Measured concentration of the control sample
S_p = True value of the control sample

- Percent Recovery (%R) for a spike is calculated as follows:

$$\%R = \frac{M - S}{S_p} \times 100$$

Where: M = Measured concentration of the spiked sample
S = Measured concentration of the sample aliquot
S_p = True value of the spike concentration

[4] ADHS Information Update #87 (issued July 7, 2005)

[*] "Quality Assurance of Chemical Measurements," Taylor, J., 1987

12.2 Precision

Precision is defined as "the degree of mutual agreement characteristic of independent measurements as the result of repeated application of the process under specified conditions." Matrix duplicates and spike duplicates are analyzed with every batch of samples or as stipulated by the test SOP to determine the precision associated with the analysis. If any method does not specify acceptance criteria for the RPD, then default criteria of RPD $\leq$ 20 is used (a value that rounds to 20 is acceptable). [5] The Relative Percent Difference (RPD) as an absolute value is calculated as follows:

$$|RPD| = \frac{(S - D)}{[(S + D) / 2]} \times 100$$

Where: S = Sample Value
D = Duplicate Value

12.3 Other Calculations

- Solids Dilution Factor (assume 100% solid for "as received" samples):

  $$\text{Dilution Factor} = \frac{V}{(W)(\%\ \text{solid})}$$

  Where: V = Final digestate volume, in mL
  W = Sample weight used, in g
  %solid = %solid or air dry solid, as a decimal

- Sample Concentration for Solids:

  - wet weight [biota tissue, fruit or vegetable matter, etc.]: $mg/Kg = \frac{DF * C * V}{W}$
  - dry weight [plant matter, grasses, soil, sludge, etc.]: $mg/Kg = SF * C * DF$

  Where: DF = instrument dilution factor
  C = raw data value, in mg/L
  V = Final volume of digestate, in L
  W = sample weight used, in Kg
  SF = soil dilution factor

- Percent Difference for Serial Dilution (SDL):

  $$|\%D| = \frac{[I - (s * 5)]}{I} \times 100$$

  Where: I = initial sample result
  s = serial dilution result (raw data value)

  For SDL calculations in LIMS, "s" is multiplied by 5 and the resulting "reg value" is compared to the "found value" to calculate %D.

[5] ADHS Information Update #87 (issued July 7, 2005)

12.4 Radiochemistry Calculations

12.4.1 Activity

The results of radioactivity are typically reported in terms of activity per unit volume or mass. Units are normally expressed in picocuries (pCi), which equal 2.22 disintegrations per minute (dpm). Specific formulas to determine activity are in the SOP for each method. The general formula is as follows:

$$C = \frac{R_{net}}{(e)(y)(i)(v)(u)}$$

Where: C = activity per unit volume (pCi/L)
R_{net} = net counts per minute
e = counting efficiency, cpm/dpm
y = chemical yield
i = ingrowth correction factor
v = volume or mass being counted (L)
u = units correction factor, 2.22 for cpm to pCi

12.4.2 Counting Error

Radiochemical data are considered incomplete without reporting associated random and systematic errors. For this reason all radiochemical results should be accompanied by a counting error at the 95% confidence level (1.96*standard deviation). The general counting error formula is as follows:

$$E = \frac{1.96\left(R_o / t_1 + B / t_2\right)^{1/2}}{(e)(y)(i)(v)(u)}$$

Where: E = counting error
R_o = gross sample, cpm
t_1 = sample count duration, min
B = background, cpm
t_2 = background count duration, min
e, y, i, v, and u are as previously defined.

12.4.3 Lower Limit of Detection (LLD)

LLD (also referred to as Minimum Detectable Activity or MDA) is considered the smallest quantity of sample radioactivity that will yield a net count for which there is a pre-determined level of confidence that radioactivity is present. At the 95% confidence level, the following equation calculates the LLD for any single nuclide. The calculation uses the standard deviation for the background counting rate, assuming the sample and background counting rates should be very similar at the LLD. The formula for determining LLD is as follows:

$$LLD_{95} = \frac{4.66 S_b}{(e)(y)(i)(v)}$$

Where : LLD_{95} = Lower limit of detection at the 95% confidence interval
S_b = Standard deviation of the instrument background counting rate, cpm
e, *y*, *i*, *v*, and *u* are as previously defined

12.4.4 Precision

The normalized absolute difference, or Replicate Error Ratio (RER), between the sample and the laboratory duplicate, given by the following equation shall be used to determine that results do not differ significantly when compared to their respective 2* sigma uncertainty.

$$RER = \frac{|Sx - Dup|}{\sqrt{(Sx_{error})^2} + \sqrt{(+(Dup_{error})^2}}$$

Where: Sx = sample concentration in pCi/L
Sx_{error} = sample counting error (in pCi/L) at the 95% confidence level.
Dup = duplicate concentration in pCi/L
Dup_{error} = duplicate counting error (in pCi/L) at the 95% confidence level.

NOTE: For Radchem Drinking Water samples, both RPD and RER are used to evaluate precision. For non-Drinking Water samples, only RER is used; however, data for both RER and RPD are uploaded to LIMS for all analyses. Use the following guidelines to correctly assess precision. Further details are provided in ACZ's Wiki and must be consulted to ensure data for each workgroup is correctly evaluated. Go to LabWeb \ Wiki \ Analytical Departments \ Radio Chemistry.

Drinking Water:

RPD $\leq$ 20, RER < 2.0 – Precision is judged to be in control
RPD $\leq$ 20, RER > 2.0 – Precision is judged to be in control; case narrative required for RER
RPD > 20, [sx] < 5x [LLD], RER < 2.0 – Precision is judged to be in control; qualify data.
RPD > 20, [sx] > 5x [LLD], RER> 2.0 – Precision of the prep batch is questionable.
RPD > 20, [sx] > 5x [LLD], RER < 2.0 – Precision of the prep batch is questionable.

Non-Drinking Water:

RER < 2.0, RPD $\leq$ 20 – Precision is judged to be in control.
RER < 2.0, RPD > 20 – Precision is judged to be in control; RPD must be qualified.
RER > 2.0, RPD $\leq$ 20 – Precision of the sample prep batch is questionable.
RER > 2.0, RPD > 20 – Precision of the sample prep batch is questionable.

13 VALIDATION & REVIEW OF ANALYTICAL DATA

ACZ has the responsibility to always provide the best data possible to ensure our clients can make sound and cost-effective decisions regarding public health and the environment. In order to generate and report reliable data, the analytical systems used need to be properly functioning, and the review process must be conducted in a manner that is logical and reasonable and would be defensible if subjected to legal scrutiny. Decisions regarding data quality must be meaningful and must be backed by good science and sound professional judgments.

The entire validation and review process encompasses more than solely evaluating the final results for client and quality control samples. To this extent, the necessary steps must also be performed *prior* to sample preparation or analysis to ensure the quality of the data. Following sample analysis, data is uploaded to the LIMS database and then submitted to a variety of process chains such as calculations, rounding, application of qualifiers, etc. A multi-level data review process is utilized to verify the uploaded analytical data meets all documented ACZ requirements as well as any client-specific quality objectives. For additional details of the data reduction, review, and validation process, refer to ACZ's SOP *Data Review Process* (SOPAD032). At a minimum, the validation process must include the following steps, as applicable:

- Monitor the expiration dates for all stock, intermediate, and working standards, reagents, and chemicals.
- Prior to analysis, determine that holding times have not been exceeded. Unless otherwise specified by the test SOP, sample preparation and analysis must be completed within the holding time.
- Prior to analyzing samples, verify the correct set-up and operation of the instrument or equipment. Perform calibration, maintenance, and optimization as necessary to ensure proper functioning.
- In general, for QC frequency of 1 per10 or less client samples, the first set of QC is associated with samples 1 – 10. If there are fewer than 20 samples in the workgroup, then the remaining client samples are associated with the second set of QC.
- Before completing workgroup creation, verify the correct PCNs and/or SCNs have been entered. Percent recovery for control samples and spikes is calculated using the information in LIMS for each.
- Verify the proper sub-sample (green dot, yellow dot, etc.) is being used for preparation or analysis.
    - Notify the supervisor or Production Manager as soon as possible if a sample cannot be located.
    - Document on the bench sheet if a sub-sample other than the type indicated in the SOP is used.
- Compare the Log-In number on the sample container to the Log-In number on the bench sheet and make a visible mark next to each sample on the workgroup to indicate the check has been performed.
- Clearly label tubes, beakers, autosampler cups, etc. to identify the sample (and dilution factor, if applicable).
- Manage sample volume to ensure all analyses from a bottle type can be completed.
- Document all dilution factors on the bench sheet at the time the dilution is performed.
- Record complete and accurate observations, as necessary, when an analysis, sample preparation, or sample matrix is unusual or problematic.

- Ensure transcription errors do not occur. Verify all data manually entered into LIMS is correct before completing the upload process.

- The calibration workgroup must be associated with all subsequent workgroups. Record the calibration workgroup number (or calibration file name) on the data review checklist.

- Provide complete traceability for all standards and reagents used for sample preparation and analysis.

- Quality control samples must be treated in the same manner as client sample, including preparation.

- If it is necessary to perform a calculation manually, use the values in the raw data [do not truncate] and then round the final result to no more than three (3) significant figures. If the final result passes the acceptance criteria then pass the QC in LIMS and note on the data review checklist that it passes.

- LIMS performs several additional QC calculations on the approved data including cation/anion balance (CAB) checks, calculated TDS versus actual TDS ratios, and Total versus Dissolved ratios. The Project Manager may update the status of the pertinent sample(s) to REDO if one of these calculations indicates a discrepancy with the associated data.

- If two attempts fail to produce acceptable data then notify the supervisor or Production Manager before taking further action. It may be necessary to first determine if a larger problem is interfering with the analysis. Investigate the problem before qualifying the associated data.

- If there is an indication that the analytical system is out of control then the issue(s) must be investigated. Notify the supervisor immediately. Conduct troubleshooting in an organized manner.

- All data must be reviewed initially in LIMS [AREV] by the analyst who performed the analysis or by another qualified individual who has previously been granted approval. The department supervisor or another qualified individual performs the secondary review [SREV]. The following are data review guidelines:

    1) A data review checklist must be completed during the review process. Verify all items listed and note any errors, problems or non-compliances and the corrective action(s) taken.

    2) If applicable, review the raw data to verify the analytical system was in control and to ensure no anomalies exist. Check for notes on the bench sheet regarding the preparation or analysis.

    3) For client samples and quality control samples, ensure all results are within the measurement range and are bracketed by a passing calibration and passing calibration verification [ICV/ICB or CCV/CCB]. Sample values outside of the measurement range must be appropriately qualified if reanalysis is not possible.

    4) The corrective action specified in the SOP must be performed if any quality control sample does not meet the acceptance criteria. Data associated with failed quality control cannot be qualified after the initial analysis without acceptable justification.

    5) Data is more acceptable if the preparation and analysis was performed within the holding time. If reprep or reanalysis will be conducted outside of the holding time, check first with the supervisor.

6) Confirm all dilutions are appropriate. A reasonable explanation must be provided on the bench sheet if a sample was diluted and the value is less than the reporting limit (refer also to section 15).

7) If the initial analysis indicates possible positive or negative matrix interference then the sample(s) should be retested on dilution to confirm. The sample needs to be retested only one time – if a background effect is still evident, then note the event on the data review checklist and qualify the associated data.

8) If a spike fails, determine if the sample concentration is disproportionate to the spike added. If the analyte concentration in the sample is > 4x the spike added then note the failure on the checklist and appropriately qualify the associated samples.

9) If a spike recovery indicates the sample was not spiked, then re-prep / retest all associated samples.

10) Each associated client sample must be appropriately qualified if the matrix spike, matrix duplicate or spike duplicate data cannot be used for validation purposes.

11) Confirm failed QC by verifying the correct PCN or SCN was entered. Make corrections if necessary before proceeding with data review.

12) Verify all assigned qualifiers are appropriate. Does use of a particular qualifier make sense ? Could data be defended using the qualifier(s) assigned to the scenario or problem ?

13) If a case narrative is necessary, the reason for accepting and reporting the data must be sound and logical. Provide sufficient and accurate verbiage to ensure the data is legally defensible.

14) If a sample was retested in the same workgroup, verify the correct data will be reported. All other data for the sample must be failed – LIMS cannot report multiple data for the same sample.

15) Confirm all samples have the correct status (PASS, FAIL, REDO, REDX) before completing the review process. For multi-parameter workgroups, all analytes must have the correct status.

16) Refer also to section 11.0 for data evaluation criteria.

14 DETECTION LEVELS

Current practice identifies several detection levels, each of which has a defined purpose: Instrument Detection Limit (IDL), Method Detection Limit (MDL), and Reporting Limit (RL) or Practical Quantitation Limit (PQL). The MDL and RL (or PQL) are stated in each test SOP and are adjusted accordingly in LIMS when data is uploaded to reflect the use of smaller sample volume (dilution) or larger sample volume (concentration).

14.1 Instrument Detection Limit (IDL)

The IDL is the concentration of substance that produces a signal greater than three standard deviations of the mean noise level or the concentration that can be determined by injecting a standard to produce a signal that is five times the signal-to-noise ratio. The IDL should always be below the MDL and is not used for compliance reporting, but is useful for estimating the amount of analyte needed to produce a signal in order to calculate an estimated method detection level and for comparing the attributes of different instruments.

14.2 Method Detection Limit (MDL)

The EPA defines the MDL as the "minimum concentration of substance that can be measured by a specific testing protocol and reported with 99% confidence that the analyte concentration is greater than zero…" This confidence interval means that any substance detected at a concentration equal to the MDL is 99% likely to be present, but it also means there is a 1% chance that the substance will be considered falsely present (false positive). The MDL procedure is designed so that the probabilities of both false positive and false negative errors are acceptably small; however, the procedure has limitations. Data users must understand the limitations when evaluating low level data and must proceed with caution when interpreting data reported between the MDL and RL in order to minimize the risk of making poor environmental decisions.

MDLs are dependent on variables (temperature, instrument conditions, analysts, matrix, etc.) and are typically determined by processing, preferably over the course of several days, at least seven individual replicates of a fortified blank sample through the method's preparation and analytical schemes. MDLs determined for the same method / matrix / technology must be compared to ensure they are in agreement.

ACZ maintains a current MDL for each method. Unless specified by a method or to meet the needs of a special project or client request, a MDL is considered current if no changes have been made to (1) extraction or analytical procedure, (2) type of column used, if applicable, (3) instrument location, (4) instrument sensitivity (i.e. no major repairs or extensive servicing), and (5) other modifications of this type. A qualitative verification of the MDL must be performed annually for each applicable method, analyte, instrument, and matrix and before a new instrument or method is utilized for client samples. Refer to ACZ's SOP *Demonstration of Capability & Method Detection Limit Studies* (SOPAD001) for additional information.

14.3 Practical Quantitation Limit (PQL) / Reporting Limit (RL)

At the MDL, data is not quantifiable, and the uncertainty is $\pm$ 100% (or $\pm$ MDL). The PQL (RL) represents the lowest quantitative level that can be achieved with good certainty during routine operations. Because data reported at or above the PQL is reproducible, the client or other end user will be assured that the result is valid and independent of variable analytical conditions. This reproducibility allows for comparison of analytical results over a relatively long period of time, which is important to the monitoring of environmental data. ACZ defines the PQL as a value typically 2 – 10 times the MDL. Reported values less than the PQL are qualified as estimated. The region between the MDL and PQL is a continuum of uncertainty, lacking distinct cutoff points, and the error below the PQL is increased to the extent that the statistical validity of the result is questionable.

15 SAMPLE DILUTIONS

Sample dilution may be necessary for one or more of the following reasons: (1) sample concentration exceeds the established measurement range of the procedure / method (2) sample volume or material is limited (3) matrix interference is indicated or suspected (4) sample matrix is reactive (5) aqueous sample contains high sediment (6) color, odor or other physical characteristics are present (7) For ICP and ICPMS, TDS is greater than 2000 mg/L. In all cases, the analyst must use good professional judgment when determining the most appropriate dilution. Whenever possible, analyze a client sample and its associated matrix spike(s) and/or matrix duplicate on the same dilution. If circumstances prohibit retesting, including reanalysis that would occur past the holding time, then the data must be reported with the appropriate qualifier(s).

For samples that contain high concentration of analyte(s), the analyst will use their knowledge of the measurement range of the procedure to determine an optimal dilution that yields quantifiable data with minimal error propagation. In general, prepare the dilution so the final concentration is near the mid-point of the measurement range. A sample must be retested on a smaller dilution if analyte concentration is less than the reporting limit – exceptions must be explained on the bench sheet. For multi-parameter analyses, it may not be possible to report all analytes within the desired range, and the analyst must use their best judgment when determining a reasonable dilution factor.

The following requirements pertain to all dilutions:

- Document all dilution factors on the bench sheet when the dilution is performed
- Assign the appropriate "D" qualifier if data for the diluted sample is less than the reporting limit
- Retest sample on smaller dilution if the result is less than the reporting limit (or document justification for accepting the data on the bench sheet or data review checklist)
- Document the reason for any dilution on the bench sheet [not required for sample values that exceed the measurement range of the procedure]
- Provide accurate documentation for the benefit of preparation of a case narrative, data validation, review by a regulatory agency or other third party, and reconstruction of the sample's history

16 ERROR CORRECTION PROTOCOL

When an error occurs in any type of record it must be crossed out with a **single line**, not erased, deleted, obliterated, or made illegible, and the correct value entered alongside. All changes to hard copy records must be initialed and dated by the person making the correction. Under no circumstances may White-Out® or any other substance be used to conceal data. Concealing or improperly altering data is fraudulent and may be cause for termination from ACZ. Equivalent measures must be taken to avoid loss or change of original data in the case of records stored electronically. Refer to section 10 for details of corrections made to electronic records. The following is an example of proper error correction:

fleece BWC 10-20-06

Mary had a little lamb, it's ~~feet~~ as white as snow. And everywhere that ~~Lary~~ went, the lamb was sure to go.

Mary BWC 10-20-06

17 COMPUTER / AUTOMATED PROCESSES

ACZ employs its proprietary LIMS2000 (Laboratory Information Management System) to acquire, record, process, store and archive our data. It is the primary application for all employees and encompasses the combination of hardware and software throughout the entire facility to provide the interface for tasks such as creating workgroups, reviewing data, and generating client reports. ACZ implements the defined standards of Good Automated Laboratory Practices (GALP) to establish a uniform set of procedures to assure that all LIMS data used by our clients are reliable, credible, and legally defensible.

17.1 Software

The software used to achieve GALP goals is a combination of industry standard commercial software and internally developed applications. Commercial software is purchased through professional and well-developed companies such as Oracle, Microsoft and Lab Vantage Systems that complete sufficient testing and quality control to assure their product(s) functions properly. Internal applications undergo testing before being implemented and distributed throughout the laboratory.

Instrument data is automatically backed up anytime a file is saved through a client-server process running on most instrument PCs. This ability allows ACZ to see any version of a file created or modified during data processing. Electronic records are protected, backed up and archived to prevent unauthorized access or amendment. Refer to section 10.0 of this document and ACZ's SOP *Backup and Archive of Instrument Data Files* (SOPAD044) for details.

17.2 Hardware

ACZ deploys many application servers using industry standard architecture. All critical servers are redundant so that one hardware failure will not cause a system failure. All servers run standard enterprise operating systems such as Microsoft Windows 2000 and SuSE Linux for file and print services, intranet, web hosting, several databases and the phone system. All servers are routinely backed up to tape to maintain a complete historical record of all data generated.

To the extent possible, instrument PCs comply with at least the recommendations of the instrument manufacturer and are connected to ACZ's network allowing transparent backup and access to computers by system administrators. On most instrument computers, a "bare metal" restore of the computer can be done for a minimum of down time in the event of a hardware failure.

17.3 Security

GALP security is controlled through a set of passwords. A log-in name and password are required to access the ACZ's network. User passwords must be at least five characters and must be changed when the user is prompted. Each user has a given set of network rights and is restricted to software necessary to complete their job functions as well as his/her own documents. Refer also to section 10.7.1 for additional information.

A very secure firewall protects the network from the outside world, or, Internet. The only traffic permitted access to the internal network is e-mail and World Wide Web access. Incoming and outgoing E-mail is scanned for viruses, then scanned for inappropriate content and quarantined if necessary. All web traffic that is potentially harmful is blocked by a scanning application running on a proxy server.

18 CLIENT SERVICES

18.1 Subcontracting

ACZ utilizes subcontract labs to perform analyses for various reasons. A subcontracted lab must, at a minimum, adhere to the same quality assurance standards implemented by ACZ and must be NELAC certified for the subcontracted analysis. When applicable, ACZ advises its clients in writing of its intentions to subcontract any portion of the testing to another party. Non-NELAC work performed by a subcontracted lab must be clearly identified in the subcontract lab's report. ACZ scans this report as an attachment to be included as part of ACZ's final report. A comment is added to ACZ's final report indicating which subcontracted laboratory performed the analyses. Refer to ACZ's SOP *Client Service Policies and Procedures* (SOPAD043) for additional information.

18.2 Data Reporting

Once all analyses and the entire review process have been completed, a client report is generated and submitted for final validation by the Project Manager. If necessary, a case narrative is written describing the details of the project and any non-conformances or other relevant issues. The PM electronically signs the report, and the Document Control department sends the report to the client in an electronic format. At a minimum, the following information appears on an ACZ analytical report:

Client Name	Sample Matrix
Client Address	Parameter/Analyte
Client Contact	Method Reference
Lab Sample ID	Result
Client Sample ID	Units
Client Project ID	LIMS Qualifier (U, B, J, H)
ACZ Report ID	MDL or LLD
Date/Time Sampled	PQL or RL
Date/Time Received	Analyst's Initials
Date/Time Analyzed	Extended Qualifiers (as separate page)

A complete electronic data package contains the analytical reports, the external chain of custody records, sample shipping documentation, and any other relevant project information. Department Reference Sheets explaining acronyms, qualifiers, and method references are also included. All of these documents are an integral part of the final data package and must always be viewed as a whole. To prevent the separation of reports, each page identifies the project number, the sequential page number, and the total number of pages in the data package. Refer to ACZ's SOP *Client Service Policies and Procedures* (SOPAD043) for more detail.

If requested by a client, custom and standard Electronic database deliverables (EDDs) are generated by the Document Control department. These deliverables, containing data in client specified format, are sent by e-mail with the client report. EDDs and analytical reports access data from the same Oracle tables, thus eliminating the possibility of inconsistent results. Refer to ACZ's SOP *Client Service Policies and Procedures* (SOPAD043) for more detail.

18.3 Data Confidentiality

ACZ has an obligation to each client to maintain custody of samples, data, and reports and to keep all data or other information confidential. To uphold this responsibility, ACZ retains custody of the information at all times – data or other client information obtained by ACZ is not allowed to leave the premises. This includes but is not limited to Chains of Custody, raw data, workgroups, run logs, logbooks, reports, QC summaries, data packages and other media containing data. Client data cannot be released to anyone except the client (as directed on the Chain of Custody) or the client's designated representative, and project data, including any client information, is not to be discussed with anyone other than ACZ employees and/or the client without first receiving written permission from the client. Additionally, client-specific information is not to be documented on raw data, workgroups, logbooks, or other records that may be provided to any client as part of an extended data package. All information must be referenced using only the ACZ log-In number. Refer to ACZ's SOP *Ethics and Proactive Prevention Program* (SOPAD039) for additional details of policies pertaining to confidentiality.

With the rapid advances of computer and information technology, it is possible for an employee to work at home and access the same electronic data and documents they could access while at ACZ. Accessing data from outside of ACZ could potentially compromise security, confidentiality and custody issues. ACZ's policy on external computer access is as follows:

External access to the ACZ network is limited to employees that may need to access information remotely. Employees requiring such access use ACZ's Virtual Private Network (VPN). The VPN client is setup on the employee's computer so that it adheres to ACZ security standards. These standards include (1) a unique user name (2) a password with at least 12 characters, and (3) 128 bit encryption of data to and from the client from the ACZ servers. After the VPN server has authenticated the employee, the employee must logon to the ACZ domain through normal domain security in order to access any ACZ network resources. Most employees initiate a "Remote Desktop" connection to their office PCs, thus ensuring that ACZ data is never accessible from the client PC hard drive. For portable computers that must directly access the ACZ network, an additional security measure is mandatory –any portable ACZ PC must have an additional "BIOS" password. Without the additional password, the PC will not boot. This security measure is in place to prevent the portable PC from being used in case of loss or theft of the computer.

ACZ has implemented the latest available technology to protect our network from malicious attacks. The bridge/router connecting the internal network to the Internet is protected by the latest implementation of a Linux firewall. Only SMTP (e-mail) and HTTP traffic are allowed between the network and the Internet. Exchange server blocks all "dangerous" attachments, such as executables, macros and VB scripts.

18.4 Client Feedback

Handling client feedback is a joint effort between QA/QC, Project Managers, Production Supervisors, and Client Service representatives. If a client has a concern or complaint, either a Project Manager or Client Service Representative takes the call and initiates the feedback procedure by documenting the complaint or problem and requesting the assistance of the Production Supervisor and/or QA/QC Officer. If the issue cannot be easily resolved then it must be documented using FRMAD024, which is routed from the initiator to other appropriate parties, including the QA/QC Officer if necessary. All client feedback is submitted to upper management as part of the Management Review of the Quality System. Refer to ACZ's SOP *Client Service Policies and Procedures* (SOPAD043) for additional information.

19 RADIOCHEMISTRY INSTRUMENTATION

Radioanalytical instrumentation is located adjacent to the radiochemistry prep lab. In order to maintain appropriate temperature control in the instrument lab, separation must be maintained. The door between the two lab areas must be kept closed when not in use. Except as noted, instrument checks and other determinations must be performed and documented annually, or more often if necessary.

NOTE: To eliminate potential contamination, planchets must be stored in a covered container or in a drawer.

19.1 Gas-Flow Proportional Counter

19.1.1 *Instrument Reliability Test (Voltage Plateau Determination)* – The proper voltage plateau for alpha and beta is where the counting rate is consistent (should not exceed > 5% over a 150 volt change in anode voltage).

19.1.2 *Cross Talk (Carryover) Check* - Cross talk is defined as the percentage of alpha counts represented on the beta plateau. Once the amount of cross talk is determined, the cross talk settings are adjusted on the instrument to eliminate cross talk.

19.1.3 *Detector Efficiency Curve (Self Absorption)* - Efficiency curves are graphs plotting counts versus sample density and determine the efficiency of the alpha and beta counter based on sample density. This factor is part of the overall determination of sample activity.

19.1.4 *Background Checks* - Characteristic of most detectors is a background or instrument count rate attributed to cosmic radiation, radioactive contaminants in instrument parts, counting room construction material and/or the proximity of radioactive sources. Placing an empty planchet in the counting chamber and counting it for as long as the longest sample-counting duration can determine the background rate (or a background check can be completed overnight). An overnight background determination must be completed at least quarterly. The daily background rate must be analyzed daily for each detector.

19.1.5 *Instrument-Response Check Source* - This continuing calibration check verifies the instrument response and stability and is performed daily for each detector. If the source count is within two standard deviations (sigma) of the previously determined average count rate, instrument reliability and stability is established. If the check source is outside the ±2 sigma-warning limit, then the variability should be further investigated. If the check source is outside the ±3 sigma out of control limits, then no further samples should be analyzed until the problem is resolved. If insufficient data exists for control charts, ±10% of the initial value is considered acceptable.

19.2 Liquid Scintillation Counter

19.2.1 *Optimal Window* - When determining radionuclides by liquid scintillation, it is necessary to select the optimal window by counting a standard for five minutes and generating a sample spectrum. For better clarity, a log scale for the channel number axis should be used. On the graph, the region of interest is determined by the energy of the peak one is trying to quantitate. The optimal window is formed by extending this region by 10% on each side of the alpha peaks.

19.2.2 *Efficiency Quench Curve* – The liquid scintillation instrument, a Beckman LS 6000TA, automatically corrects for quenching by the H - Method. Refer to SOPRC010 for details.

19.2.3 *Background Check* - Two background sources must be checked while preparing the liquid scintillation counter for analysis. The electronic (or instrument) background is the electronic noise of the system and can be determined with an empty counting chamber and a dark vial typically filled with graphite. Count as long as a sample is typically counted. The second source of background is chamber background, which is caused by contamination from instrument parts, counting room construction materials, and/or proximity of radioactive sources. Chamber background can be determined by using a vial containing liquid scintillator and a 10mL volume of Type I water (low background water). For both checks, the counting duration should be equivalent to the longest sample counting duration. Both checks must be performed on a daily basis and recorded in the instrument logbook.

19.2.4 *Instrument-Response Check Source* - This continuing calibration check verifies instrument response and stability and must be performed daily. If the source count is within two standard deviations (sigma) of the previously determined average count rate, instrument reliability and stability is established. If the source rate is outside the ±2 sigma-warning limit then the variability should be further investigated. If the source check is outside the ±3 sigma out of control limits, then no further samples should be analyzed until the problem is resolved. Resolution might include a new efficiency curve, background checks, and/or instrument maintenance. If insufficient data exists for control charts, ±10% of the initial source value is considered acceptable. The source for this check is a Tritium standard.

19.3 Alpha Spectrometer

19.3.1 *Energy vs. Channel Calibration* - Each alpha spectrometer has a set number of channels associated to it. To associate these channels to a specific alpha particle, the channels must be calibrated. One known calibrated solid source is placed into the detector and analyzed for five minutes to determine its associated channel to its calibrated energy peak. Since the energy is linear across the channels, all of the channels now have an associated energy. This determination is performed on an annual basis, or whenever maintenance is performed that could potentially affect the calibration.

19.3.2 *Background Checks* - Characteristic of most detectors is a background or instrument count rate attributed to cosmic radiation, radioactive contaminants in instrument parts, counting room construction material and/or the proximity of radioactive sources. Placing an empty planchet in the counting chamber and counting it for as long as the longest sample-counting duration can determine the background rate (or a background check can be completed overnight). An overnight background determination must be completed at least quarterly.

19.3.3 *Instrument-Response Check Source* - This continuing calibration check verifies the instrument response and stability and is performed daily. If the source count is within two standard deviations (sigma) of the previously determined average count rate, instrument reliability and stability is established. If the source rate is outside the ±2 sigma-warning limit, then the variability should be further investigated. If the source check is outside the ±3 sigma out of control limits, then no further samples should be analyzed until the problem is resolved. Resolution might include a background check, and/or instrument maintenance. If insufficient data exists for control charts then ±10% of the true value is considered acceptable.

19.4 Gamma Spectrometer

19.4.1 *Background Checks* - Characteristic of most detectors is a background or instrument count rate attributed to cosmic radiation, radioactive contaminants in instrument parts, counting room construction material and/or the proximity of radioactive sources. The background rate can be determined by placing a blank water sample within a Marinelli beaker in the counting chamber and counting it for as long as the longest sample-counting duration, or a background check can be completed overnight. A background check must be performed for every workgroup.

19.4.2 *Instrument-Response Check Source* - This continuing calibration check verifies instrument response and stability. This check is performed for every workgroup. If the source count is within two standard deviations (sigma) of the previously determined average count rate, instrument reliability and stability is established. If the source rate is outside the ±2 sigma-warning limit, then the variability should be further investigated. If the source check is outside the ±3 sigma control limits, then no further samples should be analyzed until the problem is resolved. Resolution might include a background check, and/or instrument maintenance. If insufficient data exists for control charts then ±10% of the true value is considered acceptable.

APPENDIX A Required Container Type, Preservation Techniques, and Holding Times

Parameter	Container	Preservation [a, b]	Maximum Holding Time [c]
Alkalinity	HDPE or Glass	4 °C	14 days
Acidity	HDPE or Glass	4 °C	14 days
Ammonia (N-NH_3)	HDPE or Glass	4 °C; H_2SO_4 to pH < 2	28 days
Anions	HDPE	4 °C	28 days (Br^-, F^-, Cl^-, SO_4^{2-})
BOD, CBOD	HDPE or Glass	4 °C	48 hours
COD	HDPE or Glass	4 °C; H_2SO_4 to pH < 2	28 days
Color	HDPE or Glass	4 °C	48 hours
Conductivity	HDPE or Glass	4 °C	28 days
Cyanide	HDPE or Glass	4 °C; NaOH to pH > 12	14 days
Chromium (VI)	HDPE or Glass	4 °C	Refer to SOP for holding time
Dissolved Oxygen	Glass	None required	Analyze immediately
Metals (except Cr^{6+}, Hg)	HDPE or Glass	HNO_3 to pH < 2	180 days
Mercury	HDPE or Glass	HNO_3 to pH < 2	28 days
N – NO_2 / NO_3	HDPE or Glass	4 °C; H_2SO_4 to pH < 2	28 days (48 hours if unpreserved)
N – NO_3	HDPE or Glass	4 °C; H_2SO_4 to pH < 2	28 days (48 hours if unpreserved)
N – NO_2	HDPE or Glass	4 °C	48 hours
Nitrogen, Total Kjeldahl	HDPE or Glass	4 °C; H_2SO_4 to pH < 2	28 days
Oil & Grease	Glass	4 °C; HCl or H_2SO_4 to pH < 2	28 days
Orthophosphate	HDPE or Glass	4 °C	48 hours
pH	HDPE or Glass	None required	Analyze immediately
Phenols	Glass	4 °C; H_2SO_4 to pH < 2	28 days
Phosphorus (Total)	HDPE or Glass	4 °C; H_2SO_4 to pH < 2	28 days
Sulfide	HDPE or Glass	4 °C; Zn acetate + NaOH to pH > 9	7 days

APPENDIX A Continued

Parameter	Container	Preservation	Maximum Holding Time
Sulfite	HDPE or Glass	4 °C; EDTA	Analyze immediately
Settleable Solids	HDPE or Glass	4 °C	48 hours
Total Organic Carbon	Glass only	4 °C; HCl or H_2SO_4 to pH < 2	28 days
Turbidity	HDPE or Glass	4 °C	48 hours
Total Dissolved Solids	HDPE or Glass	4 °C	7 days
Total Suspended Solids	HDPE or Glass	4 °C	7 days
Total Solids	HDPE or Glass	4 °C	7 days
Total Volatile Solids	HDPE or Glass	4 °C	7 days
Radon-222	Glass Vial [d]		4 days
Total Volatile Hydrocarbons	Glass Vial or jar [d]	4 °C; HCl to pH < 2 (water)	Refer to SOP for holding times
Total Petroleum Hydrocarbons	Amber Glass	4 °C	Refer to SOP for holding times
BTEX / MTBE	Glass Vial or jar [d]	4 °C; HCl to pH < 2 (water)	14 days
Organochlorine Pesticides	Glass Vial or jar [d]	4 °C; pH 5 – 9	Refer to SOP for holding times
PCBs	Amber Glass	4 °C	Refer to SOP for holding times
PAHs	Amber Glass	4 °C	Refer to SOP for holding times
BNAs (semi-volatiles)	Amber Glass	4 °C	Refer to SOP for holding times
VOAs (volatiles)	Glass Vial or jar [d]	4 °C; HCl to pH < 2 (water)	Refer to SOP for holding times
TCLP	Glass [d]	4 °C	Refer to SOP for holding times
Radchem (except Rn-222)	HDPE cube	HNO_3 to pH < 2	180 days

a. No pH adjustment for soil
b. Preservation with 0.008% $Na_2S_2O_3$ required only when residual chlorine is present.
c. Unless otherwise specified in the test SOP, complete sample preparation and analysis within holding time.
d. Teflon-lined septa or lid

APPENDIX B Utah BLI Certificate and List of Certified Parameters

State of Utah
JON HUNTSMAN Jr.
Governor
GARY HERBERT
Lieutenant Governor

Utah Department of Health
David N. Sundwall, MD
Executive Director

Epidemiology and Laboratory Services
Patrick F. Luedtke, MD, MPH
Director of Public Health Laboratories

Bureau of Laboratory Improvement
David B Mendenhall, MPA, MT (ASCP)
Bureau Director

NELAP
Recognized

STATE OF UTAH
DEPARTMENT OF HEALTH

ENVIRONMENTAL LABORATORY CERTIFICATION PROGRAM

CERTIFICATION

is hereby granted to

ACZ Laboratories, Inc.

2773 Downhill Drive
Steamboat Springs CO 80487

Scope of accreditiation is limited to the
State of Utah Accredited Fields of Accreditiation
Which accompanies this Certificate

Continued accredited status depends on successful
Ongoing particitpation in the program

EPA Number: CO00028
Expiration Date: 4/30/2008

Patrick F. Luedtke, MD, MPH
Director of Public Health Laboratories
Deputy Director of Epidemiology and Laboratory Services

Utah Department of Health

46 North Medical Drive • Salt Lake City, UT 84113-1105 • phone (801) 584-8469 • fax (801) 584-8501
www.health.utah.gov/els/labimp/

Utah!

State of Utah
JON HUNTSMAN Jr.
Governor
GARY HERBERT
Lieutenant Governor

Utah Department of Health
David N. Sundwall, MD
Executive Director

Epidemiology and Laboratory Services
Patrick F. Lueftke, MD, MPH
Director of Public Health Laboratories

Bureau of Laboratory Improvement
David B Mendenhall, MPA, MT (ASCP)
Bureau Director

NELAP
Recognized

6/1/2007

ACZ Laboratories, Inc.
Bradley Craig
2773 Downhill Drive
Steamboat Springs CO 80487

ID # ACZ
EPA ID: CO00028

Director,

On the basis of your most recent assessment, Proficiency Testing results and continuing compliance with the ELCP requirements, the laboratory listed is certified for environmental monitoring under the Safe Drinking Water Act and authorized to perform the following methods, for the analytes and matrix listed:

Drinking Water

Inorganics and Metals

200.8 [1994]	Antimony
200.8 [1994]	Arsenic
200.8 [1994]	Barium
200.8 [1994]	Beryllium
200.8 [1994]	Cadmium
200.8 [1994]	Chromium
200.8 [1994]	Nickel
200.8 [1994]	Selenium
200.8 [1994]	Thallium
200.8 [1994]	Uranium
245.1 [1994]	Mercury
335.4 [1993]	Cyanide
4500 (F-) C	Fluoride by Ion-Selective Method

Nitrate

353.2 [1993]	Nitrate/Nitrite

Nitrite

353.2 [1993]	Nitrite

Pb/Cu

200.8 [1994]	Copper
200.8 [1994]	Lead

Radionuclides

900.0	Gross Alpha & Beta Radioactivity in Drinking Water Evaporation Technique
900.0	Gross Alpha
900.0	Gross Beta
903.1	Radium 226 in Drinking Water Radon Emanation Technique
904.0	Radium 228 in Drinking Water Radiochemical Technique

The expiration for the laboratory's certification is 4/30/2008. The Utah Environmental Laboratory Certification Program (ELCP) encourages clients and data users to verify the most current certification letter for the authorized method. For further assistance please call Lorna Ward 801-584-8469.

Utah Department of Health

46 North Medical Drive • Salt Lake City, UT 84113-1105 • phone (801) 584-8469 • fax (801) 584-8501
www.health.utah.gov/els/labimp/

Utah!

ACZ Laboratories, Inc.
Safe Drinking Water Act
Page 2 of 2

The effective date of this certificate letter is: 5/24/2007.

The analytes by method which a laboratory is authorized to perform at any given time will be those indicated in the most recent certificate letter. The most recent certification letter supersedes all previous certification or authorization letters. It is the certified laboratory's responsibility to review this letter for discrepancies. The certified laboratory must document any discrepancies in this letter and send notice to this bureau within 15 days of receipt. This certificate letter will be recalled in the event your laboratory's certification is revoked.

Respectfully,

Patrick F. Lueetke, MD, MPH.
Director of Public Health Laboratories
Deputy Director of Epidemiology and Laboratory Services

The expiration for the laboratory's certification is 4/30/2008. The Utah Environmental Laboratory Certification Program (ELCP) encourages clients and data users to verify the most current certification letter for the authorized method. For further assistance please call Lorna Ward 801-584-8469.

Utah Department of Health

46 North Medical Drive • Salt Lake City, UT 84113-1105 • phone (801) 584-8469 • fax (801) 584-8501
www.health.utah.gov/els/labimp/

Utah!

State of Utah
JON HUNTSMAN Jr.
Governor
GARY HERBERT
Lieutenant Governor

Utah Department of Health
David N. Sundwall, MD
Executive Director

Epidemiology and Laboratory Services
Patrick F. Luedtke, MD, MPH.
Director of Public Health Laboratories

Bureau of Laboratory Improvement
David B Mendenhall, MPA, MT (ASCP)
Bureau Director

NELAP
Recognized

6/1/2007

ACZ Laboratories, Inc.
Bradley Craig
2773 Downhill Drive
Steamboat Springs CO 80487

ID # ACZ
EPA ID: CO00028

Director,

On the basis of your most recent assessment, Proficiency Testing results and continuing compliance with the ELCP requirements, the laboratory listed is certified for environmental monitoring under the Clean Water Act and authorized to perform the following methods, for the analytes and matrix listed:

Non-Potable Water

Inorganics and Metals

160.4 [1971]	Residue, Volatile (Gravimetric, Ignition at 550-C)
1631 C	Mercury in Water by Oxidation, Purge and Trap, and Cold Vapor Atomic Fluorescense Spectrometry
1664 A [1999]	Oil & Grease and Total Petroleum Hydrocarbons
180.1 [1993]	Turbidity
200.7 [1994]	Aluminum
200.7 [1994]	Antimony
200.7 [1994]	Arsenic
200.7 [1994]	Barium
200.7 [1994]	Beryllium
200.7 [1994]	Boron
200.7 [1994]	Cadmium
200.7 [1994]	Calcium
200.7 [1994]	Chromium, Total
200.7 [1994]	Cobalt
200.7 [1994]	Copper
200.7 [1994]	Iron
200.7 [1994]	Lead
200.7 [1994]	Lithium
200.7 [1994]	Magnesium
200.7 [1994]	Manganese
200.7 [1994]	Molybdenum
200.7 [1994]	Nickel
200.7 [1994]	Potassium
200.7 [1994]	Selenium
200.7 [1994]	Silica
200.7 [1994]	Silver
200.7 [1994]	Sodium
200.7 [1994]	Strontium
200.7 [1994]	Tin
200.7 [1994]	Titanium

The expiration for the laboratory's certification is 4/30/2008. The Utah Environmental Laboratory Certification Program (ELCP) encourages clients and data users to verify the most current certification letter for the authorized method. For further assistance please call Lorna Ward 801-584-8469.

Utah Department of Health

46 North Medical Drive • Salt Lake City, UT 84113-1105 • phone (801) 584-8469 • fax (801) 584-8501
www.health.utah.gov/els/labimp/

Utah! Where ideas connect™

ACZ Laboratories, Inc.
Clean Water Act
Page 2 of 4

Inorganics and Metals

200.7 [1994]	Vanadium
200.7 [1994]	Zinc
200.8 [1994]	Aluminum
200.8 [1994]	Antimony
200.8 [1994]	Arsenic
200.8 [1994]	Barium
200.8 [1994]	Beryllium
200.8 [1994]	Cadmium
200.8 [1994]	Chromium
200.8 [1994]	Cobalt
200.8 [1994]	Copper
200.8 [1994]	Lead
200.8 [1994]	Manganese
200.8 [1994]	Molybdenum
200.8 [1994]	Nickel
200.8 [1994]	Selenium
200.8 [1994]	Silver
200.8 [1994]	Thallium
200.8 [1994]	Uranium
200.8 [1994]	Vanadium
200.8 [1994]	Zinc
2310 B	Acidity (Nephelometric)
2320 B	Alkalinity (Titration)
2340 B	Hardness (Calculation)
245.1 [1994]	Mercury
2510 B [19th ED]	Conductivity (Laboratory) [SM 19th ED]
2540 B [19th ED]	Total Solids Dried at 103-105-C [SM 19th ED]
2540 C [19th ED	Total Dissolved Solids Dried at 180-C [SM 19th ED]
2540 D [19th ED	Total Suspended Solids Dried at 103-105-C [SM 19th ED]
2540 F [19th ED]	Settleable Solids [SM 19th ED]
300.0 [1993]	Bromide
300.0 [1993]	Chloride
300.0 [1993]	Fluoride
300.0 [1993]	Sulfate
3114 B [19th ED]	Selenium [SM 19th ED]
335.4 [1993]	Cyanide, Total
350.1 [1993]	Nitrogen, Ammonia
3500 (Cr) D [19t	Chromium VI (Colorimetric) [SM 19th ED]
351.2 [1993]	Nitrogen, Total Kjeldahl
353.2 [1993]	Nitrogen, Nitrate-Nitrite
365.1 [1993]	Phosphorous, Total
410.4 [1993]	Chemical Oxygen Demand
420.4 [1993]	Phenolics, Total
4500 (Cl-) E	Chloride (Ferricyanide, Automated)
4500 (CN-) I	Weak Acid Dissociable Cyanide
4500 (F-) C	Fluoride (Ion-Selective Electrode)
4500 (H+) B [19t	pH (Electrometric) [SM 19th ED]
4500 (SO42-) D	Sulfate (Gravimetric, Drying of Residue
5210 B [19th ED]	Biochemical Oxygen Demand 5-Day Test [SM 19th ED]
5210 B [19th ED]	Carboneous Biochemical Oxygen Demand (CBOD) [SM 19th ED]
5310 B [19th ED]	Total Organic Carbon (Combustion-Infrared) [SM 19th ED]

Organics

624	Purgeables
624	Bromodichloromethane

The expiration for the laboratory's certification is 4/30/2008. The Utah Environmental Laboratory Certification Program (ELCP) encourages clients and data users to verify the most current certification letter for the authorized method. For further assistance please call Lorna Ward 801-584-8469.

Utah Department of Health

46 North Medical Drive • Salt Lake City, UT 84113-1105 • phone (801) 584-8469 • fax (801) 584-8501
www.health.utah.gov/els/labimp/

Utah!

ACZ Laboratories, Inc.
Clean Water Act
Page 3 of 4

Organics

624	Bromoform
624	Bromomethane
624	Carbon Tetrachloride
624	Chlorobenzene
624	Chloroethane
624	2-Chloroethylvinyl Ether
624	Chloroform
624	Chloromethane
624	Dibromochloromethane
624	1,2-Dichlorobenzene
624	1,3-Dichlorobenzene
624	1,4-Dichlorobenzene
624	1,1-Dichloroethane
624	1,2-Dichloroethane
624	1,1-Dichloroethene
624	trans-1,2-Dichloroethene
624	1,2-Dichloropropane
624	cis-1,3-Dichloropropene
624	trans-1,3-Dichloropropene
624	Ethylbenzene
624	Methylene Chloride
624	1,1,2,2-Tetrachloroethane
624	Tetrachloroethylene
624	Toluene
624	1,1,1-Trichloroethane
624	1,1,2-Trichloroethane
624	Trichloroethene
624	Trichlorofluoromethane
624	Vinyl Chloride
625	Base/Neutrals and Acids
625	Acenaphthene
625	Acenaphthylene
625	Anthracene
625	Benzidine
625	Benzo(a)anthracene
625	Benzo(b)fluoranthene
625	Benzo(k)fluoranthene
625	Benzo(g,h,i)perylene
625	Benzo(a)pyrene
625	Benzyl Butyl Phthalate
625	bis(2-Chloroethyl)ether
625	bis(2-Chloroethoxy)methane
625	bis(2-Ethylhexyl)phthalate
625	bis(2-Chloroisopropyl)ether
625	4-Bromophenyl Phenyl Ether
625	2-Chloronaphthalene
625	Chrysene
625	Dibenz(a,h)anthracene
625	Di-n-butylphthalate
625	3,3'-Dichlorobenzidine
625	Diethyl phthalate
625	Dimethyl phthalate
625	2,4-Dinitrotoluene
625	2,6-Dinitrotoluene

The expiration for the laboratory's certification is 4/30/2008. The Utah Environmental Laboratory Certification Program (ELCP) encourages clients and data users to verify the most current certification letter for the authorized method. For further assistance please call Lorna Ward 801-584-8469.

Utah Department of Health

46 North Medical Drive • Salt Lake City, UT 84113-1105 • phone (801) 584-8469 • fax (801) 584-8501
www.health.utah.gov/els/labimp/

Utah!

ACZ Laboratories, Inc.
Clean Water Act
Page 4 of 4

Organics	
625	Di-n-octylphthalate
625	Fluoranthene
625	Fluorene
625	Hexachlorobenzene
625	Hexachlorobutadiene
625	Hexachlorocyclopentadiene
625	Hexachloroethane
625	Indeno(1,2,3-cd)pyrene
625	Isophorone
625	Naphthalene
625	Nitrobenzene
625	N-Nitrosodimethylamine
625	N-Nitrosodi-n-propylamine
625	N-Nitrosodiphenylamine
625	Phenanthrene
625	Pyrene
625	1,2,4-Trichlorobenzene
625	4-Chloro-3-methylphenol
625	2-Chlorophenol
625	2,4-Dichlorophenol
625	2,4-Dimethylphenol
625	2,4-Dinitrophenol
625	2-Methyl- 4,6-dinitrophenol
625	2-Nitrophenol
625	4-Nitrophenol
625	Pentachlorophenol
625	Phenol
625	2,4,6-Trichlorophenol
Radiological	
900.0	Gross Alpha
900.0	Gross Beta
903.0	Radium
903.0	radium-226
903.1	radium-226
904.0	radium-228
Solid & Chemical Materials	
Inorganics and Metals	
Sludge	Inorganic Pollutants

The effective date of this certificate letter is: 5/24/2007.

The analytes by method which a laboratory is authorized to perform at any given time will be those indicated in the most recent certificate letter. The most recent certification letter supersedes all previous certification or authorization letters. It is the certified laboratory's responsibility to review this letter for discrepancies. The certified laboratory must document any discrepancies in this letter and send notice to this bureau within 15 days of receipt. This certificate letter will be recalled in the event your laboratory's certification is revoked.

Respectfully,

Patrick F. Luedtke, MD, MPH,
Director of Public Health Laboratories
Deputy Director of Epidemiology and Laboratory Services

The expiration for the laboratory's certification is 4/30/2008. The Utah Environmental Laboratory Certification Program (ELCP) encourages clients and data users to verify the most current certification letter for the authorized method. For further assistance please call Lorna Ward 801-584-8469.

Utah Department of Health

46 North Medical Drive • Salt Lake City, UT 84113-1105 • phone (801) 584-8469 • fax (801) 584-8501
www.health.utah.gov/els/labimp/

Utah! Where ideas connect

State of Utah
JON HUNTSMAN Jr.
Governor
GARY HERBERT
Lieutenant Governor

Utah Department of Health
David N. Sundwall, MD
Executive Director

Epidemiology and Laboratory Services
Patrick F. Luedtke, MD, MPH.
Director of Public Health Laboratories

Bureau of Laboratory Improvement
David B Mendenhall, MPA, MT (ASCP)
Bureau Director

NELAP
Recognized

5/11/2007

ACZ Laboratories, Inc.
Bradley Craig
2773 Downhill Drive
Steamboat Springs CO 80487

ID # ACZ
Account # 8003345493

Director,

On the basis of your most recent assessment, Proficiency Testing results and continuing compliance with the ELCP requirements, the laboratory listed is certified for environmental monitoring under the Resource Conservation and Recovery Act and authorized to perform the following methods, for the analytes and matrix listed:

Characteristics

	Solid	Non-Potable Water	
1010 A	✔	✔	Ignitability
1311	✔	✔	Toxicity Characteristic Leaching Procedure Metals
1311	✔	✔	Toxicity Characteristic Leaching Procedure Semi-Volatiles
1311	✔	✔	Toxicity Characteristic Leaching Procedure Volatiles
1312	✔	✔	Synthetic Precipitation Leaching Procedure (TCLP Approval)

Inorganics

	Solid	Non-Potable Water	
9012 B	✔	✔	Total and Amenable Cyanide
9013	✔		Cyanide Extraction Procedure for Solids and Oils
9040 C		✔	pH
9045 D	✔		Soil and Waste pH
9070 A		✔	Total Recoverable Oil and Grease

Metal Digestion

	Solid	Non-Potable Water	
3005 A		✔	Acid Digestion Total Recoverable or Dissolved Metals
3010 A		✔	Acid Digestion for Total Metals
3050 B	✔		Acid Digestion of Sediments, Sludges and Soils
3051 A	✔		Microwave Acid Digestion of Sediment, Sludges, Soils & Oils
3052	✔		Microwave Acid Digestion of Siliceous and Organic Matrixes
3060 A	✔		Alkaline Digestion for Hexavalent Chromium

The expiration for the laboratory's certification is 4/30/2008. The Utah Environmental Laboratory Certification Program (ELCP) encourages clients and data users to verify the most current certification letter for the authorized method. For further assistance please call Lorna Ward 801-584-8469.

Utah Department of Health

46 North Medical Drive • Salt Lake City, UT 84113-1105 • phone (801) 584-8469 • fax (801) 584-8501
www.health.utah.gov/els/labimp/

Utah!

ACZ Laboratories, Inc.
Resource Conservation and Recovery Act
Page 2 of 6

Metals

	Solid	Non-Potable Water	
6010 B	✔	✔	Aluminum
6010 B	✔	✔	Antimony
6010 B	✔	✔	Arsenic
6010 B	✔	✔	Barium
6010 B	✔	✔	Beryllium
6010 B	✔	✔	Boron
6010 B	✔	✔	Cadmium
6010 B	✔	✔	Calcium
6010 B	✔	✔	Chromium
6010 B	✔	✔	Cobalt
6010 B	✔	✔	Copper
6010 B	✔	✔	Iron
6010 B	✔	✔	Lead
6010 B	✔	✔	Lithium
6010 B	✔	✔	Magnesium
6010 B	✔	✔	Manganese
6010 B	✔	✔	Molybdenum
6010 B	✔	✔	Nickel
6010 B	✔	✔	Potassium
6010 B	✔	✔	Selenium
6010 B	✔	✔	Silica
6010 B	✔	✔	Silicon
6010 B	✔	✔	Silver
6010 B	✔	✔	Sodium
6010 B	✔	✔	Strontium
6010 B	✔		Thallium
6010 B	✔	✔	Tin
6010 B	✔	✔	Titanium
6010 B	✔	✔	Vanadium
6010 B	✔	✔	Zinc
6020 [1994]	✔	✔	Aluminum
6020 [1994]	✔	✔	Antimony
6020 [1994]	✔	✔	Arsenic
6020 [1994]	✔	✔	Barium
6020 [1994]	✔	✔	Beryllium
6020 [1994]	✔	✔	Cadmium
6020 [1994]	✔	✔	Chromium
6020 [1994]	✔	✔	Cobalt
6020 [1994]	✔	✔	Copper
6020 [1994]	✔	✔	Lead
6020 [1994]	✔	✔	Manganese
6020 [1994]	✔	✔	Molybdenum
6020 [1994]	✔	✔	Nickel
6020 [1994]	✔	✔	Selenium
6020 [1994]	✔	✔	Silver
6020 [1994]	✔	✔	Thallium
6020 [1994]	✔	✔	Vanadium
6020 [1994]	✔	✔	Zinc
7196 A	✔	✔	Chromium, Hexavalent (Chromium, VI)
7470 A		✔	Mercury
7471 A	✔		Mercury

The expiration for the laboratory's certification is 4/30/2008. The Utah Environmental Laboratory Certification Program (ELCP) encourages clients and data users to verify the most current certification letter for the authorized method. For further assistance please call Lorna Ward 801-584-8469.

Utah Department of Health

46 North Medical Drive • Salt Lake City, UT 84113-1105 • phone (801) 584-8489 • fax (801) 584-8501
www.health.utah.gov/els/labimp/

Utah!

ACZ Laboratories, Inc.
Resource Conservation and Recovery Act
Page 3 of 6

Organic Extraction

	Solid	Non-Potable Water	
3510 C		✔	Separatory Funnel Liquid-Liquid Extractions
3520 C		✔	Continuous Liquid-Liquid Extraction
3540 C	✔		Soxhlet Extraction
3550 C	✔		Ultrasonic Extraction
3580 A	✔		Waste Dilution

Organic Instrumentation

	Solid	Non-Potable Water	
8015 B	✔	✔	Diesel Range Organics (DROs)
8015 B	✔	✔	Gasoline Range Organics (GROs)
8015 B	✔	✔	Nonhalogenated Organics Using GC/FID
8021 B	✔	✔	Aromatic and Halogenated Volatiles
8021 B	✔	✔	Benzene
8021 B	✔	✔	Ethylbenzene
8021 B	✔	✔	meta-Xylene
8021 B	✔	✔	ortho-Xylene
8021 B	✔	✔	para-Xylene
8021 B	✔	✔	Toluene
8021 B	✔	✔	Xylenes, Total
8082	✔	✔	Aroclor-1016 [PCB-1016]
8082	✔	✔	Aroclor-1221 PCB-1221]
8082	✔	✔	Aroclor-1232 [PCB-1232]
8082	✔	✔	Aroclor-1242 [PCB-1242]
8082	✔	✔	Aroclor-1248 [PCB-1248]
8082	✔	✔	Aroclor-1254 [PCB-1254]
8082	✔	✔	Aroclor-1260 [PCB-1260]
8082	✔	✔	PCBs
8260 B	✔	✔	1,1,1,2-Tetrachloroethane
8260 B	✔	✔	1,1,1-Trichloroethane
8260 B	✔	✔	1,1,2,2-Tetrachloroethane
8260 B	✔	✔	1,1,2-Trichloroethane
8260 B	✔	✔	1,1-Dichloroethane
8260 B	✔	✔	1,1-Dichloroethylene (-ethene)
8260 B	✔	✔	1,1-Dichloropropene
8260 B	✔	✔	1,2,3-Trichlorobenzene
8260 B	✔	✔	1,2,3-Trichloropropane
8260 B	✔	✔	1,2,4-Trichlorobenzene
8260 B	✔	✔	1,2,4-Trimethylbenzene
8260 B	✔	✔	1,2-Dibromo-3-chloropropane (DBCP, Dibromochloropropane)
8260 B	✔	✔	1,2-Dibromoethane (EDB, Ethylene dibromide)
8260 B	✔	✔	1,2-Dichlorobenzene
8260 B	✔	✔	1,2-Dichloroethane
8260 B	✔	✔	1,2-Dichloropropane
8260 B	✔	✔	1,3,5-Trimethylbenzene
8260 B	✔	✔	1,3-Dichlorobenzene
8260 B	✔	✔	1,3-Dichloropropane
8260 B	✔	✔	1,4-Dichlorobenzene
8260 B	✔	✔	2,2-Dichloropropane
8260 B	✔	✔	2-Chloroethyl Vinyl Ether
8260 B	✔	✔	2-Chlorotoluene

The expiration for the laboratory's certification is 4/30/2008. The Utah Environmental Laboratory Certification Program (ELCP) encourages clients and data users to verify the most current certification letter for the authorized method. For further assistance please call Lorna Ward 801-584-8469.

Utah Department of Health

46 North Medical Drive • Salt Lake City, UT 84113-1105 • phone (801) 584-8469 • fax (801) 584-8501
www.health.utah.gov/els/labimp/

Utah!

ACZ Laboratories, Inc.
Resource Conservation and Recovery Act
Page 4 of 6

Organic Instrumentation

	Solid	Non-Potable Water	
8260 B	✔	✔	2-Hexanone
8260 B	✔	✔	4-Chlorotoluene
8260 B	✔	✔	4-Methyl-2-pentanone (MIBK, Isopropylacetone, Hexone)
8260 B	✔	✔	Acetone
8260 B	✔	✔	Acrylonitrile
8260 B	✔	✔	Benzene
8260 B	✔	✔	Bromobenzene
8260 B	✔	✔	Bromochloromethane
8260 B	✔	✔	Bromodichloromethane
8260 B	✔	✔	Bromoform
8260 B	✔	✔	Carbon Disulfide
8260 B	✔	✔	Carbon Tetrachloride
8260 B	✔	✔	Chlorobenzene
8260 B	✔	✔	Chlorodibromomethane [Dibromochloromethane]
8260 B	✔	✔	Chloroethane
8260 B	✔	✔	Chloroform
8260 B	✔	✔	cis-1,2-Dichloroethene (-ethylene)
8260 B	✔	✔	cis-1,3-dichloropropene
8260 B	✔	✔	Dibromomethane
8260 B	✔	✔	Dichlorodifluoromethane
8260 B	✔	✔	Ethylbenzene
8260 B	✔	✔	Hexachlorobutadiene
8260 B	✔	✔	Isopropylbenzene
8260 B	✔	✔	meta-Xylene
8260 B	✔	✔	Methyl bromide [Bromomethane]
8260 B	✔	✔	Methyl chloride [Chloromethane]
8260 B	✔	✔	Methyl Ethyl Ketone (MEK, 2-Butanone)
8260 B	✔	✔	Methyl-t-Butyl Ether (MTBE)
8260 B	✔	✔	Methylene Chloride
8260 B	✔	✔	n-Butylbenzene
8260 B	✔	✔	n-Propylbenzene
8260 B	✔	✔	Naphthalene
8260 B	✔	✔	ortho-Xylene
8260 B	✔	✔	para-Xylene
8260 B	✔	✔	sec-Butylbenzene
8260 B	✔	✔	Styrene
8260 B	✔	✔	tert-Butylbenzene
8260 B	✔	✔	Tetrachloroethylene (Perchloroethylene -ethene)
8260 B	✔	✔	Toluene
8260 B	✔	✔	trans-1,2-Dichloroethylene (-ethene)
8260 B	✔	✔	trans-1,3-Dichloropropylene (-propene)
8260 B	✔	✔	Trichloroethene (Trichloroethylene)
8260 B	✔	✔	Trichlorofluoromethane
8260 B	✔	✔	Vinyl Acetate
8260 B	✔	✔	Vinyl Chloride
8260 B	✔	✔	Volatile Organic Compounds
8260 B	✔	✔	Xylenes, Total
8270 C	✔	✔	1,2,4-Trichlorobenzene
8270 C	✔	✔	1,2-Dichlorobenzene
8270 C	✔	✔	1,3-Dichlorobenzene
8270 C	✔	✔	1,4-Dichlorobenzene

The expiration for the laboratory's certification is 4/30/2008. The Utah Environmental Laboratory Certification Program (ELCP) encourages clients and data users to verify the most current certification letter for the authorized method. For further assistance please call Lorna Ward 801-584-8469.

Utah Department of Health

46 North Medical Drive • Salt Lake City, UT 84113-1105 • phone (801) 584-8469 • fax (801) 584-8501
www.health.utah.gov/els/labimp/

Utah!

ACZ Laboratories, Inc.
Resource Conservation and Recovery Act
Page 5 of 6

Organic Instrumentation

	Solid	Non-Potable Water	
8270 C	✔	✔	2,4,5-Trichlorophenol
8270 C	✔	✔	2,4,6-Trichlorophenol
8270 C	✔	✔	2,4-Dichlorophenol
8270 C	✔	✔	2,4-Dimethylphenol
8270 C	✔	✔	2,4-Dinitrophenol
8270 C	✔	✔	2,4-Dinitrotoluene (2,4-DNT)
8270 C	✔	✔	2,6-Dinitrotoluene (2,6-DNT)
8270 C	✔	✔	2-Chloronaphthalene
8270 C	✔	✔	2-Chlorophenol
8270 C	✔	✔	2-Methyl-4,6-dinitrophenol (4,6-Dinitro-2-methylphenol)
8270 C	✔	✔	2-Methylnaphthalene
8270 C	✔	✔	2-Methylphenol (o-cresol, 2-Hydroxytoluene)
8270 C	✔	✔	2-Nitroaniline
8270 C	✔	✔	2-Nitrophenol
8270 C	✔	✔	3,3'-Dichlorobenzidine
8270 C	✔	✔	3-Methylphenol (m-cresol, 3-Hydroxytoluene)
8270 C	✔	✔	3-Nitroaniline
8270 C	✔	✔	4-Bromophenyl Phenyl Ether
8270 C	✔	✔	4-Chloro-3-methylphenol
8270 C	✔	✔	4-Chloroaniline
8270 C	✔	✔	4-Chlorophenyl Phenyl Ether
8270 C	✔	✔	4-Methylphenol (p-cresol, 4-Hydroxytoluene)
8270 C	✔	✔	4-Nitroaniline
8270 C	✔	✔	4-Nitrophenol
8270 C	✔	✔	Acenaphthene
8270 C	✔	✔	Acenaphthylene
8270 C	✔	✔	Anthracene
8270 C	✔	✔	Azobenzene
8270 C	✔	✔	Benzo(a)anthracene
8270 C	✔	✔	Benzo(a)pyrene
8270 C	✔	✔	Benzo(b)fluoranthene
8270 C	✔	✔	Benzo(g,h,i)perylene
8270 C	✔	✔	Benzo(k)fluoranthene
8270 C	✔	✔	Benzoic Acid
8270 C	✔	✔	Benzyl alcohol
8270 C	✔	✔	bis(2-chloroethoxy)methane
8270 C	✔	✔	bis(2-Chloroethyl)ether
8270 C	✔	✔	bis(2-chloroisopropyl)ether
8270 C	✔	✔	bis(2-Ethylhexyl) phthalate (DEHP)
8270 C	✔	✔	Butyl Benzyl Phthalate
8270 C	✔	✔	Chrysene
8270 C	✔	✔	Di-n-butyl phthalate
8270 C	✔	✔	Di-n-octyl Phthalate
8270 C	✔	✔	Dibenzo(a,h)anthracene
8270 C	✔	✔	Dibenzofuran
8270 C	✔	✔	Diethyl Phthalate
8270 C	✔	✔	Dimethyl Phthalate
8270 C	✔	✔	Fluoranthene
8270 C	✔	✔	Fluorene
8270 C	✔	✔	Hexachlorobenzene
8270 C	✔	✔	Hexachlorobutadiene

The expiration for the laboratory's certification is 4/30/2008. The Utah Environmental Laboratory Certification Program (ELCP) encourages clients and data users to verify the most current certification letter for the authorized method. For further assistance please call Lorna Ward 801-584-8469.

Utah Department of Health

46 North Medical Drive • Salt Lake City, UT 84113-1105 • phone (801) 584-8469 • fax (801) 584-8501
www.health.utah.gov/els/labimp/

Utah! Where ideas connect™

ACZ Laboratories, Inc.
Resource Conservation and Recovery Act
Page 6 of 6

Organic Instrumentation

	Solid	Non-Potable Water	
8270 C	✔	✔	Hexachlorocyclopentadiene
8270 C	✔	✔	Hexachloroethane
8270 C	✔	✔	Indeno(1,2,3-cd)pyrene
8270 C	✔	✔	Isophorone
8270 C	✔	✔	n-Nitroso-di-n-Propylamine
8270 C	✔	✔	n-Nitrosodimethylamine
8270 C	✔	✔	n-Nitrosodiphenylamine
8270 C	✔	✔	Naphthalene
8270 C	✔	✔	Nitrobenzene
8270 C	✔	✔	Pentachlorophenol
8270 C	✔	✔	Phenanthrene
8270 C	✔	✔	Phenol
8270 C	✔	✔	Pyrene
8270 C	✔	✔	Semivolatile Organic Compounds

Radiochemistry

	Solid	Non-Potable Water	
9310	✔	✔	Gross Alpha and Gross Beta
9315	✔	✔	Alpha Emit Radium Isotope
9320	✔	✔	Radium 226

Volatile Organic Preparation

	Solid	Non-Potable Water	
5030 B		✔	Purge-and-Trap for Aqueous Samples

The effective date of this certificate letter is: 5/1/2007.

The analytes by method which a laboratory is authorized to perform at any given time will be those indicated in the most recent certificate letter. The most recent certification letter supersedes all previous certification or authorization letters. It is the certified laboratory's responsibility to review this letter for discrepancies. The certified laboratory must document any discrepancies in this letter and send notice to this bureau within 15 days of receipt. This certificate letter will be recalled in the event your laboratory's certification is revoked.

Respectfully,

Patrick F. Luedtke, MD, MPH.
Director of Public Health Laboratories
Deputy Director of Epidemiology and Laboratory Services

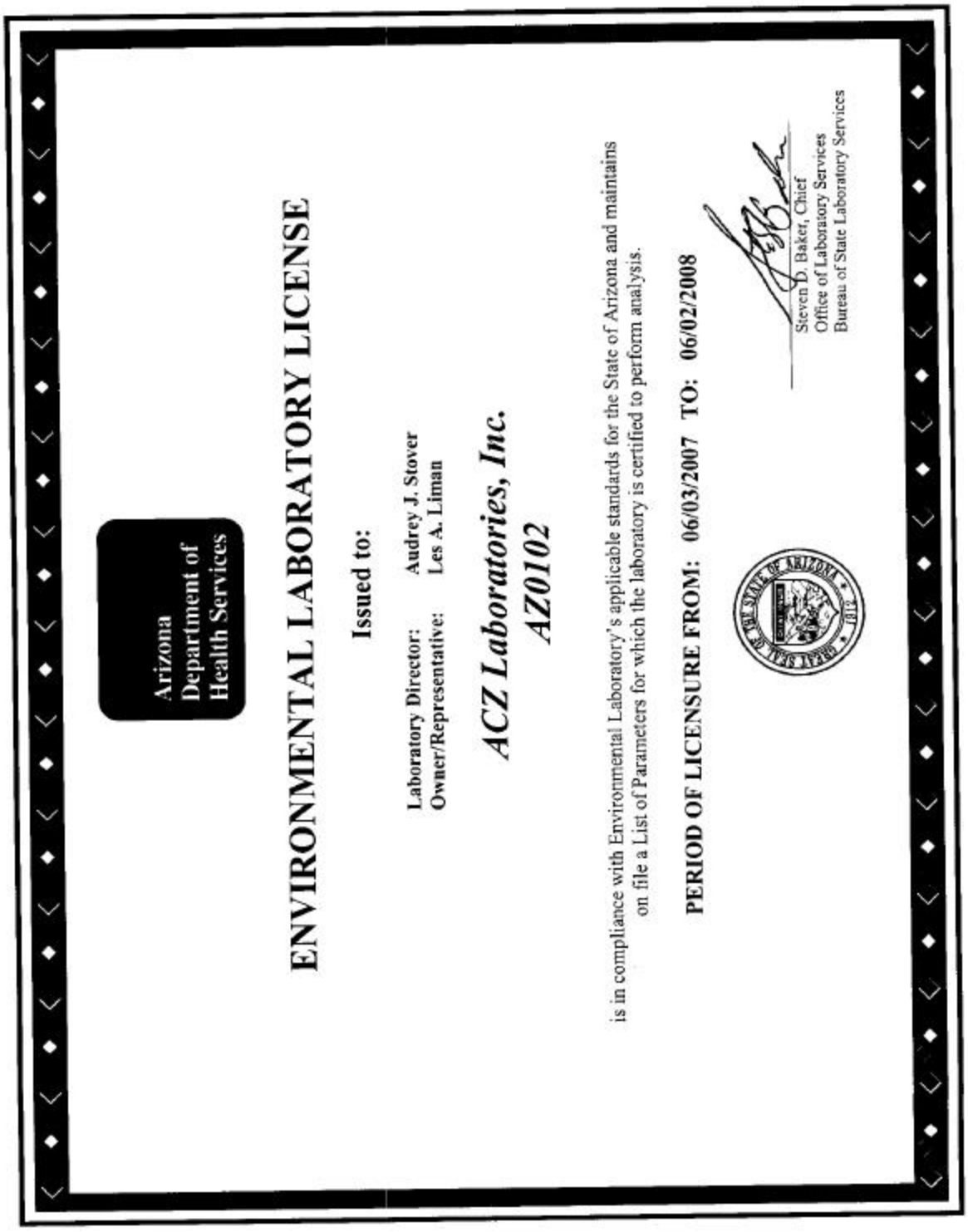
The expiration for the laboratory's certification is 4/30/2008. The Utah Environmental Laboratory Certification Program (ELCP) encourages clients and data users to verify the most current certification letter for the authorized method. For further assistance please call Lorna Ward 801-584-8469.

Utah Department of Health

46 North Medical Drive • Salt Lake City, UT 84113-1105 • phone (801) 584-8469 • fax (801) 584-8501
www.health.utah.gov/els/labimp/

Utah!

APPENDIX C ADHS Certificate and List of Certified Parameters



Arizona Department of Health Services

ENVIRONMENTAL LABORATORY LICENSE

Issued to:

Laboratory Director: Audrey J. Stover
Owner/Representative: Les A. Liman

ACZ Laboratories, Inc.
AZ0102

is in compliance with Environmental Laboratory's applicable standards for the State of Arizona and maintains on file a List of Parameters for which the laboratory is certified to perform analysis.

PERIOD OF LICENSURE FROM: 06/03/2007 TO: 06/02/2008

Steven D. Baker, Chief
Office of Laboratory Services
Bureau of State Laboratory Services

Arizona Department of Health Services
Office of Laboratory Licensure, Certification & Training
250 North 17th Avenue, Phoenix, AZ 85007

Page: 1

Wednesday, June 27 2007

AZ License: AZ0102

Lab Director: Ms. Audrey J. Stover

Lab Name: ACZ Laboratories, Inc.
Phone: (970) 879-6590
Fax: (970) 879-2216

Program HW

Parameter	EPA Method	Billing Code	Cert Date
Alkline Digestion For Hexavalent Chromium	EPA 3060A	PREP2	05/09/07
Alpha-Emitting Radium Isotopes	EPA 9315	RADIO	09/23/97
Aluminum	EPA 6010B	MTL3	06/03/98
Aluminum	EPA 6020	MTL7	04/12/04
Antimony	EPA 6010B	MTL3	05/09/02
Antimony	EPA 6020	MTL7	02/24/97
Aromatic & Halogenated Vocs	EPA 8021B	VOC1	01/15/03
Arsenic	EPA 6010B	MTL3	05/09/02
Arsenic	EPA 6020	MTL7	02/24/97
Barium	EPA 6010B	MTL3	06/03/98
Barium	EPA 6020	MTL7	02/24/97
Beryllium	EPA 6010B	MTL3	05/01/92
Beryllium	EPA 6020	MTL7	02/24/97
Boron	EPA 6010B	MTL3	04/04/06
Cadmium	EPA 6010B	MTL3	06/03/98
Cadmium	EPA 6020	MTL7	02/24/97
Calcium	EPA 6010B	MTL3	06/03/98
Chromium Total	EPA 6010B	MTL3	06/03/98
Chromium Total	EPA 6020	MTL7	02/24/97
Chromium, Hexavalent	EPA 7196A	MTL4	04/12/04
Closed System Purge And Trap Extract. Vocs	EPA 5035A	MISC21	12/05/06
Cobalt	EPA 6010B	MTL3	06/03/98
Cobalt	EPA 6020	MTL7	02/24/97
Continious Liquid-Liquid Extraction	EPA 3520C	PREP2	05/09/02
Copper	EPA 6010B	MTL3	06/03/98
Copper	EPA 6020	MTL7	02/24/97
Corrosivity Ph Determination	EPA 9040C	HAZ1	12/05/06
Cyanide	EPA 9012B	MISC7	12/05/06
Cyanide Extractions For Solids And Oils	EPA 9013A	PREP3	12/05/06
Dissolved In Water	EPA 3005A	PREP1	05/09/02
Gross Alpha And Beta	EPA 9310	RADIO	09/23/97
Hem For Aqueous Samples	EPA 9070A	MISC6	05/09/07
Hem For Sludge,Sediment And Solid Samples	EPA 9071B	MISC6	12/05/06
Hydrogen Ion (Ph)	EPA 9045D	NIA6	12/05/06
Ignitability (Flash Point)	EPA 1010A	HAZ2	12/05/06
Iron	EPA 6010B	MTL3	06/03/98
Lead	EPA 6010B	MTL3	06/03/98
Lead	EPA 6020	MTL7	02/24/97
Lithium	EPA 6010B	MTL3	06/26/02

Arizona Department of Health Services
Office of Laboratory Licensure, Certification & Training
250 North 17th Avenue, Phoenix, AZ 85007

Page: 2

Wednesday, June 27 2007

AZ License: AZ0102 **Lab Name: ACZ Laboratories, Inc.**

Program HW

Parameter	EPA Method	Billing Code	Cert Date
Magnesium	EPA 6010B	MTL3	06/03/98
Manganese	EPA 6010B	MTL3	06/03/98
Manganese	EPA 6020	MTL7	02/24/97
Mercury	EPA 7470A	MTL5	06/02/97
Mercury	EPA 7471A	MTL5	05/01/92
Microwave Assisted Digestions	EPA 3015A	PREP1	05/12/03
Microwave Assisted Digestions	EPA 3051	PREP1	06/12/03
Molybdenum	EPA 6010B	MTL3	06/03/98
Nickel	EPA 6010B	MTL3	05/01/92
Nickel	EPA 6020	MTL7	02/24/97
Nonhalogenated Organics Using Gc/Fid	EPA 8015D	VOC4	12/05/06
Paint Filter Liquids Test	EPA 9095B	MISC18	12/05/06
Pcbs By Gc	EPA 8082	SOC9	04/10/03
Potassium	EPA 6010B	MTL3	06/03/98
Purge And Trap For Aqueous Samples	EPA 5030C	PREP2	12/05/06
Radium 228	EPA 9320	RADIO	06/26/02
Sediments, Sludges And Soils	EPA 3050B	PREP1	05/09/02
Semivolatile Compounds By Gc/Ms	EPA 8270C	SOC16	06/03/98
Separatory Funnel Liquid-Liquid Extraction	EPA 3510C	PREP2	05/09/02
Silica	EPA 6010B	MTL3	04/04/06
Silver	EPA 6010B	MTL3	06/03/98
Silver	EPA 6020	MTL7	02/24/97
Sodium	EPA 6010B	MTL3	06/03/98
Soxlhet Extraction	EPA 3540C	PREP2	05/09/02
Splp	EPA 1312	HAZ6	02/15/96
Strontium	EPA 6010B	MTL3	05/09/02
Tclp	EPA 1311	HAZ5	05/01/92
Thallium	EPA 6010B	MTL3	06/26/02
Thallium	EPA 6020	MTL7	02/24/97
Tin	EPA 6010B	MTL3	06/03/98
Titanium	EPA 6010B	MTL3	04/04/06
Total Metals	EPA 3010A	PREP1	05/09/02
Total Recoverable In Water	EPA 3005A	PREP1	05/09/02
Ultrasonic Extraction	EPA 3550B	PREP2	05/09/02
Vocs By Gc/Ms	EPA 8260B	VOC8	06/03/98
Waste Dilution	EPA 3580A	PREP2	05/12/03
Zinc	EPA 6010B	MTL3	06/03/98
Zinc	EPA 6020	MTL7	02/24/97

Total Licensed Parameters in this Program: 77

Program SDW

Arizona Department of Health Services
Office of Laboratory Licensure, Certification & Training
250 North 17th Avenue, Phoenix, AZ 85007

Page: 3

Wednesday, June 27 2007

AZ License: AZ0102 **Lab Name: ACZ Laboratories, Inc.**

Program SDW

Parameter	EPA Method	Billing Code	Cert Date
Alkalinity	SM 2320B	NIA1	04/10/03
Aluminum	EPA 200.7	MTL3	04/10/03
Antimony	EPA 200.8	MTL7	04/10/03
Arsenic	EPA 200.8	MTL7	04/10/03
Barium	EPA 200.8	MTL7	04/10/03
Beryllium	EPA 200.8	MTL7	04/10/03
Bromide	EPA 300.0	NIIIA1	04/10/03
Cadmium	EPA 200.8	MTL7	04/10/03
Calcium	EPA 200.7	MTL3	04/10/03
Carbon, Total Organic	EPA 5310B	MISC1	04/10/03
Chloride	EPA 300.0	NIIIA1	04/10/03
Chromium Total	EPA 200.8	MTL7	04/10/03
Copper	EPA 200.8	MTL7	04/10/03
Cyanide	EPA 335.4	MISC7	06/26/02
Cyanide	SM 4500 CN F	MISC7	04/10/03
Fluoride	EPA 300.0	NIIIA1	04/10/03
Fluoride	SM 4500-F C	NIB9	04/10/03
Gross Alpha	EPA 900	RADIO	05/12/03
Gross Beta	EPA 900	RADIO	04/10/03
Hardness	SM 2340B	MTL3	05/09/02
Hydrogen Ion (Ph)	SM 4500-H B	NIA6	05/09/07
Iron	EPA 200.7	MTL3	04/10/03
Lead	EPA 200.8	MTL7	04/10/03
Magnesium	EPA 200.7	MTL3	04/10/03
Manganese	EPA 200.7	MTL3	04/10/03
Mercury	EPA 245.1	MTL5	04/10/03
Nickel	EPA 200.8	MTL7	04/10/03
Nitrate	EPA 353.2	NIB1	04/10/03
Nitrite	EPA 353.2	NIIB4	06/26/02
Orthophosphate	EPA 365.1	NIIB5	04/10/03
Preliminary Filtration	SM 3030B	PREP1	12/24/03
Radium 226	EPA 903.1	RADIO	04/10/03
Radium 228	EPA 904	RADIO	04/10/03
Residue, Filterable (Tds)	SM 2540C	NIIA8	04/10/03
Selenium	EPA 200.8	MTL7	04/10/03
Silica	EPA 200.7	MTL3	04/10/03
Silver	EPA 200.8	MTL7	04/10/03
Sodium	EPA 200.7	MTL3	04/10/03
Specific Conductance	SM 2510B	NIA7	04/10/03
Strontium	EPA 200.7	MTL3	04/10/03
Sulfate	EPA 300.0	NIIIA1	04/10/03

Arizona Department of Health Services
Office of Laboratory Licensure, Certification & Training
250 North 17th Avenue, Phoenix, AZ 85007

Page: 4

Wednesday, June 27 2007

AZ License: AZ0102 **Lab Name: ACZ Laboratories, Inc.**

Program SDW

Parameter	EPA Method	Billing Code	Cert Date
Thallium	EPA 200.8	MTL7	04/10/03
Turbidity, Ntu: Nephelometric	EPA 180.1	NIA9	04/10/03
Uranium	EPA 200.8	MTL7	04/13/05
Zinc	EPA 200.7	MTL3	04/10/03

Total Licensed Parameters in this Program: 45

Program WW

Parameter	EPA Method	Billing Code	Cert Date
Acidity	SM 2310B	NIIA1	06/26/02
Alkalinity, Total	SM 2320B	NIA1	06/26/02
Aluminum	EPA 200.7	MTL3	10/16/95
Aluminum	EPA 200.8	MTL7	04/12/04
Ammonia	EPA 350.1	NIIB1	05/01/92
Antimony	EPA 200.7	MTL3	05/09/02
Antimony	EPA 200.8	MTL7	02/24/97
Arsenic	EPA 200.7	MTL3	05/09/02
Arsenic	EPA 200.8	MTL7	02/24/97
Barium	EPA 200.7	MTL3	10/16/95
Barium	EPA 200.8	MTL7	02/24/97
Base/Neutrals And Acids Excluding Pesticides	EPA 625	SOC16	05/12/03
Beryllium	EPA 200.7	MTL3	10/16/95
Beryllium	EPA 200.8	MTL7	02/24/97
Biochemical Oxygen Demand	SM 5210B	DEM1	05/09/07
Boron	EPA 200.7	MTL3	05/01/92
Bromide	EPA 300.0	NIIIA1	09/27/01
Cadmium	EPA 200.7	MTL3	10/16/95
Cadmium	EPA 200.8	MTL7	02/24/97
Calcium	EPA 200.7	MTL3	05/25/94
Chemical Oxygen Demand	EPA 410.4	DEM3	05/01/92
Chloride	EPA 300.0	NIIIA1	05/25/94
Chloride	SM 4500-CL E	NIA2	05/09/07
Chromium Total	EPA 200.7	MTL3	10/16/95
Chromium Total	EPA 200.8	MTL7	02/24/97
Chromium, Hexavalent	SM 3500-CR D	MTL8	05/09/02
Cobalt	EPA 200.7	MTL3	10/16/95
Cobalt	EPA 200.8	MTL7	02/24/97
Copper	EPA 200.7	MTL3	10/16/95
Copper	EPA 200.8	MTL7	02/24/97
Cyanide, Total	EPA 335.4	MISC7	05/08/07
Fluoride	EPA 300.0	NIIIA1	05/09/02
Fluoride	SM 4500-F C	NIB3	05/09/02

Arizona Department of Health Services
Office of Laboratory Licensure, Certification & Training
250 North 17th Avenue, Phoenix, AZ 85007

Page: 5

Wednesday, June 27 2007

AZ License: AZ0102 **Lab Name: ACZ Laboratories, Inc.**

Program WW

Parameter	EPA Method	Billing Code	Cert Date
Gross Alpha	EPA 900	RADIO	04/10/03
Gross Beta	EPA 900.0	RADIO	04/10/03
Hardness	SM 2340B	NIA5	01/12/06
Hydrogen Ion (Ph)	SM 4500-H B	NIA6	05/09/07
Iron	EPA 200.7	MTL3	10/16/95
Kjeldahl Nitrogen	EPA 351.2	NIIB3	05/09/02
Lead	EPA 200.7	MTL3	10/16/95
Lead	EPA 200.8	MTL7	02/24/97
Lithium	EPA 200.7	MTL3	04/10/03
Magnesium	EPA 200.7	MTL3	05/25/94
Manganese	EPA 200.7	MTL3	10/16/95
Manganese	EPA 200.8	MTL7	02/24/97
Mercury	EPA 1631E	MTL10	04/10/03
Mercury	EPA 245.1	MTL5	10/16/95
Molybdenum	EPA 200.7	MTL3	10/16/95
Molybdenum	EPA 200.8	MTL7	02/24/97
Nickel	EPA 200.7	MTL3	10/16/95
Nickel	EPA 200.8	MTL7	02/24/97
Nitrate-Nitrite (As N)	EPA 353.2	NIB1	05/01/92
Nitrite	EPA 353.2	NIIB4	05/09/07
Oil And Grease, Tph	EPA 1664A	MISC6	12/05/06
Orthophosphate	EPA 365.1	NIIB5	05/01/92
Phenols	EPA 420.4	MISC8	05/09/07
Phosphorus Total	EPA 365.1	NIIB6	05/01/92
Potassium	EPA 200.7	MTL3	05/25/94
Purgeables	EPA 624	VOC8	05/12/03
Radium 226	EPA 903.1	RADIO	04/10/03
Residue Filterable	SM 2540C	NIA8	12/05/06
Residue Nonfilterable	SM 2540D	NIIA5	12/05/06
Residue Total	SM 2540B	NIIA4	12/05/06
Residue Volatile	EPA 160.4	NIIA7	05/01/92
Residue, Settleable Solids	SM 2540F	NIIA6	05/01/92
Selenium	EPA 200.7	MTL3	05/09/02
Selenium	EPA 200.8	MTL7	02/24/97
Selenium	SM 3114B	MTL6	05/09/02
Silica, Dissolved	EPA 200.7	MTL3	05/01/92
Silver	EPA 200.7	MTL3	10/16/95
Silver	EPA 200.8	MTL7	02/24/97
Sodium	EPA 200.7	MTL3	05/25/94
Specific Conductance	SM 2510B	NIA7	05/24/07
Strontium	EPA 200.7	MTL3	05/09/02

Arizona Department of Health Services
Office of Laboratory Licensure, Certification & Training
250 North 17th Avenue, Phoenix, AZ 85007
Wednesday, June 27 2007

Page: 6

AZ License: AZ0102 **Lab Name: ACZ Laboratories, Inc.**

Program WW

Parameter	EPA Method	Billing Code	Cert Date
Sulfate	EPA 300.0	NIIIA1	05/25/94
Sulfate	SM 4500-SO4 D	NIB3	05/18/05
Thallium	EPA 200.8	MTL7	02/24/97
Tin	EPA 200.7	MTL3	05/09/02
Total Organic Carbon	SM 5310B	MISC1	05/09/07
Turbidity	EPA 180.1	NIA9	05/01/92
Uranium	EPA 200.8	MTL7	02/24/97
Vanadium	EPA 200.7	MTL3	10/16/95
Vanadium	EPA 200.8	MTL7	02/24/97
Zinc	EPA 200.7	MTL3	10/16/95
Zinc	EPA 200.8	MTL7	02/24/97

Total Licensed Parameters in this Program: 85

Instruments	Quantity	Date
GAS CHROMATOGRAPH	4	05/25/94
GAS CHROMATOGRAPH/MASS SPECTROMETER	3	05/09/02
RADIATION COUNTING INSTRUMENT	3	07/11/01
INDUCTIVELY COUPLED PLASMA/MASS SPECTROMETER	3	07/11/01
AUTOMATED AUTOANALYZER	2	05/16/07
ION CHROMATOGRAPH	1	05/09/07
INDUCTIVELY COUPLED PLASMA SPECTROMETER	1	04/04/06
ATOMIC ABSORPTION SPECTROPHOTOMETER	1	05/09/07
MERCURY ANALYZER	1	05/09/02

Softwares
ENVIROQUANT - GCMS
AGILENT - ICP/MS
LEEMAN MERCURY ANALYZER
TJA TRACE-ICP
ENVIROQUANT - HPLC
BERTHOLD LB770 - COUNTER FOR RADIOACTIVITY
TENNELEC LB 5100 - COUNTER FOR RADIOACTIVITY
CANBERRA XLB - COUNTER FOR RADIOACTIVITY

APPENDIX D

ACZ Laboratories, Inc.
2773 Downhill Drive
Steamboat Springs, CO 80487

DEPARTMENT REPORT FOR MANAGEMENT REVIEW OF THE QUALITY SYSTEM

Department: _____ Quarter Ending: _____

OPERATIONS: EVALUATE ALL OPERATIONS (FROM LOG-IN –REPORTING) AS IT PERTAINS TO THE DEPARTMENT

What operations-related issues within the company, including client feedback, have the department encountered during the last quarter? Were any of the issues reoccurring? What actions were taken to resolve the issues? What actions can be taken to reduce/eliminate these issues in the future?

RESOURCES & PERSONNEL: EVALUATE RESOURCES & PERSONNEL AS THEY PERTAIN TO THE DEPARTMENT

Did the department have adequate resources (supplies, instrumentation, facilities, etc.) and properly trained staff for the volume of work? What resources must be available for the work expected next quarter? What obstacles do employees within the department routinely experience that hinder efficiency/productivity?

QUALITY ASSURANCE & QUALITY CONTROL: EVALUATE QA/QC AS THEY PERTAIN TO THE DEPARTMENT

Are any failed QC indicators reoccurring? If so, describe. Were any changes to policies/procedures implemented during the past quarter as a result of corrective and/or preventive actions? If yes, were they effective? If no, what changes would be effective?

MISC: PROVIDE ADDITIONAL FEEDBACK

FRMQA041.08.06.02

ACZ Laboratories, Inc.
2773 Downhill Drive
Steamboat Springs, CO 80487

MANAGEMENT REVIEW OF THE QUALITY SYSTEM

DATE OF REVIEW : _____

Attendees:

SUITABILITY OF POLICIES & PROCEDURES :

Do ACZ's policies and procedures accurately reflect management's Quality Policy Statement? Are ACZ's policies and procedures effective? If no, what changes are necessary?

REVIEW OF STAFF RESOURCES & TRAINING:

Did ACZ have appropriate staff to handle the volume of work received during the past quarter? Was all staff properly trained and was training documented before a new analyze independently analyzed client samples?

REVIEW OF INSTRUMENTATION / EQUIPMENT, SUPPLIES & CONSUMABLES :

Did ACZ have necessary and properly functioning instrumentation and equipment to perform the volume of work received last quarter? Did ACZ have adequate supplies and consumables on hand to perform the volume of work?

ACZ Laboratories, Inc.
2773 Downhill Drive
Steamboat Springs, CO 80487

MANAGEMENT REVIEW OF THE QUALITY SYSTEM

REVIEW OF RECENT INTERNAL AUDITS:

Did the QA/QC department adhere to its internal audit schedule? Did any department(s) have significant issues? Were corrective actions completed properly and within the agreed time frame? Was follow-up completed for all corrective actions?

REVIEW OF RECENT EXTERNAL AUDITS:

Did the audit report(s) cite any repeat deficiencies? Did any department(s) have significant issues? Were all corrective actions completed properly and within the agreed time frame? Was follow-up completed for all corrective actions?

REVIEW OF RECENT PROFICIENCY TESTING STUDIES:

A) Were all analyte values reported for each study?

WP	NA ☐	Yes ☐	No ☐
WS	NA ☐	Yes ☐	No ☐
RAD	NA ☐	Yes ☐	No ☐
Soil/UST	NA ☐	Yes ☐	No ☐

B) Did ACZ passed 2 out of the 3 most recent PT studies for each analyte?

WP	NA ☐	Yes ☐	No ☐
WS	NA ☐	Yes ☐	No ☐
RAD	NA ☐	Yes ☐	No ☐
Soil/UST	NA ☐	Yes ☐	No ☐

C) Were corrective actions completed within the agreed time frame for all studies?

WP	NA ☐	Yes ☐	No ☐
WS	NA ☐	Yes ☐	No ☐
RAD	NA ☐	Yes ☐	No ☐
Soil/UST	NA ☐	Yes ☐	No ☐

ACZ Laboratories, Inc.
2773 Downhill Drive
Steamboat Springs, CO 80487

MANAGEMENT REVIEW OF THE QUALITY SYSTEM

REVIEW OF RECENT CORRECTIVE / PREVENTATIVE ACTIONS:

What corrective / preventive actions were implemented during the past quarter? What trends are apparent? Were corrective actions completed within the agreed time frame? Have changes resulting from corrective / preventive actions been implemented? Are they effective?

REVIEW OF CLIENT COMPLAINTS/FEEDBACK:

Did ACZ receive client feedback (positive or negative) during the past quarter? For complaints received, did ACZ adhere to its client complaint policy? Were complaints handled in a manner satisfactory to the client? Were all complaints resolved? What quality indicators are repeated?

REVIEW OF CHANGES IN VOLUME / TYPE OF WORK:

Did ACZ experience a significant change in volume and/or type of work last quarter? How did we do? What improvements can be made? Is ACZ prepared for volume and/or type of work expected next quarter?

REVIEW OF ETHICS PROGRAM:

Were all Ombudsman issues addressed in a timely manner? Were any data intergrity issues/concerns brought to the attention of the Ombudsman issues or dilemmas? Were all employees trained on ACZ's Ethics and Proactive Prevention Program (SOPAD039)? Was follow-up training conducted within the time frame stated in SOPAD039?

ACZ Laboratories, Inc.
2773 Downhill Drive
Steamboat Springs, CO 80487

MANAGEMENT REVIEW OF THE QUALITY SYSTEM

REVIEW OF DEPARTMENTS:

Geochemistry

Clean Room / Prep

Inorganic Inst / Prep

Wet Chemistry Instrument

Wet Chemistry Manual

Organics

Radiochemistry

Log-In

Client Services (Sales / PMs)

Document Control

Information Systems

APPENDIX E REFERENCES UTILIZED BY ACZ

- "NELAC Standards," National Environmental Laboratory Accreditation Conference, (current version).
- "Guidelines Establishing Test Procedures for the Analysis of Pollutants Under the Clean Water Act," USEPA, Federal Register Vol. 67, No. 205, October 23, 2002.
- "Manual for the Certification of Laboratories Analyzing Drinking Water," USEPA, (current version).
- "Methods for the Chemical Analysis of Water and Wastes," USEPA, EPA-600/4-79-020, March 1983.
- "Test Methods for Evaluating Solid Waste," USEPA, SW-846 Third Edition, Update III, December 1996.
- "Guidelines in Establishing Test Procedures for the Analysis of Wastewater Pollutants," Code of Federal Regulations 40, Parts 136, 141, 143.
- "Quality Assurance of Chemical Measurements," Taylor, J., Lewis Publishers, Michigan, 1987
- "Annual Book of Standards, Water Analysis," ASTM, 1989.
- "Quality Control in Analytical Chemistry," Kateman, G., Vol. 60, 1985.
- "Principles of Environmental Analysis, Analytical Chemistry," Keith, L.H., et al., Vol. 55, 1983.
- "Handbook for Analytical Quality Control in Water and Wastewater Laboratories," USEPA, 1979.
- "Guidance for the Data Quality Assessment: Practical Methods for Data Analysis," USEPA, EPA 600/R-96-084, July 2000.
- "Methods for the Determination of Metals in Environmental Samples," USEPA, EPA 600/4-91-010, June 1991.
- "Methods for the Determination of Metals in Environmental Samples," Supplement I [to EPA 600/4-91-010], USEPA, EPA 600/R-94-111, May 1994.
- "Methods for the Determination of Inorganic Substances in Environmental Samples," USEPA, EPA 600/R-93-100, August 1993.
- "Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater," USEPA, EPA 821/B-96-005, December 1996.
- "Prescribed Procedures for Measurement of Radioactivity in Drinking Water," USEPA, EPA 600/4-80-032. August 1980.
- "Determination of Lead-210, Thorium, Plutonium and Polonium-210 in Drinking Water: Methods 909, 910, 911, 912," 01A0004860 (Region 1 Library), March 1982.
- "Good Automated Laboratory Practices - Principles and Guidance to Regulations for Ensuring Data Integrity in Automated Laboratory Operations" USEPA, 2185, 1995.

APPENDIX F DEFINITIONS OF TERMS

Acceptance Criteria: specified limits places on characteristics of an item, process, or service defined in requirement documents.

Accreditation: verification by a competent, disinterested, third party that a laboratory possesses the capability to produce accurate test data, and that it can be relied upon in its day-to-day operations to maintain high standards of performance.

Accuracy: the degree of agreement between an observed value and an accepted reference value. Accuracy includes a combination of random error (precision) and systematic error (bias) components which are due to sampling and analytical operations; a data quality indicator.

Analytical Spike (AS): an aliquot of client sample to which a known amount of target analyte is added and that demonstrates the absence or presence of interference in the matrix. The AS is prepared exactly the same way as the LFB, only spiking into sample instead of reagent blank, and is not prepped (digested) prior to analysis. The AS may also be referred to as a post-digestion spike.

Analytical System: the combination of events, techniques, and procedures used to generate analytical results.

Audit: a systematic evaluation to determine the conformance to quantitative and qualitative specifications of some operational function or activity.

Batch: environmental samples that are prepared and/or analyzed together with the same process and personnel, using the same lot(s) of reagents. A **preparation batch** is composed of one to 20 environmental samples of the same matrix, meeting the above criteria and with a maximum time between the start of processing of the first and last sample in the batch to be 24 hours. An **analytical batch** is composed of 20 or less prepared environmental samples (extracts, digestates or concentrates) that are analyzed together as a group.

All required QC samples must be prepared and/or analyzed with each batch at the frequency required by the method, even if there are less than 20 client samples in the batch. If the workgroup has more than 20 samples, then sufficient batch QC must be analyzed for additional samples. Every batch of environmental samples is assigned a unique (i.e. traceable) six-digit numerical identifier called the LIMS Workgroup number.

Blank: a sample that has not been exposed to the analyzed sample stream utilized to monitor contamination during sampling, transport, storage, or analysis. The blank is subjected to the usual analytical and measurement process to establish a zero baseline or background value and is sometimes used to adjust or correct routine analytical results. See also Equipment Blank, Field Blank, Instrument Blank, Method Blank, Reagent Blank. Refer to section 11.3 for types of blanks.

Blind Sample: a sub-sample for analysis with a composition known to the submitter. The analyst or laboratory may know the identity of the sample but not its composition. It is used to test the analyst or laboratory's proficiency in the execution of the measurement process.

Calibration: to determine, by measurement or comparison with a standard, the correct value of each scale reading on a meter, instrument, or other device. The levels of applied calibration standard should bracket the range of planned or expected sample measurements.

Calibration Curve: the graphical relationship between the known values, such as concentrations, or a series of calibration standards and their instrument responses.

Case Narrative: Additional documentation provided in the client report that describes any abnormalities and deviations that may affect the analytical results and summarizes any issues in the data package that need to be highlighted for the data user to help them assess the usability of the data.

Chain of Custody Form: a legal record that documents the possession of the samples from the time of collection to receipt in the laboratory. This record generally includes: the number and types of containers; the mode of collection; the collector; time of collection; preservation; and requested analyses.

Continuing Calibration Blank (CCB): the same solution as the calibration blank, it detects baseline drift in the calibration of the instrument. When specified by the method, analyze a CCB immediately after each CCV, including the final CCV.

Continuing Calibration Verification (CCV): a solution of method analytes of known concentrations used to confirm the continued calibration of the instrument. The CCV is analyzed at the frequency indicated in the test SOP.

Corrective Action: the action taken to eliminate the causes of an existing nonconformity, defect, or other undesirable situation in order to prevent recurrence.

Data Audit: a qualitative and quantitative evaluation of the documentation and procedures associated with environmental measurements to verify that the resulting data are of acceptable quality (i.e. the data meet specified acceptance criteria)

Data Reduction: the process of transforming raw data by arithmetic or statistical calculations, standard curves, concentration factors, etc., and collation into a more useable form.

Demonstration of Capability (DOC): a procedure to establish the ability of the analyst to generate acceptable accuracy [and precision, if applicable].

Detection Limit: the lowest concentration or amount of target analyte that can be identified, measured, and reported with confidence that the analyte concentration is not a false positive value (see Method Detection Limit).

Document Control: the act of ensuring that documents (and revisions thereto) are proposed, reviewed for accuracy, approved for release by authorized personnel, distributed properly, and controlled to ensure use of the correct version at the location where the prescribed activity is performed.

Equipment Blank: a sample of analyte-free media that has been used to rinse common sampling equipment to check the effectiveness of decontamination procedures.

False Positive (Type I or alpha error): concluding that a substance is present when it truly is not.

False Negative (Type II or beta error): concluding that a substance is not present when it truly is.

Field Blank: a blank prepared in the field by filling a clean container with Type I water and appropriate preservative, if any, for the specific sampling activity being undertaken.

Holding Time (Maximum Allowable Holding Time): the maximum time that samples may be held prior to analysis and still be considered valid or not compromised.

Initial Calibration Blank (ICB): a solution identical to the calibration blank and confirms the absence of background contamination in the calibration blank. When specified by the method, an ICB is analyzed immediately after the ICV.

Initial Calibration Verification (ICV): a solution of method analytes of known concentrations intended to determine the validity of the instrument calibration. The ICV must be analyzed immediately after each calibration and must be prepared from a source independent of the calibration standards, preferably purchased from a different manufacturer.

Instrument Blank: an aliquot of Type I water or solvent processed through the instrument steps of the measurement process; used to determine presence of instrument contamination.

Internal Standard (IS): a known amount of standard added to a test portion of a sample as a reference for evaluating and controlling the precision and bias of the applied analytical method.

Laboratory Control Sample (however named, such as laboratory fortified blank, spiked blank, or QC check sample): a sample matrix, free from the analytes of interest, spiked with verified known amounts of analytes or a material containing known and verified amounts of analytes. It is generally used to establish intra-laboratory or analyst specific precision and bias or to assess the performance of all or a portion of the measurement system.

Laboratory Fortified Blank (LFB): a reagent blank spiked with a known concentration of analyte. The LFB is analyzed exactly like a sample and determines whether the methodology is in control and whether the laboratory is capable of making accurate and precise measurements.

Legal Chain of Custody Protocols: procedures employed to record the possession of samples from the time of sampling until analysis and are performed at the special request of the client. These protocols include the use of a Chain of Custody form that documents the collection, transport, and receipt of compliance samples by the laboratory. In addition, these protocols document all handling of the samples within the laboratory.

Linear Dynamic Range (LDR): concentration range over which the instrument response to analyte is linear.

Matrix Duplicate (DUP): a second aliquot of a client sample that is prepared and analyzed in the same manner as all other samples in the same workgroup. The DUP demonstrates the precision of the method.

Matrix Spike (spiked sample or fortified sample): a sample prepared by adding a known amount of target analyte to a specified amount of matrix sample for which an independent estimate of target analyte concentration is available. Matrix spikes (MS or LFM) are used, for example, to determine the effect of the matrix on a method's recovery efficiency.

Matrix Spike Duplicate: a second replicate matrix spike prepared in the laboratory and analyzed to obtain a measure of the precision of the recovery for each analyte.

Maximum Contamination Limit (MCL): the numerical value expressing the maximum permissible level of contaminant in water that is delivered to any user of a public water system.

May: denotes permitted action, but not required action.

Method Blank: a sample of a matrix similar to the batch of associated samples (when available) that is free from the analytes of interest and is processed simultaneously with and under the same conditions as client samples through all steps of the analytical procedures, and in which no target analytes or interferences are present at concentrations that impact the analytical results for the sample analyses.

Method Detection Limit: the minimum concentration of an analyte, in a given fortified matrix, that can be measured and reported with 99% confidence that the concentration is greater than zero.

Must: denotes a requirement.

The NELAC Institute (TNI): a voluntary organization of state and federal environmental officials and interest groups purposed primarily to establish mutually acceptable standards for accrediting environmental laboratories.

Outlier (Statistical): an observation or data point that deviates markedly from other members of the population.

Performance Audit: the routine comparison of independently obtained qualitative and quantitative measurement system data with routinely obtained data in order to evaluate the proficiency of an analyst or laboratory.

Precision: the degree to which a set of observations or measurements of the same property, obtained under similar conditions, conform to themselves; a data quality indicator. Precision is usually expressed as standard deviation, variance or range, in either absolute or relative terms.

Preservation: refrigeration and/or reagents added at the time of sample collection (or later) to maintain the chemical and/or biological integrity of the sample.

Protocol: a detailed written procedure [SOP] for laboratory operation that must be strictly followed.

Quality Assurance: an integrated system of activities involving planning, quality control, quality assessment, reporting and quality improvement to ensure that a product or service meets defined standards of quality.

Quality Control: the overall system of technical activities whose purpose is to measure and control the quality of a product or service so that it meets the needs of users.

Quality Manual [QAP]: a document stating the management policies, objectives, principles, organizational structure and authority, responsibilities, accountability, and implementation of an agency, organization, or laboratory, to ensure the quality of its product and the utility of its product to its users.

Quality System: a structured and documented management system describing the policies, objectives, principles, organizational authority, responsibilities, accountability, and implementation plan of an organization for ensuring quality in its work processes, products, and services. The quality system provides the framework for planning, implementing, and assessing work performed by the organization and for carrying out required quality assurance and quality control.

Quantitation Limit [Reporting Limit, Practical Quantitation Limit]: level, concentration, or quantity of a target variable (i.e. target analyte) below which data is reported as estimated. The quantitation limit may or may not be statistically determined, or may be an estimate that is based upon analyst experience or judgment.

Raw Data: any original factual information from a measurement activity or study recorded in a laboratory notebook, worksheets, records, memoranda, notes, or exact copies thereof that are necessary for reconstructing and evaluating the report of the activity or study.

Reagent Blank (method reagent blank): a sample consisting only of Type I water and reagent(s) without the target analyte(s) or sample matrix, introduced into the analytical procedure at the appropriate point and carried through all subsequent steps to determine the contribution of the reagents and of the involved analytical steps.

Reference Method: a method of known and documented accuracy and precision issued by an organization recognized as competent to do so (EPA, etc.). The reference method is included on the client report.

Sample Tracking: procedures employed to record the possession of the samples from the time of sampling until analysis, reporting, and archiving. These procedures include the use of a Chain of Custody form that documents the collection, transport, and receipt of compliance samples to the laboratory. In addition, access to the laboratory is limited and controlled to protect the integrity of the samples.

Sensitivity: the capability of a method or instrument to discriminate between measurement responses representing different levels (i.e. concentrations) of a variable of interest.

Shall: denotes a requirement that is mandatory whenever the criterion for conformance with the specification requires that there is no deviation. This does not prohibit the use of alternative approaches or methods for implementing the specification so long as the requirement is fulfilled.

Should: denotes a guideline of recommendation whenever noncompliance with the specification is permissible.

Signal to Noise Ratio (S/N): a dimensionless measure of the relative strength of an analytical signal (S) to the average strength of the background instrumental noise (N) for a particular sample.

Spike: a known amount of target analyte added to a blank sample or client sub-sample; used to determine the recovery efficiency or for other quality control purposes.

Standard Deviation: the measure of the degree of agreement (precision) among replicate analyses of a sample. The population standard deviation (n degrees of freedom) should only be used for more than 25 data points; otherwise, when referenced, standard deviation implies sample standard deviation (n-1 degrees of freedom).

Standard Operating Procedure (SOP): a written document which details the manner in which an operation, analysis, or action is performed. The techniques and procedures are thoroughly prescribed in the SOP and are the accepted process for performing certain routine or repetitive tasks.

Supervisor [however named]: the individual designated as being responsible for a particular area or category of scientific analysis. This responsibility includes direct day-to-day supervision of technical employees, supply and instrument adequacy and upkeep, quality assurance/quality control duties and ascertaining that technical employees have the required balance of education, training, and experience to perform the required analyses.

Surrogate (SURR): a substance with properties that mimic the analyte of interest. It is unlikely to be found in environmental samples and is added to them for quality control purposes.

Test Method: adoptions of a scientific technique for a specific measurement problem, as documented in a laboratory SOP or published by a recognized authority.

Traceability: the property of a result of a measurement whereby it can be related to appropriate standards, generally international or national standards, through an unbroken chain of comparisons.

APPENDIX G TECHNICAL DIRECTORS

Name	Department	Degree
James Rhudy	Organics	BA, Molecular Biology; BA, Biochemistry
Matt Sowards	Radiochemistry, Wet Chemistry Manual	BS, Neurophysiology
Steve Pulford	Metals, Clean Room	BS, Chemical Engineering
Billy Grimes	Metals, Inorganic Inst	BA, Biology
Carol Poirot	Wet Chemistry Instrument	BS, Physics; MS, Material Sciences
Lee Thompson	Geochemistry	BS, Microbiology

APPENDIX E

ADEQ DATA QUALIFIERS

ARIZONA DATA QUALIFIERS

(12/11/2000)

(Developed by the Sub-committee of the Arizona Environmental Laboratory Advisory Committee)

Microbiology:

A1 = Too numerous to count.

A2 = Sample incubation period exceeded method requirement.

A3 = Sample incubation period was shorter than method requirement.

A4 = Target organism detected in associated method blank.

A5 = Incubator/water bath temperature was outside method requirements.

A6 = Target organism not detected in associated positive control.

A7 = Micro sample received without adequate headspace.

Method blank:

B1 = Target analyte detected in method blank at or above the method reporting limit.

B2 = Non-target analyte detected in method blank and sample, producing interference.

B3 = Target analyte detected in calibration blank at or above the method reporting limit.

B4 = Target analyte detected in blank at/above method acceptance criteria.

Confirmation:

C1 = Confirmatory analysis not performed as required by the method.

C2 = Confirmatory analysis not performed. Confirmation of analyte presence established by site historical data.

C3 = Qualitative confirmation performed. See case narrative.

C4 = Confirmatory analysis was past holding time.

C5 = Confirmatory analysis was past holding time. Original result not confirmed.

Dilution:

D1 = Sample required dilution due to matrix interference. See case narrative.

D2 = Sample required dilution due to high concentration of target analyte.

D3 = Sample dilution required due to insufficient sample.

D4 = Minimum reporting level (MRL) adjusted to reflect sample amount received and analyzed.

Estimated concentration:

E1 = Concentration estimated. Analyte exceeded calibration range. Reanalysis not possible due to insufficient sample.

E2 = Concentration estimated. Analyte exceeded calibration range. Reanalysis not performed due to sample matrix.

E3 = Concentration estimated. Analyte exceeded calibration range. Reanalysis not performed due to holding time requirements.

E4 = Concentration estimated. Analyte was detected below laboratory minimum reporting level (MRL).

E5 = Concentration estimated. Analyte was detected below laboratory minimum reporting level (MRL), but not confirmed by alternate analysis.

E6 = Concentration estimated. Internal standard recoveries did not meet method acceptance criteria.

E7 = Concentration estimated. Internal standard recoveries did not meet laboratory acceptance criteria.

Hold time:

H1 = Sample analysis performed past holding time. See case narrative.

H2 = Initial analysis within holding time. Reanalysis for the required dilution was past holding time.

H3 = Sample was received and analyzed past holding time.

H4 = Sample was extracted past required extraction holding time, but analyzed within analysis holding time. See case narrative.

BOD:

K1 = The sample dilutions set-up for the BOD analysis did not meet the oxygen depletion criteria of at least 2 mg/L. Any reported result is an estimated value.

K2 = The sample dilutions set up for the BOD analysis did not meet the criteria of a residual dissolved oxygen of at least 1 mg/L. Any reported result is an estimated value.

K3 = The seed depletion was outside the method acceptance limits.

K4 = The seed depletion was outside the method and laboratory acceptance limits. The reported result is an estimated value.

K5 = The dilution water D.O. depletion was > 0.2 mg/L.

K6 = Glucose/glutamic acid BOD was below method acceptance criteria.

K7 = A discrepancy between the BOD and COD results has been verified by reanalysis of the sample for COD.

Laboratory fortified blank/blank spike:

L1 = The associated blank spike recovery was above laboratory acceptance limits. See case narrative.

L2 = The associated blank spike recovery was below laboratory acceptance limits. See case narrative.

L3 = The associated blank spike recovery was above method acceptance limits. See case narrative.

L4 = The associated blank spike recovery was below method acceptance limits. See case narrative.

Note: The L1, L2, L3 & L4 footnotes need to be added to all corresponding analytes for a sample.

Matrix spike:

M1 = Matrix spike recovery was high, the method control sample recovery was acceptable.

M2 = Matrix spike recovery was low, the method control sample recovery was acceptable.

M3 = The accuracy of the spike recovery value is reduced since the analyte concentration in the sample is disproportionate to spike level. The method control sample recovery was acceptable.

M4 = The analysis of the spiked sample required a dilution such that the spike concentration was diluted below the reporting limit. The method control sample recovery was acceptable.

M5 = Analyte concentration was determined by the method of standard addition (MSA).

General:

N1 = See case narrative.

N2 = See corrective action report.

Sample quality:

Q1 = Sample integrity was not maintained. See case narrative.

Q2 = Sample received with head space.

Q3 = Sample received with improper chemical preservation.

Q4 = Sample received and analyzed without chemical preservation.

Q5 = Sample received with inadequate chemical preservation, but preserved by the laboratory.

Q6 = Sample was received above recommended temperature.

Q7 = Sample inadequately dechlorinated.

Q8 = Insufficient sample received to meet method QC requirements. QC requirements satisfy ADEQ policies 0154 and 0155.

Q9 = Insufficient sample received to meet method QC requirements.

Q10 = Sample received in inappropriate sample container.

Q11 = Sample is heterogeneous. Sample homogeneity could not be readily achieved using routine laboratory practices.

Duplicates:

R1 = RPD exceeded the method control limit. See case narrative.

R2 = RPD exceeded the laboratory control limit. See case narrative.

R3 = Sample RPD between the primary and confirmatory analysis exceeded 40%. Per EPA Method 8000B, the higher value was reported.

R4 = MS/MSD RPD exceeded the method control limit. Recovery met acceptance criteria.

R5 = MS/MSD RPD exceeded the laboratory control limit. Recovery met acceptance criteria.

R6 = LFB/LFBD RPD exceeded the method control limit. Recovery met acceptance criteria.

R7 = LFB/LFBD RPD exceeded the laboratory control limit. Recovery met acceptance criteria.

R8 = Sample RPD exceeded the method control limit.

R9 = Sample RPD exceeded the laboratory control limit.

Surrogate:

S1 = Surrogate recovery was above laboratory acceptance limits, but within method acceptance limits.

S2 = Surrogate recovery was above laboratory and method acceptance limits.

S3 = Surrogate recovery was above laboratory acceptance limits, but within method acceptance limits. No target analytes were detected in the sample.

S4 = Surrogate recovery was above laboratory and method acceptance limits. No target analytes were detected in the sample.

S5 = Surrogate recovery was below laboratory acceptance limits, but within method acceptance limits.

S6 = Surrogate recovery was below laboratory and method acceptance limits. Reextraction and/or reanalysis confirms low recovery caused by matrix effect.

S7 = Surrogate recovery was below laboratory and method acceptance limits. Unable to confirm matrix effect.

S8 = The analysis of the sample required a dilution such that the surrogate concentration was diluted below the method acceptance criteria. The method control sample recovery was acceptable.

S9 = The analysis of the sample required a dilution such that the surrogate concentration was diluted below the laboratory acceptance criteria. The method control sample recovery was acceptable.

S10 = Surrogate recovery was above laboratory and method acceptance limits. See Case narrative.

Method/analyte discrepancies:

T1 = Method promulgated by EPA, but not by ADHS at this time.

T2 = Cited ADHS licensed method does not contain this analyte as part of method compound list.

T3 = Method not promulgated either by EPA or ADHS.

T4 = Tentatively identified compound. Concentration is estimated and based on the closest internal standard.

Calibration verification:

V1 = CCV recovery was above method acceptance limits. This target analyte was not detected in the sample.

V2 = CCV recovery was above method acceptance limits. This target analyte was detected in the sample. The sample could not be reanalyzed due to insufficient sample.

V3 = CCV recovery was above method acceptance limits. This target analyte was detected in the sample, but the sample was not reanalyzed. See case narrative.

V4 = CCV recovery was below method acceptance limits. The sample could not be reanalyzed due to insufficient sample.

V5 = CCV recovery after a group of samples was above acceptance limits. This target analyte was not detected in the sample. Acceptable per EPA Method 8000B.