UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 6
1201 ELM STREET, SUITE 500
DALLAS, TEXAS 75270

September 26, 2022

Ms. Tammie J. Hynum, Quality Assurance Manager
Office of Land Resources
Arkansas Division of Environmental Quality
5301 Northshore Drive
North Little Rock, AR 72118-5317

Dear Ms. Hynum:

The Resource Conservation and Recovery Act (RCRA) Quality Assurance Project Plan (QAPP) for Sampling and Analysis of Hazardous Waste, QTRAK number 22-396 has been reviewed and approved. The expiration date is September 30, 2025. Enclosed is a copy of the signature page for your file.

We look forward to continuing to work with you and your staff. If you have questions about this matter, please contact me at (214) 665-2268 or Ms. Emily Jimenez, RCRA Project Officer, at (214) 665-2176.

Sincerely,

Althea Foster
Chief
RCRA Grants & Brownfields Section

Enclosure

cc: Ms. Lessie Redican, ADEQ QA Officer
Ms. Penny Wilson, OLR Compliance Monitoring, ADEQ

ARKANSAS
ENERGY & ENVIRONMENT | ENVIRONMENTAL QUALITY

Via e-mail: Jimenez.Emily@epa.gov

August 4, 2022

Emily Jimenez (LRCD)
U.S. EPA Region 6
1201 Elm Street
Suite 500
Dallas, Texas 75270

RE: RCRA QAPP for Sampling and Analysis of Hazardous Waste for FY2023

Dear Ms. Jimenez:

Enclosed is a copy of the Arkansas Department of Energy & Environment Division of Environmental Quality RCRA Quality Assurance Project Plan (QAPP) for FY2023. Please review and provide any comments to me at the address below or at hynum@adeq.state.ar.us . Upon receipt, please notify me of the Q-Trak Number assigned.

Once the QAPP is reviewed and approved, please return a signed copy for our files. If you have any questions, please contact me at (501) 682-0831.

Sincerely,

Tammie J. Hynum
Quality Assurance Manager
Office of Land Resources

Enclosure

cc: ADEQ RCRA Program File (w/o attachment)
Jonathan Westmoreland, AEE QA Officer, (w/o attachment)
Penny Wilson, OLR Hazardous Waste Compliance Monitoring, DEQ
Melissa Smith, EPA Region 6

Division of Environmental Quality
5301 Northshore Drive, North Little Rock, AR 72118-5317
adeq.state.ar.us

RESOURCE CONSERVATION AND RECOVERY ACT

QUALITY ASSURANCE PROJECT PLAN
for
SAMPLING AND ANALYSES
of
HAZARDOUS WASTES

Arkansas Department of Energy & Environment
Division of Environmental Quality
Office of Land Resources
5301 Northshore Drive
North Little Rock, Arkansas 72118
(501) 682-0744

APPROVAL:

Penny J. Wilson Penny J. Wilson ______ Date: 7-28-2022
Hazardous Waste Compliance Branch Manager, OLR

Scott McWilliams ______ Date: 7/25/2022
Compliance Program Manager, OLR

Nick Jones ______ Date: 8/4/2022
Senior Operations Manager, Office of Land Resources

Tammie J. Hynum ______ Date: 7/28/2022
Quality Assurance Manager, Office of Land Resources

Jonathan Westmoreland ______ Date: 7/27/22
AEE Quality Control Manager, Office of Chief Technical Officer

Emily Jimenez ______ Date: 9/27/2022
U.S. EPA LRCD, RCRA Grants & Brownfields Section Project Officer

for

Melissa Smith ______ Date: 9/26/2022
U.S. EPA Chief, RCRA, Brownfields and Solid Waste Branch

for

Harry Shah ______ Date: 9/26/2022
U.S. EPA Chief, RCRA Permits and Solid Waste Branch

Anhmai Pham AnhmaiPham ______ Date: 8/17/2022
U.S. EPA Technical Review

Effective Date of the Plan: October 1, 2022

Expiration Date: September 30, ~~2023~~ 2025

Table of Contents

Introduction

This document comprises the Quality Assurance Project Plan (QAPP) for implementing the RCRA Hazardous Waste Management Program pursuant to the Federal Resource Conservation and Recovery Act (RCRA) of 1976, as amended by the Hazardous and Solid Waste Amendments (HSWA) of 1984, and the Arkansas Hazardous Waste Management Act (Act 406 of 1979, as amended) and was developed by the Division of Environmental Quality Office of Land Resources. The QAPP outlines the general approach used by the Office of Land Resources to assure that information (data) generated and developed during sampling projects and events is accurate, precise, complete, and representative.

The Federal Resource Conservation and Recovery Act, in establishing a federal program to regulate hazardous waste management activities, provides for states like Arkansas to implement the RCRA program at state level and to receive federal monies to do so, as long as the State implements the program under specific guidelines. One of those guidelines is that the State develops and implements this QAPP.

This QAPP will become effective October 1, 2022 and remain in effect through September 30, 2023. The Plan will be reviewed at least annually, and any necessary revisions and updates will be submitted to U.S. EPA Region 6.

This QAPP is general in nature in order to accommodate the wide and highly variable range of circumstances under which the DEQ Office of Land Resources conducts waste and environmental media sampling and analysis activities in support of the hazardous waste management program. Samples collected in the course of implementing the RCRA program are collected in a variety of activities (hereafter, "projects") including, but not limited to, groundwater monitoring, complaint and spill investigations, compliance evaluation inspections, enforcement case development, and closure and remedial activities.

In connection with the various QAPPs developed by the Division's media offices that generate sampling data, the Division has developed and implemented an agency-wide Quality Management Plan (QMP). The QMP (submitted separately) outlines the Division's approach to quality assurance with respect to the generation of environmental data.

Section A1
Distribution List

The following individuals will be provided a copy of this QAPP:

DEQ Personnel:
Nick Jones, P.E., Senior Operations Manager, Office of Land Resources (OLR)
Tammie J. Hynum, Quality Assurance Manager, OLR
Scott McWilliams, Compliance Program Manager, OLR
Penny J. Wilson, Hazardous Waste Compliance Branch Manager, OLR
Ann Blake, Inspector Supervisor, OLR
Brad Toler, Inspector Supervisor, OLR
Hunter Moore, Inspector, OLR
Ashley Hahn, Inspector, OLR
Marium Dupree, Inspector, OLR
Wesley Miller, Inspector, OLR
Charles Hurt, P.E., Engineer Supervisor, OLR
Lyuquin Liu, Engineer, OLR
William Smith, Engineer, OLR
Henry McCain, Engineer, OLR
Dianna Kilburn, P.G., Assessment and Remediation Operations Manager, OLR
Blake Whittle, P.G., Groundwater Branch Manager, OLR
Bill Sadler, P.G., Geologist Supervisor, OLR
David Gillespie, P.G., Geologist, OLR
Candice Brock, Geologist, OLR
Anna Griffiths, Geologist, OLR
Jordan Anderson, Geologist, OLR
Grant Kneebone, Geologist, OLR
Matthew Carey, P.G., Geologist Supervisor, OLR
Jennifer Pearson, P.G., Geologist, OLR
Mark Moix, P.E., Engineer OLR
Clay McDaniel, Engineer, OLR
Douglas Ritchie, Environmental Epidemiology Supervisor, OLR
Tyler Wright, Environmental Epidemiologist, OLR
Megan Ruffin, Environmental Epidemiologist, OLR
Jonathan Westmoreland, AE&E Quality Control Manager

U.S. EPA Region 6 Personnel:
Emily Jimenez, LRCD, RCRA Grants & Brownfields Section Project Officer
Sala N. Senkayi, Ph.D., Region 6 Acting Quality Assurance Officer

Section A2
Project/Task Organization

The primary organization generating and interpreting sampling data for the RCRA program and its associated projects is the DEQ's Office of Land Resources (OLR).

The OLR maintains a relationship with the DEQ OWQ Laboratory to coordinate the collection and analysis of environmental samples. It may be necessary for the OLR to contract with a private laboratory to analyze a sample. In this event, only a laboratory with a current National Environmental Laboratory Accreditation Certification (NELAC) will be used for this purpose.

All project activities will be performed by or under the supervision of Division personnel. Samples from monitoring wells will be collected by geologists or inspectors in the OLR. Samples for hazardous waste analysis, as well as samples taken during the course of an on-site inspection, will be collected by hazardous waste inspectors, geologists, or engineers in the OLR.

The coordinator for all field activities that involve the hazardous waste inspectors are the Office of Land Resources' RCRA Inspector Supervisors. In his/her capacity as field coordinator, the Inspector Supervisors will be responsible for:

- Overall management of each investigation or inspection;
- Ensuring that all field QA requirements are being performed;
- Approval of all sampling plans and requests for analyses; and
- Determining the acceptability of and approving final sampling data, information, and related products for compliance assurance and enforcement purposes.

The coordinator for those field activities that involve sampling monitoring wells is the Geology Supervisor. In his/her capacity as field coordinator for groundwater monitoring and evaluations, the Geologist Supervisor will be responsible for:

- Overall management of each investigation or inspection;
- Ensuring that all field QA requirements are being performed;
- Approval of all sampling plans and requests for analyses; and
- Determining the acceptability of and approving final sampling data, information, and related products for groundwater and related remedial or corrective action purposes.

The AE&E Quality Control Officer is responsible for the overall QA program for the Department.

The QA Officer will be responsible for:

- Being the official organizational contact for all laboratory related QA matters for the project;
- Ensuring that all required laboratory QA activities are performed in accordance with the recommended guidelines; and
- Preparing an end of the year status report showing the quality and type of QA activities that were performed by the DEQ Laboratory personnel or a NELAC-laboratory.

Within the OLR, the Hazardous Waste Compliance Branch Manager has been designated as the Quality Assurance Coordinator, whose primary duties involve oversight of the RCRA Compliance Monitoring program.

The overall Division organization is shown at Appendix 1. This organization scheme includes all personnel involved in the project. The detailed organization of the Office of Land Resources is shown in Appendix 1.

All personnel in the OLR RCRA branches and the persons overseeing those branches act as principal data users and decision-makers within the RCRA program. Each and all of these individuals are routinely called upon to generate and interpret data with respect to the RCRA activities in which they are engaged.

Final laboratory results are reviewed by Laboratory personnel before being forwarded to the OLR staff person who conducted the sampling event. It is up to the OLR personnel to review and interpret the laboratory analytical data. All sampling results which are used in any type of regulatory decision-making will be compiled into a draft report (usually an inspection report) which is then reviewed by other staff members for completeness and consistency. The review loop includes the project manager's immediate supervisor, the relevant Branch Manager, and the Senior Operations Manager.

Section A3
Background

In the implementation of the hazardous waste management program and its associated waste projects, the OLR routinely collects samples of wastes and environmental media for laboratory analysis. Such samples are collected under a variety of projects, including, but not limited to, groundwater monitoring, complaint and spill investigations, compliance evaluation inspections, and closure and remedial activities. The data collected is primarily used by compliance monitoring, permitting, corrective action and risk assessment staff to determine if hazardous constituents are present at levels of concern, as defined by the Arkansas Pollution Control & Ecology Commission's Rule No. 23 and the Arkansas Hazardous Waste Management Code. Rule No. 23 is equivalent in force and effect to the federal RCRA regulations at 40 CFR 260-268, 270, 273, and 279.

The objective of this QAPP is to make available a record that will provide guidance to insure that environmental samples are properly collected, transported, and analyzed in such a manner that the data obtained from such samples can be used with confidence in evaluating environmental situations, thus reducing the risk of the decision-making on the basis of incomplete or erroneous data.

It is intended that the QAPP will serve as a document providing specific requirements that will be followed in all sampling and subsequent analyses.

DEQ sampling personnel will record all pertinent information relating to QA/QC field operations in bound logbooks.

DEQ laboratory personnel or a NELAC-laboratory will likewise keep a record of all pertinent information relating to QA/QC laboratory operations in bound lab books or in electronic form that is easily accessible.

In determining if hazardous constituents are present at significant regulatory levels, the RCRA program personnel of the OLR are the functional decision-makers, in that any RCRA employee of the OLR who engages in hazardous waste projects might, at any time, conduct a RCRA inspection or investigation, and in that capacity might be called upon to generate data through sampling, and would be called upon to interpret that data to determine if hazardous constituents were present in the sample(s). In the same manner, RCRA staff supervisors, branch managers, and the senior operation manager play a significant role in this decision-making process, although it is routinely the lead inspector, engineer, or geologist who makes most preliminary recommendations.

The principal customers of the RCRA sampling results and the associated data are primarily the businesses and the owners and managers of the businesses that are inspected or investigated, as well as members of the public who may be affected by the activities of these businesses.

Section A4
Project/Task Description

Sampling Data in the Hazardous Waste Management Program
Laboratory support is an integral part of the RCRA Hazardous Waste Program. It shall be the responsibility of the laboratory personnel to analyze samples that are generated within the confines of the RCRA Hazardous Waste Program. Sampling data can be used to determine compliance with RCRA permit conditions, environmental impact of releases from RCRA facilities and waste stream identification. Sample data also is used for evaluating the efficiency of new treatment technologies and the effectiveness of remediation technologies in regard to meeting "action levels" or closure performance standards and for enforcement or legal proceedings. Samples can come from several sources: waste samples, environmental media samples, and groundwater samples.

Waste samples are generated as a result of site inspections. The analyses performed on waste samples are used to determine whether the sampled waste is a hazardous waste in accordance with APC&EC Rule No. 23 Section 261.

Environmental samples are samples of water, sediment, or soil taken to determine the extent of contamination from hazardous waste constituents.

Groundwater samples are taken from monitoring wells as part of a site inspection process. The groundwater samples can serve as compliance monitoring samples in the sense that they can substantiate or refute any data the inspected facility or site has collected on such wells.

Applicable technical, regulatory, or program-specific quality standards, criteria, and objectives are established by the RCRA program standards set forth in 40 CFR Parts 260 through 279.

These same standards are adopted verbatim in the equivalent sections of the Arkansas Pollution Control & Ecology Commission's Rule No. 23 (Hazardous Waste Management).

State Compliance Monitoring and Enforcement Program:
An effective and efficient compliance monitoring and enforcement program is critical to the success of the Arkansas Hazardous Waste Program. The compliance monitoring system as outlined in this section is designed to assess and monitor compliance with facility standards and generator and transporter requirements equivalent to:

- Rule 23 § 262, "Standards Applicable to Generators of Hazardous Waste"
- Rule 23 § 263, "Standards Applicable to Transporters"
- Rule 23 § 264 and 265, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," "Standards Applicable to Existing Facilities with Interim Status," and any additional standards imposed by Acts 406, 1098, and the State Hazardous Waste Code.
- Rule 23 § 266, "Standards for the Management of Specific Hazardous Waste and Specific Types of Hazardous Waste Management Facilities."
- Rule 23 § 267, "Standards for Owners and Operators of Hazardous Waste Facilities Operating Under a Standardized Permit."
- Rule 23 § 268, "Land Disposal Restrictions."
- Rule 23 § 270, "Administered Permit Programs: The Hazardous Waste Permit Program."
- Rule 23 § 273, "Standards for Universal Waste Management."
- Rule 23 § 279, "Used Oil Management Standards."

DEQ has primary responsibility under the State hazardous waste management program to inspect and bring enforcement action against any hazardous waste generator, transporter, or facility in Arkansas.

DEQ agrees to take timely and appropriate enforcement action, as defined in the 2003 Hazardous Waste Enforcement Response Policy, against all persons in violation of generator and transporter standards (including manifest requirements), facility standards, Permit requirements, compliance schedules, and all other program requirements, including violations detected by State or Federal compliance inspections. Compliance monitoring activities and priorities will be specified in the annual State grant work program and shall be consistent with all applicable Federal requirements and with DEQ's Program Description. DEQ will maintain procedures for receiving and ensuring proper consideration or information about violations submitted by the public.

DEQ will retain all records for at least five (5) years unless there is an enforcement action pending, in which case the records will be retained for at least ten (10) years after resolution of the administrative case. All records will be maintained in accordance with DEQ's Records Retention Policy.

Frequency of Inspections
Frequencies of Compliance Evaluation Inspections (CEI), Groundwater Monitoring Evaluations (GME), and Operation and Maintenance (OAM) inspections are coordinated via the annual state

grant workplan. The inspection universe is defined as all facilities active in RCRAInfo, and is coordinated between DEQ and EPA Region 6 annually.

Compliance Monitoring

The first phase of the enforcement program is monitoring facilities to verify that they comply with RCRA's regulatory requirements. This monitoring serves several purposes. It allows the Division and EPA to find out which facilities are not in compliance. It also allows EPA and the State to assess the effectiveness of specific legal actions, such as administrative orders, that may have been taken against a handler. Also, the overall compliance monitoring program allows EPA to evaluate the effectiveness of State programs and to monitor nationwide compliance with RCRA. Finally, monitoring acts as a deterrent, encouraging compliance with the regulations by making non-compliers susceptible to enforcement actions.

Inspections

The primary method of collecting compliance monitoring data is through an inspection. The inspection will include a formal visit to the facility, a review of records, observation of operations, and potentially collecting samples. In addition to supplying information for enforcement proceedings, inspections are used to gather data to assist EPA in the development of RCRA regulations, and to help EPA track program progress and accomplishments.

Inspectors from the Compliance Branch or geologists from the Groundwater Branch conduct inspections. In instances where criminal activity is suspected, the Arkansas State Police or EPA's Criminal Investigation Division (CID) may become involved. Similarly, the Arkansas Highway Police and the Department of Transportation (DOT) may participate where waste transporters are involved.

The Hazardous Waste Management Act provides the authority for conducting inspections. This Act allows DEQ inspectors to enter any premises where hazardous waste is handled to examine records and take samples of the wastes.

Types of Inspections

A number of different types of inspections are conducted under the authority of the RCRA program. Inspections may be conducted by EPA, an authorized State, or both. Typically, either the State or EPA will assume overall responsibility, or the lead, for conducting the inspection. The different inspection types are explained below:

1. Compliance Evaluation Inspection (CEI) - These are routine inspections of hazardous waste generators, transporters, and TSDFs to evaluate compliance with the requirements of RCRA. CEIs encompass a file review prior to the site visit, an on-site examination of generation, treatment, storage or disposal areas, a review of records, and an evaluation of the facility's compliance with the requirements of RCRA. Sampling may be conducted during a CEI.

2. Focused Compliance Inspections (FCI) - This is an on-site inspection that addresses only a specific portion or Subpart of the RCRA regulations or authorized State regulations/programs. Some examples of an FCI are a Subpart CC inspection, BIF

inspection, Universal Waste Rule inspection, closure verification inspection, training inspections, etc.

3. Groundwater Monitoring Evaluations (GME) - The GME is conducted by geologists from the OLR Groundwater staff to ensure that groundwater monitoring systems are designed and function properly at RCRA land disposal facilities. GMEs include sampling and analysis of the facility's groundwater monitoring system and hydrogeological conditions and evaluate the facility's sampling and analysis methods and procedures.

4. Operations and Maintenance Inspection (OAM) - Many land disposal facilities close with waste in place. The purpose of OAM inspections is to ensure that groundwater monitoring and other systems continue to function properly after a land disposal facility has closed. OAM inspections are usually conducted by the Groundwater Branch at facilities that have already received a thorough evaluation of the groundwater monitoring system under a GME inspection.

Conducting the Inspection

Inspections, whether scheduled or pursuant to a citizen complaint are conducted on a no-notice basis so as to more closely ascertain the day-to-day operations of a facility. GMEs and OAMs are the exception to the no-notice rule. These groundwater inspections are coordinated with the facility to allow for observation of routine sampling events and methods and allowing for the potential to split samples during the inspection. All inspections and investigations are conducted in a courteous and professional manner. Prior to conducting an inspection and/or an investigation, the inspector familiarizes himself with the facility to be visited. This is done by reviewing all pertinent files regarding the facility.

During the site visit, the inspector makes a visual inspection of the hazardous waste generation and waste management locations. He/she also visually inspects the process area and grounds surrounding the manufacturing building(s) and waste management area(s). The purpose of this "walk-through" is to verify:

1. Physical compliance with waste management requirements.
2. Proper and accurate identification, labeling, and handling of all hazardous wastes generated or handled.
3. Approximate volume of wastes generated and/or handled.

During the course of a CEI, DEQ inspectors examine all hazardous waste management processes and waste streams which apply at that specific facility. Inspection checklists are used to insure thorough coverage of each inspected area.

All notes taken during the course of an inspection or investigation are recorded in a bound field logbook with sequentially numbered pages. These field notes are the basis for writing the resulting report, therefore entries must be dated, legible, and accurate, and contain only facts or observations. Notes must be of sufficient detail to recreate the events at the facility during the writing of the report or subsequent legal testimony, if necessary. The logbook is also used to document photographs and samples taken during the inspection. The logbook is kept in the physical possession of the inspector or in a secure location at all times. Checklists may be used to ensure all relevant data is obtained during the inspection.

Photographs taken during inspections, as well as the analytical results of samples taken, are included in the inspection report. Photographs taken during the inspection are retained in accordance with DEQ's Records Retention Policy.

Procedures for sampling during inspections and investigations are documented in this *Quality Assurance Project Plan for Sampling and Analyses of Hazardous Waste*, which is updated annually in accordance with the State's RCRA grant workplan. Additional sampling procedures as well as analytical techniques are detailed in SW-846.

All data produced are calculated according to the referenced sampling or analytical procedure and are reported in the appropriate units of mass, volume, or concentration. QA checkpoints are set up in the laboratory to check the validity of data.

The DEQ OWQ Laboratory participates in two performance testing studies using an USGS (United States Geological Survey) or TNI (The NELAC Institute) approved provider for each analytical parameter annually. These performance testing check samples and inter-laboratory studies constitute an external performance and system audit of the programs addressed in this Plan.

Field activity performance is audited by EPA Region 6. Field personnel attend EPA-sponsored sampling training classes and are further evaluated during oversight inspections.

Section A5
Data Quality Objectives (DQOs) for Measurement Data

The objective of this quality assurance plan is to provide sampling and analysis information (data) that is as complete as possible with the precision and accuracy necessary for proper interpretation. The data must also be representative of the media and conditions being measured, and must be calculated and reported in units which allow comparison of data bases among organizations. The ambient data is evaluated by statistical techniques for trends and is compared to listed concentration levels for identifying hazardous wastes and/or treatment standards. Compliance data is compared to permit or regulatory limits to verify compliance. The quality of the data should be sufficient to support specific decisions or regulatory actions. Errors resulting from faulty quality assurance measures could skew trend analysis and result in inappropriate application of the Division's work efforts for correcting and resolving problems. Errors in compliance data could additionally lead to inappropriate enforcement actions.

The geographical scope of the state's various RCRA projects encompasses the entire State of Arkansas. Decisions and conclusions made in the various RCRA projects are made in accordance with the RCRA regulations as adopted in the most current edition of Rule No. 23 (Hazardous Waste Management).

Most RCRA sampling projects are carried out in accordance with program areas that are subject to completion deadlines. For example, any sampling event which results in an enforcement action will be subject to completion time frames specified in the State/EPA Region 6 Enforcement Memorandum of Understanding and EPA's Enforcement Response Policy. Sampling events which take place in conjunction with environmental complaints are also subject to resolution time frames. Therefore, the OLR invests substantial time and energy to produce high quality data while adhering to the state and federal project-specific time constraints.

The primary use for RCRA sampling data is to determine if any hazardous constituents or substances are present at significant regulatory levels. This data may also be used to assess what, if any, toxic effects might be present that would pose a threat to the surrounding environment and that environment's natural and human population.

The users of this data are primarily DEQ RCRA personnel. However, other personnel may also benefit from the data generated by the OLR's sampling projects.

Data required by the RCRA program is that which shows whether (or not) hazardous constituents are present in the sample medium. Sample types, quantities, and matrices are specified at Section B2, which sets forth sample container volumes and types needed for given matrices of water, soil, and containerized wastes.

Action levels and standards on which decisions will be made are those specified in regulatory language contained in APC&EC Rule No. 23.

Specific measurement performance criteria are most often set forth in APC&EC Rule No. 23 Sections 260-279, or in individual permits or orders. Any testing or analysis conducted pursuant to this plan must therefore satisfy the regulatory requirements set forth in APC&EC Rule No. 23 (Hazardous Waste Management).

Quantitative levels are set out in APC&EC Rule No. 23 Sections 260-268 and 279 (e.g., testing might be conducted to see if identified hazardous constituents are present above those specified in APC&EC Rule No. 23 Section 261.21-24; or if any levels of a listed hazardous constituent are present as set forth in APC&EC Rule No 23 Section 261.30-33).

In addition to the quantitative levels set by regulations, sampling is sometimes conducted to simply identify what constituents might be present, and at what levels. Typically, these cases involve situations where a spill or release has occurred or a hazardous waste management unit is being closed. Once the presence and levels of constituents of concern have been identified, epidemiologists and other decision-makers can determine to what extent clean-up is needed. In these cases, quantitative goals may vary, depending whether the responsible party is conducting a "clean" closure or a "health-based risk" closure.

Section A6
Special Training and Certifications

The DEQ Office of Land Resources has a trained technical staff capable of ensuring that QA efforts are carried out efficiently and accurately. Office of Land Resources personnel are not permitted to enter a potential or known hazardous waste facility without an escort until forty (40) hours of Hazardous Waste Operations and Emergency Response (HAZWOPER) training has been attended in accordance with the requirements of 29 CFR 1910.120(e). Hazardous Waste personnel are also required to obtain eight (8) hours of refresher training in accordance with 29 CFR 1910.120(e) during each calendar year. Additionally, all technical staff in the RCRA Program is required to attend at least twenty-four (24) hours of Hazardous Waste Sampling training.

Additional training programs completed by OLR personnel to enhance their knowledge regarding hazardous substances may include, but are not limited to, groundwater monitoring, risk assessment, data management, data quality objectives, RCRA workshops, environmental investigations, time management, instructor training, conducting effective meetings, and CPR. Documentation is made upon receiving certification of training. Training records are kept by the DEQ Human Resources Section.

Job qualifications for the OLR's management and technical staff personnel include a Bachelor of Science degree in a physical or environmental science, Engineering, Geology, and/or Management.

Laboratory
All analyses will be performed by either DEQ OWQ Laboratory or NELAC-laboratory by analysts who have the proper familiarity and documentation of training to carry out the appropriate analyses.

Training on the use of new scientific instruments or methodologies will be provided by the vendors supplying the new equipment. Analysis of performance testing samples supplied by a TNI or USGS approved provider will demonstrate the proficiency of laboratory staff.

Section A7
Documentation and Records

Site-specific QAPPs may be developed for some RCRA inspections conducted which require samples to be taken. Additional plans that shall be developed for any RCRA inspections that require samples to be collected are a Sampling and Analysis Plan (SAP) and a Health and Safety Plan (HASP). These plans, which may be combined, will ensure thorough planning prior to the commencement of field activities. Clear and concise plans are essential for gathering quality analytical data and making sound decisions.

The design of each site-specific sampling plan will be based on the objectives of the RCRA Inspection. These plans will be made available to all DEQ personnel involved in the inspection activities. Documentation will be maintained showing the plans have been reviewed and are understood by personnel involved.

At the time of sample collection, Inspection field personnel will record collection procedures, locations, sample types, and assigned sample numbers in bound logbooks. Any deviations from the approved Sampling and Analysis Plan (SAP) shall be documented within the bound logbook. Throughout the sampling event, field personnel will maintain chain-of-custody forms. Sample collection types can include grab samples, composite samples, split samples, duplicate samples, background samples, and control samples.

The paperwork that is required for sampling activities includes all of the following:

- Sample Tags
- Chain-of-Custody Form
- Custody Seals

Inspection personnel shall specify on the Sample Tag the analytical parameters that are to be analyzed. All laboratory work will be performed by the DEQ OWQ Laboratory or a NELAC-laboratory in accordance with the laboratory's QA Plan.

After the laboratory has completed the required analytical services, the laboratory will complete a data package that will be submitted to the Inspection personnel. Data, including raw data, bench sheets, QC checks, instrument printouts, sample chain-of-custody forms, and Laboratory Request forms, if required, shall be collated and filed, available for use, for at least seven (7) years.

Turnaround times are based upon the number of samples currently being analyzed and the analyses requested on these samples. Completion of analyses on a given sample set is often done incrementally rather than in one continuous unit of time.

All samples are extracted and/or analyzed within the holding times outlined in the appropriate methods found in SW-846. Any quality control excursions occurring during sample preparation or analysis are documented by completion of a Corrective Action/Preventive Action (CAPA) Report (or equivalent) by laboratory personnel. Affected results are properly qualified, if needed, and the effect of the data excursion is discussed in the case narrative of the final report. CAPA reports are electronically generated and retained as part of the data package.

A final laboratory report, based on the data packet above, will be written for each compliance sampling inspection upon completion of the analyses and data review. This report will include all results of the analyses, description of any difficulties, and a copy of the chain-of-custody form. One copy of the report will be forwarded to the project manager; another will be retained electronically by the laboratory.

All records and documentation will be maintained in the applicable facility's file for a minimum of three (3) years. In cases where the documentation is used in an enforcement case or any other litigation, the record must be kept on file for three (3) years following the final resolution of the case or other litigation.

All laboratory data, including raw spectral data, data recorded in bound lab books, QC check sheets, and sample chain of custody forms will be stored, some electronically, and available for inspection for at least seven years.

The raw data generated by instrumentation is stored electronically as archived data and is backed up daily on the AEE-DEQ server. All other data is stored by personnel in the laboratory either electronically or in hard-copy format. When a NELAC-laboratory is utilized, the raw data generated by instrumentation will be stored electronically as archived data and backed up on an equivalent server.

Section B1
Sampling Process Design

General Experimental Design

Sampling project designs and activities will be carried out in accordance with the procedures at Appendix 2 of this QAPP. A site-specific sampling plan which adequately satisfies the regulatory and scientific objectives of the data usage will be developed for each sampling event. The OLR lead inspector for the facility or the geologist responsible for the facility is responsible for preparing a site sampling and safety plan and determining which sampling procedures will be used.

Sampling points and frequencies, field screening techniques, criteria for sample selection, collection and storage of locational data, field decontamination procedures and needed materials, and sampling equipment requirements will be determined in accordance with Section B2 below, and Appendix 2 of this plan.

Classification of Measurements

All measurements for this project are classified as "critical". No "informational purposes only" samples are anticipated.

Measurement Validation Procedures

Only normal sample matrices will be involved in these projects. All sampling and analytical methods used will be EPA-approved. As such, no additional method validation studies are planned.

Measurement of Process Conditions

No process conditions will be measured for this project.

Section B2
Sampling Methods Requirements

Hazardous waste and groundwater samples will be collected according to the criteria in Appendix 2. The following containers will be utilized during sampling:

Sample Requirements for Water

ANALYSIS	CONTAINER	PRESERVATIVE
Volatiles*	2-40ml vials with Teflon-lined septum caps (no air bubbles in the sample	Cool to ≤6° C
Semi-Volatiles*	2-½gal. or 4-1 Liter amber glass bottles with Teflon-liner	Cool to ≤6° C
Pesticides/PCBs*	2-½gal. or 4-1 Liter amber glass bottles with Teflon-liner	Cool to ≤6° C

ANALYSIS	CONTAINER	PRESERVATIVE
Metals	1-125ml plastic bottle containing Nitric Acid for preservative	Cool to ≤6° C
Cyanides*	1-1 Liter polyethylene bottle	Cool to ≤6° C; add NaOH to pH >12

*AEE Laboratory Services does not analyze for these parameters. Samples requiring these parameters must be subcontracted to an AEE-DEQ accredited commercial lab for analysis.

Sample Requirements for Containerized Liquid Waste

ANALYSIS	CONTAINER	PRESERVATIVE
Volatiles*	2-40ml vials with Teflon-lined septum caps (no air bubbles in the sample	Cool to ≤6° C
Semi-Volatiles*	2-½gal. or 4-1 Liter amber glass bottles with Teflon-liner	Cool to ≤6° C
Pesticides/PCBs*	2-½gal. or 4-1 Liter amber glass bottles with Teflon-liner	Cool to ≤6° C
Metals	1-125ml plastic bottle containing Nitric Acid for preservative	Cool to ≤6° C
Cyanides*	1-1 Liter polyethylene bottle preserved with NaOH	Cool to ≤6° C

*AEE Laboratory Services does not analyze for these parameters. Samples requiring these parameters must be subcontracted to an AEE-DEQ accredited commercial lab for analysis.

Sample Requirements for Solid Waste Samples and Soils

ANALYSIS	CONTAINER	PRESERVATIVE
Volatiles*	1-8oz. wide mouth glass with Teflon liner	Cool to ≤6° C
Semi-Volatiles*	1-8oz. wide mouth glass with Teflon liner	Cool to ≤6° C
Pesticides/PCBs*	1-8oz. wide mouth glass with Teflon liner	Cool to ≤6° C
Metals	1-8oz. wide mouth glass with Teflon liner	None
Cyanides*	1-8oz. wide mouth glass with Teflon liner	Cool to ≤6° C

Reference: SW-846
*AEE Laboratory Services does not analyze for these parameters. Samples requiring these parameters must be subcontracted to an AEE-DEQ accredited commercial lab for analysis.

Containers used to hold hazardous waste samples and groundwater samples will be wide mouth glass jars (half-pint, pint), narrow mouth liter bottles containing caps with Teflon cap liners, volatile organic vials containing caps with Teflon septa, and 250 ml plastic bottles for samples requiring metal analyses. Glass containers will be used except when the waste is suspected to contain strong alkali or hydrofluoric acids. In these cases, plastic containers will be used. The wide mouth glass jars, narrow mouth liter bottles, 250 ml plastic bottles used to contain samples for metal analyses and volatile organic vials are purchased pre-cleaned.

General Guidance for Sampling Events
The following guidelines will be employed when sampling:

Sampling personnel should either be familiar with or have in their possession a sampling plan before they attempt to take any samples. The following items should be completed before each sampling event:

1. Before sampling, the reason for sampling must be determined (unless an emergency situation has occurred). An example would be to determine if a release or solid waste was a RCRA-regulated hazardous waste.
2. Before sampling, the proposed locations of the samples must be determined (unless an emergency situation has occurred).
3. Before sampling, the specific sampling methods to be used to collect the samples must be recorded in the inspector's field logbook.
4. Before sampling, the analytical parameters and specific methods required for each sample must be determined (unless an emergency situation has occurred).
5. Prior to taking samples, Office of Land Resources personnel will coordinate with Laboratory and Monitoring Services regarding the type and amount of samples to be taken.

The following procedures should be employed as part of the sampling protocol:

1. The Office of Land Resources personnel will document, in a field logbook, sampling conditions present in the field and the sampling methods that are being employed.
2. The Office of Land Resources personnel will insure that all sampling equipment he/she expects to use is clean and in good working order. If the equipment is dirty, the inspector will use the General Guidance for Decontamination procedures to prevent possible carry-over contamination from one sample to another:
3. The number of samples taken will depend on the waste being sampled and the type of container that is holding the waste.

The following table shows the maximum holding time for each matrix:

Matrix Type	Type of Analyses	Holding Time (if properly preserved)
Concentrated waste samples	Volatile Organics	14 days
Aqueous samples with no residual Chlorine	Volatile Organics	7 days
Aqueous samples with Chlorine residual	Volatile Organics	7 days
Solid samples	Volatile Organics	7 days
Concentrated waste samples	Semivolatile Organics	Samples extracted within 14 days & extracts analyzed within 40 days following extraction
Aqueous samples with no residual Chlorine	Semivolatile Organics	Samples extracted within 7 days & extracts analyzed within 40 days following extraction
Aqueous samples with residual Chlorine	Semivolatile Organics	Samples extracted within 7 days & extracts analyzed within 40 days following extraction

Matrix Type	Type of Analyses	Holding Time (if properly preserved)
Solid samples	Semivolatile Organics	Samples extracted within 14 days & extracts analyzed within 40 days following extraction
Aqueous samples	Total Metals, except Cr(+6) and Hg	HNO_3 to pH <2, 6 months
Aqueous samples	Dissolved Metals, except Cr(+6) and Hg	Filter on-site, HNO_3 to pH <2, 6 months
Aqueous samples	Suspended Metals, except Cr(+6) and Hg	Filter on-site, 6 months
Solid samples	Total Metals, except Cr (+6) and Hg	6 months
Aqueous samples	Cr(+6)	24 hours, store at ≤6°C until analyzed
Solid samples	Cr(+6)	One month to extraction;7 days from extraction to analysis; store at ≤6°C until analyzed
Aqueous samples	Total Hg	HNO_3 to pH <2, 28 days
Aqueous samples	Dissolved Hg	Filter, HNO_3 to pH <2, 28 days
Solid samples	Total Hg	28 days, store at ≤6°C until analyzed

General Guidance for Decontamination

The following procedures will be used in the decontamination and cleaning of field equipment, except where disposable equipment is used:

1. Field cleaning procedures for Teflon field sampling equipment used for the collection of samples for trace organic compounds, and/or metals analyses.
    a. Equipment will be washed thoroughly with laboratory detergent (Liquinox, which must be used for nutrients, or Alconox) and water using a brush to remove any particulate matter or surface film.
    b. The equipment will be rinsed thoroughly with deionized water.
    c. Rinse equipment with at least a 10% nitric acid solution. HNO_3 will be used only if trace metals are to be sampled. The acid is not used on stainless steel equipment.
    d. Rinse equipment thoroughly with deionized water.
    e. Rinse equipment twice with pesticide grade isopropanol.
    f. Rinse thoroughly with analyte-free water and allow to air-dry as long as possible.

2. Field cleaning procedures for stainless steel or metal sampling equipment used for the collection of samples for trace organic compounds and/or metals analyses for soil:

   a. Wash equipment thoroughly with laboratory detergent (Liquinox or Alconox) and water using a brush to remove any particulate matter or surface film.
   b. Rinse equipment thoroughly with deionized water.
   c. Rinse equipment twice with pesticide grade or nanograde isopropanol and allow to air dry.
   d. Rinse the stainless steel or metal sampling equipment thoroughly with deionized water in the field as soon as possible after use.

3. Well sounders or tapes used to measure groundwater levels:
   a. Wash with Liquinox and deionized water, using a brush to remove any particulate mater or surface film.
   b. Rinse thoroughly with deionized water.
   c. Rinse twice with pesticide grade isopropanol.
   d. Equipment should be placed in a polyethylene bag or wrapped with polyethylene film to prevent contamination during storage or transit.

4. In-house cleaning procedures for Teflon field sampling equipment used for the collection of samples for trace organic compounds and/or metals analyses:
   a. Teflon bailers will be washed thoroughly with Liquinox and hot water using a brush to remove any particulate matter or surface film.
   b. The bailers will be rinsed thoroughly with hot tap water.
   c. Rinse the bailers with at least a 10% nitric acid solution. HNO_3 will be used only if trace metals are to be sampled. The acid is not used on stainless steel equipment.
   d. Rinse equipment thoroughly with deionized water.
   e. Rinse equipment with pesticide grade isopropanol and allow to air dry for as long as possible.
   f. Rinse with analyte-free water and allow to dry in contaminant-free environment.
   g. Wrap equipment completely with aluminum foil to prevent contamination during storage and/or transport to the field.

   NOTE: When this sampling equipment is used to collect samples that contain oil, grease, or other hard to remove materials, it may be necessary to rinse the equipment several times with pesticide grade acetone or hexane to remove the materials before proceeding with Step a. If the field equipment cannot be cleaned utilizing these procedures, it should be discarded.

5. In-house cleaning procedures for stainless steel or metal sampling equipment used for the collection of samples for trace organic compounds and/or metals analyses for soil:
   a. Wash equipment thoroughly with Liquinox and hot water using a brush to remove any particulate matter or surface film.
   b. Rinse equipment thoroughly with hot tap water.
   c. Rinse equipment thoroughly with deionized water.
   d. Rinse equipment twice with pesticide grade isopropanol and allow to air dry in a contaminant-free environment.
   e. Final rinse with deionized water.

   f. Wrap or place equipment in zipper lock bags to prevent contamination during storage and/or transport to the field.

   NOTE: When this sampling equipment is used to collect samples that contain oil, grease, or other hard to remove materials, it may be necessary to rinse the equipment several times with pesticide grade acetone or hexane to remove the materials before proceeding with Step a. In extreme cases, when equipment is painted, badly rusted, or coated with materials that are difficult to remove, it may be necessary to steam clean or wire brush equipment before preceding with Step a. (This equipment may never be used to sample for trace contaminants.) Any stainless steel sampling equipment that cannot be cleaned using these procedures will be discarded.

6. Well sounders or tapes used to measure groundwater levels:
   a. Wash with Liquinox or Alconox and deionized water.
   b. Rinse with deionized water.
   c. Rinse with analyte-free water.
   d. Equipment should be placed in a polyethylene bag or wrapped with polyethylene film to prevent contamination during storage or transit.

Rinse water used to rinse sampling equipment between sampling episodes is provided by a Millipore Milli-Q Advantage A10 that is designed to deliver Type I grade water.

The vendor and/or manufacturer as well as the lot number of all reagents that are used for sample preservation will be recorded in the sampler's logbook.

The OLR is supported in its sampling efforts by DEQ OWQ Laboratory or a NELAC-laboratory, which analyzes all RCRA samples brought in by the OLR. The Laboratory will notify field personnel if there are any problems with samples, or if there are any questions regarding the samples. Problems are discussed with the appropriate personnel and the necessary quality control measures and corrective actions are devised and implemented.

Section B3
Sample Handling and Custody Requirements

Chain of Custody

A sample is physical evidence collected from a facility or from the environment. Controlling this evidence (e.g., documenting its source, minimizing opportunities to tamper with the sample, and providing conclusive proof that the sample collected from the questioned area or activity is the same sample whose analytical results are offered in evidence) is an essential part of the hazardous waste investigation effort. To ensure that the Division's sample data and record supporting sample-related activities are admissible and have weight as evidence in any future litigation, all persons involved in the implementation of this plan shall maintain all samples and supporting records of sample handling, preparation, and analysis under chain-of-custody procedure according to the requirements in this section.

Custody

A sample is in custody if it is in any one of the following:

1. In actual physical possession;
2. In view, after being in physical possession;
3. In physical possession and locked up; or
4. In a secure area, restricted to authorized personnel.

Sample Collection

1. All samples will be tagged at the time of collection and recorded on a Chain-of-Custody and Laboratory Request form (if necessary), which documents the history of sample custody (see Appendix 3). The COC must contain at a minimum the following items: The date of the sampling event; the printed name of the sample collector; the Site Identification; the Site Address; the Sample Identification Number; and the Time each sample is collected. The sampler should write a description of the sample in the "Sample Remarks" section (i.e., 55-gallon drum, waste pile, groundwater monitoring well, etc.). On the back side of the COC form is the Laboratory Request Form and it must contain the Sample Identification Number, Sample Characteristics (i.e., grab, composite, number of containers, preservation code, and media code), and the Parameters Requested for each sample.

2. Each inspector will use and maintain a bound field logbook with consecutively numbered pages. That person will obtain and include in the logbook the following information on every sampling event: Purpose of sampling, location and address of sampling, date of sampling, type of sampling equipment used, sample number, description or location of each sample, time collected, and any deviations from the sampling plan. All entries will be signed by the inspector and all field logbooks will be stored in a safe place.

3. The sample collector is responsible for the care and custody of the samples until they are relinquished. The sample collector must provide the proper storage conditions. The samples must be in his/her physical possession, in his/her view, or stored in a secure, locked place at all times.

Sample Shipment and Transfer of Custody

1. When samples are shipped by common carrier, a bill of lading must be obtained. This bill of lading must be retained as part of the permanent chain-of-custody.

2. Samples transferred to other personnel for delivery must be accompanied by a Chain-of-Custody form. This form must include the collector's printed name and signature, identification of the samples, date, and time of collection. The transferor and transferee must print their names, sign, and state the date and time of the transfer on this custody form.

3. Samples must be delivered only to authorized laboratory personnel and the transfer of custody recorded by printed names and signatures with the date and time of the person relinquishing and the person receiving the samples.

Laboratory Custody

1. The information present on the Chain of Custody will be recorded in the Laboratory Information Management System (LIMS) by laboratory personnel. The LIMS will generate a sequential identification number. This number will be written on the sample container lid and on the Chain of Custody using indelible ink. The sample will then be considered to be "logged in". When a NELAC-laboratory is utilized, the Chain of Custody will be recorded in stored electronically in accordance with the laboratory's operation manual.

2. The person receiving the sample is responsible for distributing the samples to the laboratory personnel or storing the samples under the appropriate conditions.

3. Laboratory personnel are responsible for the care and custody of samples once they have been properly transferred and should be prepared to testify that the samples were in their possession and view or secured in the laboratory at all times.

4. The laboratory area shall be maintained as a secured area and shall be restricted to authorized personnel.

Section B4
Analytical Methods Requirements

The analytical procedures used in the analyses of hazardous waste will be appropriate to meet project requirements and will be either SW-846 or EPA approved methods.

In particular, the following methods will be used in the sample preparation and subsequent analysis:

Metals	
Total metals in a solid matrix	Digestion of the sample using method 3051A (modified) ; analysis using method 200.7/6010D or 200.8
Total metals in an aqueous matrix	Digestion of the sample using modifications of methods 200.7, 200.8, and 3005A; analysis using method 200.7/6010D or 200.8
TCLP Metals	Extraction of the sample using method 1311 followed by digestion of the sample extract ; analysis using method 6010D or most currently approved revision
Mercury in a solid matrix	Digestion of the sample using method 3051A followed by analysis using method 7473
Mercury in an aqueous matrix	Digestion of the sample using method 3010A followed by analysis using method 245.7
Mercury in an TCLP extract	Digestion of the extract using method 3010A followed by analysis using method 245.7
Organics	

Volatiles in a solid matrix	Extraction using appropriate SW-846 method, followed by purge & trap using method 5030B and analysis using method 8260C OR most recently approved revision
Volatiles in an aqueous matrix	Purge & trap technique using method 5030B followed by analysis using method 8260C OR most recently approved revision
Volatiles in TCLP extracts	Extraction of the sample using method 1311 followed by purge & trap technique using method 5030A followed by analysis using method 8260C OR most recently approved revision
Semivolatiles in a solid matrix	Extraction using appropriate SW-846 method followed by analysis using method 8270D OR most recently approved revision
Semivolatiles in an aqueous matrix	Extraction using appropriate SW-846 method followed by analysis using method 8270D OR most recently approved revision
Semivolatiles in TCLP extracts	Extraction of the sample using method 1311 followed by extraction using appropriate SW-846 method, and analysis using method 8270D OR most recently approved revision
Pesticides in a solid matrix	Extraction using appropriate SW-846 method followed by analysis using method 8270D OR most recently approved revision
Pesticides in an aqueous matrix	Extraction using appropriate SW-846 method followed by analysis using method 8270D OR most recently approved revision
Pesticides in TCLP extracts	Extraction of the sample using method 1311 followed by extraction of the TCLP extract using appropriate SW-846 method and analysis using method 8270D OR most recently approved revision
PCBs in a solid matrix	Extraction using appropriate SW-846 method followed by analysis using method 8082A OR most recently approved revision
PCBs in an aqueous matrix	Extraction using appropriate SW-846 method followed by analysis using method 8082A OR most recently approved revision
Characteristic Wastes	
Ignitability	Method 1010A
Corrosivity	Method 9040C and/or Method 1110A or most currently approved revision
Reactivity	Follow guidance found in section 7.3.1 of SW-846 for setting up test for releasable HCN and H2S. Quantify the HCN by method 9010C and the H2S by method 9030B or most currently approved revision

Toxicity Characteristic Leaching Procedure	Method 1311

Samples received at DEQ OWQ Laboratory or a NELAC-laboratory will be retained in accordance with the holding times specified in SW-846, unless the Office of Land Resources requests that the samples be retained longer. The samples will be disposed of properly when the holding times are exceeded or the Office of Land Resources has determined that they are no longer needed to support a case.

Corrective Actions
The Laboratory will notify field personnel if there are any problems with samples, or if there are any questions regarding the samples. Problems are discussed with the appropriate personnel and the quality control officer will devise and implement necessary quality control measures and corrective actions.

Section B5
Quality Control Requirements

Sampling
Field duplicate samples will be collected at a rate of 10%, or a minimum of one per sampling event. Each field inspector must collect a field duplicate sample at one site during their sampling run. A sufficient amount of sample must be collected in order to allow the laboratory to conduct matrix spikes.

Duplicate field measurements must also be made for pH and temperature and recorded in the field book and on the chain-of-custody form.

Laboratory
The quality of data from the laboratory will be assured by a system of internal checks. These include equipment checks, reagent checks, and laboratory performance checks. The results of these checks will be recorded to verify the operation of the quality control system and to monitor any changes that occur.

The performance of the laboratory will be checked with a scheduled system of duplicated samples, spiked samples, and check samples from an outside source.

1. All chemical analyses will be checked for precision by the analysis of duplicate samples. The frequency of these duplicates will be, at a minimum, one in ten samples. The duplicate samples will be collected in the field by one or more individuals comprising the collecting team. At least one duplicate analysis must be done each day a parameter is run
2. All chemical analyses possible will be checked for accuracy by the analysis of Laboratory Control Samples (LCS). A minimum of one LCS will be analyzed per batch of twenty samples. These spiked samples will be prepared by the addition of a known amount of target analyte(s) to an aliquot of de-ionized water, free of target analytes and organics. The results must be entered in a Laboratory Information QC system and verified to be within the control limits.

3. Laboratory Precision and the effect of the matrix on analyte recovery will be determined by the preparation and analysis of a minimum of one Matrix Spike/Matrix Spike duplicate (MS/MSD) per batch of twenty samples. Matrix Spike/Matrix Spike duplicate samples are prepared by adding a known amount of target analyte(s) to an aliquot of the sample which has a field duplicate. The precision and recoveries of the MS/MSD will be compared to method or lab generated acceptance criteria. The results must be entered in the LIMS QC system and verified to be within the control limits.
4. Check samples from an outside source will be analyzed semi-annually. Proficiency testing samples from TNI accredited PT providers will be used. The analyst will perform the analysis without knowing the expected value.

Procedures to assess data precision and accuracy

The precision and accuracy of all laboratory data will be assessed immediately after the analyses are performed. The data from all duplicate and spiked samples will be entered into a Laboratory Information System which will check it against the acceptance criteria, and check for violations. The system will keep the acceptance criteria used for that sample.

Precision

The precision of the data will be determined from field duplicate samples and laboratory spiked replicate samples. The control limits for precision are either method specified or lab established.

Field Precision

The field precision will be based on the relative percent differences between the sample and its field duplicate. The control limits will be based on laboratory established control limits. The relative percent difference (RPD) will be calculated as follows:

$$\text{RPD} = \{|\text{Sample 2} - \text{Sample 1}|\} \text{ X } 100 \div \{\text{Average of Sample 1 and Sample 2}\}$$

Laboratory Precision

The values from laboratory spiked replicate samples will be used to evaluate laboratory precision. Depending on the analysis, the control limits will be either method specified or based on historical data using the relative percent difference (RPD) of a past set of data, normally 12 months, with all outliers removed. The RPD will be calculated by the formula:

$$\text{RPD} = (|\text{LFM2} - \text{LFM1}|) \text{ X } 100 \div (\text{the average of LFM1 and LFM2})$$

Where: LFM1 and LFM2 are the Matrix Spike/Matrix Spike Duplicate samples

Accuracy

Depending on the analysis, the control limits for accuracy will be either method specified or based on historical data using actual sample spike data and the percent recovery of the spike.

The percent recovery, P, is defined as:

$$P = [(\text{Final Concentration} - \text{Initial Concentration}) / \text{Spike added}] \text{ X } 100$$

Any analysis will be considered to be out of control if the recovery of the LCS is outside of the acceptance criteria for that parameter.

Corrective Action

The purpose of a corrective action is to document and promptly address major and/or minor problems, and to develop a plan that will eliminate the potential for repetition of the problem. The Quality Assurance Officer will consult with field and personnel responsible for sample collection and the lab analyst if there are any problems with sampling procedures or analyses.

Corrective actions are taken when:

1. Quality control checks reveal a problem;
2. The QC data is out of control;
3. Deficiencies are cited during an audit; or
4. Data is determined to be questionable by an outlier test

Acceptance Criteria and Corrective Actions for Analytical QC Checks

QC CHECK	*ACCEPTANCE CRITERIA*	*CORRECTIVE ACTION*
Balance Check	NIST Traceable weights meet acceptance criteria in weight check	Recalibrate balance; Clean or repair balance if it cannot be calibrated.
Type I water	Resistivity > 18 megohm/cm	Replace demineralizer cartridge.
Refrigerator	≤6° C	Adjust control. Document on incident report.
Reagent Blanks	< Reporting Limit	Verify reagent sources. Review preparation and storage procedures. Discard contaminated reagent. Document on CAPA* form. If source of contamination cannot be found and/or samples cannot be re-analyzed within holding time, any positive results of the target analyte in question will be qualified.
Trip blanks for common contaminants such as VOCs	< Reporting Limit	For common volatile contaminants (methylene chloride), the trip blank is allowed to have # 5 times the reporting limit. The presence of any detected contaminate is reported with the data.
Field Duplicates	Precision within acceptance criteria	Reanalyze samples. If samples are still out of control, qualify the data from sampling event. Document on CAPA* form.
Lab Duplicates	Precision within acceptance criteria	Reanalyze samples. If samples are still out of control, perform instrument maintenance. Prepare new duplicates. Document on

QC CHECK	*ACCEPTANCE CRITERIA*	*CORRECTIVE ACTION*
		CAPA* form.
Matrix Spikes/Matrix Spike Duplicates	% Recovery and Precision within acceptance criteria	Reanalyze samples. Check spike solution. Check for matrix interferences. Document on CAPA* form.

*CAPA = Corrective Action/Preventive Action; or however named by the accredited commercial laboratory

Quality Control Limits
Quality Control (QC) accuracy limits are either method determined or lab established.
Laboratory blanks are deemed acceptable if any target analyte is present in concentrations that are less than 5% of the regulatory limit associated with the target analytes or less than 5% of the sample result for the target analytes, whichever value is the largest.

Area counts for internal standards utilized for analytes are deemed acceptable if the area counts fall within the range of 50% X to 200% X, where X is the average area of the internal standard using the values obtained from the five calibration standards.

Performance Testing Samples
The Laboratory participates semi-annually in performance testing programs for water and hazardous waste performance evaluation studies. The acceptance criteria for PT samples will be determined by the provider. All results marked "not acceptable" will require corrective actions and written explanations to the QA Officer.

Corrective actions will include:

1. Checking calculations and data transcription;
2. Checking calibration and calibration standards;
3. Investigation of possibility of analyst error or improper technique;
4. Investigation of possibility of instrument malfunction; and
5. Investigation of possibility of matrix interference.

Documentation of Corrective Actions
Any problems existing with the samples, sample data, or QC data must be documented. The Corrective Action/Preventive Action (CAPA) form (or however named by the NELAC-laboratory) will be used to document problems with the sample, (holding time errors, preservation errors) sample data, (outliers, matrix interference or QC data (out of control). The QA officer and/or Lab Supervisor must approve any data that must be voided or qualified.

Section B6
Instrument/Equipment Testing, Inspection, and Maintenance Requirements

All instruments purchased for the projects covered under this project plan will meet specific performance criteria before acceptance. The use of environmental matrix spike QC samples will be used for testing their performance.

Final acceptance
The final acceptance will be performed by the Chemist Supervisor to assure compliance with purchase requirements.

Resolution of deficiencies
If deficiencies are found during the testing procedure the vendor will be given every opportunity to correct within the available time allowed by the project and funding mechanisms.

Preventive Maintenance

1. Analytical Balance: All analytical balances must be cleaned weekly and immediately after any chemical spill. The balance table must be kept neat and cleaned after any spills. Any spills that might interfere with trace analysis, such as mercury compounds, must be immediately and thoroughly cleaned up. All analytical balances must be cleaned and checked by a balance service annually or whenever a problem is detected.

2. pH Meter: The pH electrodes shall be maintained by following the manufacturer's recommendations for electrolyte solutions and storage procedures.

3. Inductively Coupled/Mass Spectrometry System ThermoScientific ICAP RQ: : The following operations shall be performed prior to running the instrument:

   a. The gas supplies and the hoses and their connections will be inspected to insure their adequacy.
   b. The exhaust system will be inspected to insure it is operating correctly.

   The following actions shall be performed when conditions warrant them:

   a. Cleaning the cones;
   b. Cleaning the plasma torch;
   c. Changing pump tubing; and
   d. The nebulizer will be cleaned as needed.

4. Inductively Coupled/Optical Emission Spectrometry System: Agilent Technologies 5100 ICP-OES: The following operations shall be performed prior to running the instrument:
   a. The gas supplies and the hoses and their connections will be inspected to insure their adequacy.
   b. The exhaust system will be inspected to insure it is operating correctly.

   The following actions shall be performed when conditions warrant them:

   a. Cleaning the plasma torch;
   b. Changing pump tubing; and
   c. The nebulizer will be cleaned as needed.

5. Gas Chromatograph/Mass Spectrometer – preventive maintenance provided as specified by the manufacturer. Service contracts are kept current on the ICP/MS and ICP/OES

instruments. A limited number of spare parts are kept on-hand to assist with instrument repair and maintenance. . The chemists who operate the instruments are responsible for requesting consumables and spare parts as need. The analytical balance is serviced annually.

Section B7
Instrument Calibration and Frequency

Instrument Calibration Procedures

All analytical instruments and equipment will be calibrated according to the manufacturer's recommended procedures and the guidelines in SW-846. In addition the following specific procedures will be followed:

1. Each day before use, the analytical balances must be checked for calibration by using a series of NIST traceable weights demonstrating the range of the balance (1 g, 20 g, 50 g, and 100 g). The balance reading for each weight must be within a range of acceptability for the balance to meet calibration check requirements. If any balance reading falls outside of the range of acceptability, the balance must be calibrated. The range of acceptability is calculated annually for each balance by calculating the average and standard deviation of a minimum of the last twenty readings of each weight. The acceptability limits are then defined as the average ±3 SD. Each day's balance check is recorded in the Balance Calibration Log.

2. All pH meters will be calibrated each day before use with at least two buffer solutions. For best accuracy, the two buffers should bracket the expected pH range of the samples. All buffers used must be standardized against standards of the National Bureau of Standards. The pH meter must be recalibrated after every four hours of use.

3. The ICP instruments are calibrated each day before use with four standard concentrations levels of each target analyte and a blank. Initial calibration is verified with the use of a second multi-element standard that is prepared independently of the first standard.

The Gas Chromatograph/Mass Spectrometers will be tuned and calibrated as specified by the instrument manufacturer and the analysis method.

Section B8
Inspection/Acceptance Requirements for Supplies and Consumables

All chemicals and reagents will be dated upon delivery to the laboratory, inspected for their expiration date, logged into the Laboratory Information System and assigned a unique ID number before using them in analytical methods. The acceptance criteria for all standards and calibration materials will be their traceability to the National Institute for Standards and Technology. The Chemist shall inspect all supplies and consumables received for use pursuant to the requirements of this plan for ~~their~~ acceptability and suitability for use.

Section B9
Data Acquisition Requirements for Non-Direct Measurements

The OLR does not, itself, directly generate, receive, or use any type of non-measurement data. Data generated is based solely on measurements related to environmental sampling projects. As previously discussed, the OLR relies on and refers to regulatory levels for specific hazardous constituents which are promulgated as federal rules and subsequently adopted by the State. As long as we have current copies of the regulations (APC&EC Rule No. 23 Sections 260 - 268), that information is presumed to be correct.

When working on remediation projects, OLR RCRA personnel consult with the Risk Assessment Section, who often compares field measurements to specific databases (non-direct measurements). These are taken from generally-published, peer-reviewed toxicological and epidemiological information gathered from several sources.

Section B10
Data Management

QC checks of work assignment activities are performed internally by the QA manager, QC coordinator, or a senior technical specialist, who has QC experience and is not associated with the particular work assignment. The internal QC check includes, at a minimum, the following areas:

1. Adequacy of data collection and management procedures;
2. Adherence to established sampling and collection methods;
3. Implementation of health and safety procedures;
4. Compliance with applicable laws and regulations; and
5. Compliance with chain-of-custody procedures.

Laboratory Data

Manual Methods: Data generated by manual procedures, cyanides, flash point, etc., is manually entered into the Laboratory Information System by the appropriate laboratory personnel.

Automated Methods: Data generated by automated procedures, such as ICP/MS or ICP/OES is directly transferred to the Laboratory Information System. Such data is usually processed after collection in a spreadsheet or an editor to a usable form before being transferred. All instrument generated paper is stored and kept for a minimum of seven years.

Control Mechanisms for Detecting/Correcting Errors

Laboratory data is checked for errors at several points. The data must pass all precision and accuracy checks for both the field duplicates and the laboratory matrix spike replicates. The data must be within the allowable range, i.e., pH between 0 and 14. The data is manually checked for logical errors, i.e., percent of volatile constituents greater than 100. All results are reviewed by a peer analyst and lab manager or designated personnel before the data is released.

Data Storage
Each laboratory instrument's data is stored on the hard drive of its computer. This data is transferred to the Laboratory Information System and backed up daily.

Data Flow
Sample Collection:

1. Waste and environmental media samples are collected by field inspectors or geologists in the Office of Land Resources.
2. All field data is recorded on the sample tag and in a field logbook.

Laboratory:

1. All samples received in the laboratory will follow the chain of custody procedure set forth in Section B3. All of the field data is transferred to the bench sheets where analytical data is recorded.
2. Precision and accuracy of data checked and results are entered into the laboratory's Laboratory Information System and checked for meeting acceptance criteria.
3. Data is exported or entered manually into the Laboratory Information System.
4. Data is reviewed by a peer analyst and the lab manager or designated personnel for completeness and arithmetical errors. Qualifiers to the data are applied if appropriate.
5. A laboratory results report is generated, and then forwarded to the inspector or geologist for inclusion in the inspection report.

Section C1
Assessments and Response Actions

The Department's Laboratory or a NELAC-laboratory participates in two performance testing studies using a TNI approved provider for each analytical parameter annually. These performance testing check samples and inter-laboratory studies constitute an external performance and system audit of the programs addressed in this Plan.

Analytical procedures, facilities, instrumentation, and sampling methodology fall under review by the Laboratory management and staff on a day-to-day basis.

Corrective Action
Corrective actions are taken when:

1. Quality control checks reveal a problem;
2. The QC data is out of control;
3. Deficiencies are cited during an audit; or
4. Data is determined to be questionable by an outlier test.

If for any of the above reasons precision or accuracy data falls outside the boundaries of the control chart or acceptable recovery or bias standards, the analyst will consult with his supervisor. If it is determined that the analytical system is out of control, the quality control officer is consulted and the system is brought back into control. At this time, all data sets containing precision or accuracy points that have shown the analysis to be out of control are re-run.

Section C2
Reports to Management

See **Section C1.** The QA project officer reports to the AEE's QA officer on the status of any required corrective actions and any proposed revisions to the QAPP. QA/QC problems and corrective measures are reported to the U.S. EPA in accordance with Quality Assurance Management Staff (QAMS) (U.S. EPA, 1980b).

Section D1
Data Review, Validation, and Verification

Samples are received, logged in, and handled in accordance with the analytical procedure from SW-846 and the chain-of-custody process at Section B3.

All data produced is calculated according to the referenced EPA-approved procedures in SW-846 and reported in the appropriate units of mass, volume, or concentration. QA checkpoints are set up in the laboratory to check the validity of data. Data reduction will be performed by the laboratory in accordance with the instructions in SW-846 and 40 CFR Part 261, Appendix II (1990c) for each analytical method. It is the general policy that at least 10% (100%, if appropriate) of all final reports will be reviewed for analytical data and transcriptional errors. If the analytical data do not meet the minimum data quality objectives, the laboratory will implement the necessary corrective actions. All data falling outside of the QC limits will be appropriately qualified by the laboratory.

Validation of all measurement data will be based on adherence to method protocol and the prescribed QC procedures. The laboratory will perform data validation of the data package by using the criteria for specified analysis (OERR, 1988). Data validation forms for specified analysis will be completed by the laboratory data validation personnel. These checklist are used to evaluate all of the steps leading to the calculation of the final analytical results, including (1) sample holding times, (2) instrument calibration, (3) blanks, (4) check samples, (5) sample dilutions, (6) precision of duplicate analysis, (7) matrix spike recoveries, and (8) data completeness. All data elements will be qualified as "acceptable," "provisional," or "unacceptable" in accordance with U.S. EPA data qualifiers.

Data for general chemical analysis is validated as to its analytical correctness through the use of spikes, duplicates, and standards which are required for each sample set at twenty (20) sample intervals. Data for metals analysis is validated using method specified acceptance criteria to evaluate quality control samples and instrument checks. GC and GC/MS analytical data is validated through the use of spikes, surrogate standards, duplicates, and internal standards. All data reduction is computerized or computer-assisted as recommended in the SW-846 analytical procedures.

Outliers

Quality Control Data

Outliers from the laboratory quality control checks indicate sampling or analytical problems. All samples in these out-of-control situations will be re-analyzed or, if re-analysis is not possible, the data will be examined for any obvious causes.

If reasons are found for the problem (e.g., dilution error, or the field duplicate samples are obviously different) the results will be appropriately qualified and discussed in a case narrative. If the analytical process is found to be in control, based on other control samples in the same analysis set, the data for the samples may be used.

Sample Data

When a value in a data set is suspiciously high or low it must be examined to see if it must be discarded to avoid biasing the data set. The first check should be to see if there is any physical reason, e.g., high flow, low flow, abnormal temperature, or any other explanation. Results generated from samples taken at extremely high or low flow conditions can be far above or below normal. These values should be left in the database and results discussed in a case narrative.

Section D2
Validation and Verification Methods

See Section D1.

Section D3
Reconciliation with Data Quality Objectives

Results from sampling and analytical data are reconciled with the data quality objectives in a continuing process for each sampling event as described in Sections C1 and D1 above. Reliability of the data for use in decision-making (based on the ability of the data set to meet or conform to QA standards) is included with the results when reported to the appropriate decision-maker, allowing that person to make a reasoned decision using the existing information or to collect additional data.

APPENDIX 1

TO

FY2023 RCRA

QUALITY ASSURANCE PROJECT PLAN

ORGANIZATION CHART

Arkansas ENERGY & ENVIRONMENT
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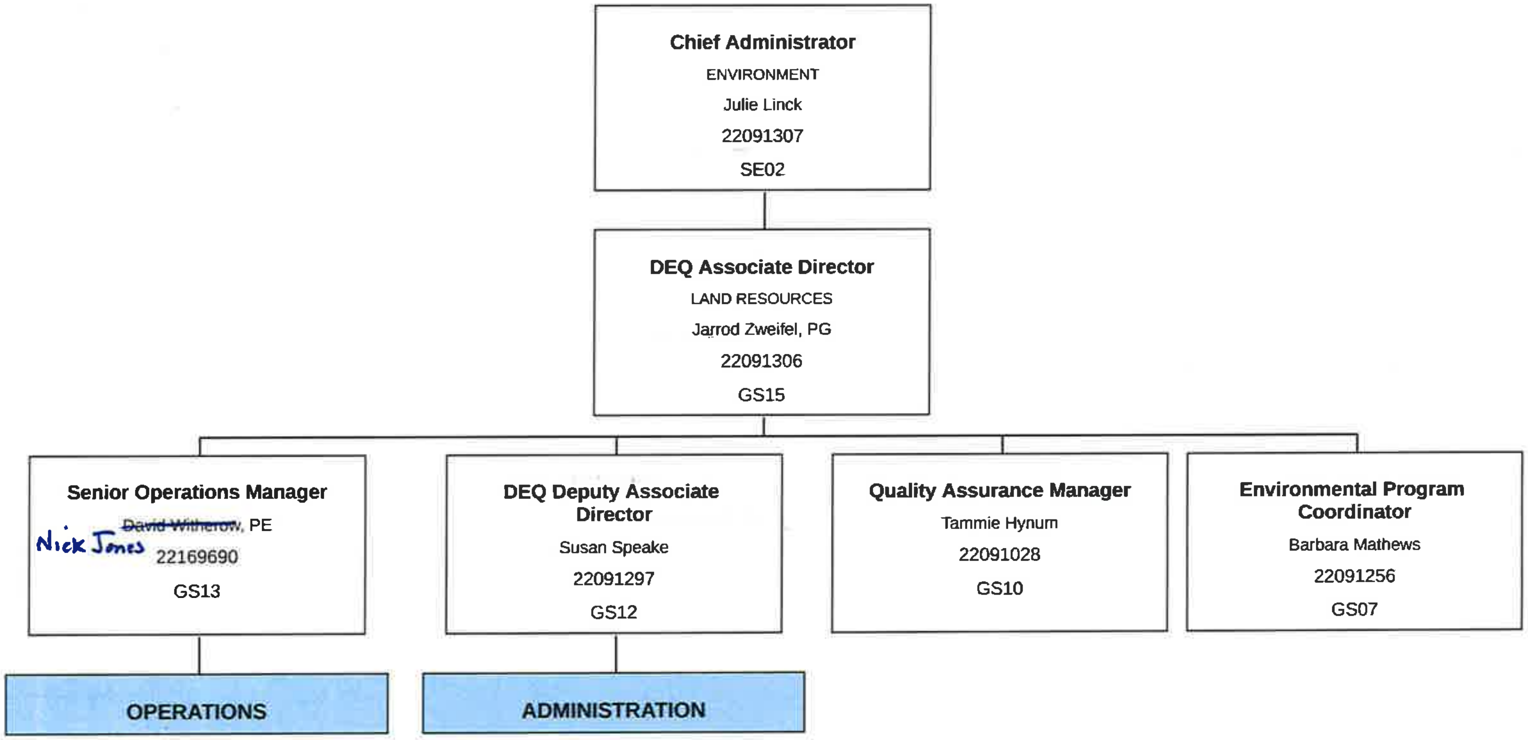


Chief Administrator
ENVIRONMENT
Julie Linck
22091307
SE02

DEQ Associate Director
LAND RESOURCES
Jarrod Zweifel, PG
22091306
GS15

Senior Operations Manager
~~David Witherow~~, PE
Nick Jones
22169690
GS13

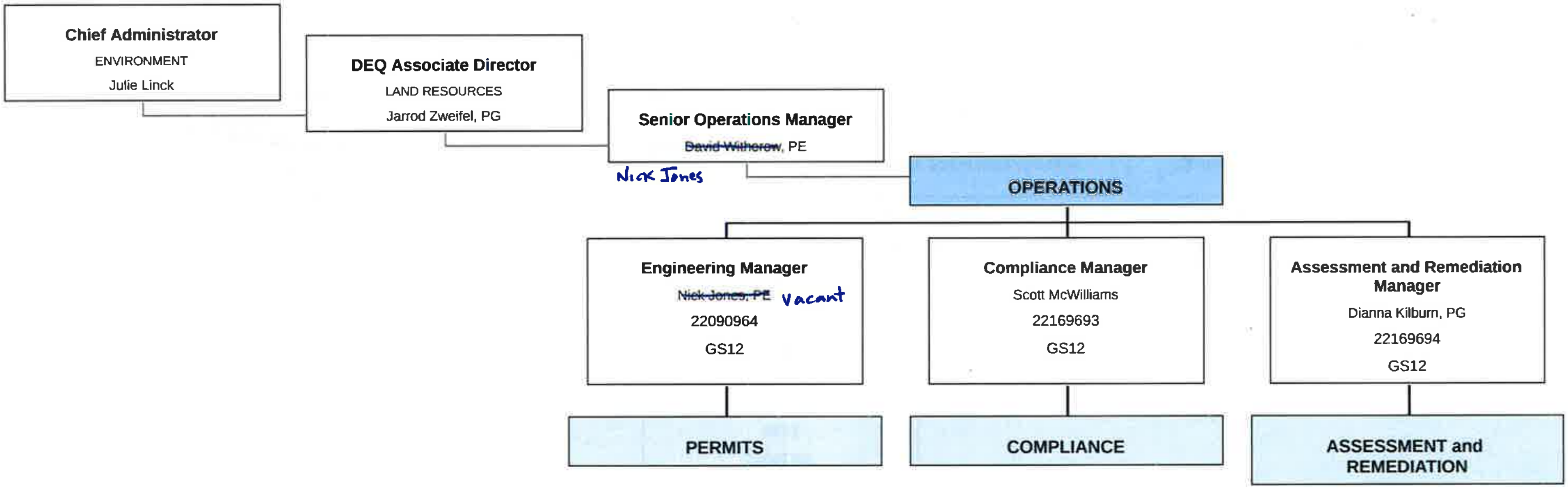
DEQ Deputy Associate Director
Susan Speake
22091297
GS12

Quality Assurance Manager
Tammie Hynum
22091028
GS10

Environmental Program Coordinator
Barbara Mathews
22091256
GS07

OPERATIONS

ADMINISTRATION



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ENVIRONMENT
Julie Linck

DEQ Associate Director
LAND RESOURCES
Jarrod Zweifel, PG

Senior Operations Manager
~~David Witherow~~, PE
Nick Jones

OPERATIONS

Engineering Manager
~~Nick Jones, PE~~ Vacant
22090964
GS12

Compliance Manager
Scott McWilliams
22169693
GS12

Assessment and Remediation Manager
Dianna Kilburn, PG
22169694
GS12

PERMITS

COMPLIANCE

ASSESSMENT and REMEDIATION

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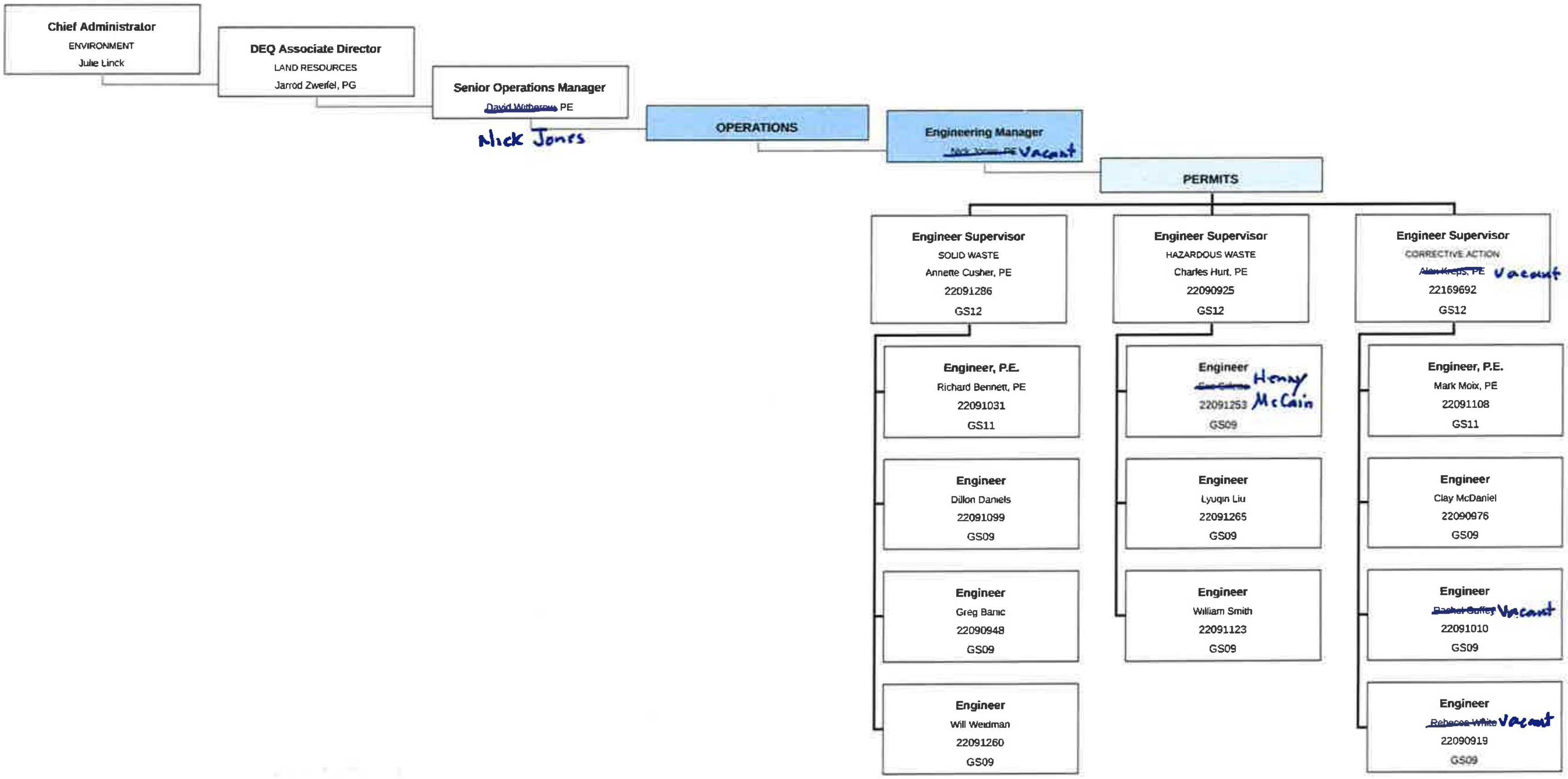

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ENVIRONMENT
Julie Linck

DEQ Associate Director
LAND RESOURCES
Jarrod Zwerlel, PG

Senior Operations Manager
~~David Witherow,~~ PE
Nick Jones

OPERATIONS

Engineering Manager
~~Nick Jones, PE~~ Vacant

PERMITS

Engineer Supervisor
SOLID WASTE
Annette Cusher, PE
22091286
GS12

Engineer, P.E.
Richard Bennett, PE
22091031
GS11

Engineer
Dillon Daniels
22091099
GS09

Engineer
Greg Banic
22090948
GS09

Engineer
Will Weidman
22091260
GS09

Engineer Supervisor
HAZARDOUS WASTE
Charles Hurt, PE
22090925
GS12

Engineer
~~[illegible]~~ Henry McCain
22091253
GS09

Engineer
Lyuqin Liu
22091265
GS09

Engineer
William Smith
22091123
GS09

Engineer Supervisor
CORRECTIVE ACTION
~~Alan Kreps, PE~~ Vacant
22169692
GS12

Engineer, P.E.
Mark Moix, PE
22091108
GS11

Engineer
Clay McDaniel
22090976
GS09

Engineer
~~Rachel Guffey~~ Vacant
22091010
GS09

Engineer
~~Rebecca White~~ Vacant
22090919
GS09

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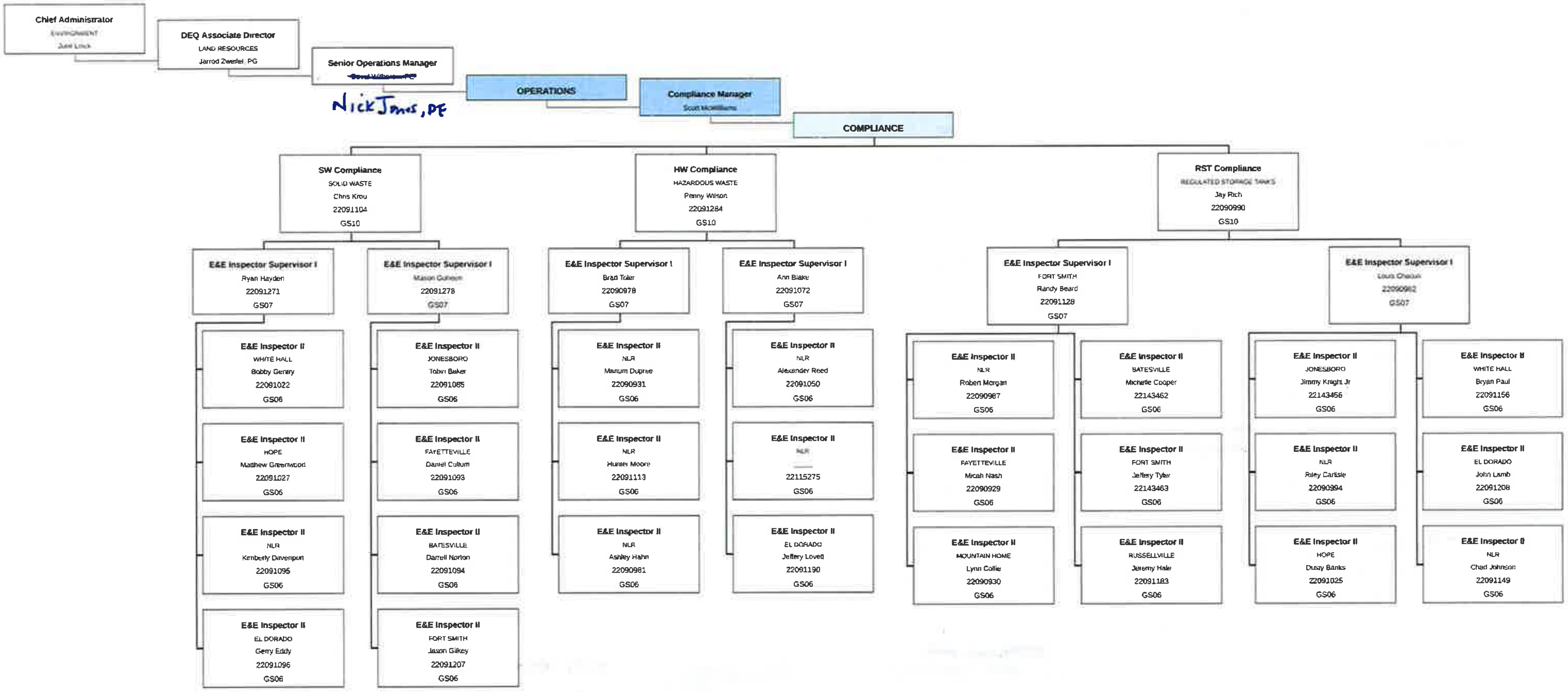

Chief Administrator
ENVIRONMENT
Julie Linck

DEQ Associate Director
LAND RESOURCES
Jarrod Zweifel, PG

Senior Operations Manager
[illegible]
Nick Jones, PE

OPERATIONS

Compliance Manager
Scott McWilliams

COMPLIANCE

SW Compliance
SOLID WASTE
Chris Krou
22091104
GS10

E&E Inspector Supervisor I
Ryan Hayden
22091271
GS07

E&E Inspector II
WHITE HALL
Bobby Gentry
22091022
GS06

E&E Inspector II
HOPE
Matthew Greenwood
22091027
GS06

E&E Inspector II
NLR
Kimberly Davenport
22091095
GS06

E&E Inspector II
EL DORADO
Gerry Eddy
22091096
GS06

E&E Inspector Supervisor I
Mason Calhoun
22091278
GS07

E&E Inspector II
JONESBORO
Tobin Baker
22091085
GS06

E&E Inspector II
FAYETTEVILLE
Daniel Cullum
22091093
GS06

E&E Inspector II
BATESVILLE
Darrell Norton
22091094
GS06

E&E Inspector II
FORT SMITH
Jason Gilkey
22091207
GS06

HW Compliance
HAZARDOUS WASTE
Penny Wilson
22091284
GS10

E&E Inspector Supervisor I
Brad Toler
22090978
GS07

E&E Inspector II
NLR
Manum Dupree
22090931
GS06

E&E Inspector II
NLR
Hunter Moore
22091113
GS06

E&E Inspector II
NLR
Ashley Hahn
22090981
GS06

E&E Inspector Supervisor I
Ann Blake
22091072
GS07

E&E Inspector II
NLR
Alexander Reed
22091050
GS06

E&E Inspector II
NLR
____
22115275
GS06

E&E Inspector II
EL DORADO
Jeffery Loveday
22091190
GS06

RST Compliance
REGULATED STORAGE TANKS
Jay Rich
22090990
GS10

E&E Inspector Supervisor I
FORT SMITH
Randy Beard
22091128
GS07

E&E Inspector II
NLR
Robert Morgan
22090987
GS06

E&E Inspector II
FAYETTEVILLE
Micah Nash
22090929
GS06

E&E Inspector II
MOUNTAIN HOME
Lynn Collie
22090930
GS06

E&E Inspector II
BATESVILLE
Michelle Cooper
22143462
GS06

E&E Inspector II
FORT SMITH
Jeffery Tyler
22143463
GS06

E&E Inspector II
RUSSELLVILLE
Jeremy Hale
22091183
GS06

E&E Inspector Supervisor I
Louis Chacon
22090982
GS07

E&E Inspector II
JONESBORO
Jimmy Knight Jr
22143456
GS06

E&E Inspector II
NLR
Riley Carlisle
22090994
GS06

E&E Inspector II
HOPE
Dusty Banks
22091025
GS06

E&E Inspector II
WHITE HALL
Bryan Paul
22091156
GS06

E&E Inspector II
EL DORADO
John Lamb
22091208
GS06

E&E Inspector II
NLR
Chad Johnson
22091149
GS06

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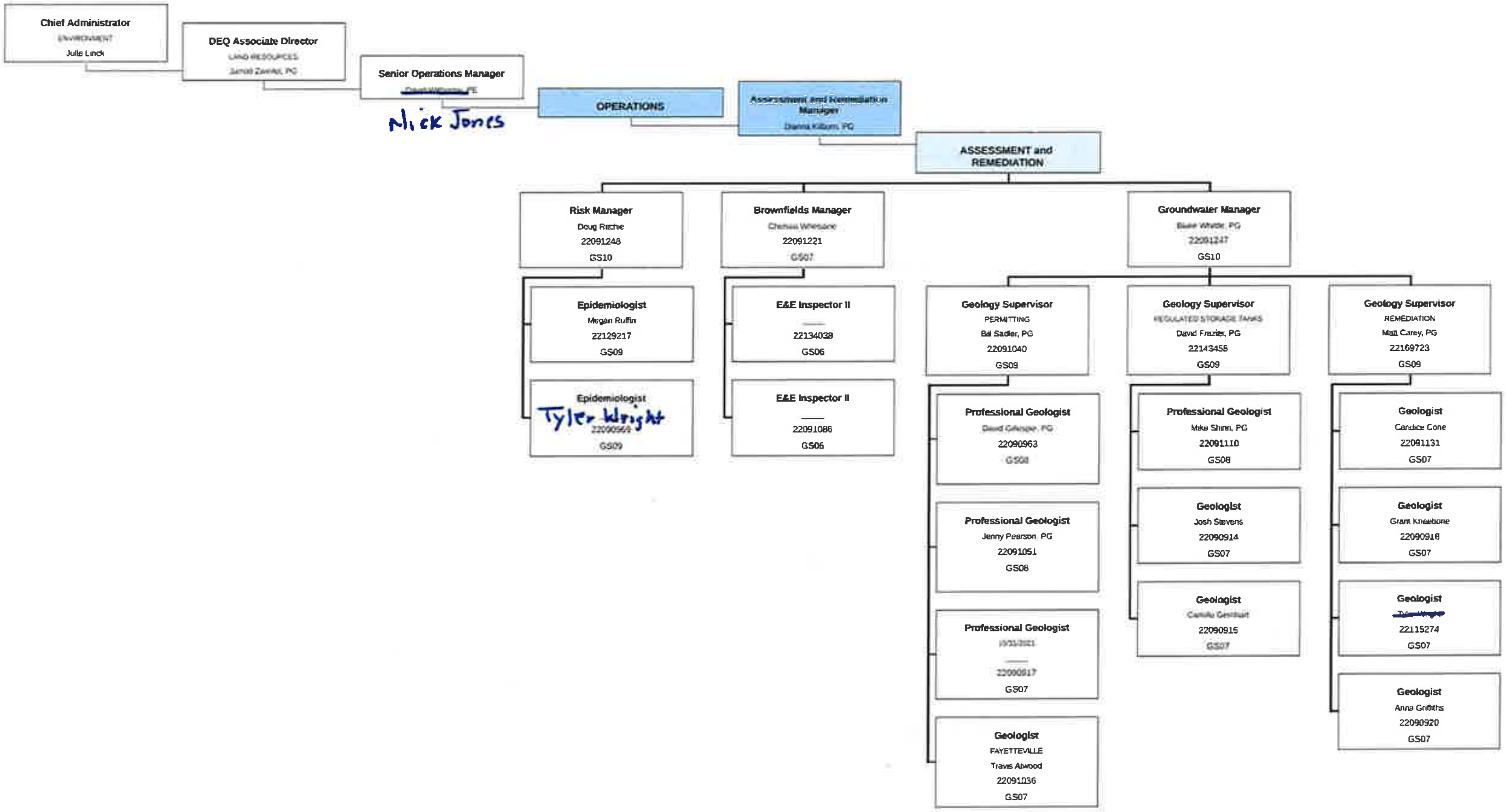

Chief Administrator
ENVIRONMENT
Julie Linck

DEQ Associate Director
LAND RESOURCES
Jarrod Zweifel, PG

Senior Operations Manager
~~David Williams~~, PE
Nick Jones

OPERATIONS

Assessment and Remediation Manager
Dianna Kilburn, PG

ASSESSMENT and REMEDIATION

Risk Manager
Doug Ritchie
22091248
GS10

Epidemiologist
Megan Ruffin
22129217
GS09

Epidemiologist
Tyler Wright
22090969
GS09

Brownfields Manager
Chelsea Whetsone
22091221
GS07

E&E Inspector II
——
22134038
GS06

E&E Inspector II
——
22091086
GS06

Groundwater Manager
Blake White, PG
22091247
GS10

Geology Supervisor
PERMITTING
Bill Sadler, PG
22091040
GS09

Professional Geologist
David Gillespie, PG
22090963
GS08

Professional Geologist
Jenny Pearson, PG
22091051
GS08

Professional Geologist
10/31/2021
——
22090917
GS07

Geologist
FAYETTEVILLE
Travis Atwood
22091036
GS07

Geology Supervisor
REGULATED STORAGE TANKS
David Frazier, PG
22143458
GS09

Professional Geologist
Mike Shinn, PG
22091110
GS08

Geologist
Josh Stevens
22090914
GS07

Geologist
Camilla Gerhart
22090915
GS07

Geology Supervisor
REMEDIATION
Matt Carey, PG
22169723
GS09

Geologist
Candice Cone
22091131
GS07

Geologist
Grant Kneebone
22090918
GS07

Geologist
~~Tyler Wright~~
22115274
GS07

Geologist
Anna Griffiths
22090920
GS07

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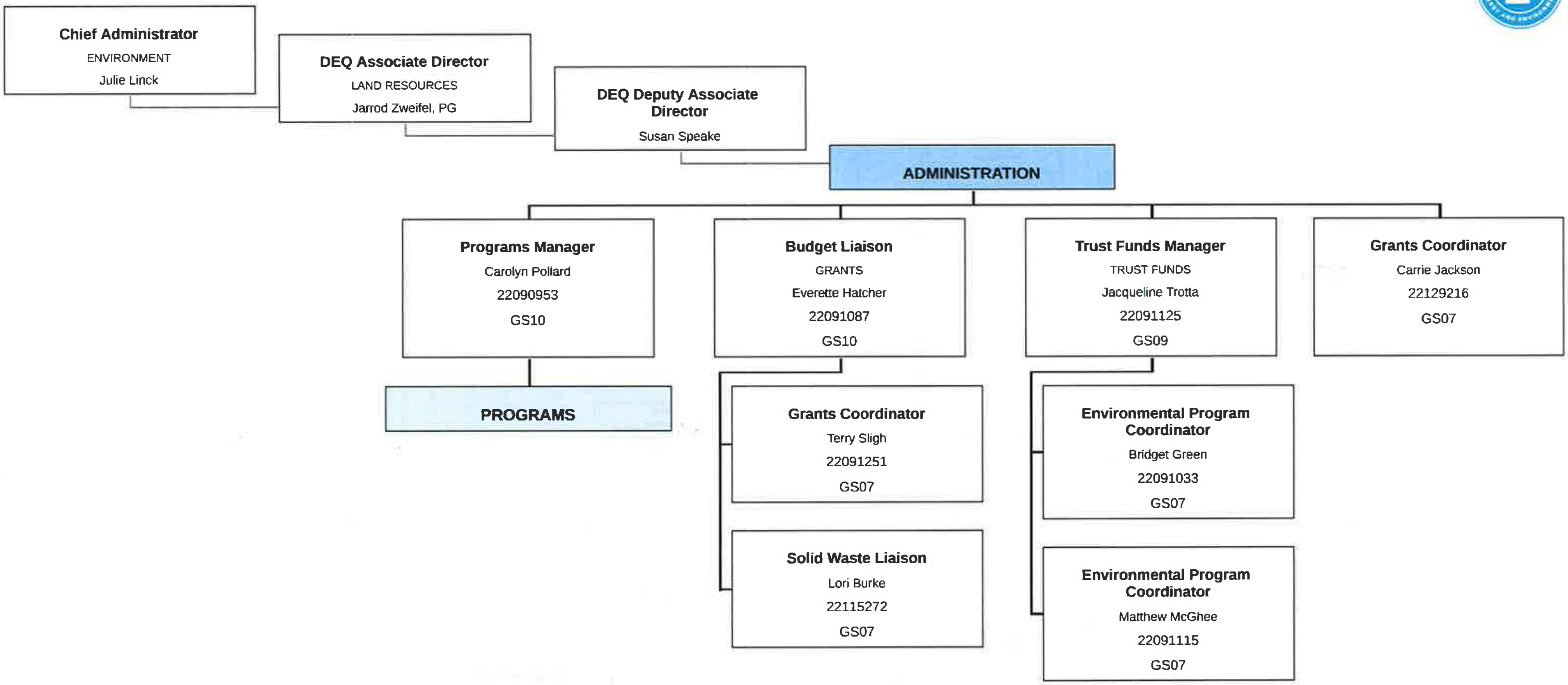

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ENVIRONMENT
Julie Linck

DEQ Associate Director
LAND RESOURCES
Jarrod Zweifel, PG

DEQ Deputy Associate Director
Susan Speake

ADMINISTRATION

Programs Manager
Carolyn Pollard
22090953
GS10

PROGRAMS

Budget Liaison
GRANTS
Everette Hatcher
22091087
GS10

Grants Coordinator
Terry Sligh
22091251
GS07

Solid Waste Liaison
Lori Burke
22115272
GS07

Trust Funds Manager
TRUST FUNDS
Jacqueline Trotta
22091125
GS09

Environmental Program Coordinator
Bridget Green
22091033
GS07

Environmental Program Coordinator
Matthew McGhee
22091115
GS07

Grants Coordinator
Carrie Jackson
22129216
GS07

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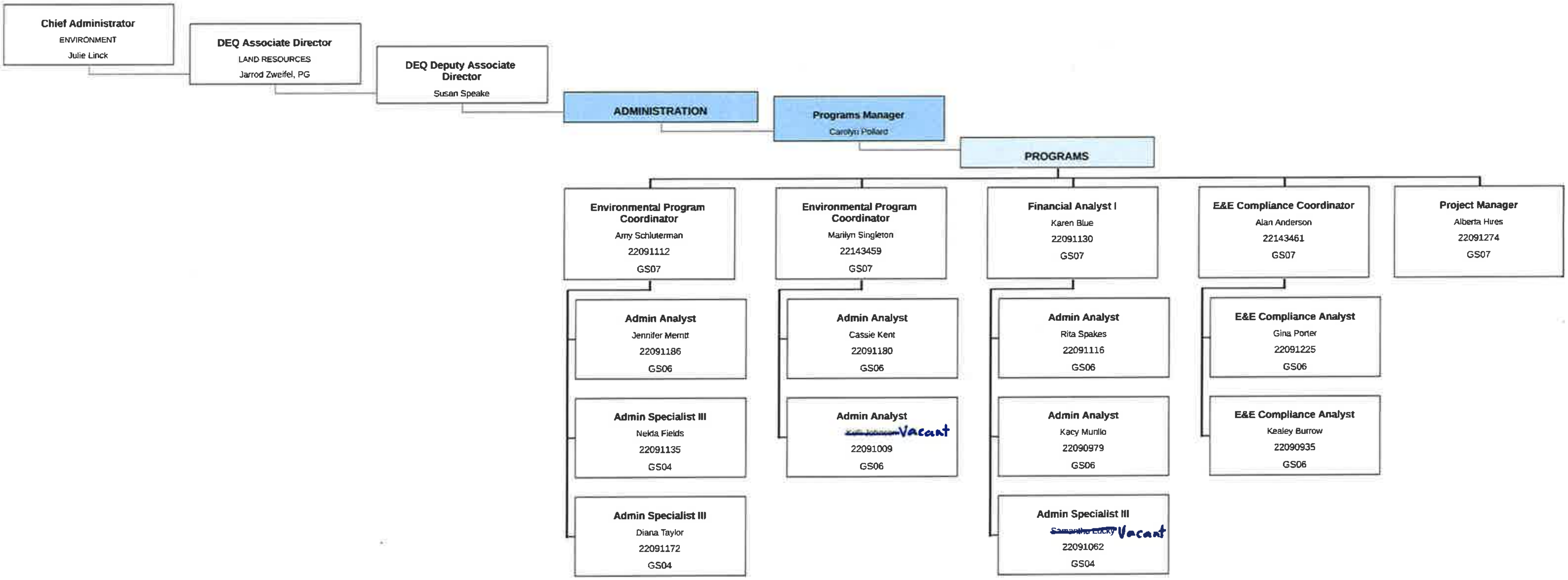

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ENVIRONMENT
Julie Linck

DEQ Associate Director
LAND RESOURCES
Jarrod Zweifel, PG

DEQ Deputy Associate Director
Susan Speake

ADMINISTRATION

Programs Manager
Carolyn Pollard

PROGRAMS

Environmental Program Coordinator
Amy Schluterman
22091112
GS07

Admin Analyst
Jennifer Merritt
22091186
GS06

Admin Specialist III
Nelda Fields
22091135
GS04

Admin Specialist III
Diana Taylor
22091172
GS04

Environmental Program Coordinator
Marilyn Singleton
22143459
GS07

Admin Analyst
Cassie Kent
22091180
GS06

Admin Analyst
~~Kelli Johnson~~ Vacant
22091009
GS06

Financial Analyst I
Karen Blue
22091130
GS07

Admin Analyst
Rita Spakes
22091116
GS06

Admin Analyst
Kacy Murillo
22090979
GS06

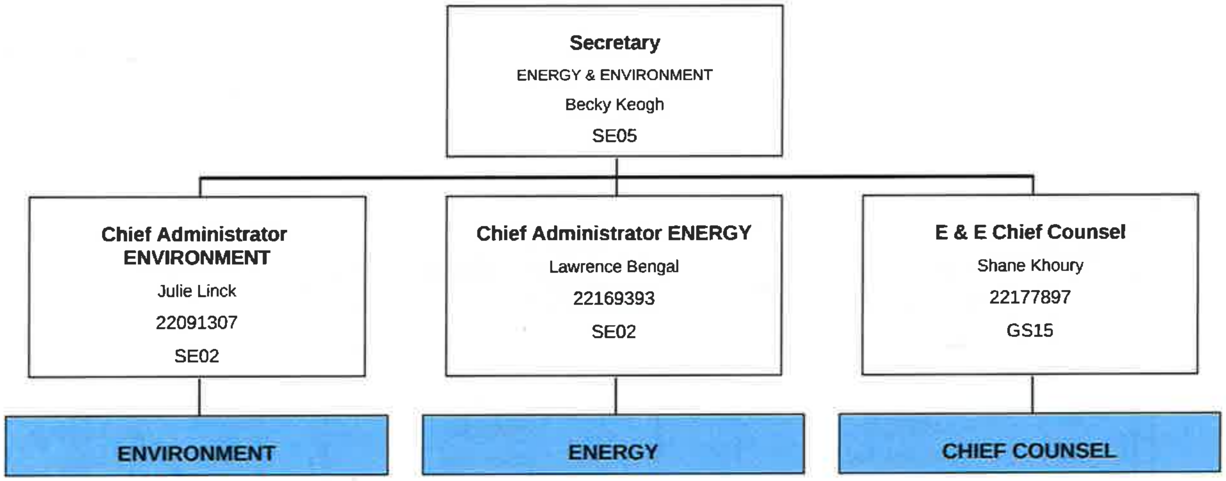
Admin Specialist III
~~Samantha Lucky~~ Vacant
22091062
GS04

E&E Compliance Coordinator
Alan Anderson
22143461
GS07

E&E Compliance Analyst
Gina Porter
22091225
GS06

E&E Compliance Analyst
Kealey Burrow
22090935
GS06

Project Manager
Alberta Hires
22091274
GS07



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ENERGY & ENVIRONMENT
Becky Keogh
SE05

Chief Administrator ENVIRONMENT
Julie Linck
22091307
SE02

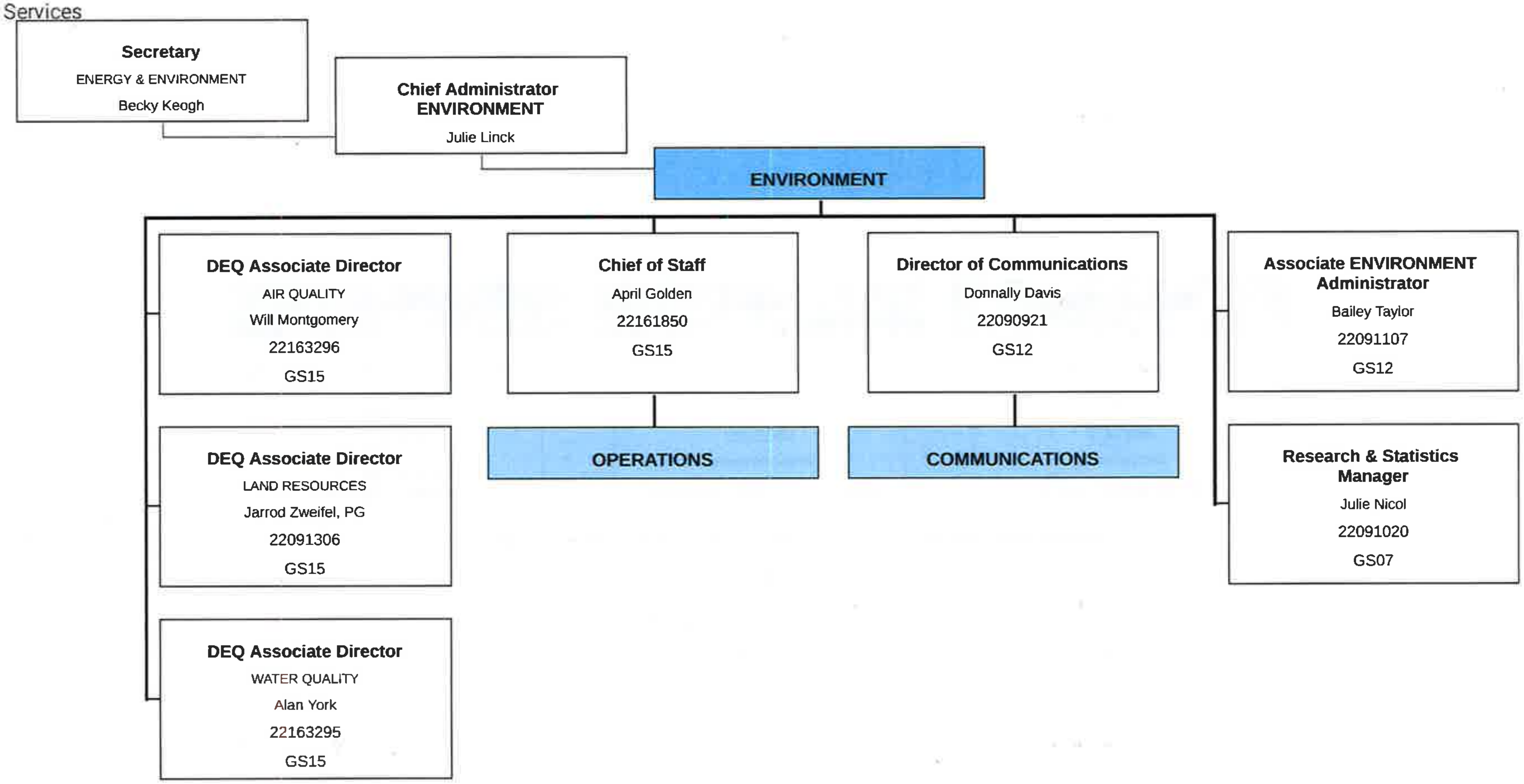
Chief Administrator ENERGY
Lawrence Bengal
22169393
SE02

E & E Chief Counsel
Shane Khoury
22177897
GS15

ENVIRONMENT

ENERGY

CHIEF COUNSEL



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ENERGY & ENVIRONMENT
Becky Keogh

Chief Administrator
ENVIRONMENT
Julie Linck

ENVIRONMENT

DEQ Associate Director
AIR QUALITY
Will Montgomery
22163296
GS15

DEQ Associate Director
LAND RESOURCES
Jarrod Zweifel, PG
22091306
GS15

DEQ Associate Director
WATER QUALITY
Alan York
22163295
GS15

Chief of Staff
April Golden
22161850
GS15

OPERATIONS

Director of Communications
Donnally Davis
22090921
GS12

COMMUNICATIONS

Associate ENVIRONMENT Administrator
Bailey Taylor
22091107
GS12

Research & Statistics Manager
Julie Nicol
22091020
GS07

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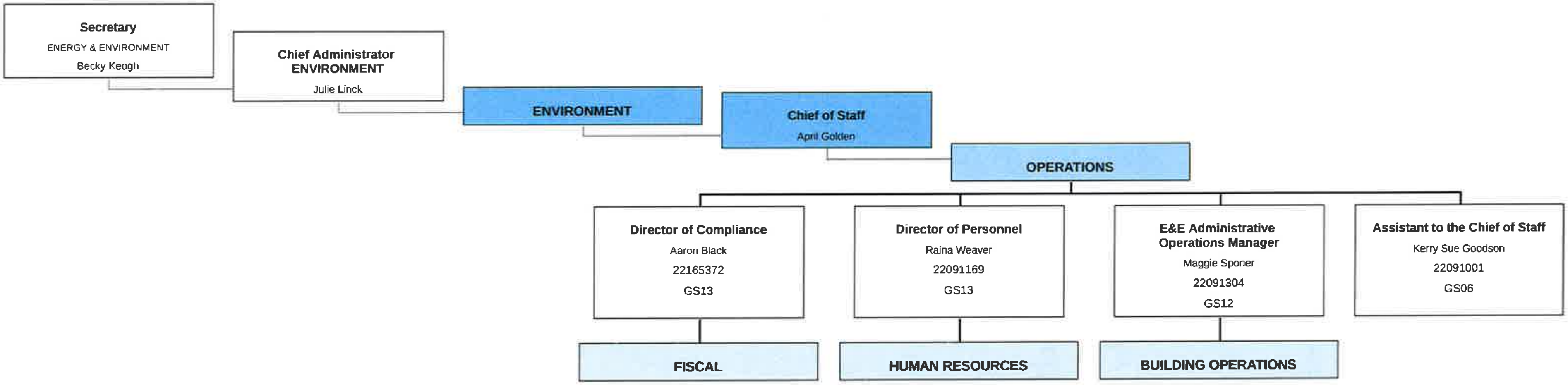
E&E | Shared Services



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Becky Keogh

Chief Administrator
ENVIRONMENT
Julie Linck

ENVIRONMENT

Chief of Staff
April Golden

OPERATIONS

Director of Compliance
Aaron Black
22165372
GS13

FISCAL

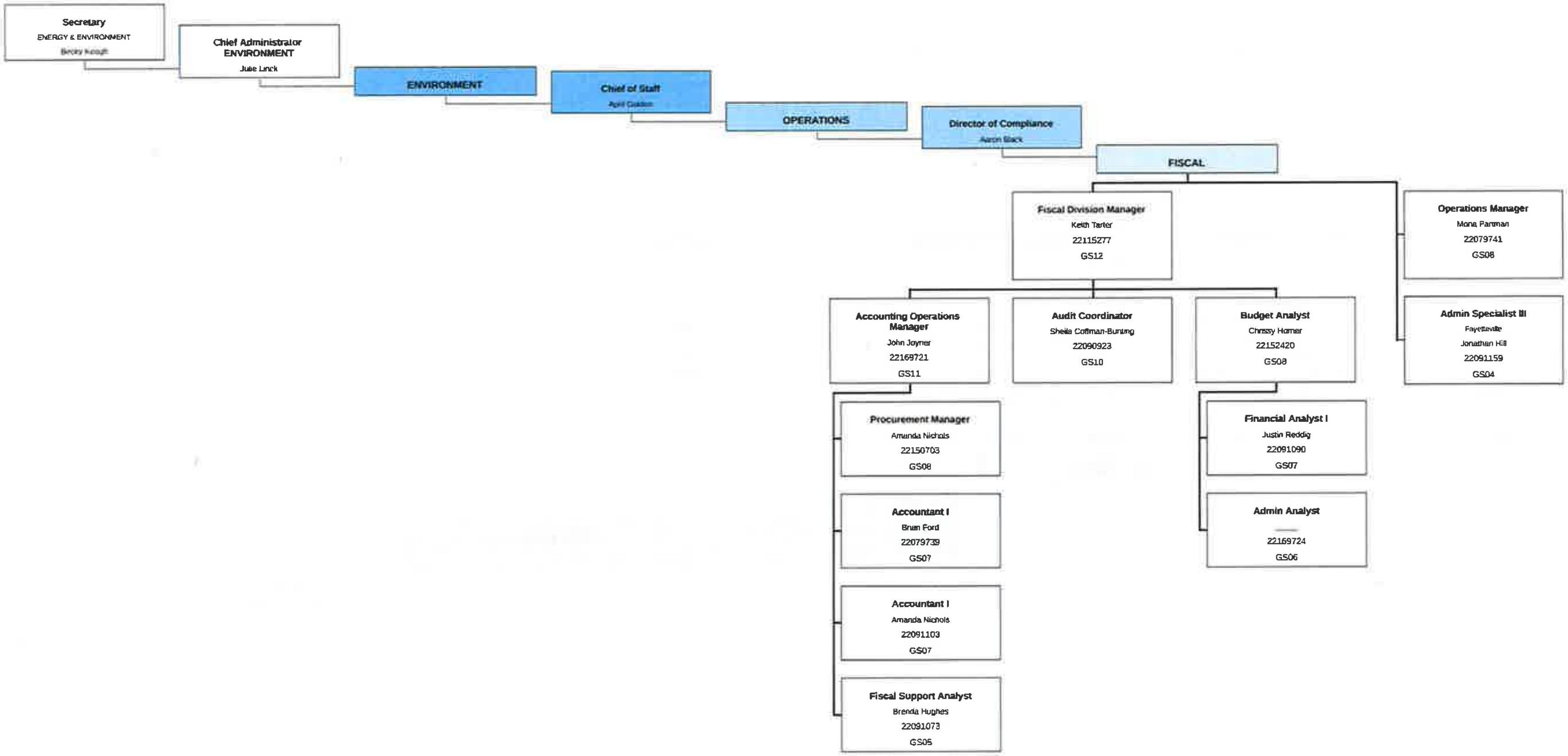
Director of Personnel
Raina Weaver
22091169
GS13

HUMAN RESOURCES

E&E Administrative Operations Manager
Maggie Sponer
22091304
GS12

BUILDING OPERATIONS

Assistant to the Chief of Staff
Kerry Sue Goodson
22091001
GS06



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Becky Keogh

Chief Administrator
ENVIRONMENT
Julie Linck

ENVIRONMENT

Chief of Staff
April Gladden

OPERATIONS

Director of Compliance
Aaron Black

FISCAL

Fiscal Division Manager
Keith Tarter
22115277
GS12

Operations Manager
Mona Farman
22079741
GS08

Admin Specialist III
Fayetteville
Jonathan Hill
22091159
GS04

Accounting Operations Manager
John Joyner
22169721
GS11

Audit Coordinator
Sheila Coffman-Bunting
22090923
GS10

Budget Analyst
Chrissy Homer
22152420
GS08

Procurement Manager
Amanda Nichols
22150703
GS08

Accountant I
Brian Ford
22079739
GS07

Accountant I
Amanda Nichols
22091103
GS07

Fiscal Support Analyst
Brenda Hughes
22091073
GS05

Financial Analyst I
Justin Reddig
22091090
GS07

Admin Analyst
—
22169724
GS06

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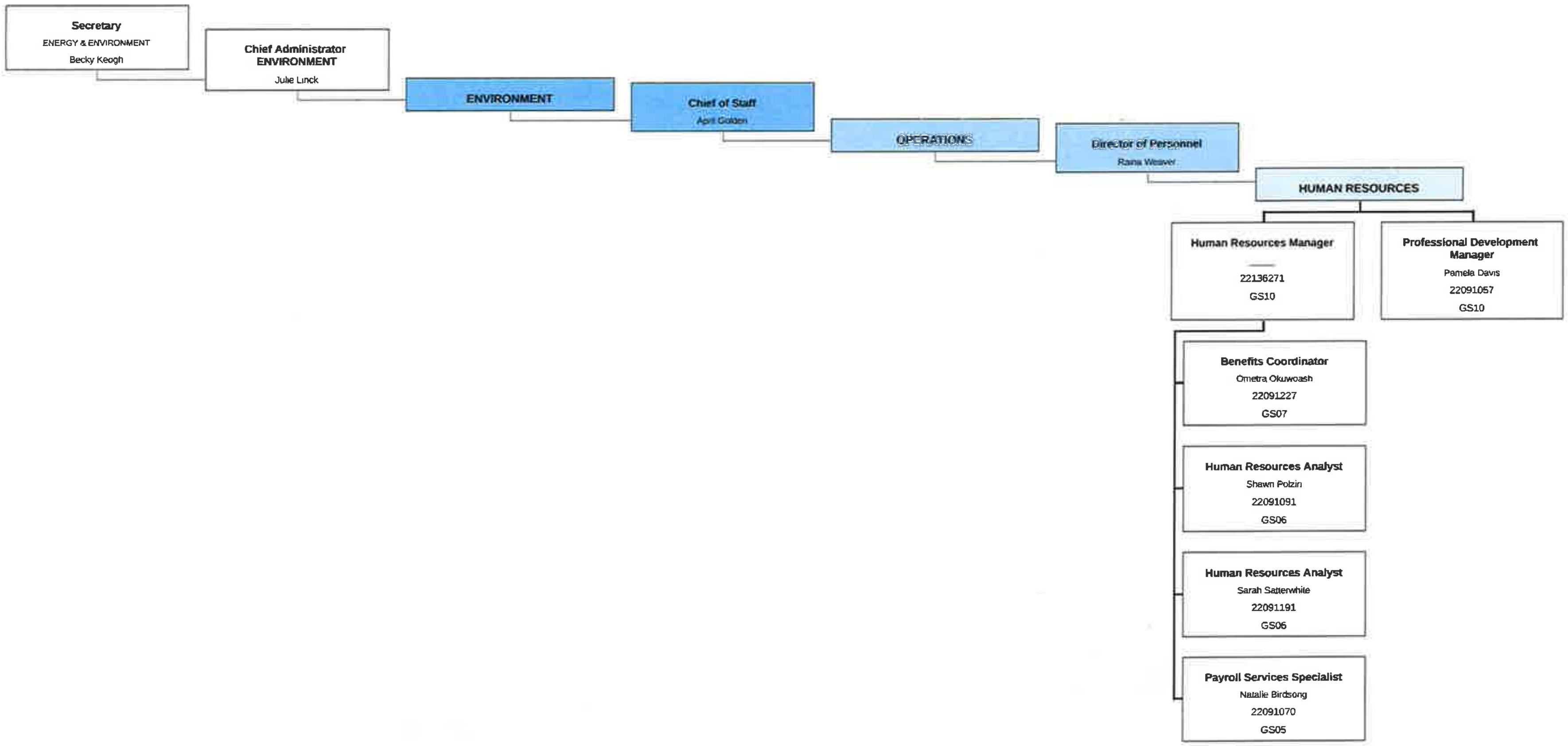

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ENERGY & ENVIRONMENT
Becky Keogh

Chief Administrator ENVIRONMENT
Julie Linck

ENVIRONMENT

Chief of Staff
April Golden

OPERATIONS

Director of Personnel
Raina Weaver

HUMAN RESOURCES

Human Resources Manager
—
22136271
GS10

Professional Development Manager
Pamela Davis
22091057
GS10

Benefits Coordinator
Ometra Okuwoash
22091227
GS07

Human Resources Analyst
Shawn Polzin
22091091
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Human Resources Analyst
Sarah Satterwhite
22091191
GS06

Payroll Services Specialist
Natalie Birdsong
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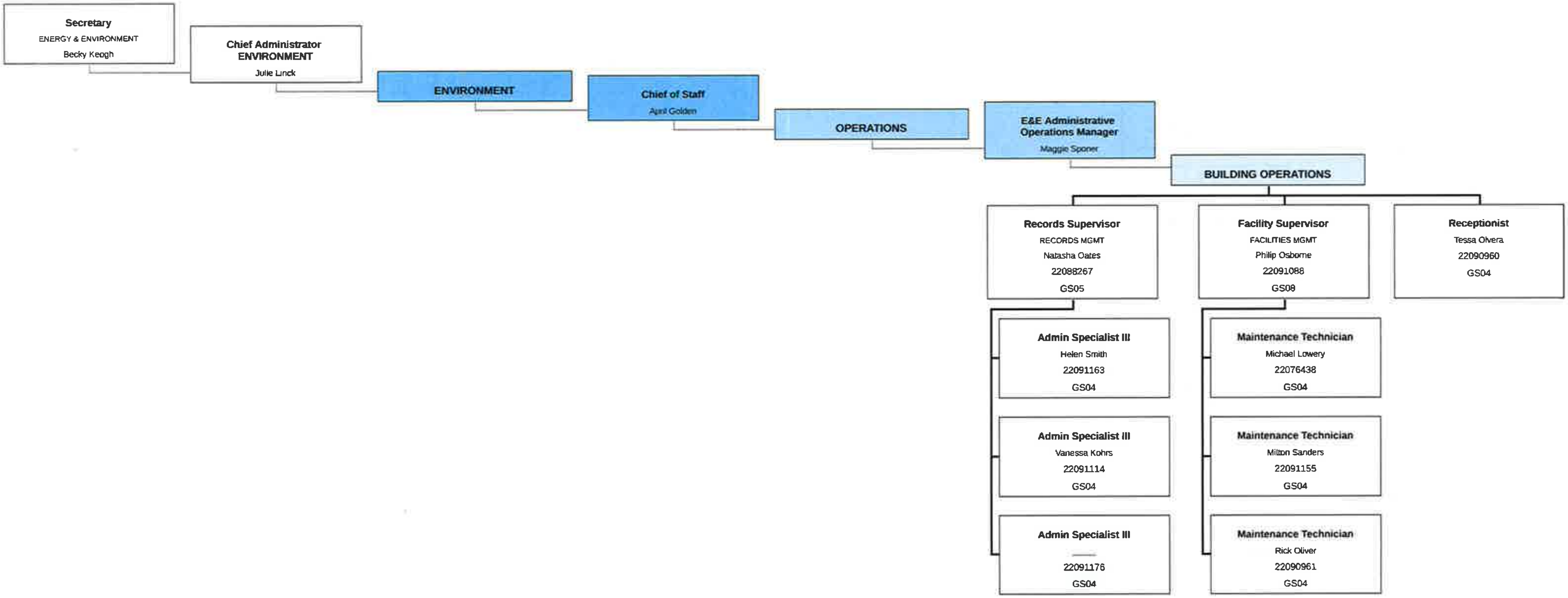
GS05



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ENERGY & ENVIRONMENT
Becky Keogh

Chief Administrator
ENVIRONMENT
Julie Linck

ENVIRONMENT

Chief of Staff
April Golden

OPERATIONS

E&E Administrative Operations Manager
Maggie Sponer

BUILDING OPERATIONS

Records Supervisor
RECORDS MGMT
Natasha Oates
22088267
GS05

Facility Supervisor
FACILITIES MGMT
Philip Osborne
22091088
GS08

Receptionist
Tessa Olvera
22090960
GS04

Admin Specialist III
Helen Smith
22091163
GS04

Admin Specialist III
Vanessa Kohrs
22091114
GS04

Admin Specialist III
——
22091176
GS04

Maintenance Technician
Michael Lowery
22076438
GS04

Maintenance Technician
Milton Sanders
22091155
GS04

Maintenance Technician
Rick Oliver
22090961
GS04

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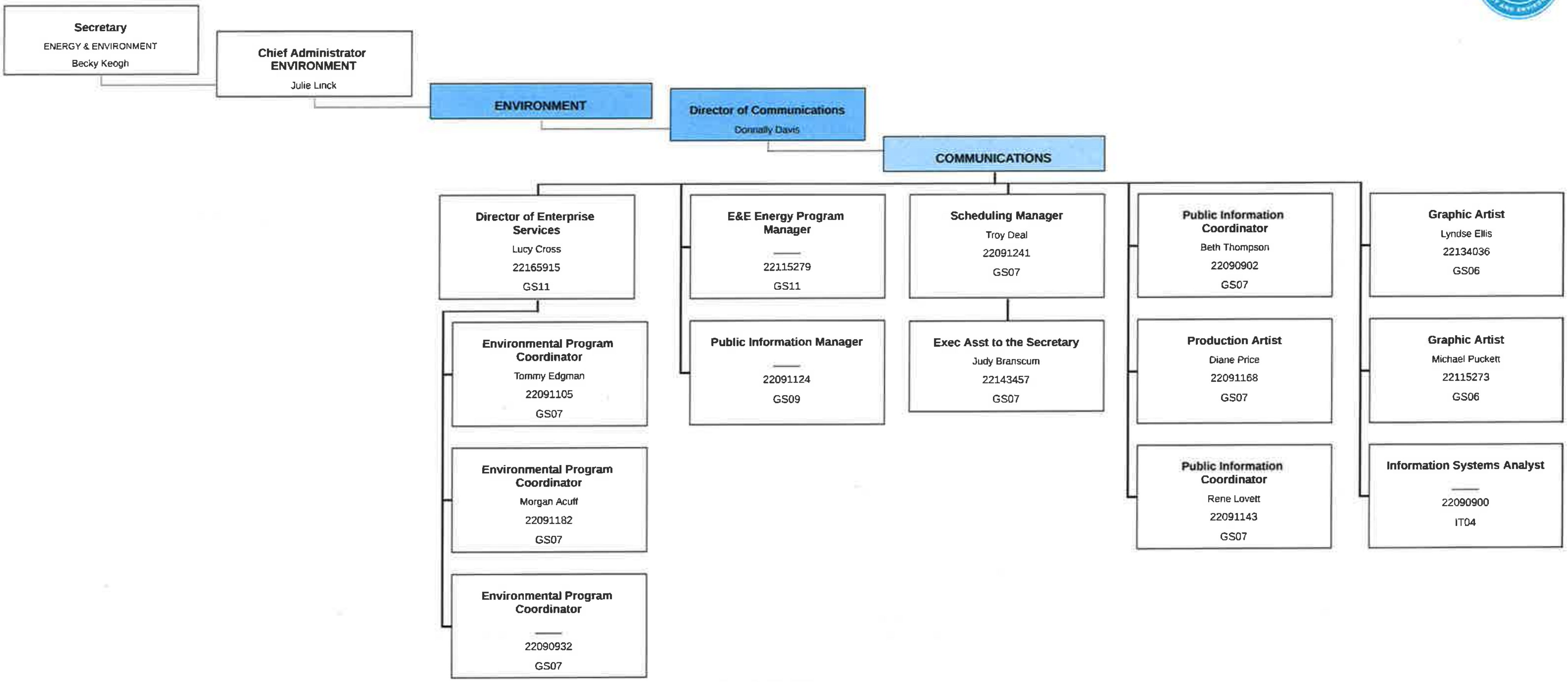

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ENERGY & ENVIRONMENT
Becky Keogh

Chief Administrator ENVIRONMENT
Julie Linck

ENVIRONMENT

Director of Communications
Donnally Davis

COMMUNICATIONS

Director of Enterprise Services
Lucy Cross
22165915
GS11

Environmental Program Coordinator
Tommy Edgman
22091105
GS07

Environmental Program Coordinator
Morgan Acuff
22091182
GS07

Environmental Program Coordinator
—
22090932
GS07

E&E Energy Program Manager
—
22115279
GS11

Public Information Manager
—
22091124
GS09

Scheduling Manager
Troy Deal
22091241
GS07

Exec Asst to the Secretary
Judy Branscum
22143457
GS07

Public Information Coordinator
Beth Thompson
22090902
GS07

Production Artist
Diane Price
22091168
GS07

Public Information Coordinator
Rene Lovett
22091143
GS07

Graphic Artist
Lyndse Ellis
22134036
GS06

Graphic Artist
Michael Puckett
22115273
GS06

Information Systems Analyst
—
22090900
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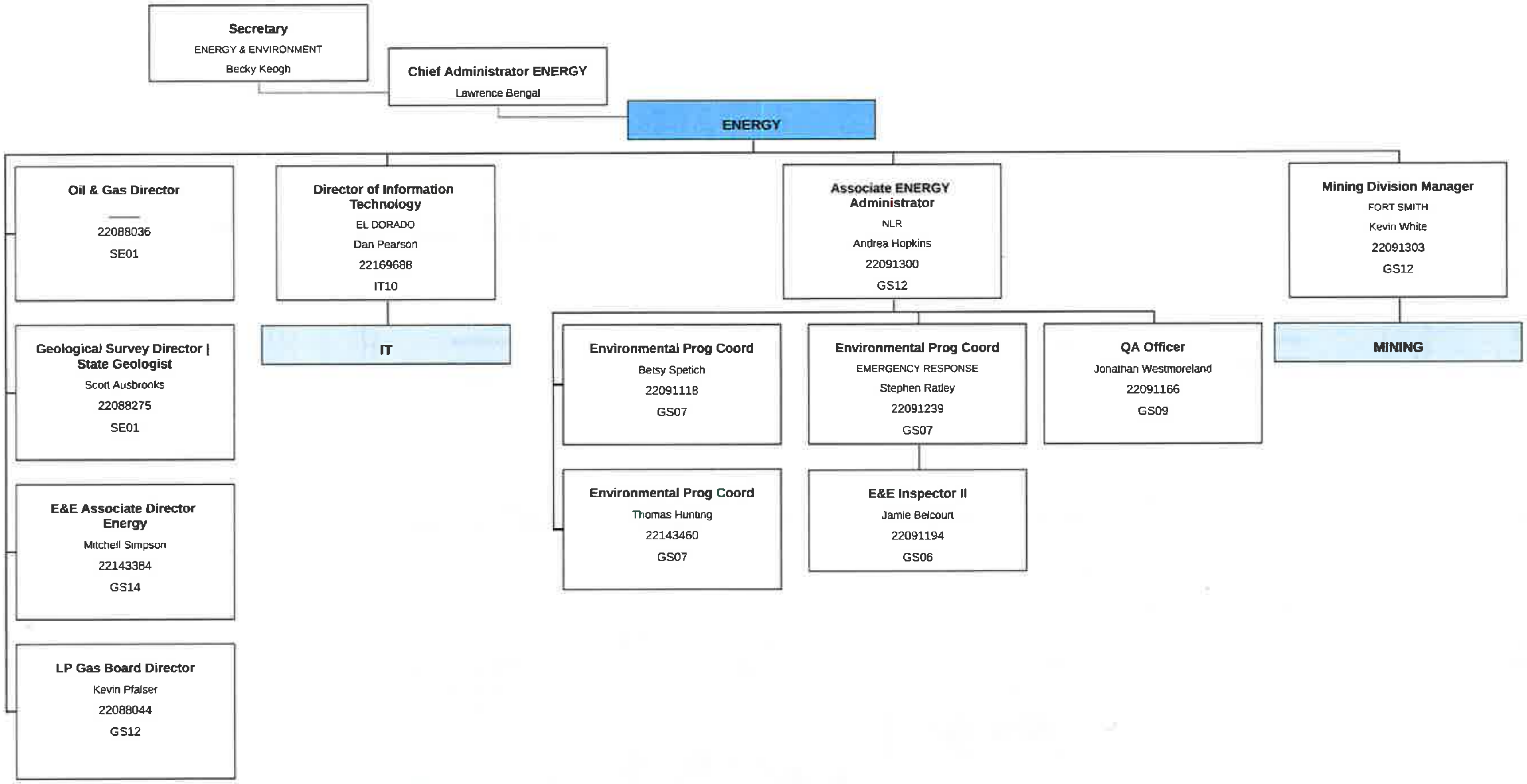


Secretary
ENERGY & ENVIRONMENT
Becky Keogh

Chief Administrator ENERGY
Lawrence Bengal

ENERGY

Oil & Gas Director
——
22088036
SE01

Geological Survey Director | State Geologist
Scott Ausbrooks
22088275
SE01

E&E Associate Director Energy
Mitchell Simpson
22143384
GS14

LP Gas Board Director
Kevin Pfalser
22088044
GS12

Director of Information Technology
EL DORADO
Dan Pearson
22169688
IT10

IT

Associate ENERGY Administrator
NLR
Andrea Hopkins
22091300
GS12

Environmental Prog Coord
Betsy Spetich
22091118
GS07

Environmental Prog Coord
Thomas Hunting
22143460
GS07

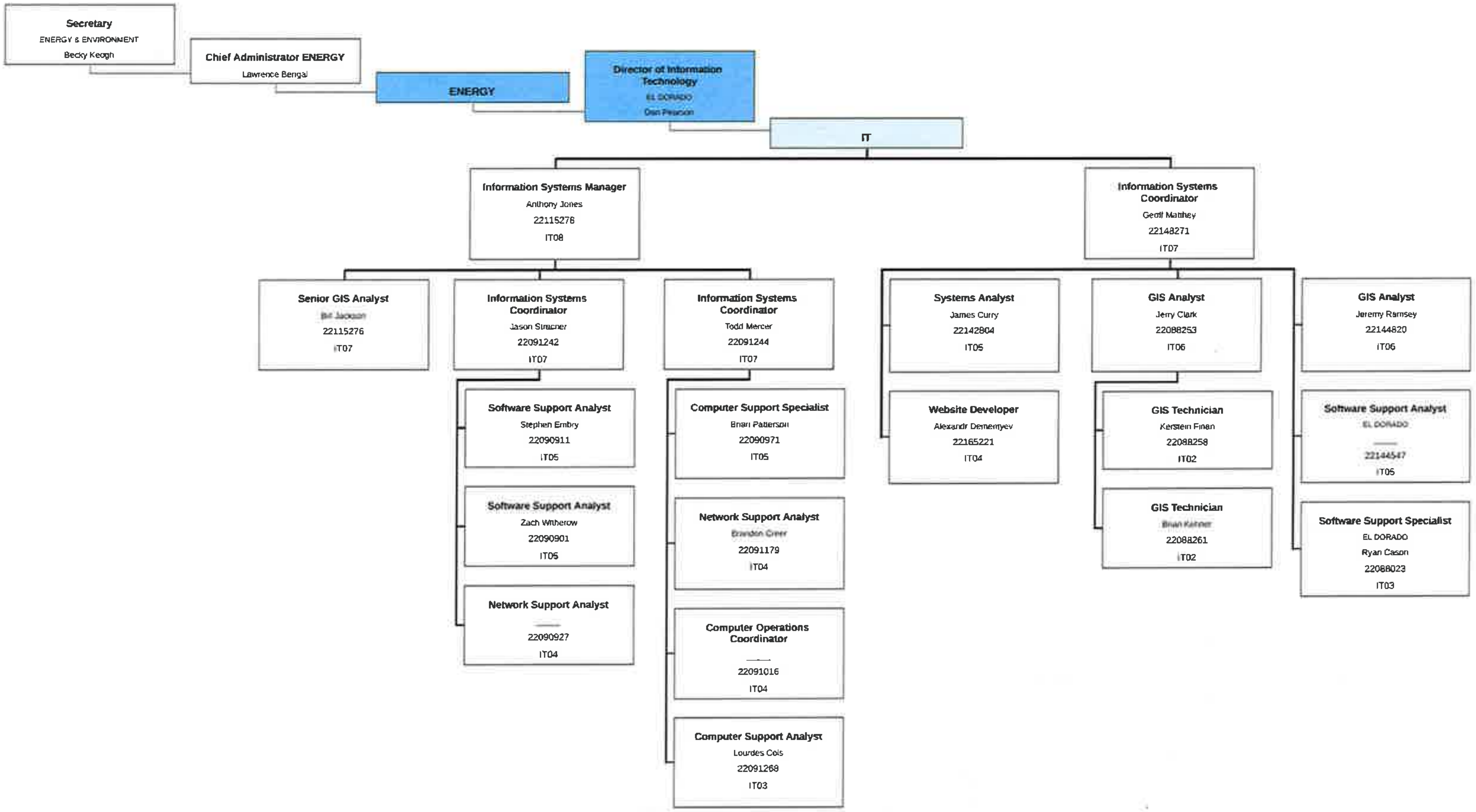
Environmental Prog Coord
EMERGENCY RESPONSE
Stephen Ratley
22091239
GS07

E&E Inspector II
Jamie Belcourt
22091194
GS06

QA Officer
Jonathan Westmoreland
22091166
GS09

Mining Division Manager
FORT SMITH
Kevin White
22091303
GS12

MINING


Secretary
ENERGY & ENVIRONMENT
Becky Keogh
Chief Administrator ENERGY
Lawrence Bengal
ENERGY
Director of Information Technology
EL DORADO
Dan Pearson
IT
Information Systems Manager
Anthony Jones
22115276
IT08
Senior GIS Analyst
Bill Jackson
22115276
IT07
Information Systems Coordinator
Jason Stracner
22091242
IT07
Software Support Analyst
Stephen Embry
22090911
IT05
Software Support Analyst
Zach Witherow
22090901
IT05
Network Support Analyst
——
22090927
IT04
Information Systems Coordinator
Todd Mercer
22091244
IT07
Computer Support Specialist
Brian Patterson
22090971
IT05
Network Support Analyst
Brandon Greer
22091179
IT04
Computer Operations Coordinator
——
22091016
IT04
Computer Support Analyst
Lourdes Cols
22091268
IT03
Information Systems Coordinator
Geoff Matthey
22148271
IT07
Systems Analyst
James Curry
22142804
IT05
Website Developer
Alexandr Dementyev
22165221
IT04
GIS Analyst
Jerry Clark
22088253
IT06
GIS Technician
Kerstein Finan
22088258
IT02
GIS Technician
Brian Kahner
22088261
IT02
GIS Analyst
Jeremy Ramsey
22144820
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Software Support Analyst
EL DORADO
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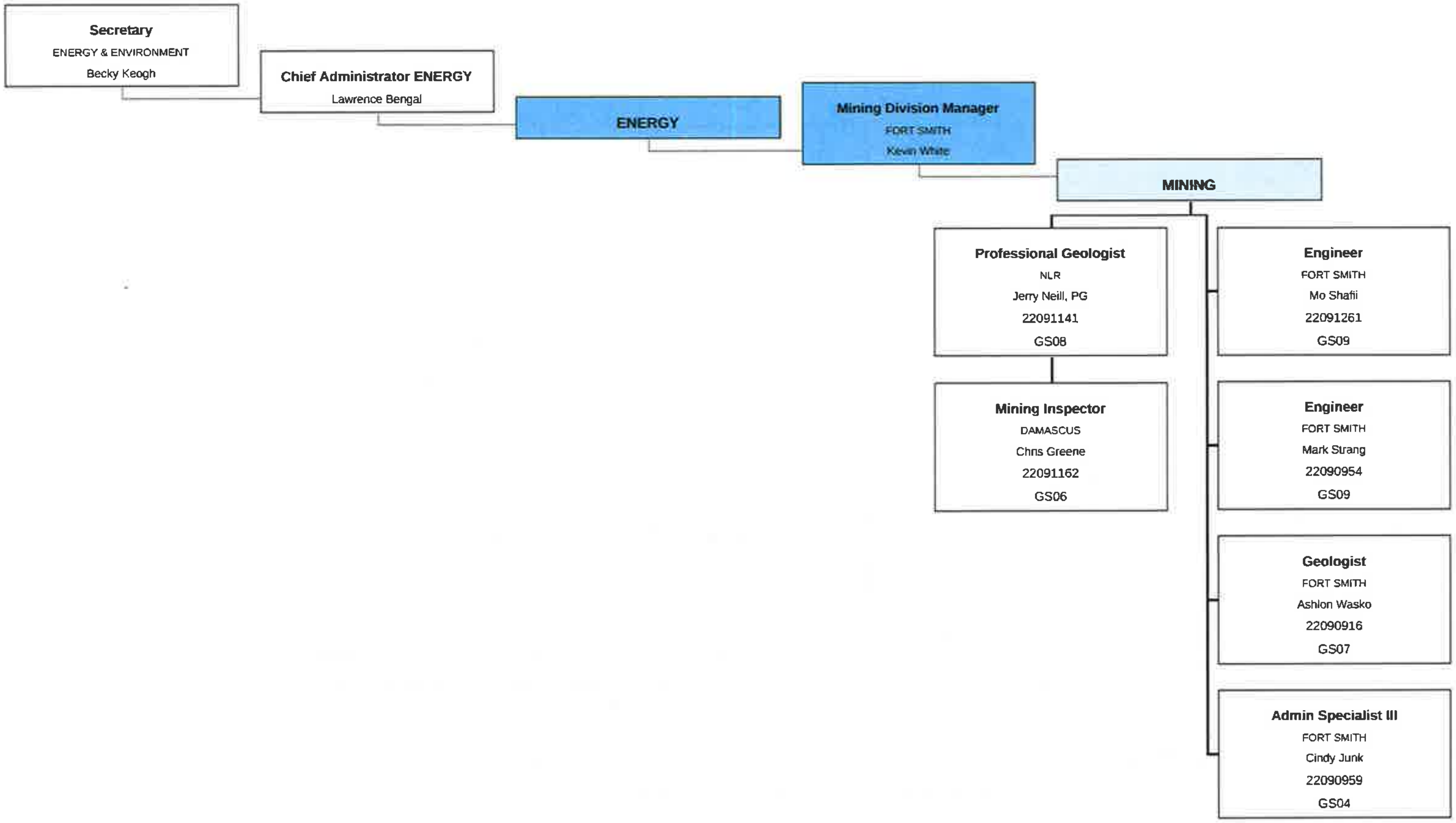
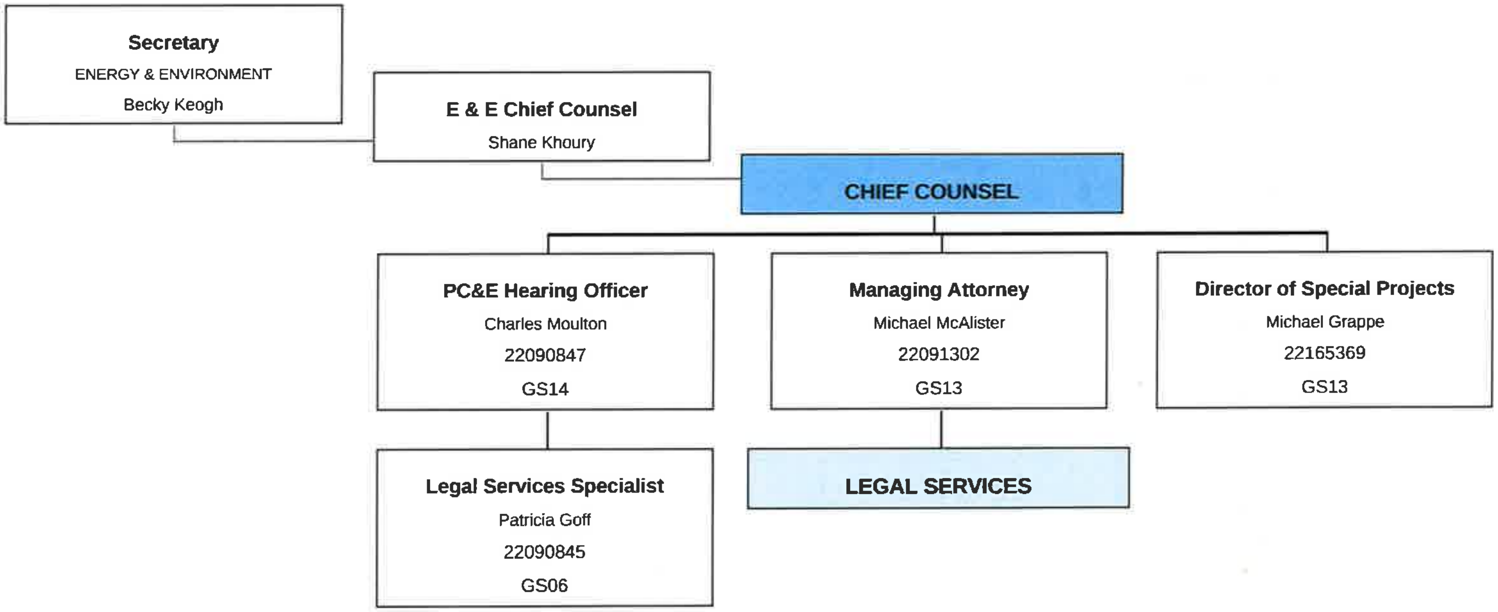
IT05
Software Support Specialist
EL DORADO
Ryan Cason
22088023
IT03


Secretary
ENERGY & ENVIRONMENT
Becky Keogh
Chief Administrator ENERGY
Lawrence Bengal
ENERGY
Mining Division Manager
FORT SMITH
Kevin White
MINING
Professional Geologist
NLR
Jerry Neill, PG
22091141
GS08
Mining Inspector
DAMASCUS
Chns Greene
22091162
GS06
Engineer
FORT SMITH
Mo Shafii
22091261
GS09
Engineer
FORT SMITH
Mark Strang
22090954
GS09
Geologist
FORT SMITH
Ashlon Wasko
22090916
GS07
Admin Specialist III
FORT SMITH
Cindy Junk
22090959
GS04



Secretary
ENERGY & ENVIRONMENT
Becky Keogh

E & E Chief Counsel
Shane Khoury

CHIEF COUNSEL

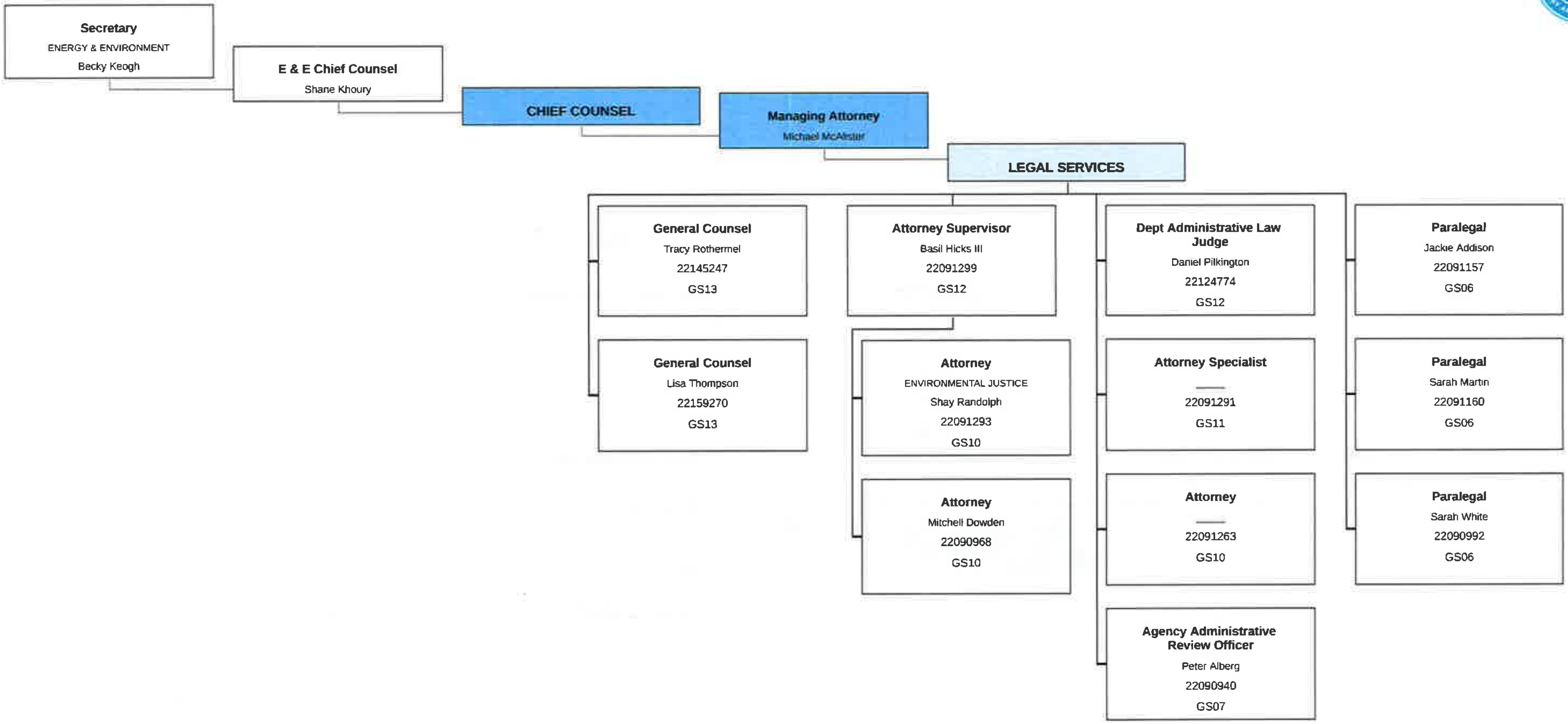
PC&E Hearing Officer
Charles Moulton
22090847
GS14

Managing Attorney
Michael McAlister
22091302
GS13

Director of Special Projects
Michael Grappe
22165369
GS13

Legal Services Specialist
Patricia Goff
22090845
GS06

LEGAL SERVICES



- **Secretary** ENERGY & ENVIRONMENT, Becky Keogh
  - **E & E Chief Counsel**, Shane Khoury
    - **CHIEF COUNSEL**
      - **Managing Attorney**, Michael McAlister
        - **LEGAL SERVICES**
          - **General Counsel**, Tracy Rothermel, 22145247, GS13
          - **General Counsel**, Lisa Thompson, 22159270, GS13
          - **Attorney Supervisor**, Basil Hicks III, 22091299, GS12
            - **Attorney** ENVIRONMENTAL JUSTICE, Shay Randolph, 22091293, GS10
            - **Attorney**, Mitchell Dowden, 22090968, GS10
          - **Dept Administrative Law Judge**, Daniel Pilkington, 22124774, GS12
          - **Attorney Specialist**, —, 22091291, GS11
          - **Attorney**, —, 22091263, GS10
          - **Agency Administrative Review Officer**, Peter Alberg, 22090940, GS07
          - **Paralegal**, Jackie Addison, 22091157, GS06
          - **Paralegal**, Sarah Martin, 22091160, GS06
          - **Paralegal**, Sarah White, 22090992, GS06

APPENDIX 2

TO

FY2023 RCRA

QUALITY ASSURANCE PROJECT PLAN

ERT COMPENDIUM OF WASTE SAMPLING PROCEDURES

COMPENDIUM
OF
WASTE SAMPLING PROCEDURES

The policies and procedures established in this document are intended solely for the guidance of Division personnel, for use in the hazardous waste management program established pursuant to the Arkansas Hazardous Waste Management Act. They are not intended, and cannot be relied upon, to create any rights, substabtive or procedural, enforceable by any party in litigation with the United States or the State of Arkansas. The Division reserves the right to act at variances with these policies and procedures and to change them at any time without public notice.

Depending on circumstances and needs, it may not be possible or appropriate to follow these procedures exactly in all situations because of site conditions, equipment limitiations, and limitations of the standard procedures. Whenever these procedures cannot be followed as written, they may be used as general guidance with any and all modifications fully documented in either site-specific QA plans, sampling plans, or final reports of results.

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SAMPLING EQUIPMENT DECONTAMINATION

SOP # 1

SCOPE AND APPLICATION

This Standard Operating Procedure (SOP) describes methods used for preventing or reducing cross-contamination, and provides general guidelines for sampling equipment decontamination procedures at a hazardous waste site. Preventing or minimizing cross-contamination in sampled media and in samples is important for preventing the introduction of error into sampling results and for protecting the health and safety of site personnel.

Removing or neutralizing contaminants that have accumulated on sampling equipment ensures protection of personnel from permeating substances, reduces or eliminates transfer of contaminants to clean areas, prevents the mixing of incompatible substances, and minimizes the likelihood of sample cross-contamination.

METHOD SUMMARY

Contaminants can be physically removed from equipment, or deactivated by sterilization or disinfection. Gross contamination of equipment requires physical decontamination, including abrasive and non-abrasive methods. These include the use of brushes, air and wet blasting, and high-pressure water cleaning, followed by a wash/rinse process using appropriate cleaning solutions. Use of a solvent rinse is required when organic contamination is present.

SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

This section is not applicable to this SOP.

INTERFERENCES AND POTENTIAL PROBLEMS

The use of distilled/deionized water commonly available from commercial vendors may be acceptable for decontamination of sampling equipment provided that it has been verified by laboratory analysis to be analyte free.

- An untreated potable water supply is not an acceptable substitute for tap water. Tap water may be used from any municipal water treatment. system for mixing of decontamination solutions.
- Acids and solvents utilized in the decontamination sequence pose the health and safety risks of inhalation or skin contact, and raise shipping concerns of permeation or degradation.
- The site work plan must address disposal of the spent decontamination solutions.
- Several procedures can be established to minimize contact with waste and the potential for contamination. For example:
    - Stress work practices that minimize contact with hazardous substances.
    - Use remote sampling, handling, and container-opening techniques when appropriate.
    - Cover monitoring and sampling equipment with protective material to minimize contamination.
    - Use disposable outer garments and disposable sampling equipment when appropriate.

EQUIPMENT / APPARATUS

- appropriate personal protective clothing
- non-phosphate detergent
- selected solvents
- long-handled brushes
- drop cloths/plastic sheeting
- trash container
- paper towels
- galvanized tubs or buckets
- tap water
- distilled/deionized water
- metal/plastic containers for storage and disposal of contaminated wash solutions
- pressurized sprayers for tap and deionized/ distilled water
- sprayers for solvents
- trashbags
- aluminum foil
- safety glasses or splash shield
- emergency eyewash bottle

REAGENTS

There are no reagents used in this procedure aside from the actual decontamination solutions and solvents. In general, the following solvents are utilized for decontamination purposes:

- 10% nitric acid[1]
- acetone (pesticide grade)[2]
- hexane (pesticide grade)[2]
- methanol

(1) Only if sample is to be analyzed for trace metals.
(2) Only if sample is to be analyzed for organics.

PROCEDURES

As part of the health and safety plan, develop and set up a decontamination plan before any personnel or equipment enter the areas of potential exposure. The equipment decontamination plan should include:

- the number; location, and layout of decontamination stations
- which decontamination apparatus is needed
- the appropriate decontamination methods
- methods for disposal of contaminated clothing, apparatus, and solutions

Decontamination Methods

All personnel, samples, and equipment leaving the contaminated area of a site must be decontaminated. Various decontamination methods will either physically remove contaminants, inactivate contaminants by disinfection or sterilization, or do both.

In many cases, gross contamination can be removed by physical means. The physical decontamination techniques appropriate for equipment decontamination can be grouped into two categories: abrasive methods and non-abrasive methods.

Abrasive Cleaning Methods

Abrasive cleaning methods work by rubbing and wear away the top layer of the surface containing the contaminant. The following abrasive methods are available:

- *Mechanical:* Mechanical cleaning methods use brushes of metal or nylon. The amount and type of contaminants removed will vary with the hardness of bristles, length of brushing time, and degree of brush contact.
- *Air blasting*: Air blasting is used for cleaning large equipment, such as bulldozers, drilling rigs or auger bits. The equipment used in air blast cleaning employs compressed air to force abrasive material through a nozzle at high velocities. The distance between the nozzle and the surface cleaned, as well as the pressure of air, the time of application, and the angle at which the abrasive strikes the surface, determines cleaning efficiency. Air blasting has several disadvantages: it is unable to control the amount of material removed, it can aerate contaminants, and it generates large amounts of waste.
- *Wet Blasting*: Wet blast cleaning, also used to clean large equipment, involves use of a suspended fine abrasive delivered by compressed air to the contaminated area. The amount of materials removed can be carefully controlled by using very fine abrasives. This method generates a large amount of waste.

Non-Abrasive Cleaning Methods

Non-abrasive cleaning methods work by forcing the contaminant off of a surface with pressure. In general, less of the equipment surface is removed using non-abrasive methods. The following non-abrasive methods are available:

- *High-Pressure Water*: This method consists of a high-pressure pump, an operator-controlled directional nozzle, and a high pressure hose. Operating pressure usually ranges from 340 to 680 atmospheres (atm) which relates to flow rates of 20 to 140 liters per minute
- *Ultra-High-Pressure Water*: This system produces a pressurized water jet (from 1,000 to 4,000 atm). The ultra-high-pressure spray removes tightly adhered surface film. The water velocity ranges from 500 m/sec (1,000 atm) to 900 m/sec (4,000 atm). Additives can enhance the method. This method is not applicable for hand-held sampling equipment.

Disinfection/Rinse Methods

- *Disinfection*: Disinfectants are a practical means of inactivating infections agents.
- *Sterilization*: Standard sterilization methods involve heating the equipment. Sterilization is impractical for large equipment.
- *Rinsing*: Rinsing removes contaminants through dilution, physical attraction, and solubilization.

Field Sampling Equipment Cleaning Procedures

Solvent rinses are not necessarily required when organics are not a contaminant of concern and may be eliminated from the sequence specified below. Similarly, an acid rinse is not required if analysis does not include inorganics.

1. Where applicable, follow the physical removal procedures specified above.
2. Wash equipment with a non-phosphate detergent solution.
3. Rinse with tap water.
4. Rinse with distilled/deionized water.
5. Rinse with 10% nitric acid if the sample will be analyzed for trace organics.
6. Rinse with distilled/deionized water.
7. Use a solvent rinse (pesticide grade) if the sample will be analyzed for organics.
8. Air dry the equipment completely.
9. Rinse again with distilled/deionized water.

Selection of the solvent for use in the decontamination process is based on the contaminants present at the site. Use of a solvent is required when organic contamination is present on-site. Typical solvents used for removal of organic contaminants include acetone, hexane, or water.

An acid rinse step is required if metals are present on-site. If a particular contaminant fraction is not present at the site, the nine-step decontamination procedure listed above may be modified for site specificity. The decontamination solvent used should not be among the contaminants of concern at the site.

Table 1 on page 4 lists solvent rinses which may be required for elimination of particular chemicals. After each solvent rinse, the equipment should be air dried and rinsed with distilled/deionized water.

Sampling equipment that requires the use of plastic tubing should be disassembled and the tubing replaced with clean tubing, before commencement of sampling and between sampling locations.

CALCULATIONS

This section is not applicable to this SOP.

QUALITY ASSURANCE / QUALITY CONTROL

One type of quality control sample specific to the field decontamination process is the rinsate blank. The rinsate blank provides information on the effectiveness of the decontamination process employed in the field. When used in conjunction with field blanks and trip blanks, a rinsate blank can detect contamination during sample handling, storage and sample transportation to the laboratory.

A rinsate blank consists of a sample of analyte-free (i.e., deionized) water which is passed over and through a field decontaminated sampling device and placed in a clean sample container.

Rinsate blanks should be run for all parameters of interest at a rate of 1 per 20 for each parameter; even if samples are not shipped that day. Rinsate blanks are not required if dedicated sampling equipment is used.

DATA VALIDATION

This section is not applicable to this SOP.

HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, OSHA and specific health and safety procedures.

Decontamination can pose hazards under certain circumstances even though performed to protect health and safety. Hazardous substances may be incompatible with decontamination methods. For example, the decontamination solution or solvent may react with contaminants to produce heat, explosion, or toxic products. Decontamination methods may be incompatible with clothing or equipment; some solvents can permeate or degrade protective clothing. Also, decontamination solutions and solvents may pose a direct health hazard to workers through inhalation or skin contact, or if they combust.

The decontamination solutions and solvents must be determined to be compatible before use. Any method that permeates, degrades, or damages personal protective equipment should not be used. If decontamination methods pose a direct health hazard, measures should be taken to protect personnel or the methods should be modified to eliminate the hazard.

DRUM SAMPLING

SOP # 2

SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure (SOP) is to provide technical guidance on safe and cost-effective response actions at hazardous waste sites containing drums with unknown contents. Container contents are sampled and characterized for disposal, bulking, recycling, grouping, and/or classification purposes.

METHOD SUMMARY

Prior to sampling, drums must be inventoried, staged, and opened. An inventory entails recording visual qualities of each drum and any characteristics pertinent to the contents' classification. Staging involves the organization, and sometimes consolidation of drums which have similar wastes or characteristics. Opening of closed drums can be performed manually or remotely. Remote drum opening is recommended for worker safety. The most widely used method of sampling a drum involves the use of a glass thief. This method is quick, simple, relatively inexpensive, and requires no decontamination.

SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

Samples collected from drums are considered waste samples. No preservatives should be added since there is a potential reaction of the sample with the preservative. Samples should, however, be cooled to 4°C and protected from sunlight in order to minimize any potential reaction due to the light sensitivity of the sample.

Sample bottles for collection of waste liquids, sludges, or solids are typically wide-mouth amber jars with Teflon-lined screw caps. Actual volume required for analysis should be determined in conjunction with the laboratory performing the analysis.

Follow these waste sample handling procedures:

1. Place sample container in two ziploc plastic bags.
2. Place each bagged container in a 1-gallon covered can containing absorbent packing material. Place the lid on the can.
3. Mark the sample identification number on the outside of the can.
4. Place the marked cans in a cooler, and fill remaining space with absorbent packing material.
5. Fill out chain of custody form for each cooler, place in plastic, and affix to inside lid of cooler.
6. Secure and custody seal the lid of cooler.
7. Arrange for the appropriate transportation mode consistent with the type of hazardous waste involved.

INTERFERENCES AND POTENTIAL PROBLEMS

The practice of tapping drums to determine their contents is neither safe nor effective and should not be used if the drums are visually overpressurized or if shock-sensitive materials are suspected. A laser thermometer may be used instead.

Drums that have been overpressurized, to the extent that the head is swollen several inches above the level of the chime, should not be moved. A number of devices have been developed for venting critically swollen drums. One method that has proven to be effective is a tube and spear device. A light aluminum tube (3 meters long) is positioned at the vapor space of the drum. A rigid, hooking device attached to the tube goes over the chime and holds the tube securely in place. The spear is inserted in the tube and positioned against the drum wall. A sharp blow on the end of the spear drives the sharpened tip through the drum and the gas vents along the grooves. The venting should be done from behind a wall or barricade. This device can be cheaply and easily designed and constructed where needed. Once the pressure has been relieved, the bung can be removed and the drum sampled.

EQUIPMENT/APPARATUS

The following are standard materials and equipment required for sampling:

- personal protection equipment
- wide-mouth glass jars with Teflon cap liner, approximately 500 mL volume
- uniquely numbered sample identification labels with corresponding data sheets
- 1-gallon covered cans half-filled with absorbent (vermiculite)
- chain of custody forms
- decontamination materials
- glass thief tubes or Composite Liquid Waste Samplers (COLIWASA)
- laser thermometer
- drum opening devices

Drum opening devices include the following:

Bung Wrench

A common method for opening drums manually is using a universal bung wrench. These wrenches have fittings made to remove nearly all commonly encountered bungs. They are usually constructed of cast iron, brass, or a bronze-beryllium, non-sparking alloy formulated to reduce the likelihood of sparks. The use of a non-sparking bung wrench does not completely eliminate the possibility of a spark being produced.

Drum Deheader

When a bung is not removable with a bung wrench, a drum can be opened manually by using a drum deheader. This tool is constructed of forged steel with an alloy steel blade and is designed to cut the lid of a drum off or part way off by means of a scissors-like cutting action. A limitation of this device is that it can be attached only to closed head drums. Drums with removable heads must be opened by other means.

Hand Pick, Pickaxe, and Hand Spike

These tools are usually constructed of brass or a non-sparking alloy with a sharpened point that can penetrate the drum lid or head when the tool is swung. The hand picks or pickaxes that are most commonly used are commercially available; whereas the spikes are generally uniquely fabricated foot-long poles with a pointed end.

Backhoe Spike

The most common means used to open drums remotely for sampling is the use of a metal spike attached or welded to a backhoe bucket. In addition to being very efficient, this method can greatly reduce the likelihood of personal exposure.

Hydraulic Drum Opener

Another remote method for opening drums is with remotely operated hydraulic devices. One such device uses hydraulic pressure to pierce through the wall of a drum. It consists of a manually operated pump which pressurizes soil through a length of hydraulic line.

Pneumatic Devices

A pneumatic bung remover consists of a compressed air supply that is controlled by a heavy-duty, two-stage regulator. A high-pressure air line of desired length delivers compressed air to a pneumatic drill, which is adapted to turn a bung fitting selected to fit the bung to be removed. An adjustable bracketing system has been designed to position and align the pneumatic drill over the bung. This bracketing system must be attached to the drum before the drill can be operated. Once the bung has been loosened, the bracketing system must be removed before the drum can be sampled. This remote bung opener does not permit the slow venting of the container, and therefore appropriate precautions must be taken. It also requires the container to be upright and relatively level. Bungs that are rusted shut cannot be removed with this device.

REAGENTS

Reagents are not typically required for preserving drum samples. However, reagents are used for decontaminating sampling equipment. Decontamination solutions are specified in SOP #1, Sampling Equipment Decontamination.

PROCEDURES

Preparation

1. Determine the extent of the sampling effort, the sampling methods to be employed, and which equipment and supplies arc needed.
2. Obtain necessary sampling and monitoring equipment.
3. Decontaminate or preclean cquipment, and ensure that it is in working order.
4. Prepare scheduling and coordinate with staff, clients, and regulatory agency, if appropriate.
5. Perform a general site survey prior to site entry in accordance with the site-specific health and safety plan.
6. Use stakes, flagging, or buoys to identity and mark all sampling locations. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions.

Drum Inspection

Appropriate procedures for handling drums depend on the contents. Thus, prior to any handling, drums should be visually inspected to gain as much information as possible about their contents. Thdse in charge of inspections should be on the look-out for:

- drum condition, corrosion, rust, and leaking contents
- symbols, words, or other markings on the drum indicating hazards (i.e., explosive, radioactive, toxic, flammable)
- signs that the drum is under pressure
- shock sensitivity

Monitor around the drums with radiation instruments, organic vapor monitors (OVA) and combustible gas indicators (CGI)

Classify the drums into categories, for instance:

- radioactive
- leaking/deteriorating
- bulging
- drums containing lab packs
- explosive/shock-sensitive

All personnel should issume that unmarked drums contain hazardous materials until their contents have been categorized, and that labels on drums may not accurately describe their contents.

If it is presumed that there are buried drums on-site, geophysical investigation techniques such as magnetometry, ground penetrating radar, and metal detection can be employed in an attempt to determine depth and location of the drums. See SOP # 8, General Surface Geophysics.

Drum Staging

Prior to sampling, the drums should be staged to allow easy access. Ideally, the staging area should be located just far enough from the drum opening area to prevent a chain reaction if one drum should explode or catch fire when opened.

While staging, physically separate the drums into the following categories: those containing liquids, those containing solids, lab packs, or gas cylinders, and those which are empty. This is done because the strategy for sampling and handling drums/containers in each of these categories will be different. This may be achieved by:

- Visual inspection of the drum and its labels, codes, etc. Solids and sludges are typically disposed of in open-top drums. Closed-head drums with a bung opening generally contain liquid.
- Visual inspection of the contents of the drum during sampling followed by restaging, if needed.

Once a drum has been excavated and any immediate hazard has been eliminated by overpacking or transferring the drum's contents, affix a numbered tag to the drum and transfer it to a staging area. Color-coded tags, labels, or bands should be used to mark similar waste types. Record a description of each drum, its condition, any unusual markings, and the location where it was buried or stored, on a drum data sheet. This data sheet becomes the principal recordkeeping tool for tracking the drum on-site.

Where there is good reason to suspect that some drums contain radioactive, explosive, and shock-sensitive materials, these drums should be staged in a separate, isolated area. Placement of explosives and shock-sensitive materials in diked and fenced areas will minimize the hazard and the adverse effects of any premature detonation of explosives.

Where space allows, the drum opening area should be physically separated from the drum removal and drum staging operations. Drums are moved from the staging area to the drum opening area one at a time using forklift trucks equipped with drum grabbers or a barrel grappler. In a large-scale drum handling operation, drums may be conveyed to the drum opening area using a roller conveyor.

Drum Opening

There are three basic techniques available for opening drums at hazardous waste sites:

- Manual opening with non-sparking bung wrenches,
- Drum deheading, and
- Remote drum puncturing or bung removal.

The choice of drum opening techniques and accessories depends on the number of drums to be opened, their waste contents, and physical condition. Remote drum opening equipment should always be considered in order to protect worker safety. Under OSHA 1910.120, manual drum opening with bung wrenches or deheaders should be performed only with structurally sound drums having contents that are known to be (1) not shock sensitive, (2) non-reactive, (3) non-explosive, and (4) nonflammable.

Manual Drum Opening with a Bung Wrench

Manual drum opening with bung wrenches (Figure 1, Appendix B) should not be performed unless the drums are structurally sound (no evidence of bulging or deformation) and their contents are known to be non-explosive. If opening the drum with bung wrenches is deemed reasonably costeffective and safe, then follow these procedures to minimize the hazard:

1. Fully outfit field personnel with protective gear.
2. Position drum upright with the bung up, or, for drums with bungs on the side, lay the drum on its side with the bung plug up.
3. Wrench the bung with a slow, steady pulling motion across the drum. If the length of the bung wrench handle provides inadequate leverage for unscrewing the plug, attach a "cheater bar" to the handle to improve leverage.

Manual Drum Opening with a Drum Deheader

Drums are opened with a drum deheader by first positioning the cutting edge just inside the top chime and then tightening the adjustment screw so that the deheader is held against the side of the drum. Moving the handle of the deheader up and down while sliding the deheader along the chime will cut off the entire top. If the top chime of a drum has been damaged or badly dented, it may not be possible to cut off the entire top. Since there is always the possibility that a drum may be under pressure, make the initial cut very slowly to allow for the gradual release of any built-up pressure. A safer technique would be to use a remote method to puncture the drum prior to using the deheader.

Self-propelled drum openers which are either electrically or pneumatically driven can be used for quicker and more efficient deheading.

Manual Drum Opening with a Hand Pick, Pickaxe, or Spike

When a drum must be opened and neither a bung wrench nor a drum deheader is suitable, the drum can be opened for sampling by using a hand pick, pickaxe, or spike. Often the drum lid or head must be hit with a great deal of force in order to penetrate it. The potential for splash or spraying is greater than with other opening methods and, therefore, this method of drum opening is not recommended, particularly when opening drums containing liquids. Some spikes used have been modified by the addition of a circular splash plate near the penetrating end. This plate acts as a shield and reduces the amount of splash in the direction of the person using the spike. Even with this shield, good splash gear is essential.

Since drums cannot be opened slowly with these tools, spray from drums is common requiring appropriate safety measures. Decontaminate the pick or spike after each drum is opened to avoid cross~contamination and/or adverse chemical reaction from incompatible materials.

Remote Drum Opening with a Backhoe Spike

Remotely operated drum opening tools are the safest available means of drum opening, Remote drum opening is slow, but is much safer compared to manual methods of opening.

Drums should be "staged" or placed in rows with adequate aisle space to allow ease in backhoe maneuvering. Once staged, the drums can be quickly opened by punching a hole in the drum head or lid with the spike.

The spike should be decontaminated after each drum is opened to prevent cross-contamination. Even though some splash or spray may occur when this method is used, the operator of the backhoe can be protected by mounting a large shatter-resistant shield in front of the operator's cage. This, combined with the required level of personal protection gear, should be sufficient to protect the operator. Additional respiratory protection can be afforded by providing the operator with an on-board airline system.

Remote Drum Opening with Hydraulic Devices

A piercing device with a metal point is attached to the end of a hydraulic line and is pushed into the drum by hydraulic pressure. The piercing device can be attached so that the sampling hole can be made on either the side or the head of the drum. Some of the metal piercers are hollow or tube-like so that they can be left in place if desired and serve as a permanent tap or sampling port. The piercer is designed to establish a tight seal after penetrating the container.

Remote Drum Opening wfth Pneumatic Devices

Pneumatically-operated devices utilizing compressed air have been designed to remove drum bungs remotely.

Drum Sampling

After the drum has been opened, monitor headspace gases using an explosimeter and organic vapor analyzer. In most cases it is impossible to observe the contents of these sealed or partially sealed vessels. Since some layering or stratification is likely in any solution left undisturbed over time, take a sample that represents the entire depth of the container.

When samplmg a previously sealed vessel, check for the presence of a bottom sludge. This is easily accomplished by measuring the depth to the apparent bottom, then comparing it to the known interior depth.

Glass Thief Sampler

The most widely used implement for samprmg is a glass tube commonly referred to as a *glass thief.* This tool is simple, cost effective, quick, and collects a sample without having to decontaminate. Glass thieves are typically 6mm to 16mm I.D. and 48 inches long.

Procedures for using a glass thief are as follows:

1. Remove cover from sample container.
2. Insert glass tubing almost to the bottom of the drum or until a solid layer is encountered. About one foot of tubing should extend above the drum.
3. Allow the waste in the drum to reach its natural level in the tube.
4. Cap the top of the sampling tube with a tapered stopper or thumb, ensuring liquid does not come into contact with stopper (or thumb).
5. Carefully remove the capped tube from the drum and insert the uncapped end in the sample container.
6. Release stopper and allow the glass thief to drain until the container is approximately 2/3 full.
7. Remove tube from the sample container, break it into pieces and place the pieces in the drum.
8. Cap the sample container tightly and place prelabeled sample container in a carrier.
9. Replace the bung or place plastic over the drum.
10. Log all samples in the site logbook and on field data sheets.
11. Package samples and complete necessary paperwork.
12. Transport sample to decontamination zone to prepare it for transport to the analytical laboratory.

In many instances a drum containing waste material will have a sludge layer on the bottom. Slow insertion of the sample tube down into this layer and then a gradual withdrawal will allow the sludge to act as a bottom plug to maintain the fluid in the tube. The plug can be gently removed and placed int6 the sample container by the use of a stainless steel lab spoon.

It should be noted that in some instances disposal of the tube by breaking it into the drum may interfere with eventual plans for the removal of its contents. This practice should be cleared with the project officer or other disposal techniques evaluated.

COLIWASA Sampler

Some equipment is designed to collect a sample from the full depth of a drum and maintain it in the transfer tube until delivery to the sample bottle. These designs include primarily the Composite Liquid Waste Sampler (COLIWASA) and modifications thereof. The COLIWASA is a much cited sampler designed to permit representative sampling of multiphase wastes from drums and other containerized wastes. One configuration consists of a 152 cm by 4 cm I.D. section of tubing with a neoprene stopper at one end attached by a rod running the length of the tube to a locking mechanism at the other end.

Manipulation of the locking mechanism opens and closes the sampler by raising and lowering the neoprene stopper. One model of the COLIWASA is shown in Appendix B; however, the design can be modified and/or adapted somewhat to meet the needs of the sampler.

The major drawbacks associated with using a COLIWASA concern decontamination and costs. The sampler is difficult, if not impossible to decontaminate in the field and its high cost in relation to alternative procedures (glass tubes) make it an impractical throwaway item. It still has applications, however, especially in instances where a true representation of a multiphase waste is absolutely necessary.

Follow these procedures for using the COLIWASA:

1. Put the sampler in the open position by placing the stopper rod handle in the T-position and pushing the rod down until the handle sits against the sampler's locking block.
2. Slowly lower the sampler into the liquid waste. Lower the sampler at a rate that permits the levels of the liquid inside and outside the sampler tube to be about the same. If the level of the liquid in the sample tube is lower than that outside the sampler, the sampling rate is too fast and will result in a non-representative sample.
3. When the sampler stopper hits the bottom of the waste container, push the sampler tube downward against the stopper to close the sampler. Lock the sampler in the closed position by turning the T-handle until it is upright and one end rests tightly on the locking block.
4. Slowly withdraw the sample from the waste container with one hand while wiping the sampler tube with a disposable cloth or rag with the other hand.
5. Carefully discharge the sample into a suitable sample container by slowly pulling the lower end of the T-handle away from the locking block while the lower end of the sampler is positioned in a sample container.
6. Cap the sample container tightly and place prelabeled sample container in a carrier.
7. Replace the bung or place plastic over the drum.
8. Log all samples in the site logbook and on field data sheets.
9. Package samples and complete necessary paperwork.
10. Transport sample to decontamination zone to prepare it for transport to the analytical laboratory.

CALCULATIONS

This section is not applicable to this SOP.

QUALITY ASSURANCE / QUALITY CONTROL

The following general quality assurance procedures apply:

- Document all data on standard chain of custody forms, field data sheets, or within site logbooks.
- Operate all instrumentation in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation, and they must be documented.

DATA VALIDATION

This section is not applicable to this SOP.

HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, OSHA, and specific health and safety procedures.

The opening of closed containers is one of the most hazardous site activities. Maximum efforts should be made to ensure the safety of the sampling team. Proper protective equipment and a general awareness of the possible dangers will minimize the risk inherent in sampling operations. Employing proper drum-opening techniques and equipment will also safeguard personnel. Use remote sampling equipment whenever feasible.

TANK SAMPLING

SOP # 3

SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure (SOP) is to provide protocols for sampling tanks and other confined spaces from outside the vessel.

METHOD SUMMARY

The safe collection of a representative sample should be the criterion for selecting sample locations. A representative sample can be collected using techniques or equipment that are designed for obtaining liquids or sludges from various depths. The structure and characteristics of storage tanks present problems with collection of samples from more than one location; therefore, the selection of sampling devices is an important consideration.

Depending on the type of vessel and characteristics of the material to be sampled, one can choose a bailer, glass thief, bacon bomb sampler, sludge judge, COLIWASA, or subsurface grab sampler to collect the sample. For depths of less than 5-feet, a baller, COLIWASA, or sludge judge can be used. A sludge judge, subsurface grab sampler$_1$ bailer, or bacon bomb sampler can be used for depths greater than 5-feet. A sludge judge or bacon bomb can be used to determine if the tank consists of various strata.

All sample locations should be surveyed for air quality prior to sampling. At no time should sampling continue with an LEL reading greater than 25%.

All personnel involved in tank sampling should be advised as to the hazards associated with working in unfavorable conditions.

SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

Samples collected from tanks are considered waste samples and, as such, addition of preservatives is not required due to the potential reaction of the sample with the preservative. Samples should, however, be cooled to 4°C and protected from sunlight in order to minimize any potential reaction due to the light sensitivity of the sample.

Sample bottles for collection of waste liquids, sludges, or solids are typically wide-mouth amber jars with Teflon-lined screw caps. Actual volume required for analysis should be determined in conjunction with the laboratory performing the analysis.

Waste sample handling procedures should be as follows:

1. Place sample container in two Ziploc plastic bags.
2. Place each bagged container in a 1-gallon covered can containing absorbent packing material. Place the lid on the can.
3. Mark the sample identification number on the outside of the can.
4. Place the marked cans in a cooler, and fill remaining space with absorbent packing material.
5. Fill out a chain of custody form for each cooler, place it in plastic, and affix it to the inside lid of the cooler.
6. Secure and custody seal the lid of cooler.
7. Arrange for the transportation appropriate for the type of hazardous waste involved.

INTERFERENCES AND POTENTIAL PROBLEMS

Sampling a storage tank requires a great deal of manual dexterity, often requiring the sampler to climb to the top of the tank upon a narrow vertical or spiral stairway or ladder while wearing protective clothing and carrying sampling equipment.

Before climbing onto the vessel, perform a structural survey of the tank to ensure the sampler's safety and accessibility prior to initiating field activities.

As in all opening of containers, take extreme caution to avoid ignition or combustion of volatile contents. All tools used must be constructed of a non-sparking material and electronic instruments must be intrinsically safe.

All sample locations should be surveyed for air quality prior to sampling. *At no tune should sampling continue with an LEL reading greater than 25%.*

EQUIPMENT/APPARATUS

Storage tank materials include liquids, sludges, still bottoms, and solids of various structures. The type of sampling equipment chosen should be compatible with the waste. Samplers commonly used for tanks indude: the bacon bomb sampler, the sludge judge, glass thief, bailer, COLIWASA, and subsurface grab sampler.

- sampling plan
- safety equipment
- tape measure
- weighted tape line or equivalent
- camera/film
- stainless steel bucket or bowl
- sample containers
- Ziploc plastic bags
- logbook
- labels
- field data sheets
- chain of custody forms
- flashlight (explosion proof)
- coolers
- ice

- decontamination supplies
- bacon bomb sampler
- sludge judge
- glass thief
- bailer
- COLIWASA
- subsurface grab sampler
- water/oil level indicator
- OVA (organic vapor analyzer or equivalent)
- explosimeter/oxygen meter
- high volume blower

REAGENTS

Reagents are not typically required for the preservation of waste samples. However, reagents will be utilized for decontamination of equipment. Decontamination solutions required are specified in SOP # 1, Sampling Equipment Decontamination.

PROCEDURES

Preparation

1. Determine the extent of the sampling effort, the sampling methods to be employed, and which equipment and supplies are needed.
2. Obtain necessary sampling and monitoring equipment.
3. Decontaminate or preclean equipment, and ensure that it is in working order.
4. Prepare scheduling and coordinate with staff, clients, and regulatory agency, if appropriate.
5. Perform a general site surveY prior to site entry in accordance with the site-specific health and safety plan.
6. Identify and mark all sampling locations.

Prelimlnary inspection

1. Inspect the external structural characteristics of each tank and record in the site logbook. Potential sampling points should be evaluated for safety, accessibility, and sample quality.
2. Prior to opening a tank for internal inspection, the tank sampling team should:
    - Review safety procedures and emergency contingency plans with the Safety Officer,
    - Ensure that the tank is properly grounded,
    - Remove all sources of ignition from the immediate area.
3. Each tank should be mounted using appropriate means. Remove manway covers using non-sparking tools.
4. Collect air quality measurements for each potential sample location using an explosimeter/oxygen meter for a lower explosive limit (LEL/O_2 reading and an OVA/HNU for an organic vapor concentration. Both readings should be taken from the tank headspace, above the sampling port, and in the breathing zone.
5. Prior to sampling, the tank headspace should be cleared of any toxic or explosive vapor concentration using a high volume blower. No work should start if LEL readings exceed 25%. At 10% LEL, work can continue but with extreme caution.

Sampling Procedures

1. Determine the depth of any and all liquid-solid interface, and depth of sludge using a weighted tape measure, probe line, sludge judge, or equivalent.
2. Collect liquid samples from 1-foot below the surface, from mid-depth of liquid, and from 1-foot above the bottom sludge layer. This can be accomplished with a subsurface grab sampler or bacon bomb. For liquids less than 5-feet in depth, use a glass thief or COLIWASA to collect the sample.

   If sampling storage tanks, vacuum trucks, or process vessels, collect at least one sample from each compartment in the tank. Samples should always be collected through an opened hatch at the top of the tank. Valves near the bottom should not be used, because of their questionable or unknown integrity. If such a valve cannot be closed once opened, the entire tank contents may be lost to the ground surface. Also, individual strata cannot be sampled separately through a valve near the bottom.
3. Compare the three samples for visual phase differences. If phase differences appear, systematic iterative sampling should be performed. By halving the distance between two discrete sampling points, one can determine the depth of the phase change.
4. If another sampling port is available, sample as above to verify the phase information.
5. Measure the outside diameter of the tank and determine the volume of wastes using the depth measurements.
6. Sludges can be collected using a bacon bomb sampler, glass thief, or sludge judge.
7. Record all information on the sample data sheet or site logbook. Label the container with the appropriate sample tag.
8. Decontaminate sampling equipment as per SOP #1, Sampling Equipment Decontamination.

Sampling Devices

Bacon Bomb Sampler

The bacon bomb sampler is designed to collect material from various levels within a storage tank. It consists of a cylindrical body usually made of chrome-plated brass and bronze with an internal tapered plunger that acts as a valve to admit the sample. A line attached to the top of the plunger opens and closes the valve. A line is attached to the removable top cover which has a locking mechanism to keep the plunger closed after sampling.

1. Attach the sample line and the plunger line to the sampler.
2. Measure and then mark the sampling line at the desired depth.
3. Gradually lower the bacon bomb sampler by the sample line until the desired level is reached.
4. When the desired level is reached, pull up on the plunger line and allow the sampler to fill before releasing the plunger line to seal off the sampler.
5. Retrieve the sampler by the sample line. Be careful not to pull up on the plunger line and thereby prevent accidental opening of the bottom valve.
6. Rinse or wipe off the exterior of the sampler body.
7. Position the sampler over the sample container and release its contents by pulling up on the plunger line.
8. Cap the sample container tightly and place prelabeled sample container in a carrier.
9. Replace the bung or place plastic over the tank-
10. Log all samples in the site logbook and on field data sheets and label all samples.
11. Package samples and complete necessary paperwork.
12. Transport sample to decontamination zone to prepare it for transport to the analytical. laboratory.

Sludge Judge

A sludge judge is used for obtaining an accurate reading of solids which can settle, in any liquid, to any depth. The sampler consists of 3-inch plastic pipe in 5-foot sections, marked at 1-foot increments, with screw-style fittings. The top section includes a nylon line for raising the sampler.

1. Lower the sludge judge to the bottom of the tank.
2. When the bottom has been reached, and the pipe has filled to surface level, tug slightly on the rope as you begin to raise the unit. This will seat the check valve, trapping the column of material.
3. When the unit has been raised clear of the tank liquid, the amount of sludge in the sample can be read using the 1-foot increments marked on the pipe sections.
4. By touching the pin extending from the bottom section against a hard surface, the material is released from the unit.
5. Cap the sample container tightly and place prelabeled sample container in a carrier.
6. Replace the bung or place plastic over the tank.
7. Log all samples in the site logbook and on field data sheets and label all samples.
8. Package samples and complete necessary paperwork.
9. Transport sample to decontamination zone to prepare it for transport to the analytical laboratory.

Subsurface Grab Sampler

Subsurface grab samplers are designed to collect samples of liquids at various depths. The sampler is usually constructed of aluminum or stainless steel tubing with a polypropylene or Teflon head that attaches to a 1-liter sample container.

1. Screw the sample bottle onto the sampling head.
2. Lower the sampler to the desired depth.
3. Pull the ring at the top which opens the spring-loaded plunger in the head assembly.
4. When the bottle is full,, release the ring, lift sampler, and remove sample bottle.
5. Cap the sample container tightly and place prelabeled sample container in a carrier.
6. Replace the bung or place plastic over the tank.
7. Log all samples in the site logbook and on field data sheets and label all samples.
8. Package samples and complete necessary paperwork.
9. Transport sample to decontamination zone to prepare it for transport to the analytical laboratory.

Glass Thief

The most widely used implement for sampling is a glass tube commonly referred to as a glass thief. This tool is simple, cost effective, quick, and collects a sample without having to decontaminate. Glass thieves are typically 6mm to 16mm I.D. and 48 inches long.

1. Remove cover from sample container.
2. Insert glass tubing almost t6 the bottom of the tank or until a solid layer is encountered. About 1 foot of tubing should extend above the tank.
3. Allow the waste in the tank to reach its natural level in the tube.

4. Cap the top of the sampling tube with a tapered stopper or thumb, ensuring liquid does not come into contact with stopper.
5. Carefully remove the capped tube from the tank and insert the uncapped end in the sample container. Do not spill liquid on the outside of the sample container.
6. Release stopper and allow the glass thief to drain until the container is approximately 2/3 full.
7. Remove tube from the sample container, break it into pieces and place the pieces in the tank.
8. Cap the sample container tightly and place prelabeled sample container in a carrier.
9. Replace the bung or place plastic over the tank.
10. Log all samples in the site logbook and on field data sheets and label all samples.
11. Package samples and complete necessary paperwork.
12. Transport sample to decontamination zone to prepare it for transport to the analytical laboratory.

In many instances a tank containing waste material will have a sludge layer on the bottom. Slow insertion of the sample tube down into this layer and then a gradual withdrawal will allow the sludge to act as a bottom plug to maintain the fluid in the tube. The plug can be gently removed and placed into the sample container by the use of a stainless steel lab spoon.

Bailer

The positive-displacement volatile sampling bailer (manufactured by GPI or equivalent) is perhaps the most appropriate for collecting water samples for volatile analysis. Other bailer types (messenger, bottom fill, etc.) are less desirable, but may be mandated by cost and site conditions. Generally, bailers can provide an acceptable sample, providing that the sampling personnel use extra care in the collection process.

1. Make sure clean plastic sheeting surrounds the tank.
2. Attach a line to the bailer.
3. Lower the bailer slowly and gently into the tank so as not to splash the bailer into the tank contents.
4. Allow the bailer to fill completely and retrieve the bailer from the tank.
5. Begin slowly pouring from the bailer.
6. Cap the sample container tightly and place prelabeled sample container in a carrier.
7. Replace the bung or place plastic over the tank.
8. Log all samples in the site logbook and on field data sheets and label all samples.
9. Package samples and complete necessary paperwork.
10. Transport sample to decontamination zone to prepare it for transport to an analytical laboratory.

COLIWASA

Some equipment is designed to collect a sample from the full depth of a tank and maintain it in the transfer tube until delivery to the sample bottle. These designs indude primarily the Composite Liquid Waste Sampler (COLIWASA) and modifications thereof. The COLIWASA is a much dted sampler designed to permit representative sampling of multiphase wastes from tanks and other containerized wastes. One configuration consists of a 152 cm by 4 cm I.D. section of tubing with a neoprene stopper at one end attached by a rod running the length of the tube to a locking mechanism at the other end. Manipulation of the locking mechanism opens and closes the sampler by raising and lowering the neoprene stopper.

The major drawbacks associated with using a COLIWASA concern decontamination and costs. The sampler is difficult if not impossible to decontaminate in the field and its high cost in relation to alternative procedures (glass tubes) make it an impractical throwaway item. It still las applicat ions, however, especially in instances where a true representation of a multiphase waste is absolutely necessary.

1. Put the sampler in the open position by placing the stopper rod handle in the T-position and pushing the rod down until the handle sits against the sampler's locking block.
2. Slowly lower the sampler into the liquid waste. Lower the sampler at a rate that permits the levels of the liquid inside and outside the sampler tube to be about the same. If the level of the liquid in the sample tube is lower than that outside the sampler, the sampling rate is too fast and will result in a non-representative sample.
3. When the sampler stopper hits the bottom of the waste container, push the sampler tube downward against the stopper to close the sampler. Lock the sampler in the closed position by turning the T-handle until it is upright and one end rests tightly on the locking block.
4. Slowly withdraw the sample from the waste container with one hand while wiping the sampler tube with a disposable cloth or rag with the other hand.
5. Carefully discharge the sample into a suitable sample container by slowly pulling the lower end of the T-handle away from the locking block while the lower end of the sampler is positioned in a sample container.
6. Cap the sample container tightly and place prelabeled sample container in a carrier.

7. Replace the bung or place plastic over the tank.
8. Log all samples in the site logbook and on field data sheets and label all samples.
9. Package samples and complete necessary paperwork.
10. Transport sample to decontamination zone to prepare it for transport to the analytical laboratory.

CALCULATIONS

Not applicable to this section.

QUALITY ASSURANCE / QUALITY CONTROL

There are no specific quality assurance activities which apply to the implementation of these procedures. However, the following general QA procedures apply:

- All data must be documented on field data sheets or within site logbooks.
- All instrumentation must be operated in accordance with operating instructions supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation and they must be documented.

DATA VALIDATION

This section is not applicable to this SOP.

HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, OSHA, and specific health and safety procedures. More specifically, the hazards associated with tank sampling may cause bodily injury, illness, or death to the worker. Failure to recognize potential hazards of waste containers is the cause of most accidents. It should be assumed that the most unfavorable conditions exist, and that the danger of explosion and poisoning will be present. Hazards specific to tank sampling are:

- Hazardous atmospheres can be flammable, toxic, asphyxiating, or corrosive.
- If activating electrical or mechanical equipment would cause injury, each piece of equipment should be manually isolated (locked out and tagged out) to prevent inadvertent activation while workers are occupied.
- Communication is of utmost importance between the sampling worker and the standby person to prevent distress or injury going unnoticed. The Illuminating Engineers Society Lighting Handbook requires suitable illumination to provide sufficient visibility for work.
- Noise reverberation may disrupt verbal communication with standby personnel.
- Tank vibration may affect multiple body parts and organs of the sampler depending on vibration characteristics.
- General hazards include falling scaffolding, surface residues (which could cause electrical shock, incompatible material reactions, slips, or falls), and structural objects (including baffles/trays in horizontal/vertical tanks, and overhead structures).

CHIP, WIPE, AND SWEEP SAMPLING

SOP #4

SCOPE AND APPLICATION

This Standard Operating Procedure (SOP) outlines the recommended protocol and equipment for collection of representative chip, wipe, and sweep samples to monitor potential surficial contamination.

This method of sampling is appropriate for surfaces contaminated with non-volatile species of analytes (i.e., PCB, PCDD, PCDF, metals, cyanide, etc. Detection limits are analyte specific. Sample size should be determined based upon the detection limit desired and the amount of sample requested by the analytical laboratory. Typical sample area is 1 square foot. However, based upon sampling location, the area may need modification due to area configuration.

METHOD SUMMARY

Since surface situations vary widely, no universal sampling method can be recommended. Rather, the method and implements used must be tailored to suit a specific sampling site. The sampling location should be selected based upon the potential for contamination as a result of manufacturing processes or personnel practices.

Chip sampling is appropriate for porous surfaces and is generally accomplished with either a hammer and chisel, or an electric hammer. The sampling device should be laboratory cleaned and wrapped in clean, autoclaved aluminum foil until ready for use. To collect the sample, a measured and marked off area is chipped both horizontally and vertically to an even depth of 1/8 inch. The sample is then transferred to the proper sample container.

Wipe samples are collected from smooth surfaces to indicate surficial contamination; a sample location is measured and marked off. Sampling personnel wear a new pair of surgical gloves to open a sterile gauze pad, and then soak it with solvent. The solvent used is dependent on the surface being sampled. This pad is then stroked firmly over the sample surface, first vertically, then horizontally, to ensure complete coverage. The pad is then transferred to the sample container.

Sweep sampling is an effective method for the collection of dust or residue on porous or nonporous surfaces. To collect such a sample, an appropriate area is measured and marked off. Then, while wearing a new pair of disposable surgical gloves, sampling personnel use a dedicated brush to sweep material into a dedicated dust pan. The sample is then transferred to the proper sample container.

Samples collected by all three methods are sent to the laboratory for analysis.

SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

Samples should be stored out of direct sunlight to reduce photodegradation and shipped on ice (4°C) to the laboratory performing the analysis. Appropriately-sized, laboratory-cleaned, glass sample jars should be used for sample collection. The amount of sample required is determined in concert with the analytical laboratory.

INTERFERENCES AND POTENTIAL PROBLEMS

This method has few significant interferences or problems. Typical problems result from rough porous surfaces which may be difficult to wipe, chip, or sweep.

EQUIPMENT / APPARATUS

- lab-clean sample containers of proper size and composition
- field and travel blanks
- site logbook
- sample analysis request forms
- chain of custody forms
- custody seals
- sample labels
- disposable surgical gloves
- sterile wrapped gauze pad (3 in. x 3 in.)
- appropriate pesticide (HPLC) grade solvent
- medium-sized, laboratory-cleaned paint brush
- medium-sized, laboratory-cleane~d chisel
- autoclaved aluminum foil
- camera
- hexane (pesticide/HPLC grade)
- isooctane
- distilled/deionized water

REAGENTS

Reagents are not required for preservation of chip, wipe or sweep samples. However, reagents will be utilized for decontamination of sampling equipment. Decontamination solutions are specified in SOP #1, Sampling Equipment Decontamination.

PROCEDURES

Preparation

1. Determine the extent of the sampling effort, the sampling methods to be employed, and the types and amounts of equipment and supplies needed.

2. Obtain necessary sampling and monitoring equipment.
3. Decontaminate or preclean equipment, and ensure that it is in working order.
4. Prepare scheduling and coordinate with staff, clients, and regulatory agencies, if appropriate.
5. Perform a general site survey prior to site entry in accordance with the site-specific health and safety plan.
6. Mark all sampling locations. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions.

Chip Sample Collection

Sampling of porous surfaces is generally accomplished by using a chisel and hammer or electric hammer. The sampling device should be laboratory-cleaned or field decontaminated as per SOP# 1, Sampling Equipment Decontamination. It is then wrapped in cleaned, autoclaved aluminum foil. The sampler should remain in this wrapping until it is needed. Each sampling device should be used for only one sample.

1. Choose appropriate sampling points; measure off the designated area and photo document.
2. To facilitate later calculations, record surface area to be chipped.
3. Don a new pair of disposable surgical gloves.
4. Open a laboratory-cleaned chisel or equivalent sampling device.
5. Chip the sample area horizontally, then vertically to an even depth of approximately 1/8 inch.
6. Place the sample in an appropriately-prepared sample container with a Teflon-lined cap.
7. Cap the sample container, attach the label and custody seal, and place in a double plastic bag. Record all pertinent data in the site logbook. Complete the sampling analysis request form and chain of custody form before taking the next sample.
8. Store samples out of direct sunlight and cool to 4°C.
9. Leave contaminated sampling device in the sampled material, unless decontamination is practical.
10. Follow proper decontamination procedures, then deliver sample(s) to the laboratory for analysis.

Wipe Sample Collection

Wipe sampling is accomplished by using a sterile gauze pad, adding a solvent in which the contaminant is most soluble, then wiping a predetermined, pre-measured area. The sample is packaged in an amber jar to prevent photodegradation and packed in coolers for shipment to the lab. Each gauze pad is used for only one wipe sample.

1. Choose appropriate sampling points; measure off the designated area and photo document.
2. To facilitate later calculations, record surface area to be wiped.
3. Don a new pair of disposable surgical gloves.
4. Open new sterile package of gauze pad.
5. Soak the pad with the appropriate solvent.
6. Wipe the marked surface area using firm strokes. Wipe vertically, then horizontally to ensure complete surface coverage.
7. Place the gauze pad in an appropriately prepared sample container with a Teflon-lined cap.
8. Cap the sample container, attach the label and custody seal, and place in a double plastic bag. Record all pertinent data in the site logbook. Complete the sampling analysis request form and chain of custody form before taking the next sample.
9. Store samples out of direct sunlight and cool to 4°C.
10. Follow proper decontamination procedures, then deliver sample(s) to the laboratory for analysis.

Sweep Sample Collection

Sweep sampling is appropriate for bulk contamination. This procedure utilizes a dedicated, hand-held sweeper brush to acquire a sample from a pre-measured area.

1. Choose appropriate sampling points; measure off the designated area and photo document.
2. To facilitate later calculations, record the surface area to be swept.
3. Don a new pair of disposable surgical gloves.
4. Sweep the measured area using a dedicated brush; collect the sample in a dedicated dust pan.
5. Transfer sample from dust pan to sample container.
6. Cap the sample container, attach the label and custody seal, and place in a double plastic bag. Record all pertinent data in the site logbook. Complete the sampling analysis request form and chain of custody form before taking the next sample.
7. Store samples out of direct sunlight and cool to 4°C.
8. Leave contaminated sampling device in the sample material, unless decontamination is

practical.

9. Follow proper decontamination procedures, then deliver sample(s) to the laboratory for analysis.

CALCULATIONS

Results are usually provided in mg/g, ng/g or another appropriate weight per unit weight measurement. Results may also be given in a mass per unit area.

QUALITY ASSURANCE / QUALITY CONTROL

The following general quality assurance procedures apply:

- All data must be documented on standard chain of custody forms, field data sheets or within the site logbook.
- All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless other-vise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation, and they must be documented.

The following specific quality assurance activities apply to wipe samples:

- A blank should be collected for each sampling event. This consists of a sterile gauze pad, wet with the appropriate solvent, and placed in a prepared sample container. The blank will help identify potential introduction of contaminants via the sampling methods, the pad, solvent or sample container.
- Spiked wipe samples can also be collected to better assess the data being generated. These are prepared by spiking a piece of foil of known area with a standard of the analyte of choice. The solvent containing the standard is allowed to evaporate, and the foil is wiped in a manner identical to the other wipe samples.

Specific quality assurance activities for chip and sweep samples should be determined on a site-specific basis.

DATA VALIDATION

Review the quality control samples and use the data to qualify the environmental results.

HEALTH AND SAFETY

When working with potentially hazardous matenals, follow U.S. EPA, OSHA and specific health and safety procedures.

WASTE PILE SAMPLING

SOP # 5

SCOPE AND APPLICATION

The objective of this Standard Operating Procedure (SOP) is to outline the equipment and methods used in collecting representative samples from waste piles, sludges or other solid or liquid waste mixed with soil.

METHOD SUMMARY

Stainless steel shovels or scoops shouid be used to clear away surface material before samples are collected. For samples at depth, a decontaminated auger may be required to advance the hole, then another decontaminated auger used for sample collection. For a sample core, thin-wall tube samplers or grain samplers may be used. Near surfaces samples can be collected with a clean stainless steel spoon or trowel.

All samples collected, except those for volatile organic analysis, should be placed into a Teflon-lined or stainless steel pail and mixed thoroughly before being transferred to an appropriate sample container.

SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

Chemical preservation of solids is generally not recommended. Refrigeration to 4°C is usually the best approach, supplemented by a minimal holding time.

Wide mouth glass containers with Teflon-lined caps are typically used for waste pile samples. Sample volume required is a function of the analytical requirements and should be specified in the work plan.

INTERFERENCES AND POTENTIAL PROBLEMS

There are several variables involved in waste sampling, including shape and size of piles, compactness, and structure of the waste material. Shape and size of waste material or waste piles vary greatly in areal extent and height. Since state and federal regulations often require a specified number of samples per volume of waste, size and shape must be used to calculate volume and to plan for the correct number of samples. Shape must also be accounted for when planning physical access to the sampling point and when selecting the appropriate equipment to successfully collect the sample at that location.

Material to be sampled may be homogeneous or heterogeneous. Homogeneous material resulting from known situations may not require an extensive sampling protocol. Heterogeneous and unknown wastes require more extensive sampling and analysis to ensure the different components are being represented.

The term "representative sample" is commonly used to denote a sample that has the properties and composition of the population from which it was collected, in the same proportions as found in the population. This can be misleading unless one is dealing with a homogenous waste from which one sample can represent the whole population.

The usual options for obtaining the most "representative sample" from waste piles are simple or stratified random sampling. Simple random sampling is the method of choice unless (1) there are known distinct strata; (2) one wants to prove or disprove that there are distinct strata; or (3) one is limited in the number of samples and desires to minimize the size of a "hot spot" that could go unsampled. If any of these conditions exist, stratified random sampling would be the better strategy.

This strategy, however, can be employed only if all points within the pile can be accessed. In such cases, the pile should be divided into a three-dimensional grid system; the grid sections assigned numbers; and the sampling points chosen using random-number tables or random-number generators. The only exceptions to this are situations in which representative samples cannot be collected safely or where the investigative team is trying to determine worst-case conditions. If sampling is limited to certain portions of the pile, a statistically based sample will be representative only of that portion, unless the waste is homogenous.

EQUIPMENT / APPARATUS

Waste pile solids include powdered, granular, or block materials of various sizes, shapes, structure, and compactness. The type of sampler chosen should be compatible with the waste. Samplers commonly used for waste piles include: stainless steel scoops, shovel~ trowels, spoons, and stainless steel hand augers, sampling triers, and grain sampler.

Waste pile sampling equipment check list:

- sampling plan
- maps/plot plan
- safety equipment, as specified in the health and safety plan
- compass
- tape measure
- survey stakes or flags
- camera and film
- stainless steel, plastic, or other appropriate homogenization bucket or bowl
- 1-quart mason jars w/Teflon liners
- ziploc plastic bags
- logbook
- labels
- chain of custody forms and seals

- field data sheets
- cooler(s)
- ice
- decontamination supplies/equipment
- canvas or plastic sheet
- spade or shovel
- spatula
- scoop
- plastic or stainless steel spoons
- trowel
- continuous flight (screw) auger
- bucket auger
- post hole auger
- extension rods
- T-handle
- thin-wall tube sampler
- sampling trier
- grain sampler

REAGENTS

No chemical reagents are used for the preservation of waste pile samples; however, decontamination solutions may be required. If decontamination of equipment is required, refer to ERT Standard Operating Procedure (SOP) #1, Sampling Equipment Decontamination, and the site-specific work plan.

PROCEDURES

Preparation

1. Determine the extent of the sampling effort, the sampling methods to be employed, and which equipment and supplies are required.
2. Obtain necessary sampling and monitoring equipment.
3. Decontaminate or preclean equipment, and ensure that it is in working order.
4. Prepare scheduics, and coordinate with staff, client, and regulatory agencies, if appropriate.
5. Perform a general site survey prior to site entry in accordance with the site-specific health and safety plan.
6. Use stakes or flagging to identity and mark all sampling locations. Specific site factors, including extent and nature of contaminants, should be considered when selecting sample locations. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions.

Sample Collection

SAMPLING WITH SHOVELS AND SCOOPS

Collection of samples from surface portions of the pile can be accomplished with tools such as spades, shovels, and scoops. Surface material can be removed to the required depth with this equipment, then a stainless steel or plastic scoop can be used to collect the sample.

Accurate, representative samples can be collected with this procedure depending on the care and precision demonstrated by sample team members. Use of a flat, pointed mason trowel to cut a block of the desired material can be helpful when undisturbed profiles are required. A stainless steel scoop, lab spoon, or plastic spoon will suffice in most other applications. Care should be exercised to avoid the use of devices plated with chrome or other materials. Plating is particularly common with implements such as garden trowels.

Use the following procedure to collect surface samples:

1. Carefully remove the top layer of material to the desired sample depth with a precleaned spade.
2. Using a precleaned stainless steel scoop, plastic spoon, or trowel, remove and discard a thin layer of material from the area which came in contact with the spade.
3. If volatile organic analysis is to be performed, transfer the sample into an appropriate, labeled sample container with a stainless steel lab spoon, plastic lab spoon, or equivalent and secure the cap tightly. Place the remainder of the sample into a stainless steel, plastic, or other appropriate homogenization container, and mix thoroughly to obtain a homogenous sample representative of the entire sampling interval. Then, either place the sample into appropriate, labeled containers and secure the caps tightly; or, if composite samples are to be collected, place a sample from another sampling interval into the homogenization container and mix thoroughly. When compositing is complete, place the sample into appropriate, labeled containers and secure the caps tightly.

SAMPLING WITH AUGERS AND THINWALL TUBE SAMPLERS

This system consists of an auger, a series of extensions, a T- handle, and a thin-wall tube sampler (Figure 13, Appendix B). The auger is used to bore a hole to a desired sampling depth, and is then withdrawn. The sample may be collected directly from the auger. If a core sample is to be collected, the auger tip is then replaced with a thin-wall tube sampler. The system is then lowered down the borehole, and driven into the pile at the completion depth. The system is withdrawn and the core collected from the thin-wall tube sampler.

Several augers are available. These include: bucket, continuous flight (screw), and post hole augers. Bucket augers are better for direct sample recovery since they provide a large volume of sample in a short time. When continuous flight augers are used, the sample can be collected directly from the flights, which are usually at 5-foot intervals. The continuous flight augers are satisfactory for use when a composite of the complete waste pile column is desired. Post hole augers have limited utility for sample collection as they are designed to cut through fibrous, rooted, swampy areas.

Use the following procedure for collecting waste pile samples with the auger:

1. Attach the auger bit to a drill rod extension, and attach the T-handle to the drill rod.
2. Clear the area to be sampled of any surface debris. It maybe advisable to remove the first 3 to 6 inches of surface material for an area approximately 6 inches in radius around the drilling location.
3. Begin augering, periodically removing and depositing accumulated materials onto a plastic sheet spread near the hole. This prevents accidental brushing of loose material back down the borehole when removing the auger or adding drill rods. It also facilitates refilling the hole, and avoids possible contamination of the surrounding area.
4. After reaching the desired depth, slowly and carefully remove the auger from boring. When sampling directly from the auger, collect sample after the auger is removed from boring and proceed to Step 10.
5. Remove auger tip from drill rods and replace with a precleaned thin-wall tube sampler. Install proper cutting tip.
6. Carefully lower the tube sampler down the borehole. Gradually force the tube sampler into the pile. Care should be taken to avoid scraping the borehole sides. Avoid hammering the drill rods to facilitate coring as the vibrations may cause the boring walls to collapse.
7. Remove the tube sampler, and unscrew the drill rods.
8. Remove the cutting tip and the core from device.
9. Discard the top of the core approximately 1-inch)₁ as this represents material collected before penetration of the layer of concern. Place the remainlng core into the appropriate labeled sample container. Sample homogenization is not required.
10. If volatile organic analysis is to be performed, transfer the sample into an appropriate, labeled sample container with a stainless steel lab spoon, plastic lab spoon, or equivalent and secure the cap tightly. Place the remainder of the sample into a stainless steel, plastic, or other appropriate homogenization container, and mix thoroughly to obtain a homogenous sample representative of the entire sampling interval. Then, either place the sample into appropriate, labeled containers and secure the caps tightly; or, if composite samples are to be collected, place a sample from another sampling interval into the homogenization container and mix thoroughly. When compositing is complete, place the sample into appropriate, labeled containers and secure the caps tightly.
11. If another sample is to be collected in the same hole, but at a greater depth, reattach the auger bit to the drill and assembly, and follow steps 3 through 11, making sure to decontaminate the auger and tube sampler between samples.

SAMPLING WITH A TRIER

This system consists of a trier and a T-handle. The auger is driven into the waste pile and used to extract a core sample from the appropriate depth.

Use the following procedure to collect waste pile samples with a sampling trier:

1. Insert the trier into the material to be sampled at a 0 to 450-degree angle from horizontal. This orientation minimizes spillage of the sample. Extraction of the samples might require tilting of the sample containers.
2. Rotate the trier once or twice to cut a core of material.
3. Slowly withdraw the trier, making sure that the slot is facing upward.
4. If volatile organic analysis is to be performed, transfer the sample into an appropriately labeled sample container with a stainless steel lab spoon, plastic lab spoon, or equivalent and secure the cap tightly. Place the remainder of the sample into a stainless steel, plastic, or other appropriate homogenization container, and mix thoroughly to obtain a homogenous sample representative of the entire sampling interval. Then, either place the sample into appropriate, labeled containers and secure the caps tightly; or, if composite samples are being collected, place samples from the other sampling intervals into the homogenization container and mix thoroughly. When compositing is complete, place the sample into appropriate, labeled containers and secure the caps tightly.

SAMPLING WITH A GRAIN SAMPLER

The grain sampler is used for sampling powdered or granular wastes or materials in bags, fiberdrums, sacks, similar containers or piles. This sampler is most useful when the solids are no greater than 0.6 cm (1/4 inch) in diameter.

This sampler consists of two slotted telescoping brass or stainless steel tubes. The outer tube has a conical, pointed tip at one end that permits the sampler to penetrate the material being sampled. The sampler is opened and closed by rotating the inner tube. Grain samplers are generally 61 to 100 cm (24 to 40 inch) long by 1.7 to 2.54 cm (1/2 to 1 inch) in diameter and are commercially available at laboratory supply houses.

Use the following procedures to collect waste pile samples with a grain sampler:

1. With the sampler in the closed position, insert it into the granular or powdered material or waste being sampled from a point near a top edge or corner, through the center, and to a point diagonally opposite the point of entry.
2. Rotate the sampler inner tube into the open position.
3. Wiggle the sampler a few times to allow material to enter the open slots.
4. With the sampler in the closed position) withdraw it from the material being sampled.
5. Place the sampler in a horizontal position with the slots facing upward.
6. Rotate the outer tube and slide it away from the inner tube.
7. If volatile organic analysis is to be performed, transfer the sample into an appropriate, labeled sample container with a stainless steel lab spoon, plastic lab spoon, or equivalent and secure the cap tightly. Place the remainder of the sample into a stainless steel, plastic, or other appropriate homogenization container, and mix thoroughly to obtain a homogenous sample representative of the entire sampling interval. Then, either place the sample into appropriate, labeled containers and secure the caps tightly; or, if composite samples are to be collected, place a sample from another sampling interval into the homogenization container and mix thoroughly. When compositing is complete, place the sample into appropriate, labeled containers and secure the caps tightly.

QUALITY ASSURANCE / QUALITY CONTROL

There are no specific quality assurance activities which apply to the implementation of these procedures. However, the following QA procedures apply:

- All data must be documented on field data sheets or within site logbooks.
- All instrumentation must he operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation, and they must be documented.

CALCULATIONS

This section is not applicable to this SOP.

DATA VALIDATION

This section is not applicable to this SOP.

HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, OSHA and specific health and safety procedures.

SOIL SAMPLING

SOP # 6

SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure (SOP) is to describe the procedures for collecting representative soil samples. Analysis of soil samples may determine whether concentrations of specific soil pollutants exceed established action levels, or if the concentrations of soil pollutants present a risk to public health, welfare, or the environment.

METHOD SUMMARY

Soil samples may be collected using a variety of methods and equipment. The methods and equipment used are dependent on the depth of the desired sample, the type of sample required (disturbed versus undisturbed), and the type of soil. Near-surface soils may be easily sampled using a spade, trowel, and scoop. Sampling at greater depths may be performed using a hand auger, a trier, a split -spoon, or, if required, a backhoe.

SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

Chemical preservation of solids is not generally recommended. Refrigeration to 4°C, supplemented by a minimal holding time, is usually the best approach.

INTERFERENCES AND POTENTIAL PROBLEMS

There are two primary interferences or potential problems associated with soil sampling. These include cross-contamination of samples and improper sample collection. Cross-contamination problems can he eliminated or minimized through the use of dedicated sampling equipment. If this is not possible or practical, then decontamination of sampling equipment is necessary. Improper sample collection can involve using contaminated equipment, disturbance of the matrix resulting in compaction of the sample, or inadequate homogenization of the samples where required, resulting in variable, non-representative results.

EQUIPMENT / APPARATUS

- sampling plan
- maps/plot plan
- safety equipment, as specified in the health and safety plan
- compass
- tape measure
- survey stakes or flags
- camera and film
- stainless steel, plastic, or other appropriate homogenization bucket or bowl
- 1-quart mason jars w/Teflon liners
- Ziploc plastic bags
- logbook
- labels
- chain of custody forms and seals
- field data sheets
- cooler(s)
- ice
- decontamination supplies/equipment
- canvas or plastic sheet
- spade or shovel
- spatula
- scoop
- plastic or stainless steel spoons
- trowel
- continuous flight (screw) auger
- bucket auger
- post hole auger
- extension rods
- T-handle
- sampling trier
- thin-wall tube sampler
- Vehimeyer soil sampler outfit
    - tubes
    - point
    - drive head
    - drop hammer
    - puller jack and grip
- backhoe

REAGENTS

Reagents are not used for the preservation of soil samples. Decontamination solutions are specified in SOP #1, Sampling Decontamination.

PROCEDURES

Preparation

1. Determine the extent of the sampling effort, the sampling methods to be employed, and which equipment and supplies are required.
2. Obtain necessary sampling and monitoring equipment.
3. Decontaminate or preclean equipment, and ensure that it is in working order.
4. Prepare schedules, and coordinate with staff, client, and regulatory agencies, if appropriate.

5. Perform a general site survey prior to site entry in accordance with the site-specific health and safety plan.

6. Use stakes, buoys, or flagging to identify and mark all sampling locations. Consider specific site factors, including extent and nature of contaminant, when selecting sample location. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions. All staked locations will be utility-cleared by the property owner prior to soil sampling.

Sample Collection

Surface Soil Samples

Collect samples from near-surface soil with tools such as spades, shovels, and scoops. Surface material can be removed to the required depth with this equipment, then a stainless steel or plastic scoop can be used to collect the sample.

This method can be used in most soil types but is limited to sampling near surface areas. Accurate, representative samples can be collected with this procedure depending on the care and precision demonstrated by the sampling team member. The use of a flat, pointed mason trowel to cut a block of the desired soil can be helpful when undisturbed profiles are required. A stainless steel scoop, lab spoon, or plastic spoon will suffice in most other applications. Avoid the use of devices plated with chrome or other materials. Plating is particularly common with garden implements such as potting trowels.

Follow these procedures to collect surface soil samples.

1. Carefully remove the top layer of soil or debris to the desired sample depth with a pre-cleaned spade.
2. Using a pre-cleaned, stainless steel scoop, plastic spoon, or trowel, remove and discard a thin layer of soil from the area which came in contact with the spade.
3. If volatile organic analysis is to be performed, transfer a portion of the sample directly into an appropriate, labeled sample container(s) with a stainless steel lab spoon, plastic lab spoon, or equivalent and secure the cap(s) tightly. Place the remainder of the sample into a stainless steel, plastic, or other appropriate homogenization container, and mix thoroughly to obtain a homogenous sample representative of the entire sampling interval. Then, either place the sample into an appropriate, labeled container(s) and secure the cap(s) tightly; or, if composite samples are to be collected, place a sample from another sampling interval into the homogenization container and mix thoroughly. When compositing is c6mplete, place the sample into appropriate, labeled container(s) and secure the cap(s) tightly.

Sampling at Depth with Augers and Thin-Wall Tube Samplers

This system consists of an auger, a series of extensions, a T-handle, and a thin-wall tube sampler. The auger is used to bore a hole to a desired sampling depth, and is then withdrawn. The sample may be collected directly from the auger. If a core sample is to be collected, the auger tip is then replaced with a thin-wall tube sampler. The system is then lowered down the borehole, and driven into the soil at the completion depth. The system is withdrawn and the core collected from the thin-wall tube sampler.

Several types of augers are available. These include: bucket, continuous flight (screw), and posthole augers. Bucket augers are better for direct sample recovery since they provide large volume of sample in a short time. When continuous flight augers are used, the sample can be collected directly from the flights, which are usually at 5-feet intervals. The continuous flight augers are satisfactory for use when a composite of the complete soil column is desired. Posthole augers have limited utility for sample collection as they are designed to cut through fibrous, rooted,. swampy soil.

Follow these procedures for collecting soil samples with the auger and a thin-wall tube sampler.

1. Attach the auger bit to a drill rod extension, and attach the T-handle to the drill rod.
2. Clear the area to be sampled of any surface debris (e.g., twigs, rocks, litter). It may be advisable to remove the first 3 to 6 inches of surface soil for an area approximately 6 inches in radius around the drilling location.
3. Begin augering, periodically removing and depositing accumulated soils onto a plastic sheet spread near the hole. This prevents accidental brushing of loose material back down the borehole when removing the auger or adding drill rods. It also facilitates refilling the hole, and avoids possible contamination of the surrounding area.
4. After reaching the desired depth, slowly and carefully remove the auger from boring. When sampling directly from the auger, collect sample after the auger is removed from boring and proceed to Step 10.
5. Remove auger tip from drill rods and replace with a pre-cleaned thin-wall tube sampler. Install proper cutting tip.
6. Carefully lower the tube sampler down the borehole. Gradually force the tube sampler into the soil. Care should be taken to avoid scraping the borehole sides. Avoid hammering the drill rods to

facilitate coring as the vibrations may cause the boring walls to collapse.

7. Remove the tube sampler, and unscrew the drill rods.
8. Remove the cutting tip, and unscrew the drill rods.
9. Discard the top of the core (approximately 1 inch), as this represents material collected before penetration of the layer of concern. Place the remaining core into the appropriate labeled sample container(s). Sample homogenization is not required.
10. If volatile organic analysis is to be performed, transfer a portion of the sample directly into an appropriate, labeled sample container(s) with a stainless steel lab spoon, plastic lab spoon, or equivalent and secure the cap(s) tightly. Place the remainder of the sample into a stainless steel, plastic, or other appropriate homogenization container) and mix thoroughly to obtain a homogenous sample representative of the entire sampling interval- Then, either place the sample into an appropriate, labeled container(s) and secure the cap(s) tightly; or, if composite samples are to be collected, place a sample from another sampling interval into the homogenization container and mix thoroughly. When compositing is complete, place the sample into the appropriate, labeled container(s) and secure the cap(s) tightly.
11. If another sample is to.be collected in the same hole, but at a greater depth, reattach the auger bit to the drm and assembly, and follow steps 3 through 11, making sure to decontaminate the auger and tube sampler between samples.
12. Abandon the hole according to applicable state regulations. Generally, shallow holes can simply be backfilled with the removed soil material.

Sampling at Depth with a Trier

The system consists of a trier, and a T-handle. The auger is driven into the soil to be sampled and used to extract a core sample from the appropriate depth.

Follow these procedures to collect soil samples with a sampling trier.

1. Insert the trier into the material to be sampled at a 0 to 45-degree angle from horizontal. This orientation minimizes the spillage of sample.
2. Rotate the trier once or twice to cut a core of material.
3. Slowly withdraw the trier, making sure that the slot is facing upward.
4. If volatile organic analysis is to be performed, transfer a portion of the sample directly into an appropriate, labeled sample container(s) with a stainless steel lab spoon, plastic lab spoon, or equivalent and secure the cap(s) tigbdy. Place the remainder of the sample into a stainless steel, plastic, or other appropriate homogenization container, and mix thoroughly to obtain a homogenous sample representative of the entire sampling interval. Then, either place the sample into an appropriate, labeled container(s) and secure the cap(s) tightly; or, if composite samples are to be collected, place a sample from another sampling interval into the homogenization container and mix thoroughly. When compositing is complete, place the sample into an appropriate, labeled container(s) and secure the cap(s) tightly.

Sampling at Depth with a Split Spoon (Barrel) Sampler

The procedure for split spoon sampling describes the collection and extraction of undisturbed soil cores of 18 or 24 inches in length. A series of consecutive cores may be extracted with a split spoon sampler to give a complete soil column profile, or an auger may be used to drill down to the desired depth for sampling. The split spoon is then driven to its sampling depth through the bottom of the augured hole and the core extracted.

When split tube sampling is performed to gain geologic information, all work should be performed in accordance with ASTM D 1586-67 (reapproved 1974).

Follow these procedures for collecting soil samples with a split spoon.

1. Assemble the sampler by aligning both sides of the barrel and then screwing the bit onto the bottom and the hea~ier head piece onto the top.
2. Place the sampler in a perpendicular position on the samplc material.
3. Using a sledge hammer or well ring, if available, drive the tube. Do not drive past the bottom of the head piece or compression of the sample will result.
4. Record in the site logbook or on field data sheets the length of the tube used to penetrate the material being sampled, and the number of blows required to obtain this depth.
5. Withdraw the sampler, and open by unscrewing the bit and head and splitting the barrel. If a split sample is desired, a cleaned, stainless steel knife should be used to divide the tube contents in half longitudinally. This sampler is typically available in diameters of 2 and 3 1/2 inches. However, in order to obtain the required sample volume, use of a larger barrel may be required.
6. Without disturbing the core, transfer it to an appropriate labeled sample container(s) and seal tightly.

Test Pit/Trench Excavation

These relatively large excavations are used to remove sections of soil, when detailed examination of soil characteristics (horizontal structure, color, etc.) are required. It is the least cost effective sampling method due to the relatively high cost of backhoe operation.

Follow these procedures for collecting soil samples from test pit/trench excavations.

1. Prior to any excavation with a backhoe, it is important to ensure that all sampling locations are clear of utility lines and poles (subsurface as well as above surface).
2. Using the backhoe, dig a trench to approximately 3 feet in width and approximately 1 foot below the cleared sampling location. Place removed or excavated soils on plastic sheets. Trenches greater than 5 feet deep must be sloped or protected by a shoring system, as required by OSHA regulations.
3. Use a shovel to remove a 1- to 2-inch layer of soil from the vertical face of the pit where sampling is to be done.
4. Take samples using a trowel, scoop, or coring device at the desired intervals. Be sure to scrape the vertical face at the point of sampling to remove any soil that may have fallen from above, and to expose fresh soil for sampling. In many instances, samples can be collected directly from the backhoe bucket.
5. If volatile organic analysis is to be performed, transfer a portion of the sample directly into an appropriate, labeled sample container(s) with a stainless steel lab spoon, plastic lab spoon, or equivalent and secure the cap(s) tightly. Place the remainder of the sample into a stainless steel, plastic, or other appropriate homogenization container, and mix thoroughly to obtain a homogenous sample representative of the entire sampling interval. Then, either place the sample into an appropriate, labeled container(s) and secure the cap(s) tightly; or, if composite samples are to be collected, place a sample from another sampling interval into the homogenization container and mix thoroughly. When compositing is complete, place the sample into appropriate, labeled container(s) and secure the cap(s) tightly.
6. Abandon the pit or excavation according to applicable state regulations. Generally, shallow excavations can simply be backfilled with the removed soil material.

CALCULATIONS

This section is not applicable to this SOP.

QUALITY ASSURANCE / QUALITY CONTROL

There are no specific quality assurance activities which apply to the implementation of these procedures. However, the following QA procedures apply:

- All data must be documented on field data sheets or within site logbooks.
- All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation, and they must be documented.

DATA VALIDATION

This section is not applicable to this SOP.

HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, OSHA, and specific health and safety procedures.

SOIL GAS SAMPLING

SOP # 7

SCOPE AND APPLICATION

Soil gas monitoring provides a quick means of waste site evaluation. Using this method, underground contamination can be identified, arid the source, extent, and movement of the pollutants can be traced.

This Standard Operating Procedure (SOP) outlines the methods used by EPA/ERT in installing soil gas wells; measuring organic levels in the soil gas using an HNU PI 101 Portable Photoionization Analyzer and/or other air monitoring devices; and sampling the soil gas using Tedlar bags, Tenax sorbent tubes, and SUMMA canisters.

METHOD SUMMARY

A 3/8.inch diameter hole is driven into the ground to a depth of 4 to 5 feet using a commercially available "slam bar". (Soil gas can also be sampled at other depths by the use of a longer bar or bar attachments.) A 1/4 inch O.D. stainless steel probe is inserted into the hole. The hole is then sealed at the top around the probe using modeling clay. The gas contained in the interstitial spaces of the soil is sampled by pulling the sample through the probe using an air sampling pump. The sample may be stored in Tedlar bags, drawn through sorbent cartridges, or analyzed directly using a direct reading instrument.

The air sampling pump is not used for SUMMA canister sampling of soil gas. Sampling is achieved by soil gas equilibration with the evacuated SUMMA canister. Other field air monitoring devices, such as the combustible gas indicator (MSA CGJ/02 Meter, Model 260) and the organic vapor analyzer (Foxboro OVA, Model 128), can also be used depending on specific site conditions. Measurement of soil temperature using a temperature probe may also be desirable. Bagged samples are usually analyzed in a field laboratory using a portable Photovac GC.

Power driven sampling probes may be utilized when soil conditions make sampling by hand unfeasible (i.e., frozen ground, very dense clays, pavement, etc.). Commercially available soil gas sampling probes (hollow, 1/2-inch O.D. steel probes) can be driven to the desired depth using a power hammer (e.g., Bosch Demolition Hammer). Samples can be drawn through the probe itself, or through Teflon tubing inserted through the probe arid attached to the probe point. Samples are collected and analyzed as described above.

SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

Tedlar Bag

Soil gas samples are generally contained in 1 L Tedlar bags. Bagged samples are best stored in coolers to protect the bags from any damage that may occur in the field or in transit. In addition, coolers ensure the integrity of the samples by keeping them at a cool temperature and out of direct sunlight. Samples should be analyzed as soon as possible, preferably within 24 to 48 hours.

Tenax Tube

Bagged samples can also be drawn into Tenax or other sorbent tubes to undergo lab GC/MS analysis. If Tenax tubes are to be utilized, special care must be taken to avoid contamination. Handling of the tubes should be kept to a minimum, and samplers must wear nylon or other lint-free gloves. After sampling, each tube should be stored in a clean. sealed culture tube; the ends packed with clean glass wool to protect the sorbent tube from breakage. The culture tubes should be kept cool and wrapped in aluminum foil to prevent any photodegradation of samples.

SUMMA Canister

The SUMMA canisters used for soil gas sampling have a 6-L sample capacity and are certified clean by GC/MS analysis before being utilized in the field. After sampling is completed, they are stored and shipped in travel cases.

INTERFERENCES AND POTENTIAL PROBLEMS

HNU Measurements

A number of factors can affect the response of the HNU PI 101. High humidity can cause lamp fogging and decreased intensity. This can be significant when soil moisture levels are high, or when a soil gas well is actually in groundwater. High concentrations of methane can cause a downscale deflection of the meter. High and low temperature, electrical fields, FM radio transmission, and naturally occurring compounds, such as terpenes in wooded areas, will also affect instrument response.

Other field screening instruments can be affected by interferences. Consult the manufacturers' manuals.

Factors Affecting Organic Concentrations In Soil Gas

Concentrations in soil gas are affected by dissolution, adsorption, and partitioning. Partitioning refers to the ratio of component found in a saturated vapor above an aqueous solution to the amount in the solution; this can, in theory, be calculated using the Henry's Law constants.

Contaminants can also be adsorbed onto inorganic soil components or "dissolved" in organic components. These factors can result in a lowering of the partitioning coefficient.

Soil "tightness" or amount of void space in the soil matrix, will affect the rate of recharging of gas into the soil gas well.

Existence of a high, or perched, water table, or of an impermeable underlying layer (such as a clay lens or layer of buried slag) may interfere with sampling of the soil gas. Knowledge of site geology is useful in such situations, and can prevent inaccurate sampling.

Soil Probe Clogging

A common problem with this sampling method is soil probe clogging. A clogged probe can be identified by using an in-line vacuum gauge or by listening for the sound of the pump laboring. This problem can usually be eliminated by using a wire cable to clear the probe.

Underground Utilities

Prior to selecting sample locations, an underground utility search is recommended. The local utility companies can be contacted and requested to mark the locations of their underground lines. Sampling plans can then be drawn up accordingly. Each sample location should also be screened with a metal detector or magnetometer to verity that no underground pipes or drums exist.

EQUIPMENT / APPARATUS

Slam Bar Method

- slam bar (one per sampling team)
- soil gas probes, stainless steel tubing, 1/4 inch O.D., 5 foot length
- flexible wire or cable used for clearing the tubing during insertion into the well.
- "quick connect" fittings to connect sampling probe tubing, monitoring instruments, and Gilian pumps to appropriate fittings on vacuum box
- modeling clay
- vacuum box for drawing a vacuum around Tedlar bag for sample collection (one per sampling team)
- Gilian pump Model HFS113A adjusted to approximately 3.0 L/min (one to two per sampling team)
- 1/4 inch Teflon tubing, 2 to 3 foot lengths, for replacement of contaminated sample line
- Tedlar bags, 1 liter, at least one bag per sample point
- soil gas sampling labels, field data sheets, logbook, etc.
- HNU Model PI 101, or other field air monitoring devices, (one per sampling team)
- ice chest, for carrying equipment and for protection bf samples (two per sampling team)
- metal detector or magnetometer, for detecting underground utilities/ pipes/drums (one per sampling team)
- Photovac GC, for field-lab analysis of bagged samples
- SUMMA canisters (plus their shipping cases) for sample, storage and transportation

Power Hammer Method

- Bosch demolition hammer
- 1/2-inch O.D. steel probes, extensions, and points
- dedicated aluminum sampling points
- Teflon tubing, 1/4 inch O.D.
- "quick connect" fittings to connect sampling probe tubing, monitoring instruments, and Gilian pumps to appropriate fittings on vacuum box
- modeling clay
- vacuum box for drawing a vacuum around Tedlar bag for sample collection (one per sampling team)
- Gilian pump Model HFS113A adjusted to approximately 3.0 L/min (one to two per sampling team)
- 1/4 inch Teflon tubing, 2 to 3 foot lengths, for replacement of contaminated sample line
- Tedlar bags, 1 liter, at least one bag per sample point
- soil gas sampling labels, field data sheets, logbook, etc.
- HNU Model PI 101, or other field air monitoring devices, (one per sampling team)
- ice chest, for carrying equipment and for protection of samples (two per sampling team)
- metal detector or magnetometer, for detecting underground utilities/ pipes/drums (one per sampling team)
- Photovac GC, for field-lab analysis of bagged samples
- SUMMA canisters (plus their shipping cases) for sample storage and transportation
- generator with extension cords
- high lift jack assembly for removing probes

REAGENTS

- HNU Systems Inc. Calibration Gas for HNU Model P1101, and/or calibration gas for other field air monitoring devices
- deionized organic-free water, for decontamination
- methanol, HPLC grade, for decontamination
- ultra-zero grade compressed air, for field blanks

- standard gas preparations for Photovac GC calibration and Tedlar bag spikes

PROCEDURES

Soil Gas Well Installation

1. Initially, make a hole slightly deeper than the desired depth. For sampling up to 5 feet, use a 5-foot single piston slam bar. For deeper depths, use a piston slam bar with threaded 4-foot-long extensions. Other techniques can be used, so long as holes are of narrow diameter and no contamination is introduced.
2. After the hole is made, carefully withdraw the slam bar to prevent collapse of the walls of the hole. Then insert the soil gas probe.
3. It is necessary to prevent plugging of the probe, especially for deeper holes. Place a metal wire or cable, slightly longer than the probe, into the probe prior to inserting into the hole. Insert the probe to full depth, then pull it up 3 to 6 inches, then clear it by moving the cable up and down. The cable is removed before sampling.
4. Seal the top of the sample hole at the surface against ambient air infiltration by using modeling day molded around the probe at the surface of the hole.
5. If conditions preclude hand installation of the soil gas wells, the power driven system may be employed. Use the generator-powered demolition hammer to drive the probe to the desired depth (up to 12 feet may be attained with extensions). Pull the probe up 1 to 3 inches if the retractable point is used. No clay is needed to seal the hole. After sampling, retrieve the probe using the high lift jack assembly.
6. If semi-permanent soil gas wells are required, use the dedicated aluminum probe points. Insert these points into the bottom of the power-driven probe and attach it to the Teflon tubing. Insert the probe as in step 5. When the probe is removed, the point and Teflon tube remain in the hole, which may be scaled by backfilling with sand, bentonite, or soil.

Screening with Field Instruments

1. The well volume must be evacuated prior to sampling. Connect the Gillan pump, adjusted to 3.0 L/min, to the sample probe using a section of Teflon tubing as a connector. Turn the pump on, and a vacuum is pulled through the probe for approximately 15 seconds. A longer time is required for sample wells of greater depths.
2. After evacuation, connect the monitoring instrument(s) to the probe using a Teflon connector. When the reading is stable, or peaks, record the reading, For detailed procedures on HNU field protocol, see the attached protocol, and refer to the manufacturer's instructions.
3. Some readings may be above or below the range set on the field instruments. The range may be reset, or the response recorded as a figure greater than or less than the range. Consider the recharge rate of the well with soil gas when sampling at a different range setting.

Tedlar Bag Sampling

1. Follow step 1 of the procedure immediately above to evacuate well volume. If air monitoring instrument screening was performed prior to sampling, evacuation is not necessary.
2. Use the vacuum box and sampling train (Figure 1) to take the sample. The sampling train is designed to minimize the introduction of contaminants and losses due to adsorption. All wetted parts are either Teflon or stainless steel. The vacuum is drawn indirectly to avoid contamination from sample pumps.
3. Place the Tedlar bag inside the vacuum box, and attach it to the sampling port. Attach the sample probe to the sampling port via Teflon tubing and a "quick connect" fitting.
4. Draw a vacuum around the outside of the bag, using a Gilian pump connected to the vacuum box evacuation port, via Tygon tubing and a "quick connect" fitting. The vacuum causes the bag to inflate, drawing the sample.
5. Break the vacuum by removing the Tygon line from the pump. Remove the bagged sample from the box and close valve. Label bag, record data on data sheets or in logbooks. Record the date, time, sample location ID, and the HNU, or other instrument reading(s) on sample bag label.

CAUTION: Labels should not be pasted directly onto the bags, nor should bags be labeled directly using a marker or pen. Inks and adhesive may diffuse through the bag material, contaminating the sample. Place labels on the edge of the bags, or tie the labels to the metal eyelets provided on the bags. Markers with inks containing volatile organics (i.e., permanent ink markers) should not be used.

Tenax Tube Sampling

Samples collected in Tedlar bags may be sorbed onto Tenax tubes for further analysis by GC/MS.

Additional Apparatus

- Syringe with a luer-lock tip capable of drawing a soil gas or air sample from a Tedlar bag onto a Tenax/CMS sorbent tube. The syringe capacity is dependent upon the volume of sample being drawn onto the sorbent tube.

- Adapters for fitting the sorbent tube between the Tedlar bag and the sampling syringe. The adapter attaching the Tedlar bag to the sorbent tube consists of a reducng union (1/4inch to 1/16 inch O.D. — Swagelok cat. # 55-400-6-ILV or equivalent) with a length of 1/4-inch O.D. Teflon tubing replacing the nut on the 1/6-inch (Tedlar bag) side. A 1/4-inch I.D. silicone Q-ring replaces the ferrules in the nut on the 1/4-inch (sorbent tube) side of the union.

The adapter attaching the sampling syringe to the sorbent tube consists of a reducing union (1/4-inch to 1/16-inch O.D. — Swagelok Cat. # 55-400-6-ILV or equivalent) with a 1/4-inch I.D. silicone O ring replacing the ferrules in the nut on the 1/4-inch (sorbent tube) side and the needle of a luer-lock syringe needle inserted into the 1/16-inch side (held in place with a 1/16-inch ferrule). The luer-lock end of the needle can be attached to the sampling syringe. It is useful to have a luer-lock on/off valve situated between the syringe and the ‘needle.

- Two-stage glass sampling cartridge (1/4 inch O.D. x 1/~inch I.D. x. 5 1/8 inch) contained in a flame-sealed tube (manufactured by Supelco Custom Tenax/Spherocarb Tubes or equivalent) containing two sorbent sections retained by glass wool:

Front section: 150 mg of Tenax-GC
Back section: 150 mg of CMS
(Carbonized Molecular Sieve)

Sorbent tubes may also be prepared in the lab and stored in either Teflon-capped culture tubes or stainless steel tube containers. Sorbent tubes stored in this manner should not be kept more than 2 weeks without reconditioning.

- Teflon-capped culture tubes or stainless steel tube containers for sorbent tube storage. These containers should be conditioned by baking at 120°C for at least 2 hours. The culture tubes should contain a glass wool plug to prevent sorbent tube breakage during transport. Reconditioning of the containers should occur between usage or after extended periods of disuse (i.e., 2 weeks or more).
- Nylon gloves or lint-free cloth. (Hewlett Packard Part # 8650-0030 or equivalent.)

Sample Collection

1. Handle sorbent tubes with care, using nylon gloves (or. other lint-free material) to avoid contamination.
2. Immediately before sampling, break one end of the sealed tube and remove the Tenax cartridge. For in-house prepared tubes, remove cartridge from its container.
3. Connect the valve on the Tedlar bag to the sorbent tube adapter. Connect the sorbent tube to the sorbent tube adapter with the Tenax (white granular) side of the tube facing the Tedlar bag.
4. Connect the sampling syringe assembly to the CMS (black) side of the sorbent tube. Fittings on the adapters should be very tight.
5. Open the valve on the Tedlar bag.
6. Open the on/off valve of the sampling syringe.
7. Draw a predetermined volume of sample onto the sorbent tube. (This may require dosing the syringe valve, emptying the syringe and then repeating the procedure, depending upon the syringe capacity and volume of sample required.)
8. After sampling, remove the tube from the sampling train with gloves or a clean cloth. ***Do not label or write on the Tenax/CMS tube.***
9. Place the sorbent tube in a conditioned stainless steel tube holder or culture tube. Culture tube caps should be sealed with Teflon tape.

Sample Labeling

Each sample tube container (not tube) must be labeled with the site name, sample station number, sample date, and sample volume.

Chain of custody forms must accompany all samples to the laboratory.

Quality Assurance

Before field use, a QA check should be performed on each batch of sorbent tubes by analyzing a tube with thermal desorption/cryogenic trapping GC/MS.

At least one blank sample must be submitted with each set of samples collected at a Site. This trip blank must be treated the same as the sample tubes except no sample will be drawn through the tube.

Sample tubes should be stored out of UV light (i.e., sunlight) and kept on ice until analysis.

Samples should be taken in duplicate, when possible.

SUMMA Canister Sampling

1. Follow item 1 in step 3.7.2 to evacuate well volume. If HNU analysis was performed prior to taking a sample, evacuation is not necessary.
2. Attach a certified clean, evacuated ~L SUMMA canister via the 1/~mch Teflon tubing.

3. Open the valve on SUMMA canister. The soil gas sample is drawn into the canister by pressure equilibration. The approximate sampling time for a 6-L canister is 20 minutes.
4. Site name, sample. location, number, and date must be recorded on a chain of custody form and on a blank tag attached to the canister.

CALCULATIONS

Field Screening Instruments

Instrument readings are usually read directly from the meter. In some cases, the background level at the soil gas station may be subtracted:

Final Reading = Sample Reading — Background

Photovac GC Analysis

Calculations used to determine concentrations of individual components by Photovac GC analysis are beyond the scope of this SOP and are covered in ERT SOP #2109, Photovac GC Analysis for Soil, Water and Air/Soil Gas.

QUALITY ASSURANCE / QUALITY CONTROL

Field Instrument Calibration

Consult the manufacturers' manuals for correct use and calibration of all instrumentation. The HNU should be calibrated at least once a day.

Gilian Model HFS113A Air Sampling Pump Calibration

Flow should be set at approximately 3.0 L/min; accurate flow adjustment is not necessary. Pumps should be calibrated prior to bringing into the field.

Sample Probe Contamination

Sample probe contamination is checked between each sample by drawing ambient air through the probe via a Gilian pump and checking the response of the HNU PI 101. If HNU readings are higher than background, replacement or decontamination is necessary.

Sample probes may be decontaminated simply by drawing ambient air through the probe until the HNU reading is at background. More persistent contamination can be washed out using methanol and water, then air drying. Having more than one probe per sample team will reduce lag times between sample stations while probes are decontaminated.

Sample Train Contamination

The Teflon line forming the sample train from the probe to the Tedlar bag should be changed on a daily basis. If visible contamination (soil or water) is drawn into the sampling train, it should be changed immediately. When sampling in highly contaminated areas, the sampling train should be purged with ambient air, via a Gilian pump, for approximately 30 seconds between each sample. After purging, the sampling train can be checked using an HNU, or other field monitoring device, to establish the cleanliness of the Teflon line.

Field Blank

Each cooler containing samples should also contain one Tedlar bag of ultra-zero grade air, acting as a field blank. The field blank should accompany the samples in the field (while being collected) and when they are delivered for analysis. A fresh blank must be provided to be placed in the empty cooler pending additional sample collection. One new field blank per cooler of samples is required. A chain of custody form must accompany each cooler of samples and should include the blank that is dedicated to that group of samples.

Trip Standard

Each cooler containing samples should contain a Tedlar bag of standard gas to calibrate the analytical instruments (Photovac GC, etc.). This trip standard will be used to determine any changes in concentrations of the target compounds during the course of the sampling day (e.g., migration through the sample bag, degradation, or adsorption). A fresh trip standard must be provided and placed in each cooler pending additional sample collection. A chain of custody form should accompany each cooler of samples and should include the trip standard that is dedicated to that group of samples.

Tedlar Bag Check

Prior to use, one bag should be removed from each lot (case of 100) of Tedlar bags to be used for sampling and checked for possible contamination as follows: the test bag should be filled with ultra-zero grade air; a sample should be drawn from the bag and analyzed via Photovac GC or whatever method is to be used for sample analysis. This procedure will ensure sample container cleanliness prior to the start of the sampling effort.

SUMMA Canister Check

From each lot of four cleaned SUMMA canisters, one is to be removed for a GC/MS certification check. If the canister passes certification, then it is re-evacuated and all four canisters from that lot are available for sampling.

If the chosen canister is contaminated, then the entire lot of four SUMMA canisters must be recleaned, and a single canister is re-analysed by GC/MS for certification.

Options

Duplicate Samples

A minimum of 5% of all samples should be collected in duplicate (i.e., if a total of 100 samples are to be collected, five samples should be duplicated). In choosing which samples to duplicate, the following criterion applies: if, after filling the first Tedlar bag, and, evacuating the well for 15 seconds, the second HNU (or other field monitoring device being used) reading matches or is close to (within *50%)* the first reading, a duplicate sample may be taken.

Spikes

A Tedlar bag spike and Tenax tube spike may be desirable in situations where high concentrations of contaminants other than the target compounds are found to exist (landfills, etc.). The additional level of QA/QC attained by this practice can be useful in determining the effects of interferences caused by these non-target compounds. SUMMA canisters containing samples are not spiked.

DATA VALIDATION

For each target compound, the level of concentration found in the sample must be greater than three times the level (for that compound) found in the field blank which accompanied that sample to be considered valid. The same criteria apply to target compounds detected in the Tedlar bag pre-sampling contamination check.

HEALTH AND SAFETY

Because the sample is being drawn from underground, and no contamination is introduced into the breathing zone, soil gas sampling usually occurs in Level D, unless the sampling location is within the hot zone of a site, which requires Level B or Level C protection. However, to ensure that the proper level of protection is utilized, constantly monitor the ambient air using the HNU PI 101 to obtain background readings during the sampling procedure. As long as the levels in ambient air do not rise above background, no upgrade of the level of protection is needed.

Also, perform an underground utility search prior to sampling . When working with potentially hazardous materials, follow U.S. EPA, OSHA, and specific health and safety procedures.

GENERAL SURFACE GEOPHYSICS

SOP # 8

SCOPE AND APPLICATION

This Standard Operating Procedure (SOP) describes the general procedures used to acquire surface geophysical data. This data is used for delineating subsurface waste, arid for interpreting geological; hydrogeologic or other data related to hazardous waste site characterization.

The media pertinent to these surface geophysical methods are soil/r6ck and groundwater. The sensitivity or minimum response of a given method depends on the comparison of the object or area of study to that of its background (i.e., what the media's response would be like without the object of study). Therefore, the suitability of surface geophysical methods for a given investigation must be judged on the object's ability to be measured and the extent to which the specific setting of the study interferes with the measurement.

The surface geophysical method(s) selected for application at a site are dependent on site conditions, such as depth to bedrock, depth to target, urban disturbances (fences, power lines, surface debris, etc.) and atmospheric conditions. Detectability of the target is dependent on the sensitivity of the instrument and the variation of the field measurement from the ambient noise. Ambient noise is the pervasive noise associated with an environment. Therefore, the applicability of geophysical methods at a given site is dependent on the specific setting at that site.

Five geophysical methods may be utilized in hazardous waste site characterization: magnetometry, electromagnetics, resistivity, seismology arid ground penetrating radar (GPR). Magnetometers may be used to locate buried ferrous metallic objects and geologic information. Electromagnetic methods can be used to determine the presence of metals, electrical conductivity of the terrain, and geologic information. Resistivity methods are used to determine the electrical resistivity of the terrain and geologic information. Seismic methods are useful in determining geologic stratigraphy arid structure. GPR may be used to locate disturbance in (he soil (i.e., trenches, buried utilities and fill boundaries) and some near-surface geologic information.

These procedures may be varied or changed as required, dependent on site conditions, equipment limitations or limitations imposed by the procedure. In all instances, the procedures employed should be documented and associated with the final report.

METHOD SUMMARY

Magnetics

A magnetometer is an instrument which measures magnetic field strength in units of gammas (nanoteslas). Local variations, or anomalies, in the earth's magnetic field are the result of disturbances caused mostly by variations in concentrations of ferromagnetic material in the vicinity of the magnetometer's sensor. A buried ferrous object, such as a steel drum or tank, locally distorts the earth's magnetic field and results in a magnetic anomaly. The objective of conducting a magnetic survey at a hazardous waste or groundwater pollution site is to map these anomalies and delineate the area containing buried sources of the anomalies.

Analysis of magnetic data can allow an experienced geophysicist to estimate the a real extent of buried ferrous targets, such as a steel tank or drum. Often, areas of burial can be prioritized upon examination of the data, with high priority areas indicating a near certainty of buried ferrous material. In some instances, estimates of depth of burial can be made from the data. Most of these depth estimates are graphical methods of interpretation, such as slope techniques and half-width rules, as described by Nettleton (1976). The accuracy of these methods is dependent upon the quality of the data and the skill of the interpreting geophysicist. An accuracy of 10 to 20 percent is considered acceptable. The magnetic method may also be used to map certain geologic features, such as igneous intrusions, which may play an important role in the hydrogeology of a groundwater pollution site.

Advantages

Advantages of using the magnetic method for the initial assessment of hazardous waste sites are the relatively low cost of conducting the survey arid the relative ease of completing a survey in a short amount of time. Little, if any, site preparation is necessary. Surveying requirements are not as stringent as for other methods and may be completed with a transit or Brunton-type pocket transit and a non-metallic measuring tape. Often, a magnetic investigation is a very cost-effective method for initial assessment of a hazardous waste site where buried steel drums or tanks are a concern.

Disadvantages

"Cultural noise" is a limitation of the magnetic method in certain areas. Man-made structures that are constructed with ferrous material, such as steel, have a detrimental effect on the quality of the data. Avoid features such as steel structures, power lines, metal fences, steel reinforced concrete, pipelines arid underground utilities. When these features are unavoidable, note their locations in a field notebook and on the site map.

Another limitation of the magnetic method is the inability of the interpretation methods to differentiate between various steel objects. For instance, it is not possible to determine if an anomaly is the result of a steel tank, or a group of steel drums, or old washing machines. Also, the magnetic method does not allow the interpreter to determine the contents of a buried tank or drum.

Electromagnetics

The electromagnetic method is a geophysical technique based on the physical principles of inducing and detecting electrical current flow within geologic strata. A receiver detects these induced currents by measuring the resulting time-varying magnetic field. The electromagnetic method measures bulk conductivity (the inverse of resistivity) of geologic materials beneath the transmitter and receiver coils. Electromagnetics should not be confused with the electrical resistivity method. The difference between the two techniques is in the method which the electrical currents are forced to flow in the earth. In the electromagnetic method, currents are induced by the application of time-varying magnetic fields, whereas in the electrical resistivity method, current is injected into the ground through surface electrodes.

Electromagnetics can be used to locate pipes, utility lines, cables, buried steel drums, trenches, buried waste, and concentrated contaminant plumes. The method can also be used to map shallow geologic features, such as lithologic changes and fault zones.

Advantages

Electromagnetic measurements can be collected rapidly and with a minimum number of field personnel. Most electromagnetic equipment used in groundwater pollution investigations is lightweight and easily portable. The electromagnetic method is one of the more commonly used geophysical techniques applied to groundwater pollution investigations.

Disadvantages

The main limitation of the electromagnetic method is "cultural noise". Sources of "cultural noise" can include: large metal objects, buried cables, pipes, buildings, arid metal fences.

The electromagnetic method has limitations in areas where the geology varies laterally. These can cause conductivity anomalies or lineations, which might be misinterpreted as contaminant plumes.

Electrical Resistivity

The electrical resistivity method is used to map subsurface electrical resistivity structure, which is in turn interpreted by the geophysicist to determine the geologic structure and/or physical properties of the geologic materials. Electrical resistivities of geologic materials are measured in ohm-meters, and are functions of porosity, permeability, water saturation and the concentration of dissolved solids in the pore fluids.

Resistivity methods measure the bulk resistivity of the subsurface, as do the electromagnetic methods. The difference between the two methods is in the way that electrical currents are forced to flow in the earth. In the electrical resistivity method, current is injected into the ground through surface electrodes, whereas in electromagnetic methods currents are induced by application of time-varying magnetic fields.

Advantages

The principal advantage of the electrical resistivity method is that quantitative modeling is possible using either computer software or published master curves. The resulting models can provide accurate estimates of depths, thicknesses and resistivities of subsurface layers. The layer resistivities can then be used to estimate the resistivity of the saturating fluid, which is related to the total concentration of dissolved solids in the fluid.

Disadvantages

The limitations of using the resistivity method in groundwater pollution site investigations are largely due to site characteristics, rather than in any inherent limitations of the method. Typically, polluted sites are located in industrial areas that contain an abundance of broad spectrum electrical noise. In conducting a resistivity survey, the voltages are relayed to the receiver over long wires that are grounded at each end. These wires act as antennae receiving the radiated electrical noise that in turn degrades the quality of the measured voltages.

Resistivity surveys require a fairly large area, far removed from pipelines and grounded metallic structures such as metal fences, pipelines and railroad tracks. This requirement precludes using resistivity on many polluted sites. However, the resistivity method can often be used successfully offsite to map the stratigraphy of the area surrounding the site. A general "rule of thumb" for resistivity surveying is that grounded structures be at least half of the maximum electrode spacing distance away from the axis of the survey line.

Another consideration in the resistivity method is that the fieldwork tends to he more labor intensive than some other geophysical techniques. A minimum of two to three crew members are required for the fieldwork.

Seismic

Surface seismic techniques used in groundwater pollution site investigations are largely restricted to seismic refraction and seismic reflection methods. The equipment used for both methods is fundamentally the same and both methods measure the travel-time of acoustic waves propagating through the subsurface. In the refraction method, the travel-time of waves refracted along an acoustic interface is measured, and in the reflection method, the travel-time of a wave which reflects or echoes off an interface is measured.

The interpretation of seismic data will yield subsurface velocity information, which is dependent upon the acoustic properties of the subsurface material. Various geologic materials can he categorized by their acoustic properties or velocities. Depth to geologic interfaces are calculated using the velocities obtained from a seismic investigation. The geologic information gained from a seismic investigation is then used in the hydrogeologic assessment of a groundwater pollution site and the surrounding area. The interpretation of seismic data indicates changes in lithology or stratigraphy, geologic structure, or water saturation (water table). Seismic methods are commonly used to determine the depth and structure of geologic and hydrogeologice units, to estimate hydraulic conductivity, to detect cavities or voids, to determine structure stability, to detect fractures and fault zones, and to estimate ripability. The choice of method depends upon the information needed and the nature of the study area. This decision must he made by a geophysicist who is experienced in both methods, is aware of the geologic information needed by the hydrogeologist, and is also aware of the environment of the study area. The refraction technique has been used more often than the reflection technique for hazardous waste site investigations.

Seismic Refraction Method

Seismic refraction is most commonly used at sites where bedrock is less than 500 feet below the ground surface. Seismic refraction is simply the travel path of a sound wave through an upper medium and along an interface and then back to the surface. A detailed discussion of the seismic refraction technique can be found in Dobrin (1976), Tefford, et. al. (1985), and Musgrave (1967).

Advantages:

Seismic refraction surveys are more common than reflection surveys for site investigations. The velocities of each layer can be determined from refraction data, and a relatively precise estimate of the depth to different interfaces can be calculated.

Refraction surveys add to depth information in-between boreholes. Subsurface information can be obtained between boreholes at a fraction of the cost of drilling. Refraction data can be used to determine the depth to the water table or bedrock. In buried valley areas, refraction surveys map the depth to bedrock. The velocity information obtained from a refraction survey can be related to various physical properties of the bedrock. Rock types have certain ranges of velocities and these velocities are not always unique to a particular rock type. However, they can allow a geophysicist to differentiate between certain units, such as shales and granites.

Disadvantages:

The seismic refraction method is based on several assumptions. To successfully resolve the subsurface using the refraction method, the conditions of the geologic environment must approximate these assumptions:

- the velocities of the layers increase with depth,
- the velocity contrast between layers is sufficient to resolve the interface, and
- the geometry of the geophones in relation to the refracting layers will permit the detection of thin layers.

These conditions must be met for accurate depth information.

Collecting and interpreting seismic refraction data has several disadvantages. Data collection can be labor intensive. Also, large line lengths are needed; therefore, as a general rule, the distance from the shot, or seismic source, to the first geophone station must be at least three times the desired depth of exploration.

Seismic Reflection Method

The seismic reflection method is not as commonly used on groundwater pollution site investigations as seismic refraction. In the seismic reflection method, a sound wave travels down to a geologic interface and reflects back to the surface. Reflections occur at an interface where there is a change in the acoustic properties of the subsurface material.

Advantages:

The seismic reflection method yields information that allows the interpreter to discern between fairly discrete layers, so it is useful for mapping stratigraphy. Reflection data is usually presented in profile form, and depths to interfaces are represented as a function of time. Depth information can be obtained by converting time sections into depth measurements using velocities obtained from seismic refraction data, sonic logs, or velocity logs. The reflection technique requires much less space than refraction surveys. The long offsets of the seismic source from the geophones, common in refraction surveys, are not required in the reflection method. In some geologic environments, reflection data can yield acceptable depth estimates.

Disadvantages:

The major disadvantage to using reflection data is that a precise depth determination cannot be made. Velocities obtained from most reflection data are at least 10% and can be 20% of the true velocities. The interpretation of reflection data requires a qualitative approach. In addition to being more labor intensive, the acquisition of reflection data is more complex than refraction data.

The reflection method places higher requirements on the capabilities of the seismic equipment. Reflection data is commonly used in the petroleum exploration industry and requires a large amount of data processing time and lengthy data collection procedures. Although mainframe computers are often used in the reduction and analysis of large amounts of reflection data, recent advances have allowed for the use of personal computers on small reflection surveys for engineering purposes. In most cases, the data must be recorded digitally or converted to a digital format, to employ various numerical processing operations. The use of high resolution reflection seismic methods relies heavily on the geophysicist, the computer capacity, the data reduction and processing programs, resolution capabilities of the seismograph and geophones, and the ingenuity of the interpreter. Without these capabilities, reflection surveys are not recommended.

Ground Penetrating Radar

The ground penetrating radar (GPR) method is used for a variety of civil engineering, groundwater evaluation and hazardous waste site applications. This geophysical method is the most site-specific of all geophysical techniques, providing subsurface information ranging in depth from several tens of meters to only a fraction of a meter. A basic understanding of the function of the GPR instrument, together with a knowledge of the geology and mineralogy of the site, can help determine if GPR will be successful in the site assessment. When possible, the GPR technique should be integrated with other geophysical and geologic data to provide the most c$_9$mprehensive site assessment.

The GPR method uses a transmitter that emits pulses of high-frequency electromagnetic waves into the subsurface. The transmitter is either moved slowly across the ground surface or inoved at fixed station intervals. The penetrating electromagnetic waves are scattered at. points of change in the complex dielectric permittivity, which is a property of the subsurface material dependent primarily upon the bulk density, day content and water content of the subsurface (Olhoeft, 1984). The electromagnetic energy which is scattered back to the receiving antenna on the surface is recorded as a function of time.

Depth penetration is severely limited by attenuation of the transmitted electromagnetic waves into the ground. Attenuation is caused by the sum of electrical conductivity, dielectric relaxation, and geometric scattering losses in the subsurface. Generally, penetration of radar frequencies is minimized by a shallow water table, an increase in the day content of the subsurface, and in environments where the electrical resistivity of the subsurface is less than 30 ohm-meters (Olhoeft, 1986). Ground penetrating radar works best in dry sandy soil above the water table. At applicable sites, depth resolution should be between 1 and 10 meters (Benson, 1982).

The analog plot produced by a continuously recording GPR system is analogous to a seismic reflection profile; that is, data is represented as a function of horizontal distance versus time. This representation should not be confused with a geologic cross section which represents data as a function of horizontal distance versus depth. Because very high-frequency electromagnetic waves in the megahertz range are used by radar systems, and time delays are measured in nanoseconds (10^{-9} seconds), very high resolution of the subsurface is possible using GPR. This resolution can be as high as 0.1 meter. For depth determinations, it is necessary to correlate the recorded features with actual depth measurements from boreholes or from the results of other geophysical investigations. When properly interpreted, GPR data can optimally resolve changes in soil horizons, fractures, water insoluble contaminants, geological features, manmade buried objects, and hydrologic features such as water table depth and wetting fronts.

Advantages

Most GPR systems can provide a continuous display of data along a traverse which can often be interpreted qualitatively in the field. GPR is capable of providing high resolution data under favorable site conditions. The real-time capability of GPR results in a rapid turnaround, and allows the geophysicist to quickly evaluate subsurface site conditions.

Disadvantages

One of the major limitations of GPR is the site-specific nature of the technique. Another limitation is the cost of site preparation which is necessary prior to the survey. Most GPR units are towed across the ground surface. Ideally, the ground surface should be flat, dry, and clear of any brush or debris. The quality of the data can be degraded by a variety of factors, such as an uneven ground surface or various cultural noise sources. For these reasons, it is mandatory that the site be visited by the project geophysicist before a GPR investigation is proposed. The geophysicist should also evaluate all stratigraphic information available, such as borehole data and information on the depth to water table in the survey area.

SAMPLE PRESERVATION, CONTAINERS, HANDLING AND STORAGE

This section is not applicable to this SOP.

INTERFERENCES AND POTENTIAL PROBLEMS

See above for a discussion of limitations of the various methods.

EQUIPMENT / APPARATUS

Magnetics

- GEM GSM-19G magnetometer/gradiometer, EDA OMNI Iv magnetometer/gradiometer, Geonics 856AGX (with built-in datalogger) or equivalent
- magnetometer base station
- 300-foot tape measure
- non-ferrous survey stakes (wooden or plastic)

Electromagnetics

- Geonics EM-31, EM-34 or equivalent
- Polycorder datalogger
- Dat 310 software (data dump software)
- 300-foot tape measure
- survey stakes

Electrical Resistivity

- DC resistivity unit (non-specific)
- 4 electrodes and appropriate cables (length dependent on depth of survey)
- 1 or 2 12-volt car batteries
- 300-foot tape measure

Seismic

- 12 or 24-channel seismograph (Geometries 2401 or equivalent)
- 30 10Hz to 14Hz geophones (for refraction)
- 30 50Hz or greater geophones (for reflection)
- 300-foot tape measure
- survey stakes
- sledge hammer and metal plate or explosives

Ground Penetrating Radar

- GSSI SIR-8 or equivalent.
- 80 Mhz, 100 Mhz, or 300 Mhz antenna/ receiver pit
- 200-foot cable
- 300-foot tape measure

REAGENTS

This section is not applicable to this SOP.

PROCEDURES

Refer to the manufacturer's operating manual for specific procedures relating to operation of the equipment.

CALCULATIONS

Calculations vary based on the geophysical method employed. Refer to the instrument-specific users manual for specific formulae.

QUALITY ASSURANCE / QUALITY CONTROL

The following general quality assurance activities apply to the implementation of these procedures.

- All data must be documented on field data sheets or within site logbooks.
- All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation, and they must be documented.

Method-specific quality assurance procedures may be found in the user's manual.

DATA VALIDATION

Evaluate data as per the criteria established above.

HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, OSHA and specific health and safety procedures.

SURFACE WATER SAMPLING

SOP # 9

SCOPE AND APPLICATION

This Standard Operating Procedure (SOP) is applicable to the collection of representative liquid samples, both aqueous and nonaqueous from streams, rivers, lakes, ponds, lagoons, and surface impoundments. It includes samples collected from depth, as well as samples collected from the surface.

METHOD SUMMARY

Sampling situations vary widely and therefore no universal sampling procedure can be recommended.

However, sampling of both aqueous and nonaqueous liquids from the above mentioned sources is gencrally accomplished through the use of one of the following samplers or techniques:

- Kemmerer bottle
- bacon bomb sampler
- dip sampler
- direct method

These sampling techniques will allow for the collection of representative samples from the majority of surface waters and impoundments encountered.

SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

Once samples have been collected, follow these procedures:

1. Transfer the sample(s) into suitable labeled sample containers.
2. Preserve the sample if appropriate, or use pre-preserved sample bottles.
3. Cap the container, put it in a Ziploc plastic bag and place it on ice in a cooler.
4. Record all pertinent data in the site logbook and on a field data sheet.
5. Complete the chain of custody form.
6. Attach custody seals to the cooler prior to shipment.
7. Decontaminate all sampling equipment prior to the collection of additional samples.

INTERFERENCES AND POTENTIAL PROBLEMS

There are two primary interferences or potential problems with surface water sampling. These include cross-contamination of samples and improper sample collection.

- Cross-contamination problems can be eliminated or minimized through the use of dedicated sampling equipment. If this is not possible or practical, then decontamination of sampling equipment is necessary. Refer to SOP # 1, Sampling Equipment Decontamination.
- Improper sample collection can involve using contaminated equipment, disturbance of the stream or impoundment substrate, and sampling in an obviously disturbed area.

Following proper decontamination procedures and minimizing disturbance of the sample site will eliminate these problems.

EQUIPMENT / APPARATUS

Equipment needed for collection of surface water samples includes:

- Kemmerer bottles
- bacon bomb sampler
- dip sampler
- line and messengers
- sample bottle preservatives
- Ziploc bags
- ice
- cooler(s)
- chain of custody forms, field data sheets
- decontamination equipment
- maps/plot plan
- safety equipment
- compass
- tape measure
- survey stakes, flags, or buoys and anchors
- camera and film
- logbook/waterproof pen
- sample bottle labels

REAGENTS

Reagents will be utilized for preservation of samples and for decontamination of sampling equipment. The preservatives required are specified by the analysis to be performed. Decontamination solutions are specified in SOP #1, Sampling Equipment Decontamination.

PROCEDURES

Preparation

1. Determine the extent of the sampling effort, the sampling methods to be employed, and which equipment and supplies are needed.
2. Obtain necessary sampling and monitoring equipment.
3. Decontaminate or preclean equipment, and ensure that it is in working order.
4. Prepare scheduling and coordinate with staff, clients, and regulatory agency, if

appropriate.

5. Perform a general site survey prior to site entry in accordance with the site-specific health and safety plan.

6. Use stakes, flags, or buoys to identify and mark all sampling locations. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions.

Sampling Considerations: Representative Samples

In order to collect a representative sample, the hydrology and morphometrics (e.g., measurements of volume, depth, etc.) of a stream or impoundment should be determined prior to sampling. This will aid in determining the presence of phases or layers in lagoons or impoundments, flow patterns in streams, and appropriate sample locations and depths.

Water quality data should be collected in impoundments to determine if stratification is present. Measurements of dissolved oxygen, pH, and temperature can indicate if strata exist which would effect analytical results. Measurements should be collected at 1-meter intervals from the substrate to the surface using an appropriate instrument, such as a Hydrolab (or equivalent).

Water quality measurements such as dissolved oxygen, pH, temperature, conductivity, and oxidation-reduction potential can assist in the interpretation of analytical data and the selection of sampling sites and depths anytime surface water samples are collected.

Generally, the deciding factors in the selection of a sampling device for sampling liquids in streams, rivers, lakes, ponds, lagoons, and surface impoundments are:

- Will the sample be collected from the shore or from a boat on the impoundment?
- What is the desired depth at which the sample is to be collected?
- What is the overall depth and flow direction of river or stream?

Sampler Composition

The appropriate sampling device must be of a proper composition. Samplers constructed of glass, stainless steel, PVC or PTFE (Teflon) should be used based upon the analyses to be performed.

Sample Collection *Kemmerer Bottle*

A Kemmerer bottle may be used in most situations where site access is from a boat or structure such as a bridge or pier, and where samples at depth are required. Sampling procedures are as follows:

1. Using a properly decontaminated Kemmerer bottle, set the sampling device so that the sampling end pieces are pulled away from the sampling tube, allowing the substance to be sampled to pass through this tube.
2. Lower the pre-set sampling device to the predetermined depth. Avoid bottom disturbance.
3. When the Kemmerer bottle is at the required depth, send down the messenger, closing the sampling device.
4. Retrieve the sampler and discharge the first 10 to 20 mL to clear any potential contamination on the valve. Transfer the sample to the appropriate sample container.

Bacon Bomb Sampler

A bacon bomb sampler may be used in similar situations to those outlined for the Kemmerer bottle. Sampling procedures are as follows:

1. Lower the bacon bomb sampler carefully to the desired depth, allowing the line for the trigger to remain slack at all times. When the desired depth is reached, pull the trigger line until taut.
2. Release the trigger line and retrieve the sampler.
3. Transfer the sample to the appropriate sample container by pulling the trigger.

Dip Sampler

A dip sampler is useful for situations where a sample is to be recovered from an outfall pipe or along a lagoon bank where direct access is limited. The long handle on such a device allows access from a discrete location. Sampling procedures are as follows:

1. Assemble the device in accordance with the manufacturer's instructions.
2. Extend the device to the sample location and collect the sample.
3. Retrieve the sampler and transfer the sample to the appropriate sample container.

Direct Method

For streams, rivers, lakes, and other surface waters, the direct method may be utilized to collect water samples from the surface. This method is not to be used for sampling lagoons or other impoundments where contact with contaminants are a concern.

Using adequate protective clothing, access the sampling station by appropriate means. For shallow stream stations, collect the sample under the water surface pointing the sample container upstream. The container must be upstream of the collector. Avoid disturbing the substrate. For lakes and other impoundments, collect the sample under the water surface avoiding surface debris and the boat wake.

When using the direct method, do not use pre-preserved sample bottles as the collection method may dilute the concentration of preservative necessary for proper sample preservation.

CALCULATIONS

This section is not applicable to this SOP.

QUALITY ASSURANCE / QUALITY CONTROL

There are no specific quality assurance activities which apply to the implementation of these procedures. However, the following general QA/QC procedures apply:

- All data must be documented on field data sheets or within site logbooks.
- All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior 10 sampling/operation and they must be documented.

DATA VALIDATION

This section is not applicable to this SOP.

HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, OSHA and specific health and safety procedures.

More specifically, when sampling lagoons or surface impoundments containing known or suspected hazardous substances, take adequate precautions. The sampling team member collecting the sample should not get too close to the edge of the impoundment, where bank failure may cause him or her to lose their balance. The person performing the sampling should be on a lifeline and be wearing adequate protective equipment. When conducting sampling from a boat in an impoundment or flowing waters, follow appropriate boating safety procedures.

SEDIMENT SAMPLING

SOP # 10

SCOPE AND APPLICATION

This Standard Operating Procedure (SOP) is applicable to the collection of representative sediment samples. Analysis of sediment may determine whether concentrations of specific contaminants exceed established threshold action levels, or if the concentrations present a risk to public health, welfare, or the environment.

The methodologies discussed in this procedure are applicable to the sampling of sediment in both flowing and standing water. They are generic in nature and may be modified in whole or part to meet the handling and analytical requirements of the contaminants of concern, as well as the constraints presented by the sampling area. However, if modifications occur, they should be documented in the site logbook or report summarizing field activities.

For the purposes of this procedure, sediments are those mineral and organic materials situated beneath an aqueous layer. The aqueous layer may be either static, as in lakes, ponds, or other impoundments or flowing, as in rivers and streams.

METHOD SUMMARY

Sediment samples may be recovered using a variety of methods and equipment, depending on the depth of the aqueous layer, the portion of the sediment profile required (surface versus subsurface), the type of sample required (disturbed versus undisturbed) and the sediment type.

Sediment is collected from beneath an aqueous layer either directly, using a hand-held device such as a shovel, trowel, or auger, or indirectly using a remotely activated device such as an Ekman or Ponar dredge. Following collection, the sediment is placed into a container constructed of inert material, homogenized, and transferred to the appropriate sample containers. The homogenization procedure should not be used if sample analysis includes volatile organics.

SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

- Chemical preservation of solids is generally not recommended. Cooling is usually the best approach, supplemented by the appropriate holding time.
- Wide-mouth glass containers with Teflon-lined caps are utilized for sediment samples. The sample volume is a function of the analytical requirements and will be specified in the work plan.
- Transfer sediment from the sample collection device to an appropriate sample container using a stainless steel or plastic lab spoon or equivalent. If composite samples are collected, place the sediment sample in a stainless steel, plastic or other appropriate composition (e.g.: Teflon) bucket, and mix thoroughly to obtain a homogeneous sample representative of the entire sampling interval. Then place the sediment sample into labeled containers.
- Samples for volatile organic analysis must be collected directly from the bucket, before mixing the sample, to minimize loss due to volatilization of contaminants.
- All sampling devices should be decontaminated, then wrapped in aluminum foil. The sampler should remain in this wrapping until it is needed. Each sampler should be used for only one sample. Dedicated samplers for sediment samples may be impractical due to the large number of sediment samples which may be required and the cost of the sampler. In this case, samplers should be cleaned in the field using the decontamination procedure described in SOP# 1, Sampling Equipment Decontamination.

INTERFERENCES AND POTENTIAL PROBLEMS

Substrate particle size and organic content are directly related to water velocity and flow characteristics of a body of water. Contaminants are more likely to be concentrated in sediments typified by fine particle size and a high organic content. This type of sediment is most likely to be collected from depositional zones. In contrast, coarse sediments with low organic content do not typically concentrate pollutants and are found in erosional zones. The selection of a sampling location can, therefore, greatly influence the analytical results.

EQUIPMENT / APPARATUS

Equipment needed for collection of sediment samples includes:

- maps/plot plan
- safety equipment
- compass
- tape measure
- survey stakes, flags, or buoys and anchors
- camera and film
- stainless steel, plastic, or other appropriate composition bucket
- 4-oz, 8-oz, and one-quart, wide-mouth jars w/ Teflon-lined lids
- ziploc plastic bags
- logbook

- sample jar labels
- chain of custody forms, field data sheets
- cooler(s)
- ice
- decontamination supplies/equipment
- spade or shovel
- spatula
- scoop
- trowel
- bucket auger
- thin-walled auger
- extension rods
- T-handle
- sampling trier
- sediment coring device (tubes, points, drive head, drop hammer, "eggshell" check valve devices, acetate cores)
- Ponar dredge
- Ekman dredge
- nylon rope

REAGENTS

Reagents are not used for preservation of sediment samples. Decontamination solutions are specified in SOP # 1, Sampling Equipment Decontamination.

PROCEDURES

Preparation

1. Determine the extent of the sampling effort, the sampling methods to be employed, and which equipment and supplies are required.
2. Obtain necessary sampling and monitoring equipment.
3. Decontaminate or preclean equipment, and ensure that it is in working order.
4. Prepare schedules, and coordinate with staff, client, and regulatory agencies, if appropriate.
5. Perform a general site survey prior to site entry in accordance with the site-specific health and safety plan.
6. Use stakes, flags, or buoys to identify and mark all sampling locations. Specific site characteristics, including flow regime, basin morphometry, sediment characteristics, depth of overlying aqueous layer, and extent and nature of contaminant should be considered when selecting sample location. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions.

Sample Collection

Selection of a sampling device is most often contingent upon: (1) the depth of water at the sampling location, and (2) the physical characteristics of the medium to be sampled.

Sampling Surface Sediments with a Trowel or Scoop From Beneath a Shallow Aqueous Layer

Collection of surface sediment from beneath a shallow aqueous layer can be accomplished with tools such as spades, shovels, and scoops. Surface material can be removed to the required depth; then a stainless steel or plastic scoop should be used to collect the sample.

This method can be used to collect consolidated sediments but is limited somewhat by the depth of the aqueous layer. Accurate, representative samples can be collected with this procedure depending on the care and precision demonstrated by the sample team member. A stainless steel or plastic scoop or lab spoon will suffice in most applications. Care should be exercised to avoid the use of devices plated with chrome or other materials. Plating is particularly common with garden trowels.

Follow these procedures to collect sediment samples with a scoop or trowel:

1. Using a precleaned stainless steel scoop or trowel, remove the desired thickness of sediment from the sampling area.
2. Transfer the sample into an appropriate sample or homogenization container.

Sampling Surface Sediments with a ThinWall Tube Auger From Beneath a Shallow Aqueous Layer

This system consists of an auger, a series of extension rods, and a T-handle. The auger is driven into the sediment and used to extract a core. A sample of the core is taken from the appropriate depth.

Use the following procedure to collect sediment samples with a thin-walled auger:

1. Insert the auger into the material to be sampled at a 0 to 45-degree angle from vertical. This orientation minimizes spillage of the sample from the sampler. Extraction of samples may require tilting of the sampler.
2. Rotate the auger once or twice to cut a core of material.
3. Slowly withdraw the auger, making sure that the slot is facing upward.
4. An acetate core may be inserted into the auger prior to sampling if characteristics of the sediments or body of water warrant. By using this technique, an intact core can be extracted.
5. Transfer the sample into an appropriate sample or homogenization container.

Sampling Deep Sediments with Augers and Thin-Wall Tube Samplers From Beneath a Shallow Aqueous Layer

This system uses an auger, a series of extension rods, a T- handle, and a thin-wall tube sampler. The auger bores a hole to a desired sampling depth and then is withdrawn. The auger tip is then replaced with a tube core sampler, lowered down the borehole, and driven into the sediment at the completion depth. The core is then withdrawn and the sample collected. This method can be used to collect consolidated sediments, but is somewhat limited by the depth of the aqueous layer.

Several augers are available which include bucket and posthole augers. Bucket augers are better for direct sample recovery, are fast, and provide a large volume of sample. Posthole augers have limited utility for sample collection as they are designed more for their ability to cut through fibrous, rooted, swampy areas.

Follow these procedures to collect sediment samples with a hand auger:

1. Attach the auger bit to a drill extension rod, then attach the T-handle to the drill extension rod.
2. Clear the area to be sampled of any surface debris.
3. Begin augering, periodically removing any accumulated sediment from the auger bucket.
4. After reaching the desired depth, slowly and carefully remove the auger from boring. (When sampling directly from the auger, collect sample after the auger is removed from boring and proceed to Step 10.)
5. Remove auger lip from drill rods and replace with a precleaned thin-wall tube sampler. Install proper cutting tip.
6. Carefully lower tube sampler down borehole. Gradually force the sampler into sediment. Care should be taken to avoid scraping the borehole sides. Also, avoid hammering of the drill rods to facilitate coring, since the vibrations may cause the boring walls to collapse.
7. Remove tube sampler and unscrew drill rods.
8. Remove cutting tip and remove core from device.
9. Discard top of core (approximately 1 inch), as this represents material collected by the tube sampler before penetration of the layer of concern.
10. Transfer sample into an appropriate sample or homogenization container.

Sampling Surface Sediments From Beneath a Deep Aqueous Layer with an Ekman or Ponar Dredge

This technique consists of lowering a sampling device to the sediment by use of a rope, cable, or extended handle. The mechanism is triggered, and the device entraps sediment in spring-loaded jaws, or within lever-operated jaws.

Follow these procedures for collecting sediment with an Ekman dredge:

1. Thread a sturdy nylon or stainless steel cable through the bracket, or secure the extended handle to the bracket with machine bolts.
2. Attach springs to both sides. Arrange the Ekman dredge sampler so that the jaws are in the open position and trip cables are positioned over the release studs.
3. Lower the sampler to a point just above the sediment surface.
4. Drop the sampler sharply onto the sediment.
5. Trigger the jaw release mechanism by lowering a messenger down the line, or by depressing the button on the upper end of the extended handle.
6. Raise the sampler and slowly decant any free liquid through the top of the sampler. Be careful to retain fine sediments.
7. Open the dredge and transfer the sediment into a stainless steel or plastic bucket. Continue to collect additional sediment until sufficient material has been secured. Thoroughly mix sediment to obtain a homogeneous sample, and then transfer to the appropriate sample container.
8. Samples for volatile organic analysis must be collected directly from the bucket before mixing the sample to minimize volatilization of contaminants.

Follow these procedures for collecting sediment with a Ponar dredge:

1. Attach a sturdy nylon or steel cable to the hook provided on top of the dredge.
2. Arrange the Ponar dredge sampler in the open position, setting the trip bar so the sampler remains open when lifted from the top.
3. Slowly lower the sampler to a point just above the sediment.
4. Drop the sampler sharply into the sediment, then pull sharply up on the line, thus releasing the trip bar and closing the dredge.
5. Raise the sampler to the surface and slowly decant any free liquid through the screens on top of the dredge. Be careful to retain fine sediments.
6. Open the dredge and transfer the sediment to a stainless steel or plastic bucket. Continue to collect additional sediment until sufficient material has been gained. Thoroughly mix sediment to obtain a homogeneous sample, and then transfer to the appropriate sample container.
7. Samples for volatile organic analysis must be collected directly from the bucket before mixing the sample to minimize volatilization of contaminants.

Sampling Subsurface Sediments From Beneath a Deep Aqueous Layer with a Sample Coring Device

Follow these procedures when using a sample coring device to collect subsurface sediments. It consists of a coring device, handle, and acetate core utilized in the following procedure:

1. Assemble the coring device by inserting the acetate core into the sampling tube.
2. Insert the "eggshell" check valve mechanisms into the tip of the sampling tube with the convex surface positioned inside the acetate core.
3. Screw the coring point onto the tip of the sampling tube.
4. Screw the handle onto the upper end of the sampling tube and add extension rods as needed.
5. Place the sampler in a perpendicular position on the material to be sampled.
6. This sampler may be used with either a drive hammer for firm consolidated sediments, or a T-handle for soft sediments. If the T-handle is used, place downward pressure on the device until the desired depth is reached. Rotate the sampler to shear off the core of the bottom, retrieve the device and proceed to Step 15.
7. If the drive hammer is selected, insert the tapered handle (drive head) of the drive hammer through the drive head.
8. With left hand holding the tube, drive the sampler into the material to the desired depth. Do not drive the tube further than the tip of the hammer's guide.
9. Record the length of the tube that penetrated the sample material, and the number of blows required to obtain this depth.
10. Remove the drive hammer and fit the keyhole-like opening on the flat side of the hammer onto the drive head. in this position, the hammer serves as a handle for the sampler.
11. Rotate the sampler at least two revolutions to shear off the sample at the bottom.
12. Lower the sampler handle (hammer) until it just clears the two car-like protrusions on the drive head, and rotate about 90°.
13. Withdraw the sampler by pulling the handle (hammer) upwards and dislodging the hammer from the sampler.
14. Unscrew thè coring point and remove the "eggshell" check valve.
15. Slide the acetate core out of the sampler tube. The acetate core may be capped at both ends. The sample may be used in this fashion, or the contents transferred to a stainless steel or plastic bucket and mixed thoroughly to obtain a homogeneous sample representative of the entire sampling interval.
16. Samples for volatile organic analysis must collected directly from the bucket before mixing the sample to minimize volatilization of contaminants.

CALCULATIONS

This section is not applicable to this SOP.

QUALITY ASSURANCE / QUALITY CONTROL

There are no specific quality assurance activities which apply to the implementation of these procedures. However, the following QA/QC procedures apply:

1. All data must be documented on field data sheets or within site logbooks.
2. All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation, and they must be documented.

DATA VALIDATION

This section is not applicable to this SOP.

HEALTH AND SAFETY

When working with potentially hazardous materials follow U.S. EPA, OSHA and specific health and safety procedures.

More specifically, when sampling sediment from bodies of water containing known or suspected hazardous substances, adequate precautions must be taken to ensure the sampler's safety. The team member collecting the sample should not get too close to the edge of the water, where bank failure may cause him or her to lose their balance. To prevent this, the person performing the sampling should be on a lifeline, and be wearing adequate protective equipment. If sampling from a vessel is. necessary, implement appropriate protective measures.

GROUNDWATER WELL SAMPLING

SOP # 11

SCOPE AND APPLICATION

The objective of this Standard Operating Procedure (SOP) is to provide general reference information on sampling of groundwater wells. This guideline is primarily concerned with the collection of water samples from the saturated zone of the subsurface. Every effort must made to ensure that the sample is representative of the particular zone of water being sampled. These procedures are designed to be used in conjunction with analyses for the most common types of groundwater contaminants (e.g., volatile and semi-volatile organic compounds, pesticides, metals, biological parameters).

METHOD SUMMARY

Prior to sampling a monitoring well, the well must be purged. This may be done with a number of instruments. The most common of these are the bailer, submersible pump, non-gas contact bladder pump and inertia pump. At a minimum, three well volumes should be purged, if possible. Equipment must be decontaminated prior to use and between wells. Once purging is completed and the correct laboratory-cleaned sample containers have been prepared, sampling may proceed. Sampling may be conducted with any of the above instruments, and need not be the same as the device used for purging. Care should be taken when choosing the sampling device as some will affect the integrity of the sample. Sampling equipment must also be decontaminated. Sampling should occur in a progression from the least to most contaminated well, if this information is known.

SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

The type of analysis for which a sample is being collected determines the type of bottle, preservative, holding time, and filtering requirements. Samples should be collected directly from the sampling device into appropriate laboratory-cleaned containers. Check that a Teflon liner is present in the cap, if required. Attach a sample identification label. Complete a field data sheet, a chain of custody form and record all pertinent data in the site logbook.

Samples shall be appropriately preserved, labeled, logged, and placed in a cooler to be maintained at 4°C. Samples must be shipped well before the holding time is over and ideally should be shipped within 24 hours of sample collection. It is imperative that these samples be shipped or delivered daily to the analytical laboratory in order to maximize the time available for the laboratory to perform the analysis. The bottles should be shipped with adequate packing and cooling to ensure that they arrive intact.

Certain conditions may require special handling techniques. For example, treatment of a sample for volatile organic (VOA) analysis with sodium thiosulfate preservative is required if there is residual chlorine in the water (such as public water supply) that could cause free radical chlorination and change the identity of the original contaminants. However, sodium thiosulfate should not be used if chlorine is not present in the water. Special requirements must be determined prior to conducting fieldwork.

INTERFERENCES AND POTENTIAL PROBLEMS

General

The primary goal of groundwater sampling is to obtain a representative sample of the groundwater body. Analysis can be compromised by field personnel in two primary ways: (1) taking an unrepresentative sample, or (2) by incorrect handling of the sample. There are numerous ways of introducing foreign contaminants into a sample, and these must be avoided by following strict sampling procedures and only utilizing trained field personnel.

Purging

In a non-pumping well, there will be little or no vertical mixing of the water, and stratification will occur. The well water in the screened section will mix with the groundwater due to normal flow patterns, but the well water above the screened section will remain isolated, become stagnant and lack the VOCs representative of the groundwater. Sampling personnel should realize that stagnant water may contain foreign material inadvertently or deliberately introduced from the surface, resulting in an unrepresentative sample. To safeguard against collecting nonrepresentative stagnant water, follow these guidelines during sampling:

- As a general rule, all monitoring wells should be pumped or. bailed prior to sampling. Purge water should be containerized on site or handled as specified in the site-specific project plan. Evacuation of a minimum of one volume of water in the well casing, and preferably three to five volumes, is recommended for a representative sample. In a high-yielding ground water formation and where there is no stagnant water in the well above the screened section, evacuation prior to sample withdrawal is not as critical. However, in all cases where the monitoring data is to be used for enforcement actions, evacuation is recommended.

- For wells that can be pumped or bailed to dryness with the equipment being used, the well should be evacuated and allowed to recover prior to sample withdrawal. If the recovery rate is fairly rapid and the schedule allows, evacuation of more than one volume of water is preferred. If recovery is slow, sample the well upon recovery after one evacuation.
- A nonrepresentative sample can also result from excessive pre-pumping of the monitoring well. Stratification of the leachate concentration in the groundwater formation may occur, or heavier-than-water compounds may sink to the lower portions of the aquifer. Excessive pumping can dilute or increase the contaminant concentrations from what is representative of the sampling point of interest.

Materials

Samplers and evacuation equipment (bladders., pumps, bailers, tubing, etc.) should be limited to those made with stainless steel, Teflon, and glass in areas where concentrations are expected to be at or near the detection limit. The tendency of organics to leach into and out of many materials make the selection of materials critical for trace analyses. The use of plastics, such as PVC or polyethylene, should be avoided when analyzing for organics. However, PVC may be used for evacuation equipment as it will not come in contact with the sample.

Table 2 on page 46 discusses the advantages and disadvantages of certain equipment.

EQUIPMENT / APPARATUS

General

- water level indicator
  - electric sounder
  - steel tape
  - transducer
  - reflection sounder
  - airline
- depth sounder
- appropriate keys for well cap locks
- steel brush
- HNU or OVA (whichever is most appropriate)
- logbook
- calculator
- field data sheets
- chain of custody forms
- forms and seals
- sample containers
- Engineer's rule
- sharp knife (locking-blade)
- tool box (to include at least: screwdrivers, pliers, hacksaw hammer, flashlight, adjustable wrench)
- leather work gloves
- appropriate health and safety gear
- 5-gallon pail
- plastic sheeting
- shipping containers
- packing materials
- bolt cutters
- Ziploc plastic bags
- containers for evacuation of liquids
- decontamination solutions
- tap water
- non-phosphate soap several brushes
- pails or tubs
- aluminum foil
- garden sprayer
- preservatives
- distilled or deionized water

Bailer

- clean, decontaminated bailer(s) of appropriate size and construction material
- nylon line, enough to dedicate to each well
- Teflon-coated bailer wire
- sharp knife
- aluminum foil (to wrap clean ballers)
- 5-gallon bucket

Submersible Pump

- pump(s)
- generator (110, 120, or 240 volt) or 12-volt battery if inaccessible to field vehicle
- 1-inch black PVC coil pipe — enough to dedicate to each well
- hose clamps
- safety cable
- tool box supplement
  - pipe wrenches, 2
  - wire strippers
  - electrical tape
  - heat shrink
  - hose connectors
  - Teflon tape
- winch or pulley
- gasoline for generator
- flow meter with gate valve
- 1-inch nipples and various plumbing (i.e., pipe connectors)

Non-Gas Contact Bladder Pump

- non-gas contact bladder pump compressor or nitrogen gas tank
- batteries and charger
- Teflon tubing — enough to dedicate to each well

- swagelock fitting
- toolbox supplements — same as submersible pump

Suction Pump

- pump
- black coil tubing enough to dedicate to each well
- gasoline — if required
- toolbox
- plumbing fittings
- flow meter with gate valve

Inertia Pump

- pump assembly (WaTerra pump, piston pump)
- 5-gallon bucket

REAGENTS

Reagents will be utilized for preservation of samples and for decontamination of sampling equipment. The preservation required is specified by the analysis to be performed. Decontamination solutions are specified in SOP #1, Sampling Equipment Decontamination.

PROCEDURES

Preparation

1. Determine the extent of the sampling effort, the sampling methods to be employed, and which equipment and supplies are needed.
2. Obtain necessary sampling and monitoring equipment.
3. Decontaminate or preclean equipment, and ensure that it is in working order.
4. Prepare scheduling and coordinate with staff, clients, and regulatory agency, if appropriate.
5. Perform a general site survey prior to site entry in accordance with the site-specific health and safety plan.
6. Identify and mark all sampling locations.

Field Preparation

1. Start at the least contaminated well, if known.
2. Lay plastic sheeting around the well to minimize likelihood of contamination of equipment from soil around the well.
3. Remove locking well cap, note location, time of day, and date in field notebook or an appropriate log form.
4. Remove well casing cap.
5. Screen headspace of well with an appropriate monitoring instrument to determine the presence of volatile organic compounds and record in site logbook.
6. Lower water level measuring device or equivalent (i.e. permanently installed transducers or airline) into well until water surface is encountered.
7. Measure distance from water surface to reference measuring point on well casing or protective barrier post and record in site logbook. Alternatively, if there is no reference point, note that water level measurement is from top of steel casing, top of PVC riser pipe, from ground surface, or some other position on the well head.
8. Measure total depth of well (do this at least twice to confirm measurement) and record in site logbook or on log form.
9. Calculate the volume of water in the well and the volume to be purged using the calculations in Section 2.8.
10. Select the appropriate purging and sampling equipment.

Evacuation of Static Water (Purging)

The amount of flushing a well receives prior to sample collection depends on the intent of the monitoring program as well as the hydrogeologic conditions. Programs where overall quality determination of water resources are involved may require long pumping periods to obtain a sample that is representative of a large volume of that aquifer. The pumped volume can be determined prior to sampling so that the sample is a composite of known volume of the aquifer, or the well can be pumped until the stabilization of parameters such as temperature, electrical conductance, or pH has occurred.

However, monitoring for defining a contaminant plume requires a representative sample of a small volume of the aquifer. These circumstances require that the well be pumped enough to remove the stagnant water but not enough to induce flow from other areas. Generally, three well volumes are considered effective, or calculations can be made to determine, on the basis of the aquifer parameters and well dimensions, the appropriate volume to remove prior to sampling.

During purging, water level measurements may be taken regularly at 15- to 30-second intervals. This data may be used to compute aquifer transmissivity and other hydraulic characteristics.

The following well evacuation devices are most commonly used. Other evacuation devices are available, but have been omitted in this discussion due to their limited use.

Bailer

Bailers are the simplest purging device used and have many advantages. They generally consist of a rigid length of tube, usually with a ball check-valve at the bottom. A line is used to lower the bailer into the well and retrieve a volume of water. The three most common types of bailer are PVC, Teflon, and stainless steel.

This manual method of purging is best suited to shallow or narrow diameter wells. For deep, larger diameter wells which require evacuation of large volumes of water, other mechanical devices may be more appropriate.

Bailing equipment includes a clean decontaminated bailer, Teflon or nylon line, a sharp knife, and plastic sheeting.

1. Determine the volume of water to be purged as described in Section 2.7.2, Field Preparation.
2. Lay plastic sheeting around the well to prevent contamination of the bailer line with foreign materials.
3. Attach the line to the bailer and lower until the bailer is completely submerged.
4. Pull bailer out ensuring that the line either falls onto a clean area of plastic sheeting or never touches the ground.
5. Empty the bailer into a pail until full to determine the number of bails necessary to achieve the required purge volume.
6. Thereafter, pour the water into a container and dispose of purge waters as specified in the site-specific project plan.

Submersible Pump

Submersible pumps are generally constructed of plastic, rubber, and metal parts which may affect the analysis of samples for certain trace organics and inorganics. As a consequence, submersible pumps may not be appropriate for investigations requiring analyses of samples for trace contaminants. However, they are still useful for pre-sample purging. However, the pump must have a check valve to prevent water in the pump and the pipe from rushing back into the well.

Submersible pumps generally use one of two types of power supplies, either electric or compressed gas. Electric pumps can be powered by a 12-volt DC rechargeable battery, or a 110 or 220-volt AC power supply. Those units powered by compressed gas normally use a small electric compressor which also needs 12-volt DC or 110-volt AC power. They may also utilize compressed gas from bottles. Pumps differ according to the depth and diameter of the monitoring wells.

1. Determine the volume of water to be purged as described in the section on Field Preparation.
2. Lay plastic sheeting around the well to prevent contamination of pumps, hoses or lines with foreign materials.
3. Assemble pump $_1$ hoses and safety cable, and lower the pump into the well. Make sure the pump is deep enough so that purging does not evacuate all the water. (Running the pump without water may cause damage.)
4. Attach flow meter to the outlet hose to measure the volume of water purged.
5. Attach power supply, and purge well until specified volume of water has been evacuated (or until field parameters, such as temperature, pH, conductivity, etc. have stabilized). Do not allow the pump to run dry. If the pumping rate exceeds the well recharge rate, lower the pump further into the well, and continue pumping.
6. Collect and dispose of purge waters as specified in the site-specific project plan.

Non-Contact Gas Bladder Pump

For this procedure, an all stainless-steel and Teflon Middleburg-squeeze bladder pump (e.g., IEA, TIMCO, Well Wizard, Geoguard, and others) is used to provide the least amount of material interference to the sample (Barcelona, 1985). Water comes into contact with the inside of the bladder (Teflon) and the sample tubing, also Teflon, that may be dedicated to each well. Some wells may have permanently installed bladder pumps (i.e., Well Wizard, Geoguard), that will be used to sample for all parameters.

1. Assemble Teflon tubing, pump and charged control box.
2. Use the same procedure for purging with a bladder pump as for a submersible pump.
3. Be sure to adjust flow rate to prevent violent jolting of the hose as sample is drawn in.

Suction Pump

There are many different types of suction pumps. They include: centrifugal, peristaltic and diaphragm. Diaphragm pumps can be used for well evacuation at a fast pumping rate and sampling at a low pumping rate. The peristaltic pump is a low-volume pump that uses rollers to squeeze the flexible tubing, thereby creating suction. This tubing can be dedicated to a well to prevent cross-contamination. Peristaltic pumps, however, require a power source.

1. Assemble the pump, tubing, and power source if necessary.
2. To purge with a suction pump, follow the exact procedures outlined for the submersible pump.

Inertia Pump

Inertia pumps, such as the WaTerra pump and piston pump, are manually operated. They are appropriate to use when wells are too deep to bail by hand, but are not inaccessible enough to warrant an automatic (submersible, etc.) pump. These pumps are made of plastic and may be either decontaminated or discarded, after use.

1. Determine the volume of water to be purged as described in Section 2.7.2, Field Preparation.
2. Lay plastic sheeting around the well to prevent contamination of pumps or hoses with foreign materials.
3. Assemble pump, and lower to the appropriate depth in the well.
4. Begin pumping manually, discharging water into a 5-gallon bucket (or other graduated vessel). Purge until specified volume of water has been evacuated (or until field parameters such as temperature, pH, conductivity, etc. have stabilized).
5. Collect and dispose of purge waters as specified in the site-specific project plan.

Sampling

Sample withdrawal methods require the use of pumps, compressed air, bailers, and samplers. Ideally, purging and sample withdrawal equipment should be completely inert, economical to use, easily cleaned, sterilized, reusable, able to operate at remote sites in the absence of power resources, and capable of delivering variable rates for sample collection.

There are several factors to take into consideration when choosing a sampling device. Care should be taken when reviewing the advantages or disadvantages of any one device. It may be appropriate to use a different device to sample than that which was used to purge. The most common example of this is the use of a submersible pump to purge and a bailer to sample.

Bailer

The positive-displacement volatile sampling bailer (by GPI) is perhaps the most appropriate for collection of water samples for volatile analysis. Other bailer types (messenger; bottom fill, etc.) are less desirable, but may be mandated by cost and site conditions. Generally, bailers can provide an acceptable sample, providing that sampling personnel use extra care in the collection process.

1. Surround the monitoring well with clean plastic sheeting.
2. Attach a line to the bailer. If a bailer was used for purging, the same bailer and line may be used for sampling.
3. Lower the bailer slowly and gently into the well, taking care not to shake the casing sides or to splash the bailer into the water. Stop lowering at a point adjacent to the screen.
4. Allow bailer to fill and then slowly and gently retrieve the bailer from the well, avoiding contact with the casing, so as not to knock flakes of rust or other foreign materials into the bailer.
5. Remove the cap from the sample container and place it on the plastic sheet or in a location where it will not become contaminated.
6. Begin pouring slowly from the bailer.
7. Filter and preserve samples as required by sampling plan.
8. Cap the sample container tightly and place prelabeled sample container in a carrier.
9. Replace the well cap.
10. Log all samples in the site logbook and on field data sheets and label all samples.
11. Package samples and complete necessary paperwork.
12. Transport sample to decontamination zone to prepare it for transport to analytical laboratory.

Submersible Pump

Although it is recommended that samples not be collected with a submersible pump, there are some situations where they may be used.

1. Allow the monitoring well to recharge after purging, keeping the pump just above the screened section.
2. Attach gate valve to hose (if not already fitted), and reduce flow of water to a manageable sampling rate.
3. Assemble the appropriate bottles.
4. If no gate valve is available, run the water down the side of a dean jar and fill the sample bottles from the jar.
5. Cap the sample container tightly and place prelabeled sample container in a carrier.
6. Replace the well cap.
7. Log all samples in the site logbook and on the field data sheets and label all samples.
8. Package samples and complete necessary paperwork.
9. Transport sample to decontamination zone for preparation for transport to analytical laboratory.
10. Upon completion, remove pump and assembly and fully decontaminate prior to setting into the next sample well. Dedicate the tubing to the hole.

Non-Gas Contact Bladder Pump

The use of a non-gas contact positive displacement bladder pump is often mandated by the use of dedicated pumps installed in wells. These pumps are also suitable for shallow (less than 100 feet) wells. They are somewhat difficult to clean, but may be used with dedicated sample tubing to avoid cleaning. These pumps require a power supply and a compressed gas supply (or compressor). They may be operated at variable flow and pressure rates making them ideal for both purging and sampling.

Barcelona (1984) and Nielsen (1985) report that the non-gas contact positive displacement pumps cause the least amount of alteration in sample integrity as compared to other sample retrieval methods.

1. Allow well to recharge after purging.
2. Assemble the appropriate bottles.
3. Turn pump on, increase the cycle time and reduce the pressure to the minimum that will allow the sample to come to the surface.
4. Cap the sample container tightly and place prelabeled sample container in a carrier.
5. Replace the well cap.
6. Log all samples in the site logbook and on field data sheets and label all samples.
7. Package samples and complete necessary paperwork.
8. Transport sample to decontamination zone for preparation for transport to analytical laboratory.
9. On completion, remove the tubing from the well and either replace the Teflon tubing and bladder with new dedicated tubing and bladder or rigorously decontaminate the existing materials.
10. Collect non-filtered samples directly from the outlet tubing into the sample bottle.
11. For filtered samples, connect the pump outlet tubing directly to the filter unit. The pump pressure should remain decreased so that the pressure build-up on the filter does not blow out the pump bladder or displace the filter. For the Geotech barrel filter, no actual connections are necessary so this is not a concern.

Suction Pump

In view of the limitations of suction pumps, they are not recommended for sampling purposes.

Inertia Pump

Inertia pumps may be used to collect samples. It is more common; however, to purge with these pumps and sample with a bailer.

1. Following well evacuation, allow the well to recharge.
2. Assemble the appropriate bottles.
3. Since these pumps are manually operated, the flow rate may be regulated by the sampler. The sample may be discharged from the pump outlet directly into the appropriate sample container.
4. Cap the sample container tightly and place prelabeled sample container In a carrier.
5. Replace the well cap.
6. Log all samples in the site logbook and on field data sheets and label all samples.
7. Package samples and complete necessary paperwork.
8. Transport sample to decontamination zone for preparation for transport to analytical laboratory.
9. Upon completion, remove pump and decontaminate or discard, as appropriate.

Filtering

For samples that require filtering, such as samples which will be analyzed for total metals, the filter must be decontaminated prior to use and between uses. Filters work by two methods; A barrel filter such as the "Geotech" filter works with a bicycle pump, which is used to build up positive pressure in the chamber containing the sample. The sample is then forced through the filter paper (minimum size 0.45 um) into a jar placed underneath. The barrel itself is filled manually from the bailer or directly via the hose of the sampling pump. The pressure must he maintained up to 30 psi by periodic pumping.

A vacuum-type filter involves two chambers, the upper chamber contains the sample and a filter (minimum size 0.45 pm) divides the chambers. Using a hand pump or a Gilian type pump, air is withdrawn from the lower chamber, creating a vacuum and thus causing the sample to move through the filter into the lower chamber where it is drained into a sample jar; repeated pumping may be required to drain all the sample into the lower chamber. If preservation of the sample is necessary, this should he done after filtering.

Post Operation

After all samples are collected and preserved, the sampling equipment should be decontaminated prior to sampling another well. This will prevent cross-contamination of equipment and monitoring wells between locations.

1. Decontaminate all equipment.
2. Replace sampling equipment in storage containers.
3. Prepare and transport water samples to the laboratory. Check sample documentation and make sure samples are properly packed for shipment.

Special Considerations for VOA Sampling

The proper collection of a sample for volatile organics requires minimal disturbance of the sample to limit volatilization and therefore a loss of volatiles from the sample.

Sample retrieval systems suitable for the valid collection of volatile organic samples are: positive displacement bladder pumps, gear driven submersible pumps, syringe samplers and bailers (Barcelona, 1984; Nielsen, 1985). Field conditions. and other constraints will limit the choice of appropriate systems. The focus of concern must be to provide a valid sample for analysis, one which has been subjected to the least amount of turbulence possible.

The following procedures should be followed:

1. Open the vial, set cap in a clean place, and collect the sample during the middle of the cycle. When collecting duplicates, collect both samples at the same time.
2. Fill the vial to just overflowing. Do not rinse the vial, nor excessively overfill it. There should be a convex meniscus on the top of the vial.
3. Check that the cap has not been contaminated (splashed) and carefully cap the vial. Place the cap directly over the top and screw down firmly. Do not overtighten and break the cap.
4. Invert the vial and tap gently. Observe vial for at least 10 seconds. If an air bubble appears, discard the sample and begin again. It is imperative that no entrapped air is in the sample vial.
5. Immediately place the vial in the protective foam sleeve and place into the cooler, oriented so that it is lying on its side, not straight up.
6. The holding time for VOAs is 7 days. Samples should be shipped or delivered to the laboratory daily so as not to exceed the holding time. Ensure that the samples remain at 4°C, but do not allow them to freeze.

CALCULATIONS

There are no calculations necessary to implement this procedure. However, if it is necessary to calculate the volume of the well, utilize the following equation:

Well volume = nr^2h (cf) [Equation 1]

where:

n = pi
r = radius of monitoring well (feet)
h = height of the water column (feet) [This may be determined by subtracting the depth to water from the total depth 6f the well as measured from the same reference pointi
cf = conversion factor (gal/ft^3 = 7.48 gal/ft^3 [In this equation, 7.48 gal/ft^3 is the necessary conversion factor.]

Monitoring wells are typically 2, 3, 4, or 6 inches in diameter. If you know the diameter of the monitoring well, there are a number of standard conversion factors which can be used to simplify the equation above.

The volume, in gallons per linear foot, for various standard monitoring well diameters can be calculated as follows:

v = nr^2 (cf) [Equation 2]

where:

v = volume in gallons per linear foot
n = pi
r = radius of monitoring well (feet)
d = conversion factor (7.48 gal/ft^3)

For a 2-inch diameter well, the volume in gallons per linear foot can be calculated as follows:

v = nr^2 (cf) [Equation 2]
= 314 $(1/12\ ft)^2$ 7.48 gal/ft^3
= 0.1632 gal/ft

Remember that if you have a 2-inch diameter, well you must convert this to the radius in feet to be able to use the equation.

The volume in gallons per linear foot for the common size monitoring wells are as follows:

Well Diameter	V (volume in gal/ft.)
2 inches	0.1632
3 inches	0.3672
4 inches	0.6528
6 inches	1.4688

If you utilize the conversion factors above, Equation 1 should be modified as follows:

Well volume = (h)(v) [Equation 3]

where:

h = height of water column (feet)
V = volume in gallons per linear foot as calculated from Equation 2

QUALITY ASSURANCE / QUALITY CONTROL

There are no specific quality assurance activities which apply to the implementation of these procedures. However, the following general QA procedures apply:

- All data must be documented on field data sheets or within site logbooks.
- All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation and they must be documented.

DATA VALIDATION

This section is not applicable to this SOP.

HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, OSHA and specific health and safety procedures. More specifically, depending upon the site-specific contaminants, various protective programs must be implemented prior to sampling the first well. The site health and safety plan should be reviewed with specific emphasis placed on the protection program planned for the well sampling tasks. Standard safe operating practices should be followed such as minimizing contact with potential contaminants in both the vapor phase and liquid matrix through the use of respirators and disposable clothing.

For volatile organic contaminants:

- Avoid breathing constituents venting from the well.
- Pre-survey the well head-space with an FID/PID prior to sampling.
- If monitoring results indicate organic constituents; sampling activities may be conducted in Level C protection. At a minimum, skin protection will be afforded by disposable protective clothing.

Physical hazards associated with well sampling are:

- Lifting injuries associated with pump and bailer retrieval; moving equipment.
- Use of pocket knives for cutting discharge hose.
- Heat/cold stress as a result of exposure to extreme temperatures (may be heightened by protective clothing).
- Slip, trip, fall conditions as a result of pump discharge.
- Restricted mobility due to the wearing of protective clothing.

MONITORING WELL INSTALLATION

SOP # 12

SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure (SOP) is to provide an overview of the methods used for monitoring well installation. Monitoring well installation creates a permanent access for the collection of samples to determine groundwater quality and the hydrogeologic properties of the aquifer in which the contaminants exist. Such wells should not alter the medium which is being monitored.

The most commonly used drilling methods are: (1) hollow-stem augers, (2) cable tool drills, and (3) rotary drills. Rotary drilling can be divided into a mud rotary or air rotary method.

METHOD SUMMARY

There is no ideal monitoring well installation method for all conditions; therefore, hydrogeologic conditions at the site and project objectives must be considered before deciding which drilling method to use.

Hollow-Stem Augering

Hollow-stem augering is fast and relatively less expensive than cable tool or rotary drilling methods. It is possible to drill several hundred feet of borehole per day in unconsolidated formations.

Cable Tool Drilling

Cable tool drilling method involves lifting and dropping a heavy, solid chisel-shaped bit, suspended on a steel cable. This bit pounds a hole through soil and rock. Temporary steel casing is used while drilling to keep the hole open and to isolate strata. The temporary casing is equipped with a drive shoe, which is attached to the lower end, and which aids the advancement of the casing by drilling out a slightly larger diameter borehole than the hole made by the drill bit alone.

Water is sometimes used when drilling above the saturated zone to reduce dust and to form a slurry with the loosened material. This facilitates removal of cuttings using a bailer or a sand pump. Potable water or distilled/ deionized water should be used to prevent the introduction of contamination into the borehole.

Rotary Drilling

Mud Rotary Method

In the mud rotary method, the borehole is advanced by rapid rotation of the drill bit, which cuts and brealts the material at the bottom of the hole into smaller pieces. Cuttings are removed by pumping drilling fluid (water, or water mixed with bentonite) down through the drill rods and bit, and up the annulus between the borehole and the drill rods. The drilling fluid also serves to cool the drill bit and prevent the borehole from collapsing in unconsolidated formations.

Air Rotary Method

The air rotary method is the same as the mud rotary except that compressed air is pumped down the drill rods and returns with the drill cuttings up through the annulus. Air rotary method is generally limited to consolidated and semi-consolidated formations. Casing is sometimes used to prevent cavings in semi-consolidated formations. The air must be filtered to prevent introduction of contamination into the borehole.

SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

Often, a primary object of the drilling program is to obtain representative lithologic or environmental samples. Lithologic samples are taken in order to determine the geologic or hydrogeologic regime at a site. The most common techniques for retrieving lithologic samples in unconsolidated formations are described below.

- Split spoon sampling, carried out continuously or at discrete intervals during drilling, is used to make a field description of the sample and create a log of each boring.
- Shelby tube sampling, is used when an undisturbed sample is required from claycy or silty soils, especially for geotechnical evaluation or chemical analysis.
- Cuttings description is used when a general lithologic description and approximate depths are sufficient.

The most common techniques for retrieving lithologic sampling in consolidated formations are described below.

- Rock coring is carried out continuously or at discrete intervals during drilling and enables the geologist to write a field description of the sample, create a log of each boring, and map occurrences and orientation of fractures.
- Cuttings description is used when a general lithologic description and approximate depths are sufficient.

INTERFERENCES AND POTENTIAL PROBLEMS

Table 3 on page 54 displays the advantages and disadvantages of the various drilling techniques.

EQUIPMENT / APPARATUS

The drilling contractor will provide all operational equipment for the drilling program which is outlined. The geologist should bring:

- well log sheets
- metal case (container for well logs)
- ruler
- depth sounder
- water level indicator
- all required health and safety gear
- sample collection jars
- trowels
- description aids (Munsell, grain size. charts, etc.)

REAGENTS

No chemical reagents are used inthis procedure. Decontamination of drilling equipments should follow SOP #1, Sampling Equipment Decontamination and the site-specific work plan.

PROCEDURES

Preparation

The planning, selection and implementation of any monitoring well installation program should include the following steps.

1. Review existing data on site geology and hydrogeology including publications, air photos, water quality data, and existing maps. These may be obtained from local, state, or federal agencies.
2. Visit the site to observe field geology and potential access problems for drill rig, to establish water supply, and drill equipment and materials storage area.
3. Prepare site safety plan.
4. Define project objectives; select drilling, well development, and sampling methods.
5. Select well construction materials including well construction specifications (i.e., casing and screen materials, casing and screen diameter, screen length and screen interval, filter pack and screen size).
6. Determine need for containing drill cuttings/fluids and their disposal.
7. Prepare work plan including all of the above.
8. Prepare and execute the drilling contract.
9. Implement the drilling program.
10. Prepare the final report, including background data, project objective, field procedure, well construction data including well logs and well construction.

All drilling and well installation programs must be planned and supervised by a professional geologist/ hydrogeologist.

Field Preparation

1. Prior to the mobiliztion of the drill rig, thoroughly decontaminate the rig and all associated equipment to remove all oil, grease, mud, etc.
2. Before drilling each boring, steam-clean and rinse all the "down-the-hole" drill equipment with potable water to minimize cross-contamination. Special attention should be given to the thread section of the casings, and to the drill rods. All drilling equipment should be steam-cleaned at completion of the project to ensure that no contamination is transported to or from the sampling site.
3. Record lithologic descriptions and all field measurements and comments on the well log form. Include well construction diagrams on the well log form for each well installed. At a minimum, the well construction information should show depth from surface grade, the bottom of the boring, the screened interval, casing material, casing diameter, gravel pack location, grout seal and height of riser pipe above the ground. Also record the actual compositions of the grout and seal on the well log form.

Well Construction

The most commonly used casing materials include stainless steel, polyvinyl chloride (PVC) and Teflon. Monitoring wells are constructed with casings and materials that are resistant to the subsurface environment. The selection of well construction material is based on the material's long-term interaction with the contaminated groundwater. Construction materials should not cause an analytical bias in the interpretation of the chemical analysis of the water samples.

Well casing material should also be judged from a structural standpoint. Material should be rigid and nonporous, with a low surface-area-to-water ratio in the wellbore relative to the formation materials (U.S. EPA, 1987).

1. Fill the annular space between the well screen and the boring with a uniform gravel/sand pack to serve as a filter media. For wells deeper than approximately *50* feet, or when recommended by the site geologist, emplace the sand pack using a tremie pipe (normally consisting of a 1.25-inch PVC or steel pipe). Pump sand slurry composed of sand and potable water through the tremie pipe into the annulus throughout the entire screened interval, and over the top of the screen. It is necessary to pump sufficient sand/gravel slurry to cover the screen after the sand/gravel

pack has settled and become dense.

2. Determine the depth of the top of the sand using the tremie pipe, thus verifying the thickness of the sand pack. Add more sand to bring the top of the sand pack to approximately 2-3 feet above the top of the well screen. Under no circumstances should the sand pack extend into any aquifer other than the one to be monitored. In most cases, the well design can be modified to allow for a sufficient sand pack without threat of crossflow between producing zones through the sand pack.

3. In materials that will not maintain an open hole, withdraw the temporary or outer casing gradually during placement of sand pack/grout to the extent practical.

For example, after filling 2 feet with sand pack, the outer casing should be withdrawn 2 feet. This step of placing more gravel and withdrawing the outer casing should be repeated until the level of the sand pack is approximately 3 feet above the top of the well screen. This ensures that there is no locking of the permanent (inner) casing in the outer casing.

4. Emplace a bentonite seal, composed of pellets, between the sand pack and grout to prevent infiltration of cement into the filter pack and the well screen.

These pellets should have a minimum purity of 90% montmorillonite clay, and a minimum dry bulk density of 75 lb/ft^3 for 1/2-inch pellets, as provided by American Colloid, or equivalent. Bentonite pellets shall be poured directly down the annulus.

Care must be taken to avoid introducing pellets into the well bore. A cap placed over the top of the well casing before pouring the bentonite pellets from the bucket will prevent this. To ensure even application, pour the pellets from different points around the casing. To avoid bridging of pellets, they should not be introduced at a rate faster than they can settle. A tremie pipe may be used to redistribute and level out the top of the seal.

5. If using a slurry of bentonite as an annular seal, prepare it by mixing powdered or granular bentonite with potable water. The slurry must be of sufficiently high specific gravity and viscosity to prevent its displacement by the grout to be emplaced above it. As a precaution, regardless of depth, and depending on fluid viscosity, add a few handfuls of bentonite pellets to solidity the bentonite slurry surface.

6. Place a mixture of cement and bentonite grout from the top of the bentonite seal to the ground surface.

Only Type I or II cement without accelerator additives may be used. An approved source of potable water must be used for mixing grouting materials. The following mixes are acceptable:

- Neat cement, a maximum of 6 gallons of water per 94-pound bag of cement
- Granular bentonite, 1.5 pounds of bentonite per 1 gallon of water
- Cement-bentonite, 5 pounds of pure bentonite per 94-pound bag of cement with 7-8 gallons of water; 13-14 pounds weight, if dry mixed
- Cement-bentonite, 6 to 8 pounds of pure bentonite per 94-pound bag of cement with 8-10 gallons of water, if water mixed
- Non-expandable cement, mixed at 7.5 gallons of water to 1/2 teaspoon of aluminum hydroxide, 94 pounds of neat cement (Type I) and 4 pounds of bentonite
- Non-expandable cement, mixed at 7 gallons of water to 1/2 teaspoon of aluminum hydroxide, 94 pounds of neat cement (Type I and Type II)

7. Pump grout through a tremie pipe to the bottom of the open annulus until undiluted grout flows from the annulus at the ground surface.

8. In materials that will not maintain an open hole, the temporary steel casing should be withdrawn in a manner that prevents the level of grout from dropping below the bottom of the casing.

9. Additional grout may be added to compensate for the removal of the temporary casing and the tremie pipe to ensure that the top of the grout is at or above ground surface.

10. Place the protective casing. Protective casings should be installed around all monitoring wells. Exceptions are on a case-by-case basis. The minimum elements in the protection design include:

- A protective steel cap to keep precipitation out of the protective casing, secured to the casing by padlocks.
- A 5-foot-minimum length of black iron or galvanized pipe, extending about *1.5* to 3 feet, above the ground surface, and set in cement grout. The pipe diameter should be 8 inches for 4-inch wells, and 6 inches for 2-inch wells (depending on approved borehole size). A 0.5-inch drain hole near ground level is permitted.
- The installation of guard posts in addition to the protective casing, in areas where vehicular traffic may pose a hazard. These guard posts consist of 3-inch diameter steel posts or tee-bar driven steel posts. Groups of three are radially located 4 feet around each well 2 feet below and 4 feet above ground surface, with flagging in areas of high vegetation. Each post is cemented in-

place.

- A flush mount of protective casing may also be used in areas of high traffic or where access to other areas would be limited by a well with stickup.

After the grout sets (about 48 hours), fill any depression due to settlement with a grout mix similar to that described above.

CALCULATIONS

To maintain an open borehole using sand or water rotary drilling, the drilling fluid must exert a pressure greater than the formation pore pressure. Typical pore pressure for an unconfined aquifer is 0.433 psi/ft and for a confined aquifer is 0.465 psi/ft.

The calculation for determining the hydrostatic pressure of the drilling fluid is:

Hydrostatic Pressure (psi) = Fluid Density (lb/gal) x Height of Fluid Column (ft) x 0.052

The minimum grout volume necessary to grout a well can be calculated using:

$$\text{Grout Volume (cf)} = \text{Vol of Borehole (ft}^3\text{)} — \text{Vol of Casing (ft}^3\text{)}$$
$$= L(r_B^2 — r_C^2)$$

where:

r_B = radius of boring (ft)

r_C = radius of casing (ft)

L = length of borehole to be grouted (ft)

QUALITY ASSURANCE / QUALITY CONTROL

There are no specific quality assurance activities which apply to the implementation of these procedures. However, the following general QA procedures apply:

- All data must be documented on standard well completion forms, field data sheets or within field/site loghooks.
- All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation and they must be documented.

DATA VALIDATION

This section is not applicable to this SOP.

HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, OSHA, and specific health and safety procedures.

WATER LEVEL MEASUREMENT

SOP # 13

SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure (SOP) is to set guidelines for the determination of the depth to water in an open borehole, cased borehole, monitoring well or piezometer.

Generally, water level measurements from boreholes, piezometers, or monitoring wells are used to construct water table or potentiometric surface maps. Therefore, all water level measurements at a given site should be collected within a 2~hour period. Certain situations may necessitate that all water level measurements be taken within a shorter time interval. These situations may include:

- the magnitude of the observed changes between wells appears too large.
- atmospheric pressure changes
- aquifers which are tidally influenced
- aquifers affected by river stage, impoundments, and/or unlined ditches
- aquifers stressed by intermittent pumping of production wells
- aquifers being actively recharged due to precipitation events

METHOD SUMMARY

A survey mark should be placed on the casing for use as a reference point for measurement. Many times the lip of the riser pipe is not flat. Another measuring reference should be located on the grout apron. The measuring point should be documented in the site logbook and on the groundwater level data form.

Water levels in piezometers and monitoring wells should be allowed to stabilize for a minimum of 24 hours after well construction and development, prior to measurement. In low yield situations, recovery may take longer.

Working with decontaminated equipment, proceed from the least to the most contaminated wells. Open the well and monitor headspace with the appropriate monitoring instrument to determine the presence of volatile organic compounds. Lower the water level measurement device into the well until water surface or bottom of casing is encountered. Measure distance from water surface to the reference point on the well casing and record in the site logbook and/or groundwater level data form. Remove all dowuhole equipment, decontaminate as necessary, and replace well casing cap.

SAMPLE PRESERVATION, CONTAINERS, HANDLING AND STORAGE

This section is not applicable to this SOP

INTERFERENCES AND POTENTIAL PROBLEMS

- The chalk used on steel tape may contaminate the well.
- Cascading water may obscure the water mark or cause it to be inaccurate.
- Many types of electric sounders use metal indicators at 5-foot intervals around a conducting wire. These intervals should be checked with a surveyor's tape to ensure accuracy.
- If there is oil present on the water, it can insulate the contacts of the probe on an electric sounder or give false readings due to thickness of the oil. Determining the thickness and density of the oil layer may be warranted, in order to determine the correct water level.
- Turbulence in the well and/or cascading water can make water level determination difficult with either an electric sounder or steel tape.
- An airline measures drawdown during pumping. It is only accurate to 0.5 foot unless it is calibrated for various "drawdowns".

EQUIPMENT / APPARATUS

There are a number of devices which can be used to measure water levels, such as steel tape or airlines. The device should be adequate to attain an accuracy of 0.01 feet.

The following equipment is needed to measure water levels:
air monitoring equipment

- water level measurement device
- electronic water level indicator
- metal tape measure
- airline
- steel tape
- chalk
- ruler
- notebook
- paper towels
- decontamination solution and equipment
- groundwater level data forms

REAGENTS

No chemical reagents are used in this procedure, with the exception of decontamination solutions. Where decontamination of equipment is required, refer to SOP #1, Sampling Equipment Decontamination and the site-specific work plan.

PROCEDURES

Preparation

1. Determine the extent of the sampling effort, the sampling methods to be employed, and which equipment and supplies are needed.
2. Obtain necessary sampling and monitoring equipment.
3. Decontaminate or preclean equipment, and ensure that it is in working order.
4. Prepare scheduling and coordinate with staff, clients, and regulatory agency, if appropriate.
5. Perform a general site survey prior to site entry in accordance with the site-specific health and safety plan.
6. Identity and mark all sampling locations.

Procedures

1. Make sure water level measuring equipment is in good operating condition.
2. If possible and where applicable, start at those wells that are least contaminated and proceed to those wells that are most contaminated.
3. Clean all equipment entering the well by the following decontamination procedure:
   - Triple rinse equipment with deionized water.
   - Wash equipment with an Alconox solution followed by a deionized water rinse.
   - Rinse with an approved solvent (e.g., methanol, isopropyl alcohol, acetone) as per the work plan, if organic contamination is suspected.
   - Place equipment on clean surface such as a Teflon or polyethylene sheet.
4. Remove locking well cap, note location, time of day, and date in site notebook or an appropriate groundwater level data form.
5. Remove well casing cap.
6. If required by site-specific condition, monitor headspace of well with PID or FID to determine presence of volatile organic compounds and record in site logbook.
7. Lower electric water level measuring device or equivalent (i.e., permanently installed tranducers or airline) into the well until water surface is encountered.
8. Measure the distance from the water surface to the reference measuring point on the well casing or protective barrier post and record in the field logbook. In addition, note that the water level measurement was from the top of the steel casing, top of the PVC riser pipe, from the ground surface, or from some other position on the well head.
9. The groundwater level data form should be completed as follows:
   - site name
   - logger name: person taking field notes
   - date: the date when the water levels are being measured
   - location, monitor well number and physical location
   - time: the military time at which the water level measurement was recorded
   - depth to water: the water level measurement in feet, or in tenths or hundreds of feet, depending on the equipment used
   - comments: any information the field personnel feels to be applicable
   - measuring point: marked measuring point on PVC riser pipe, protective steel casing or concrete pad surrounding well casing from which all water level measurements for individual wells should be measured. This provides consistency in future water level measurements.
10. Measure total depth of well (at least twice to confirm measurement) and record in site notebook or on log form.
11. Remove all downhole equipment, replace well casing cap and lock steel caps.
12. Rinse all downhole equipment and store for transport to next well.
13. Note any physical changes such as erosion or cracks in protective concrete pad or variation in total depth of well in field notebook and on field data sheets.
14. Decontaminate all equipment as outlined in Step 3 above.

CALCULATIONS

To determine groundwater elevation above mean sea level, use the following equation:

$$E_w = E - D$$

where:

E_w = Elevation of water above mean sea level
E = Elevation above sea level at point of measurement
D = Depth to water

QUALITY ASSURANCE / QUALITY CONTROL

The following general quality assurance procedures apply:

- All data must be documented on standard chain of custody forms, field data sheets or within personal/site logbooks.
- All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation, and they must be documented.
- Each well should be tested at least twice in order to compare results.

DATA VALIDATION

This section is not applicable to this SOP.

HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, OSHA, and speciric health and safety procedures.

WELL DEVELOPMENT

SOP # 14

SCOPE AND APPLICATION

The purpose of monitoring well development is to ensure removal of fines from the vicinity of the well screen. This allows free flow of water from the formation into the well and also reduces the turbidity of the water during sampling events. The most common well development methods are: surging, jetting, and overpumping.

Surging involves raising and lowering a surge block or surge plunger inside the well. The resulting motion surges water into the formation and loosens sediment to be pulled from the formation into the well. Occasionally, sediment must be removed from the well with a sand bailer to prevent sand locking of the surge block. This method may cause the sand pack around the screen to be displaced to a degree that damages its value as a filtering medium. For example, channels or voids may form near the screen if the filter pack sloughs away during surging (Keely and Boateng, 1987).

Jetting involves lowering a small diameter pipe into the well to a few feet above the well screen, and injecting water or air through the pipe under pressure so that sediments at the bottom are geysered out the top of the well. It is important not to jet air or water directly across the screen. This may cause fines in the well to be driven into the entrance of the screen openings thereby causing blockages.

Overpumping involves pumping at a rate rapid enough to draw the water level in the well as low as possible, and allowing it to recharge. This process is repeated until sediment-free water is produced. Overpumping is not as vigorous as surging and jetting and is probably the most desirable for monitoring well development.

METHOD SUMMARY

Development of a well should occur as soon as practical after installation, but not sooner than 48 hours after grouting is completed, if a rigorous well development is being used. If a less rigorous method, such as bailing, is used for development, it may be initiated shortly after installation. The main concern is that the method being used for development does not interfere with allowing the grout to set.

Open the monitoring well, take initial measurements (e.g. head space air monitoring readings, water level, well depth, pH, temperature, and speefic conductivity) and record results in the site logbook. Develop the well by the appropriate method (ie., overpumping, jetting, or surging) to accommodate site conditions and project requirements. Continue until the developed water is clear and free of sediment. Containerize all discharge water from known or suspected contaminated areas. Record final measurements in the logbook. Decontaminate equipment as appropriate prior to use in the next well.

SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

This section is not applicable to this Standard Operating Procedure (SOP).

INTERFERENCES AND POTENTIAL PROBLEMS

The following interferences or problems may occur during well development:

- The possibility of disturbing the filter pack increases with surging and jetting well development methods.
- The introduction of external water or air by jetting may alter the hydrochemistry of the aquifer.

EQUIPMENT / APPARATUS

The type of equipment used for well development is dependent on the diameter of the well. For example, submersible pumps cannot be used for well development unless the wells are 4 inches or greater in diameter, because the smallest submersible pump has a 3 1/4 inch O.D.

In general, the well should be developed shortly after it is drilled. Most drilling rigs have air compressors or pumps that may be used for the development process.

REAGENTS

No chemical reagents are used in this procedure except for decontamination solutions. For guidelines on equipment decontamination, refer to SOP #1, Sampling Equipment Decontamination and the site-specific work plan.

PROCEDURES

Preparation

1. Coordinate site access and obtain keys to the monitoring well security cap locks.
2. Obtain information on each well to be developed (i.e., drilling, method, well diameter, depth, screened interval, anticipated contaminants, etc.).
3. Obtain a water level meter, air monitoring equipment, materials for decontamination, pH and

electrical conductivity meters, a thermometer, and a stopwatch.

4. Assemble containers for temporary storage of water produced during well development. Containers must be structurally sound, compatible with anticipated contaminants, and easy to manage in the field. The use of truck-mounted tanks may be necessary in some cases; alternately, a portable water treatment unit (e.g. activated carbon) may be used to decontaminate the purge water.

Operation

The development should be performed as soon as practical after the well is installed, but no sooner than 48 hours after grouting is completed. Dispersing agents, acids, or disinfectants should not be used to enhance development of the well.

1. Assemble necessary equipment on a plastic sheet around the well.
2. Record pertinent information in field logbook (personnel, time, location ID, etc.).
3. Open monitoring well, and take air monitoring readings at the top of casing and in the breathing zone as appropriate.
4. Measure depth to water and the total depth of the monitoring well from the same datum point.
5. Measure the initial pH, temperature, and specific conductivity of the water and record in the logbook.
6. Develop the well until the water is clear and appears to be free of sediment. Note the initial color, clarity and odor of the water.
7. All water produced by development in contaminated or suspected contaminated areas must be containerized or treated. Clearly label each container with the location ID. Determination of the appropriate disposal method will be based on the first round of analytical results from each well.
8. No water should be added to the well to assist development without prior approval by the site geologist. If a well cannot be cleaned of mud to produce formation water because the aquifer yields insufficient water, small amounts of potable water may be injected to clean up this poorly yielding well. This may be done by dumping in buckets of water. When most of the mud is out, continue development with formation water only. It is essential that at least five times the amount of water injected must be produced back from the well in order to ensure that all injected water is removed from the formation.
9. Note the final color, clarity and odor of the water.
10. Measure the final pH, temperature and specific conductance of the water and record in the field logbook.
11. Record the following data in the field logbook:
    - well designation (location ID)
    - date(s) of well installation
    - date(s) and time of well development static water level before and after development
    - quantity of water removed and time of removal
    - type and size/capacity of pump and/or bailer used
    - description of well development techniques used

Post Operation

1. Decontaminate all equipment.
2. Store containers of purge water produced during development in a safe and secure area.
3. After the first round of analytical results have been received, determine and implement the appropriate purge water disposal method.

CALCULATIONS

There are no calculations necessary to implement this procedure.

QUALITY ASSURANCE / QUALITY CONTROL

There are no specific quality assurance activities which apply to the implementation of these procedures. However, the following general QA procedures apply:

- All data must be documented on standard chain of custody forms, field data sheets or personal/site logbooks.
- All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation and they must be documented.

DATA VALIDATION

This section is not applicable to this SOP.

HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, OSHA, and specific health and safety procedures.

CONTROLLED PUMPING TEST

SOP # 15

SCOPE AND APPLICATION

The most reliable and commonly used method of determining aquifer characteristics is by controlled aquifer pumping test. Groundwater flow varies in space and time and depends on the hydraulic properties of the rocks and the boundary conditions imposed on the groundwater system. Pumping tests provide results that are more representative of aquifer characteristics than those predicted by slug or bailer tests. Pumping tests require a greater degree of activity and expense, however, and are not always justified for all levels of investigation. For example, slug tests may be acceptable at the reconnaissance level whereas pumping tests are usually performed as part of a feasibility study in support of designs for aquifer remediation.

Aquifer characteristics which may be learned using pumping tests include hydraulic conductivity (K), transmissivity ~ specific yield (Sy) for unconfined aquifers, and storage coefficient (S) for confined aquifers. These parameters can be determined by graphical solutions and computerized programs. This Standard Operating Procedure (SOP) outlines the protocol for conducting controlled pumping tests.

METHOD SUMMARY

It is desirable to monitor pre-test water levels at the test site for about 1 week prior to performance of the pump test. This information allows for the determination of the barometric efficiency of the aquifer, as well as noting changes in head, due to recharging or pumping in the area adjacent to the well. Prior to initiating the long term pump test, a step test is conducted to estimate the greatest flow rate that may be sustained by the pump well.

After the pumping well has recovered from the step test, the long term pumping test begins. At the beginning of the test, the discharge rate is set as quickly and accurately as possible. The water levels in the pumping well and observation wells are recorded accordingly with a set schedule. Data is entered on the Pump/Recovery Test Data Sheet. The duration of the test is determinated by project needs and aquifer properties, but rarely goes beyond 3 days or until water levels become constant.

SAMPLE PRESERVATION$_3$ CONTAINERS, HANDLING, AND STORAGE

This section is not applicable to this SOP.

INTERFERENCES AND POTENTIAL PROBLEMS

Interferences and potential problems include:

- atmospheric conditions
- impact of local potable wells
- compression of the aquifer due to trains, heavy traffic, etc.

EQUIPMENT/APPARATUS

- tape measure (subdivided into tenths of feet)
- submersible pump
- water pressure transducer
- electric water level indicator
- weighted tapes
- steel tape (subdivided into tenths of feet)
- generator
- electronic data-logger (if transducer method is used)
- watch or stopwatch with second hand
- semilogarithmic graph paper (if required)
- water proof ink pen and logbook
- thermometer
- appropriate references and calculator
- a barometer or recording barograph (for tests conducted in confined aquifers)
- heat shrinks
- electrical tape
- flashlights and lanterns
- pH meter
- conductivity mcter
- discharge pipe
- flow meter

REAGENTS

No chemical reagents are used for this procedure; however, decontamination solutions. may be necessary. If decontamination of equipment is required, refer to SOP #1, Sampling Equipment Decontamination and the site-specific work plan.

PROCEDURES

Preparation

1. Determine the extent of the sampling effort, the sampling methods to be employed, and which equipment and supplies are needed.
2. Obtain necessary sampling and monitoring equipment.
3. Decontaminate or preclean equipment, and ensure that it is in working order.
4. Prepare scheduling and coordinate with staff, clients, and regulatory agency, if

appropriate.

5. Perform a general site survey prior to site entry in accordance with the site-specific health and safety plan.
6. Identify and mark all sampling locations.

Field Preparation

1. Review the site work plan and become familiar with information on the wells to be tested.
2. Check and ensure the proper operation of all field equipment. Ensure that the electronic data-logger is fully charged, if appropriate. Test the electronic data-logger using a container of water. Always bring additional transducers in case of malfunctions.
3. Assemble a sufficient number of field data forms to complete the field assignment.
4. Develop the pumping well prior to testing, per SOP #14 , Well Development.
5. Provide an orifice, weir, flow meter, container or other type of water measuring device to accurately measure and monitor the discharge from the pumping well.
6. Provide sufficient pipe to transport the discharge from the pumping well to an area beyond the expected cone of depression. Conducting a pumping test in contaminated groundwater may require treatment, special handling, or a discharge permit before the water can be discharged.
7. The discharge pipe must have a gate valve to control the pumping rate.
8. Determine if there is an outlet near the well head for water quality determination and sampling.

Pre-Test Monitorlng

It is desirable to monitor pretest water levels at the test site for, about 1 week prior to performance of the test. This can be accomplished by using a continuous-recording device such as a Stevens recorder. This information allows the determination of the barometric efficiency of the aquifer when barometric records are available. It also helps determine if the aquifer is experiencing an increase or decrease in head with time due to recharge or pumping in the nearby area, or diurnal effects of evapotranspiration. Changes in barometric pressure are recorded during the test (preferably with an on-site barograph) in order to correct water levels for any possible fluctuations which may occur due to changing atmospheric conditions. Pretest water level trends are projected for the duration of the test. These trends and/or barometric changes are used to “correct” water levels during the test so they are representative of the hydraulic response of the aquifer due to pumping of the test well.

Step Test

Conduct a step test prior to initiating a long term pumping test. The purpose of a step test is to estimate the greatest flow rate that may be sustained during a long term test. The test is performed by progressively increasing the flow rate at 1 hour intervals. The generated drawdown versus time data is plotted on semilogarithinic graph paper, and the discharge rate is determined from this graph.

Pump Test

Time Intervals

After the pumping well has fully recovered from the step test, the long term pumping test may start. At the beginning of the test, the discharge rate should be set as quickly and accurately as possible. The water levels in the pumping well and observation wells will be recorded according to Tables 4 and 5 below.

Water Level Measurements

Water levels will be measured as specilied in SOP #14, Well Level Measurement. During the early part of the test, sufficient personnel should be available to have at least one person at each observation well and at the pumping well. After the first 2 hours, two people are usually sufficient to continue the test. It is not necessary that readings at the wells be taken simultaneously. It is very important that depth to water readings be measured accurately and readings recorded at the exact time measured. Alternately, individual pressure transducers and electronic data-loggers maybe used to reduce the number of field personnel hours required to complete the pumping test.

During a pumping test, the following data must be recorded accurately on the aquifer test data form:

1. Site ID — A number (EPA ID Number) assigned to identify a specific site.
2. Location — The location of the well in which water level measurements are being taken.
3. Distance from Pumped Well — Distance between the observation well and the puinping well, in feet.
4. Logging Company — The company conducting the pumping test.
5. Test Start Date — The date when the pumping test began.
6. Test Start Time - Start time, using a 24-hour clock.
7. Static Water Level (Test Start) — Depth to water, in feet and tenths of feet, in the observation well at the beginning of the pumping test.
8. Test End Date — The date when the pumping test was completed.
9. Test End Time — End time, using a 24-hour clock.
10. Static Water Level (Test End) — Depth to water, in feet and tenths of feet, in the observation well at the end of the pumping test.

11. Average Pumping Rate — Summation of all entries recorded in the Pumping Rate (gal/min) column divided by the total number of Pumping Rate (gal/min) readings.

12. Measurement Methods — Type of instrument used to measure depth-to-water (this may include steel tape, electric sounding probes, Stevens recorders, or pressure transducers).

13. Comments — Appropriate observations or information which have not been recorded elsewhere, including notes on sampling.

14. Elapsed Time (min) -- Time of measurement recorded continuously from start of test (time 00.00).

15. Depth to Water (ft) — Depth to water, in feet and tenths of feet, in the observation well at the time of the water level measurement.

16. Pumping Rate (gal/min) — Flow rate of pump measured from an orifice, weir, flow meter, container or other type of water-measuring device.

Test Duration

The duration of the test is determined by the needs of the project and properties of the aquifer. One simple test for determining adequacy of data is when the log-time versus drawdown for the most distant observation well begins to plot as a straight line on the semilogarithmic graph paper. There are several exceptions to this simple rule of thumb; therefore, it should be considered a minimum criterion. Different hydrogeologic conditions can produce straight line trends on log-time versus drawdown plots. In general, longer tests produce more definitive results. A duration of 1 to 3 days is desirable, followed by a similar period of monitoring the recovery of the water level. Unconfined aquifers and partially penetrating wells may have shorter test durations. Knowledge of the local hydrogeology, combined with a clear understanding of the overall project objectives, is necessary in interpreting just how long the test should be conducted. There is no need to continue the test if the water level becomes constant with time. This normally indicates that a hydrogeologic source has been intercepted and that additional useful information will not be collected by continued pumping.

Post Operation

1. After completion of water level recovery measurements, decontaminate and/or dispose of equipment as per SOP #1, Sampling Equipment Decontamination.

2. When using an electronic data-logger, use the following procedures.
   - Stop logging sequence.
   - Print data, or save memory and disconnect battery at the end of the day's activities.

3. Replace testing equipment in storage containers.

4. Check sampling equipment and supplies. Repair or replace all broken or damaged equipment.

5. Review field forms for completeness.

6. Interpret pumping/recovery test field results.

CALCULATIONS

There are several accepted methods for determining aquifer properties such as transmissivity, storativity, and conductivity. However, the method to use is dependent on the characteristics of the aquifer being tested (confined, unconfined, leaky confining layer, etc.). When reviewing pump test data, texts by Fetter, or Driscoll or Freeze and Cherry may be used to determine the method most appropriate to your case. (See Fetter, *Applied Hydrology*, 2nd Ed., Chapter 6 and references therein.)

QUALITY ASSURANCE / QUALITY CONTROL

Calibrate all gauges, transducers, flow meters, and other equipment used in conducting pumping tests before use at the site.

Obtain records of the instrument calibration and file with the test data records. The calibration records will consist of laboratory measurements. If necessary, perform any on-site zero adjustment and/or calibration. Where possible, check all flow and measurement meters on-site using a container of measured volume and stopwatch; the accuracy of the meters must be verified before testing proceeds.

DATA VALIDATION

This section is not applicable to this SOP.

HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, OSHA, and specific health and safety procedures.

SLUG TEST

SOP # 16

SCOPE AND APPLICATION

This procedure can determine the horizontal hydraulic conductivity of distinct geologic horizons under in situ conditions. The hydraulic conductivity (K) is an important parameter for modeling the flow of groundwater in an aquifer.

METHOD SUMMARY

A slug test involves the instantaneous injection of a slug (a solid cylinder of known volume) or withdrawal of a volume of water. A slug displaces a known volume of water from a well and measures the artificial fluctuation of the groundwater level.

There are several advantages to using slug tests to estimate hydraulic conductivities. First, estimates can be made *in situ*, thereby avoiding errors incurred in laboratory testing of disturbed soil samples. Second, compared with pump tests, slug tests can be performed quickly and at relatively low cost, because pumping and observation wells are not required. And last, the hydraulic conductivity of small discrete portions of an aquifer can be estimated (e.g., sand layers in a clay).

SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

This section is not applicable to this Standard Operating Procedure (SOP).

INTERFERENCES AND POTENTIAL PROBLEMS

- Only the hydraulic conductivity of the area immediately surrounding the well is estimated, which may not be representative or the average hydraulic conductivity of the area.
- The storage coefficient, S, usually cannot be determined by this method.

EQUIPMENT / APPARATUS

The following equipment is needed to perform slug tests. All equipment which comes in contact with the well should be decontaminated and tested prior to commencing field activities.

- tape measure (subdivided into tenths of feet)
- water pressure transducer
- electric water level indicator
- weighted tapes
- steel tape (subdivided into tenths of feet)
- electronic data-logger (if transducer method is used)
- stainless steel slug of a known volume
- watch or stopwatch with second hand
- semilogarithmic graph paper (if required)
- waterproof ink pen and logbook
- thermometer
- appropriate references and calculator
- electrical tape
- 21X micrologger
- portable (notebook) computer or equivalent with *Grapher* installed on the hard disk

REAGENTS

No chemical reagents are used in this procedure; however, decontamination solvents may be necessary. When decontaminating the slug or equipment, refer to SOP #1, Sampling Equipment Decontamination, and the site-specific work plan.

PROCEDURES

Field Procedures

When the slug test is performed using an electronic data-logger and pressure transducer, all data will be stored internally or on computer diskettes or tape. The information will be transferred directly to the main computer and analyzed. Keep a computer printout of the data in the files as documentation.

If the slug test data is collected and recorded manually, the slug test data form will be used to record observations. The slug test data form should include the following information:

- site EPA ID number— identification number assigned to the site
- location ID — identification of location being tested
- date — the date when the test data were collected in this order: year, month, day (e.g., 900131 for January 31, 1990)
- slug volume (W) — manufacturer's specification for the known volume or displacement of the slug device
- logger — identifies the company or person responsible for performing the field measurements
- test method — the slug device either is injected or lowered into the well, or is withdrawn or pulled-out from the monitor well. Check the method that is applicable to the test situation being run.
- comments - appropriate observations or

information for which no other blanks are provided.

- elapsed time (minutes) — cumulative time readings from beginning of test to end of test, in minutes
- depth to water (feet) — depth to water recorded in tenths of feet

The following general procedures may be used to collect and report slug test data. These procedures may be modified to reflect site-specific conditions:

1. Decontaminate the transducer and cable.
2. Make initial water level measurements on monitoring wells in an upgradient-to-downgradient sequence, if possible, to minimize the potential for cross-contamination.
3. Before beginning the slug test, record information into the electronic data-logger. The type of information may vary depending on the model used. When using different models, consult the operator's manual for the proper data entry sequence to be used.
4. Test wells from least contaminated to most contaminated, if possible.
5. Determine the static water level in the well by measuring the depth to water periodically for several minutes and taking the average of the readings, (see SOP #14 , Water Level Measurement).
6. Cover sharp edges of the well casing with duct tape to protect the transducer cables.
7. Install the transducer and cable in the well to a depth below the target drawdown estimated for the test but at least 2 feet from the bottom of the well. Be sure the depth of submergence is within the design range stamped on the transducer. Temporarily tape the transducer cable to the well to keep the transducer at a constant depth.
8. Connect the transducer cable to the electronic data-logger.
9. Enter the initial water level and transducer design range into the recording device according to the manufacturer's instructions. The transducer design range will be stamped on the side of the transducer. Record the initial water level on the recording device.
10. "Instantaneously" introduce or remove a known volume or slug of water to the well. Another method is to introduce a solid cylinder of known volume to displace and raise the water level, allow the water level to restabilize and remove the cylinder. It is important to remove or add the volumes as quickly as possible because the analysis assumes an "instantaneous" change in volume is created in the well.
11. Consider the moment of volume addition or removal as time zero. Measure and record the depth to water and the time at each reading. Depths should be measured to the nearest 0.01 foot. The number of depth-time measurements necessary to complete the test is variable. It is critical to make as many measurements as possible in the early part of the test. The number and intervals between measurements will be determined from previous aquifer tests or evaluations.
12. Continue measuring and recording depth-time measurements until the water level returns to equilibrium conditions or a sufficient number of readings have been made to clearly show a trend on a semilogarithniic plot of time versus depth.
13. Retrieve slug (if applicable).

Note: The time required for a slug test to be completed is a function of the volume of the slug, the hydraulic conductivity of the formation and the type of well completion. The slug volume should be large enough that a sufficient number of water level measurements can be made before the water level returns to equilibrium conditions. The length of the test may range from less than a minute to several hours. If the well is to be used as a monitoring well, precautions against contaminating it should be taken. If water is added to the monitoring well, it should be from an uncontaminated source and transported in a clean container. Bailers or measuring devices should be decontaminated prior to the test. If tests are performed on more than one monitoring well, care must be taken to avoid cross-contamination of the wells.

Slug tests should be conducted on relatively undisturbed wells. If a test is conducted on a well that has recently been pumped for water sampling purposes, the measured water level must be within 0.1 foot of the static water level prior to sampling, At least 1 week should elapse between the drilling of a well and the performance of a slug test.

Post Operation

When using an electronic data-logger, use the following procedure:

1. Stop logging sequence.
2. Print data.
3. Send data to computer by telephone.
4. Save memory and disconnect battery at the end of the day's activities.
5. Review field forms for completeness.

CALCULATIONS

The simplest interpretation of piezometer recovery is that of Hvorslev (1951). The analysis assumes a homogenous, isotropic medium in which soil and water are incompressible. Hvorslev's expression for hydraulic conductivity (K) is:

$$K = \frac{r^2 \ln(L/R)}{2LT_0}$$

for L/R > 8 where:

K hydraulic conductivity [feet/second]
r = casing radius [feet]
L = length of open screen (or open borehole) [feet]
R = filter pack (borehole) radius [feet]
T_0 = Basic Time Lag [seconds]; value of t on semilogarithmic plot of $(H-h)/(H-H_0)$ vs. t, when $(H-h)/(H-H_0) = 0.37$

where:

H = initial water level prior to removal of slug
H_0 = water level at $t = 0$
h = recorded water level at $t > 0$

(Hvorslev, 1951; Freeze and Cherry, 1979)

The Bower and Rice method is also commonly used for K calculations. However, it is much more time consuming than the Hvorslev method. Refer to Freeze and Cherry or Fetter for a discussion of these methods.

QUALITY ASSURANCE / QUALITY CONTROL

The following general quality assurance procedures apply:

- All data must be documented on standard chain of custody forms, field data sheets, or within personal/site logbooks.
- All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation, and they must be documented.

The following specific quality assurance activity will apply:

- Each well should be tested at least twice in order to compare results.

DATA VALIDATION

This section is not applicable to this SOP.

HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, OSHA, and specific health and safety procedures.

FIELD MEASUREMENT OF pH

SOP # 17

SCOPE AND APPLICATION

Probably no water quality parameter is measured as frequently as pH. The measurement is so easily made that the attention given to it is often inadaequate. This is unfortunate, because an accurate pH determination in critical for the prediction and interpretation of the reactions and migrations of dissolved species. This procedure is designed to provide a useful pH measurement under most field situations. Conditions under which accurate measurements cannot be made are also described.

METHOD SUMMARY

There are numerous types of pH meters available. Meters used in waste sampling should have temperature and slope adjustment, and a repeatability of +/- 0.01. There is nothing to be gained by purchasing an instrument that exceeds this precision because this would also exceed the accuracy of the calibration.

pH meters for field use should be of rugged construction. A foam-lined carrying case is convenient both for travel and for use as a work table. Battery operation with easy replacement and/or recharge of batteries is required.

Combination pH electrodes are recommended for field use. Although more expensive than a simple glass and reference electrode pair, convenience of use easily outweighs the additional cost. Always carry a spare electrode and keep the spare and working electrodes immersed in pH 4 or pH 7 buffer when not in use.

SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

This section is not applicable to this Standard Operating Procedure (SOP).

INTERFERENCES AND POTENTIAL PROBLEMS

Temperature, atmospheric contamination, and ionic strength are factors that affect pH measurements; the presence of color, turbidity, or colloids will not affect pH measurements.

Temperature. The temperature compensation on a pH meter only permits adjustment of the electrode slope. It does not compensate for changes in the potential of the reference electrode, the asymmetry potential of the glass electrode, or the liquid junction potential. Nor does it compensate for changes in pH due to temperature of the sample. Thus, the temperature of the sample and the reference buffer must be recorded at the time of measurement. Ideally, their temperatures will be within 2°C.

Atmospheric contamination - Atmospheric contamination can be a significant problem for groundwater samples. Dissolved oxygen and carbon dioxide can be evolved or dissolved when the sample is exposed to air, resulting in a considerable change in pH. For best results, a groundwater sample should be pumped through a closed chamber in which pH and temperature probes are immersed. The sampling pump should be stopped prior to recording the data because a streaming potential results with flowing sample.

Ionic strength - Because of errors due to ionic strength (which are not worth correcting in the field), pH measurements should be accompanied by a measurement of the specific conductance. pH is a measure of the hydrogen ion activity. An ideal solution is assumed in which other ions do not affect the hydrogen activity. This assumption deteriorates if the ionic strength is too high. Some waste sampling investigations include sampling waste ponds or other highly contaminated water. Since buffer solutions used in the field are not made with a similar concentration of dissolved ions, the pH measurement will be inaccurate. Similarly, samples with very low ionic strength will cause difficulties because the resistance of the sample approaches that of the glass electrode. For best results, samples with very low ionic strength should be stirred for a few seconds prior to the reading. Even then, it may take several minutes for teh reading to stabilize.

High sodium and alkalinity may also produce errors in the pH measurement. For pH >9 and a sodium concentration of 10 moles/liter, a special electrode is required. (One can be purchased from any of the major electrode manufacturers.) Similarly, any pH value that is less than 1 or greater than 9 will have a greater uncertainty associated with it because the electrode response is non-Nernstian in these regions. (Langmuir, 1971)

EQUIPMENT / APPARATUS

The following apparatus are recommended for the field measurement of pH:

- pH meter with repeatability of +/- 0.01.
- Buffer solutions of pH 4.0, 7.0, and 9.0
- Combination pH electrode
- Reference electrode filling solution
- Electrode holder
- Thermometer
- Distilled water and wash bottle
- Disposable beakers

REAGENTS

Commercially-prepared buffer solutions are used for calibration. Solutions traceable to the National Bureau of Standards can be purchased inexpensively fromany major laboratory supply house. These solutions are certified withan accuracy of +/- 0.01 pH units at a specific temperature, usually 25°C. Theoretically, buffer solutions are stable indefinitely. However, they are susceptible to contamination. Old, partially full bottles are often contaminated and should be replaced.

Decontamination solvents may be necessary. When decontaminating the meter and related equipment, refer to SOP #1, Sampling Equipment Decontamination, and the site-specific work plan.

PROCEDURES

Calibration

The user must be familiar with the manufacturer's instructions for his particular instrument. The following general guidelines should be followed for calibration of any pH meter:

1. Calibrate the meter with two buffer solutions. (The slope cannot be adjusted with a one-point calibration. The slope check is the best way to determine if the electrodes are in working order.)
2. The two buffers used for calibration should bracket the anticipated pH of the unknown. For an anticipated pH of 6, calibrate with pH 4 and pH 7 buffers; for an anticipated pH of 8, calibrate with pH 7 and pH 9.
3. Ensure that the buffers are at the same temperature.
4. Adjust the instrment to read the pH 7 buffer accurately. Remember to take into account variations in pH caused by temperature. Adjust temperature compensator according to the manufacturer's instructions.
5. Read the second buffer. Adjust slope to obtain the correct reading. (If the slope deviates greatly from its correct value, check for defective electrodes or contaminated buffer solution.)

Measurement Procedure

Samples should not be filtered prior to analysis. A submersible pump or bladder pump is preferred for obtaining groundwater samples because degassing of the sample is minimized. The pH measurements must be done in the field.

These steps should be followed for the field measurement of pH:

1. Calibrate the instrument according to the maufacturer's instructions and the guidelines provided above.
2. Set temperature compensation to the temperature of the sample.
3. Rinse electrode with deionized water and with the sample. Immerse electrode in the solution, and record the value. If the sample is being pumped through a closed container, wait for temperature and pH to stabilize. Stop sample flow (to reduce the streaming potential) and record the pH.

Field measurements of pH are ordinarily recorded to +/- 0.1 pH unit. The variety of possible errors makes more accurate measurements very difficult. All field measurements of pH should be recorded with the temperatures of the buffers and sample and the specific conductance of the sample. The pH measurement cannot be safely interpreted without this information.

CALCULATIONS

QUALITY ASSURANCE / QUALITY CONTROL

The following general quality assurance procedures apply:

- All data must be documented on standard chain of custody forms, field data sheets, or within personal/site logbooks.
- All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation, and they must be documented.

The following specific quality assurance procedures must be logged for all pH measurements:

- Time when the two-buffer calibration was last performed. (The two-buffer calibration should be performed at each sample site, or once each hour.)
- Buffer temperature at time of calibration
- Sample temperature at time of measurement
- Specific conductance of sample.
- Measurement conditions, e.g., in situ, open container, or air-exclusion container

DATA VALIDATION

This section is not applicable to this SOP.

HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, OSHA, and specific health and safety procedures.

APPENDIX 3

TO

FY2023 RCRA

QUALITY ASSURANCE PROJECT PLAN

CHAIN-OF-CUSTODY

DIVISION OF ENVIRONMENTAL QUALITY
CHAIN-OF-CUSTODY

Date		Sampler (print)	
Site Identification			
Site Address			

Sample ID	Sample Remarks	Time (hhmm)	Latitude	Longitude	Lab ID

Lab Use ONLY: Custody seal on each container? YES ☐ NO ☐ Labels/COC agree?: YES ☐ NO ☐

Date/Time	**Relinquished By**	**Received By**
Date	Name/Title	Name/Title
Time	Signature	Signature
Date	Name/Title	Name/Title
Time	Signature	Signature
Date	Name/Title	Name/Title
Time	Signature	Signature
Date	Name/Title	Name/Title
Time	Signature	Signature

Legal COC Form
Revision 002

Effective Date: 10/1/2019

ARKANSAS
ENERGY & ENVIRONMENT | ENVIRONMENTAL QUALITY

Laboratory Request Form
Office of Land Resources

Facility, Project, Complaint Name, Property Owner AFIN#	Sample Characteristics					Parameters Requested			
Printed Name of Sampler									
Sample ID	Grab	Composite	No. of Containers	Preservation Code	Media Code				

Media Code	**Preservation Code**
W = Water	A = Cool to 4°C
G – Groundwater	B = Sulfuric Acid
L = Liquid (not water)	C = Nitric Acid
S = Soil or Solid	D = NaOH
B = Other	F = Other (specify)