ELECTRICAL RESISTANCE HEATING REMEDIAL ACTION WORK PLAN

CTS OF ASHEVILLE, INC. SUPERFUND SITE

235 Mills Gap Road
Asheville, Buncombe County, North Carolina
EPA ID: NCD003149556
Consent Decree – Civil Action No. 1:16-cv-380

Prepared for:

CTS Corporation
4925 Indiana Avenue
Lisle, Illinois 60532

Prepared by:

Amec Foster Wheeler Environment & Infrastructure, Inc.
1308 Patton Avenue
Asheville, North Carolina 28806

Amec Foster Wheeler Project 6252-16-2012

January 17, 2018

January 17, 2018

Mr. Craig Zeller, P.E.
Superfund Remedial and Site Evaluation Branch
U.S. Environmental Protection Agency
61 Forsyth Street, S.W.
Atlanta, Georgia 30303-8960
zeller.craig@epa.gov

Subject: **Electrical Resistance Heating Remedial Action Work Plan**
CTS of Asheville, Inc. Superfund Site
235 Mills Gap Road, Asheville, Buncombe County, North Carolina
EPA ID: NCD003149556
Consent Decree – Civil Action No. 1:16-cv-380
Amec Foster Wheeler Project 6252-16-2012

Dear Mr. Zeller:

Please find attached the Electrical Resistance Heating Remedial Action Work Plan (RAWP) for the above-referenced Site. Amec Foster Wheeler Environment & Infrastructure, Inc. prepared this RAWP on behalf of CTS Corporation to comply with the Consent Decree for Interim Remedial Design/Remedial Action at the CTS of Asheville, Inc. Superfund Site between the United States of America and CTS Corporation, Mills Gap Road Associates, and Northrop Grumman Systems Corporation (entered on March 7, 2017).

If you have questions regarding this RAWP, please contact us at (828) 252-8130.

Sincerely,

Amec Foster Wheeler Environment & Infrastructure, Inc.

Susan E. Avritt, P.E., L.G.
Senior Engineer

Matthew E. Wall
Matthew E. Wallace, P.E.
Principal Engineer

24933
1/17/18

SEA/MEW:sea

cc: George Lytwynyshyn, CTS Corporation
Andrew Warren, CTS Corporation
Jane Story, Jones Day
Beth Hartzell, NCDEQ
Kurt Batsel, Northrop Grumman
Michael Shannon, Northrop Grumman
William Clarke, Roberts & Stevens, P.A

Correspondence:
Amec Foster Wheeler Environment & Infrastructure, Inc.
1308 Patton Avenue
Asheville, North Carolina 28806
Tel 828.252.8130
License Number: NC Corporate Engineering F-0653

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ACRONYMS

BMP	best management practice
CD	Consent Decree
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
ERH	electrical resistance heating
FSAP	Field Sampling and Analysis Plan
HASP	Health and Safety Plan
LGAC	liquid-phase granular activated carbon
LNAPL	light non-aqueous phase liquid
$\mu g/m^3$	micrograms per cubic meter
MSD	Metropolitan Sewerage District (of Buncombe County)
NAPL	non-aqueous phase liquid
NCDEQ	North Carolina Department of Environmental Quality
O&M	operation and maintenance
OSHA	Occupational Safety and Health Administration
ppb(v)	parts per billion (volume)
PID	photoionization detector
PCU	power control unit
QAPP	Quality Assurance Project Plan
QA/QC	quality assurance/quality control
RAO	remedial action objective
RAWP	Remedial Action Work Plan
RD	Remedial Design
RTO	regenerative thermal oxidizer
SOW	Statement of Work
TCE	trichloroethene (also, trichloroethylene)
TMP	temperature monitoring point
USEPA	United States Environmental Protection Agency
VGAC	vapor-phase granular activated carbon
VOC	volatile organic compound
WNCRAQA	Western North Carolina Regional Air Quality Agency

DOCUMENT REVISION LOG

Revision	Date	Description
0	1/17/2018	Initial Issuance

1.0 INTRODUCTION

This document presents the Remedial Action Work Plan (RAWP) for implementation of the electrical resistance heating (ERH) interim remedial action at the CTS of Asheville, Inc. Superfund Site (Site) located at 235 Mills Gap Road in Asheville, Buncombe County, North Carolina (Figure 1). This ERH RAWP has been prepared to comply with Paragraph 4.1 of the Statement of Work (SOW) of the Consent Decree for Interim Remedial Design/Remedial Action (CD) at the Site between the United States of America and CTS Corporation, Mills Gap Road Associates, and Northrop Grumman Systems Corporation.

1.1 SITE DESCRIPTION

The approximate center of the Site is located at north latitude 35°29’36” and west longitude 82°30’25”. The Site formerly contained an approximate 95,000-square foot, single-story brick and metal structure on the southern portion of the Site. The building was demolished in December 2011 and the concrete building pad remains intact. The northeastern portion of the Site contains an asphalt-paved parking area, and asphalt-paved driveways are located parallel to the north (front) of the building pad and southeast (rear) of the building pad. A six-foot high chain-link fence surrounds the Site and a locked gate at the north end of the Site controls access to the Site from Mills Gap Road. The Site is unoccupied. The Site and surrounding area is illustrated on Figure 2. A Site map with existing features and property boundaries is included as Figure 3.

1.2 BACKGROUND

A non-aqueous phase liquid (NAPL) investigation was conducted at the Site in 2013 and 2014. An approximate one-acre area containing light NAPL (LNAPL) with comingled trichloroethene (TCE) was identified (Amec, 2014a). A Focused Feasibility Study was conducted to evaluate potential remedial alternatives for the one-acre NAPL area. ERH was chosen as the recommended alternative (Amec Foster Wheeler, 2015a). An additional approximate 0.2-acre area located adjacent and upgradient of the NAPL area where elevated TCE concentrations had been detected was added to the proposed treatment area (Amec Foster Wheeler, 2015b). This 1.2-acre area is considered the TCE source area.

The United States Environmental Protection Agency (USEPA) approved ERH as the recommended interim remedial alternative for the source area and memorialized the decision in the Interim Record of Decision in February 2016. The CD was entered by the United States District Court for the Western District of North Carolina on March 7, 2017. A Remedial Design Work Plan was submitted to USEPA on April 19, 2017, and approved by USEPA on May 1, 2017.

The ERH Final Remedial Design was submitted to USEPA on November 27, 2017. USEPA provided notice to proceed with installation of subsurface components (e.g., electrodes and monitoring wells) on December 7, 2017, and the ERH Final Remedial Design was approved by USEPA on December 18, 2017. This RAWP describes activities that will be undertaken to implement the ERH Final Remedial Design.

1.3 REMEDIAL ACTION OBJECTIVE

ERH will be implemented in the approximate 1.2-acre source area. In addition to TCE, the source area contains LNAPL from weathered fuel oil. In this area, TCE exists in three states: dissolved in groundwater, sorbed to saturated soil, and partitioned in the petroleum LNAPL. A remedial action objective (RAO) of a 95 percent reduction of TCE concentrations will be applied to soil, groundwater and LNAPL samples collected in the ERH treatment area.

A Technical Memorandum concerning the RAO (RAO Tech Memo) was submitted to USEPA on September 13, 2017. The RAO Tech Memo presented the methodology for determining successful achievement of the RAO. Using a ‘population of data approach’, the arithmetic average TCE concentration for each media in each treatment area will be determined from multiple baseline samples collected, and 5 percent of the arithmetic average TCE concentration will be calculated for each media (i.e., 95 percent TCE removal). These concentrations will become the target concentration for each media in the treatment area. Based on ERH remediation system performance indicators, at a time mutually-agreed upon with the ERH contractor, “confirmation” or post-remediation soil, groundwater, and LNAPL samples will be collected. The RAO will be met when the arithmetic average TCE concentration of each media type is at or less than 5 percent of the pre-remediation arithmetic average TCE concentration. If confirmation sampling indicates a portion(s) of the ERH treatment area has met the RAO, consideration will be given to terminating operation of the remediation system in that portion. USEPA will be notified of such potential partial system operation termination.

Additional information on the ERH performance monitoring is described in Section 4.0.

1.4 REMEDIAL ACTION CONSTRUCTION SCHEDULE

A Remedial Action Construction Schedule, that includes construction, operation, and demobilization activities, is included in Appendix A.

2.0 REMEDIAL ACTION

2.1 ERH DESCRIPTION

ERH is a process whereby soil and groundwater are heated by passing an electrical current through the subsurface between electrodes. Resistance of the flow of electrical current by the subsurface materials (primarily groundwater) induces the heating. A power control unit (PCU), which is a variable transformer system capable of providing multiple simultaneous power outputs at automatically adjustable levels, delivers energy to the electrodes.

The electrodes consist of the electrode element(s) and backfill consisting of graphite and steel shot. The backfill materials are conductive and essentially increase the surface area of the electrode. The heat created by resistance to the current creates steam and also evaporates the volatile contaminants. Vacuum blowers at ground surface connected to vapor recovery wells create a negative pressure in the treatment area. The steam generated by ERH acts as a carrier gas to transport volatile organic compounds (VOCs) to the VR wells. Steam and contaminant vapors are then transported to the ERH treatment compound. The heat generated in the subsurface is monitored by temperature monitoring points (TMPs), which contain multi-level temperature probes at each TMP.

2.2 ERH TREATMENT AREA

The ERH treatment area is approximately 1.2 acres in size and is located in the south-central portion of the property located at 235 Mills Gap Road. A portion of the ERH treatment area extends onto the adjacent property to the east. The area of ERH treatment is approximate 1.2 acres and the treatment volume is approximately 47,250 cubic yards.

2.3 ERH REMEDIAL DESIGN

A remedy employing ERH with vapor/liquid treatment was developed by TRS, the selected ERH contractor. A Final Design, Execution, and Operation & Maintenance Plan (Final Execution Plan) was prepared by TRS and included in the Final Remedial Design. The Final Execution Plan described the components of the ERH heating and vapor/water treatment systems. The Final Execution Plan also contained drawings, descriptions of operation and maintenance (O&M) activities, and safety procedures.

2.4 INFRASTRUCTURE REQUIREMENTS

The following utilities will be required for operation of the ERH system:

- Electricity
- Water
- Sewer
- Natural gas

Duke Energy maintains overhead electrical power along Mills Gap Road and along the eastern property border and fence. Electrical connections from Duke Energy's system will be made to the ERH system for powering the equipment (PCUs, treatment units, controllers, etc.). The electrical connection will include a 'drop' from Duke Energy's distribution network to new supply poles equipped with appropriate transformers, as well as connections from the supply poles to the PCUs and treatment system. The PCUs provide electricity to the electrodes.

The existing Site overhead power line is located where drilling activities will be conducted; therefore, a temporary power line will be installed by Duke Energy. Drilling will be conducted first along the path of the temporary power line, and then the temporary power line will be installed by Duke Energy (see Drawing Y-2 in the Final Execution Plan). Once the temporary power line has been installed, and the existing line removed, drilling will be conducted where the former line was located. Upon completion of the ERH remediation, the power line will be relocated to the original position by Duke Energy.

The City of Asheville maintains a water supply main along Mills Gap Road. Water is necessary for the scrubber that neutralizes the acid gas stream from the regenerative thermal oxidizer (RTO) and makeup water is necessary for the cooling tower recirculation loop that runs through the heat exchanger in the condenser. A new connection to the water supply main will be used to supply water to the treatment system. The City of Asheville will provide the water main connection and meter for the property. Water will also be needed for the installation of electrodes, temperature monitoring points, and monitoring wells. It is anticipated that a temporary connection to the water supply hydrant will be used for drilling activities until the connection to the water supply main is completed.

The Metropolitan Sewerage District (MSD) of Buncombe County maintains a sewer line adjacent to Mills Gap Road. The former Site facility was connected to the sewer line during operation, but it is unclear if the connection remains or is in adequate condition to transfer treated water from the vapor/liquid treatment system to the MSD system. An evaluation of the sewer connection will be performed during the MSD industrial pretreatment permitting phase prior to initiating transfer of wastewater from the system. If repairs/modifications to the existing piping, or a new connection, is necessary, the connection will be constructed and tested prior to wastewater transfer. MSD industrial pretreatment permit requirements will be met during operation of the ERH system, including monitoring, sampling, and reporting.

PSNC Energy maintains a natural gas line along Mills Gap Road. Natural gas will be used to operate the RTO. PSNC Energy will provide the natural gas connection and meter to the property.

2.5 PERMIT REQUIREMENTS

Under Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Section 121(e)(1), federal, state, or local permits are not required for the portion of any removal or remedial action conducted entirely on site as defined in 40 CFR 300.5 (see also 40 CFR 300.400(e)(1) and (2)). In addition, CERCLA actions must only comply with the “substantive requirements,” not the administrative requirements of regulations. Administrative requirements include permit applications, reporting, record keeping, and consultation with administrative bodies.

The following agency regulations requiring a permit/adherence have been identified for implementation of ERH at the Site:

- Western North Carolina Regional Air Quality Agency (WNCRAQA) limits on total VOC discharge and constituent concentrations in ambient air at the property boundary
- North Carolina Department of Environmental Quality (NCDEQ) well construction and abandonment standards
- NCDEQ Underground Injection Control Program rules for subsurface injection, if applicable (described in Section 3.5)

- State and federal hazardous and non-hazardous waste characterization, storage, and disposal requirements
- NCDEQ erosion and sedimentation control requirements

Permits for the following are anticipated to be obtained:

- MSD of Buncombe County industrial wastewater pretreatment discharge
- Buncombe County electrical construction

Actions to comply with the substantive requirements of the aforementioned regulations are described in Sections 3.0 and 5.0.

2.6 ERH SYSTEM INSTALLATION

Prior to subsurface system component installation activities, the following Site preparation activities will be/were conducted:

- Clearing of vegetation around the Site entrance to provide improved ingress/egress visibility from/to Mills Gap Road.
- Installation of signage along Mills Gap Road notifying traffic of the Site entrance.
- Installation of new/additional fencing and gate at the entrance to the Site with a holding area to reduce traffic congestion at the entrance. A Site trailer was installed along the new fencing in such a way that Site visitors can only enter the restricted-access area through the Site trailer.
- Installation of a gravel drive to the northwestern area of the former building pad to allow for heavy equipment and supply unloading on the former building pad.
- Clearing/grubbing in the treatment area to remove vegetation and other surface obstructions.
- Clearing and tree removal in the southern and southeastern portion of the treatment area, as necessary for drill rig access and piping installation.

Prior to installation of subsurface components on the adjacent property to the east, a portion of the fence where the treatment area extends off-Site to the east will be removed and a temporary fence will be installed approximately 10 feet to the east, on the adjacent Off-Site property. The temporary fence will have screens to prevent persons from being able to contact the area on the interior of the fence, where electrode components will be located.

Existing monitoring wells/piezometers that are constructed of polyvinyl chloride were abandoned prior to beginning installation of the ERH system components. The wells were abandoned using a neat cement grout placed via tremie pipe. The following wells were abandoned:

- Monitoring well MW-3A
- Piezometers PZ-1, PZ-2 and PZ-3
- Soil vapor extraction wells VE-1 through VE-15
- Soil vapor extraction pilot test observation wells OW-1, OW-3 and OW-4 (OW-2 could not be located)

Subsurface component installation activities will be conducted using four auger drill rigs operating at the same time. Vertical borings will be advanced at most locations. Angled borings will be advanced where there are surface obstructions or steep topography (the slopes will not be regraded for staging the drill rigs). Also, angled borings will be advanced at the eastern property boundary/fence to access the subsurface treatment area on the adjacent off-Site property to the east. Electrode installation activities are described in Section 5.1 of the Field Sampling and Analysis Plan (FSAP; Appendix B).

The electrodes with vapor recovery points will be installed using nominal 8.25-inch diameter hollow-stem augers (creating a 12-inch diameter borehole). The TMPs and two individual vapor recovery points will be installed using nominal 3.25-inch hollow-stem augers (creating a nominal 8-inch diameter borehole). Cross section details depicting the electrode and TMP designs are included in Appendix B of the Final Execution Plan.

The subsurface equipment (e.g., augers, cables, drill rods) used in drilling activities will not be decontaminated between electrode/TMP borings, as the area where the borings are advanced will subsequently be treated by ERH. Drilling equipment will be decontaminated between borings for installation of monitoring wells, as described in Section 6.0 of the FSAP.

TRS will be responsible for procuring, mobilizing, setting up, and testing system components prior to use. These activities are described in the Final Execution Plan.

Based on evaluation of hydrogeologic conditions in the treatment area, an electrode wetting, or drip, system is not currently proposed. However, piping will be installed in the electrode borings so that if a drip system is determined to be necessary based on operational parameters, the system can be installed and readily connected to the electrodes. Also, if a drip system is required, NCDEQ will be notified and the appropriate injection permit/notification form will be submitted.

2.7 ERH SYSTEM OPERATION AND MAINTENANCE

TRS will be responsible for O&M of the ERH system with oversight by Amec Foster Wheeler. O&M information is included in the Final Execution Plan.

2.8 ERH SYSTEM DECOMMISSIONING AND DEMOBILIZATION

TRS will be responsible for decommissioning the ERH system and demobilization from the Site, with oversight by Amec Foster Wheeler. The decommissioning will include disconnection of electrical/utilities and piping from the electrodes and equipment, relocation of the power line by Duke Energy, abandonment of vapor recovery points, and relocation/reinstallation of permanent fencing. TRS will demobilize their equipment and other appurtenances from the Site.

3.0 WASTE MANAGEMENT

Multiple waste streams will be generated during implementation of ERH. This section describes how waste will be characterized, stored, and disposed.

3.1 WASTE STREAMS

The following waste streams are expected to be generated:

- General/Non-regulated solid waste
- Soil from drill cuttings
- Water from monitoring well development and groundwater purging
- Water from decontamination activities
- Treated condensate and waste from the RTO acid gas scrubber
- LNAPL
- Vapor as air effluent
- Liquid-phase granular activated carbon (LGAC)
- Vapor-phase granular activated carbon (VGAC), if used/generated.

Wastes will be managed in accordance with Section 4.4 of the SOW and applicable regulations, as described below.

3.2 SOLID WASTE

General/Non-regulated solid waste will include used disposable items, such as personal protective equipment, disposable sampling equipment, and general refuse. The items will be placed in plastic bags and deposited in a bulk solid water collection container for transport and disposal at the permitted Buncombe County municipal solid waste landfill.

3.3 SOIL

Soil will be generated during the installation of monitoring wells, electrodes, and TMPs. Based on the analytical results of soil samples collected from the vadose zone in the ERH treatment area (Amec, 2014b), unsaturated soil can be managed as non-hazardous waste. Similarly, it is anticipated that saturated soil will be managed as hazardous waste due to TCE concentrations in soil. During drilling operations, soil cuttings will be transported to roll-off containers staged at the Site. The roll-off containers will be lined with plastic sheeting and will have covers that can be placed over the soil when not being filled. The containers will be visually inspected daily to identify potential leaks. If leaks are identified, temporary containment facilities will be constructed.

Unsaturated and saturated soil samples will be collected during installation of the subsurface components for characterization of the contaminant concentrations. The samples will be analyzed for total VOCs according to USEPA Method 8260, semi-volatile organic compounds according to USEPA Method 8270, and metals (arsenic, barium, cadmium, chromium, lead, selenium, silver and mercury; for unsaturated soil samples only) according to the Toxicity Characteristic Leaching Procedure Method 1311, as required by the disposal contractor and/or disposal facility.

Based on the analytical results of the soil samples, the soil will be manifested as either a non-hazardous waste and disposed of at a Subtitle D landfill, or as a hazardous waste and disposed of at a Subtitle C landfill or other appropriate disposal facility.

In accordance with Section 4.4 of the SOW, for out-of-state shipments, the USEPA Project Coordinator and the receiving facility state’s environmental official will be notified prior to shipment of the waste.

3.4 NON-TREATED WATER

Non-treated water includes groundwater generated during monitoring well installation/ development, groundwater generated during purging/sampling monitoring wells, and water generated during decontamination activities. Non-treated water will be accumulated in labeled 55-gallon drums and staged in a designated area at the Site for disposal as an anticipated hazardous waste.

3.5 WASTEWATER

Condensate water will be treated by LGAC and discharged under an industrial pretreatment permit to MSD. Wastewater from the RTO acid scrubber will also be discharged to MSD. Periodic sampling/monitoring will be conducted as required by the MSD permit.

3.6 LNAPL

LNAPL recovered by the ERH system will be accumulated in an on-Site aboveground storage tank with sufficient containment in the event of a spill. The LNAPL will be sampled and analyzed for characteristic properties. It is anticipated that the LNAPL will be disposed as a hazardous waste.

3.7 LIQUID-PHASE GRANULAR ACTIVATED CARBON

Two LGAC vessels in series will be used to treat the condensate water. The LGAC will be sampled and analyzed for characteristic properties and disposed of as either a non-hazardous or hazardous waste depending on the analytical results.

3.8 VAPOR-PHASE GRANULAR ACTIVATED CARBON

As contaminant concentrations begin to decrease in recovered vapors near the expected end of the treatment period, the use of the RTO might be terminated and VGAC implemented to treat the recovered vapors. Two VGAC vessels (sized according to contaminant concentrations) would be operated in series. If utilized, the VGAC would be sampled and analyzed for characteristic properties and disposed of as either a non-hazardous or hazardous waste depending on the analytical results.

4.0 PERFORMANCE MONITORING

Performance monitoring will be conducted to determine when the RAOs have been achieved and to monitor compliance with regulatory requirements during system operation.

4.1 GROUNDWATER

Groundwater will be monitored in the ERH treatment area to determine if/when the groundwater RAO has been met. Existing monitoring wells MW-2 and MW-3, which are located in the ERH treatment area, will be used for groundwater monitoring during the ERH remedial actions. Ten additional monitoring well pairs (10 shallow and 10 deep overburden at each location) will be installed and used for additional groundwater monitoring. The locations of the new monitoring wells will be based on the final ERH electrode spacing/locations. The new and existing monitoring wells will be fitted with a sealed wellhead that allows for groundwater samples to be collected via dedicated tubing and a pump. Monitoring well installation procedures are described in the FSAP contained in Appendix B.

The following table contains screened intervals of the proposed and existing monitoring wells. The monitoring wells are depicted in Figure 4.

Shallow Monitoring Well	Screened Interval (feet below ground surface)	Deep Monitoring Well	Screened Interval (feet below ground surface)
MW-2[1]	18 – 28	N/A	N/A
MW-3[1]	26 – 36	N/A	N/A
MW-23	30 – 35	MW-23A	45 – 50
MW-24[2]	25 – 30	MW-24A[3]	50 – 55
MW-25	30 – 35	MW-25A	45 – 50
MW-26	25 – 30	MW-26A	40 – 45
MW-27[2]	20 – 25	MW-27A[3]	40 – 45
MW-28	25 – 30	MW-28A	40 – 45
MW-29[2]	20 – 25	MW-29A	30 – 35
MW-30	20 – 25	MW-30A[3]	35 – 40
MW-31	30 – 35	MW-31A[3]	45 – 50
MW-32[2]	20 – 25	MW-32A	40 – 45

Notes:
1 – existing monitoring well
2 – anticipated well screened at water table
3 – anticipated well screened near bottom of treatment zone

The proposed monitoring well screened intervals are intended to be distributed throughout the treatment volume without bias toward areas that are potentially more or less contaminated than other areas. Some of the monitoring wells are intended to be screened across the water table (top of treatment zone), some wells screened in the middle of the treatment zone, and some wells screened near the bottom of the treatment zone. The actual depths/screened intervals of the water table monitoring wells will be determined in the field based on the depth of the water table during drilling. The actual depths/screened intervals of the monitoring wells to be installed near the bottom of the treatment zone will be dependent upon the shallowest depth of the nearest three electrodes which are installed to drilling refusal (i.e., the treatment zone generally will not extend below the shallowest electrode).

Baseline groundwater samples will be collected prior to initiating heating of the subsurface. Groundwater samples will be collected using low-flow purging/sampling. Water quality parameters (pH, temperature, conductivity, dissolved oxygen and oxidation reduction potential) will be monitored during purging. The groundwater samples will be submitted for analysis of TCE according to USEPA Method 8260. Groundwater sampling procedures are described in the FSAP, and quality assurance/quality control (QA/QC) procedures and documentation are described in the Quality Assurance Project Plan (QAPP) which is contained in Appendix C.

Confirmation groundwater samples will be collected from the 22 monitoring wells. The determination of when the confirmation groundwater samples should be collected will be based on ERH system operational parameters (e.g., declining or asymptotic contaminant concentrations in influent vapor and/or achieving a target subsurface temperature). Because the groundwater will be hot from heating, hot groundwater sampling procedures will be implemented to prevent the volatilization of TCE from the groundwater prior to sample collection. Hot groundwater sampling procedures are contained in the FSAP.

4.2 SATURATED SOIL

Saturated soil will be monitored in the ERH treatment area to determine if/when the soil RAO has been met. Baseline soil samples will be collected from 15 boring locations in the ERH treatment area (Figure 4), and samples will be collected at approximate 10-foot intervals from below the top of the treatment zone to the bottom of the treatment zone. The treatment zone at a particular boring will be from the water table to the depth of the shallowest electrode or drilling refusal, whichever occurs first. Once the apparent water table is encountered, a soil sample will be collected at a depth of five feet below the water table, and at 10-foot intervals thereafter. A soil sample will not be collected in the bottom interval if the interval is five feet in length or less. The soil samples will be collected prior to initiating heating of the subsurface using direct-push technology sampling equipment. Based on the anticipated treatment zone thickness, a total of approximately 45 saturated soil samples are anticipated to be collected.

Confirmation soil samples will be collected at approximately the same locations/depths of the baseline soil samples. The determination of when the confirmation soil samples should be collected will be based on operational parameters (e.g., declining or asymptotic contaminant concentrations in influent vapor and/or achieving a target subsurface temperature). Because the soil will be hot from heating, hot soil sampling procedures will be implemented to prevent the volatilization of TCE from the soil prior to sample collection. Hot soil sampling procedures are contained in the FSAP.

The soil samples will be submitted for analysis of TCE according to USEPA Method 8260. Soil sampling procedures are described in the FSAP, and QA/QC procedures and documentation are described in the QAPP.

4.3 LNAPL

LNAPL will be monitored in the ERH treatment area to determine if/when the LNAPL RAO has been met. Up to five baseline LNAPL samples will be collected from monitoring wells where sufficient LNAPL has accumulated for collection of an LNAPL sample. The LNAPL samples will be collected prior to initiating heating of the subsurface in accordance with procedures contained in the FSAP.

Up to five confirmation LNAPL samples will be collected from the monitoring wells where LNAPL was collected prior to heating. If sufficient LNAPL is not present in a monitoring well for collection of a post-remediation sample, the TCE concentration will be considered to be zero at that location for averaging purposes. The determination of when the confirmation samples should be collected will be based on operational parameters (e.g., declining or asymptotic contaminant concentrations in influent vapor and/or achieving a target subsurface temperature). Because the LNAPL will be hot from heating, hot sampling procedures will be implemented to prevent the volatilization of TCE from the LNAPL prior to sample collection. Baseline and confirmation LNAPL samples will be collected using procedures contained in the FSAP.

The LNAPL samples will be submitted for analysis of TCE according to USEPA Method 8260. QA/QC procedures and documentation are contained in the QAPP.

4.4 PERIMETER AMBIENT AIR

During drilling operations at the Site, ambient air will be monitored using a photoionization detector (PID) around the perimeter of the drilling operations (i.e., between the drilling equipment and the property boundary) and around the roll-off containers containing soil waste. A PID capable of measuring total VOCs in the parts per billion (ppb) concentration range will be used to monitor the ambient air

Continuous ambient air monitoring will be conducted at the Site during ERH operations (i.e., heating/treatment operations). Ambient air monitoring will be conducted at four locations adjacent to the Site fence. The locations will generally be north, east, south, and west of the treatment system discharge stack, as shown on Figure 5. The air monitors will be PIDs capable of measuring total VOCs in the ppb concentration range. The WNCRAQA regulations do not have a short-term/acute limit for total VOCs in ambient air. However, the limit for TCE in ambient air at a fenceline is 59 micrograms per cubic meter (µg/m^3) on an annual averaged basis. The ambient air monitor will be set to alarm if the concentration exceeds a 24-hour time weighted average of 11 parts per billion VOCs (59 µg/m^3 TCE equals 11 ppbv TCE). If the alarm concentration is exceeded during ERH operations, an evaluation of the ERH system will be conducted to determine how to reduce the VOC concentrations in the effluent air that are affecting the ambient air concentrations.

Baseline ambient air samples will be collected/analyzed prior to initiation of heating. The baseline ambient air samples will be collected at the locations of the continuous ambient air monitors, and will provide baseline/background VOC concentrations. Ambient air samples will also be collected during ERH operations to provide a comparison to the measurements recorded by the ambient air monitors. Ambient air samples will be collected after two weeks of initial ERH operation/heating, weekly during the period of greatest VOC mass removal (anticipated to be approximately 5 weeks), and monthly thereafter. Ambient air samples will be collected in accordance with the procedures and QA/QC documentation included in the Supplement to Vapor Intrusion Assessment Work Plan (Revision 4) dated, June 11, 2014, but will be submitted for the full VOC list according to Method TO-15.

4.5 VAPOR DISCHARGE

The WNCRAQA regulations have discharge limits for various compounds, including TCE (4,000 pounds per year) when a permit is required. System effluent samples will be collected during system operation to estimate the total TCE effluent. Effluent air samples will be collected bi-weekly during initial operation, weekly during the period of greatest VOC mass removal, and every two weeks or monthly thereafter. Effluent samples will be collected using Tedlar bags and analyzed for VOCs according to TO-15. Sampling procedures are contained in the FSAP, and QA/QC procedures and documentation are contained in the QAPP.

5.0 PROTECTING HUMAN HEALTH AND THE ENVIRONMENT

The ERH remedial activities will be implemented in a manner that is protective of human health and the environment. Protection of human health includes Site workers, persons on neighboring properties, and the community at large. A Health and Safety Plan (HASP) has been developed for workers conducting Site activities. The HASP conforms to applicable Occupational Safety and Health Administration (OSHA) regulations. The Site HASP has been updated to include health and safety information related to the ERH remedial action activities and is submitted under separate cover. A HASP specific for ERH operations has been prepared by TRS, and is also submitted under separate cover.

Environmental protection is the prevention and control of environmental pollution and the reduction of habitat disruption that may occur to soil, groundwater, biological systems, surface water and air. To the extent possible, Site personnel will manage or reduce the impact to visual aesthetics, noise, and generation of waste streams (solid, liquid, and gas). Environmental resources within and adjacent to the project boundaries that may potentially be affected by the remedial activities will be identified and protected to the extent possible.

5.1 TRAINING

Site personnel that will be involved with below-grade construction, treatment system operation or sampling will be trained in 40-hour Hazardous Waste Operations and Emergency Response in accordance with OSHA 29 Code of Federal Regulations, with current annual refresher training.

Site personnel will also be trained in environmental protection and pollution control. An awareness briefing discussing environmental protection and pollution control as they relate to the construction and operation of the ERH system will be conducted prior to initiating work at the Site. Additional meetings will be conducted for new personnel and when Site conditions change.

5.2 SITE ACCESS

The project will require various personnel to enter the Site and project area. Only those persons who are properly trained or otherwise require access will be allowed to enter. A six-foot high chain-link fence surrounds the Site and a locked gate at the north end of the Site controls access to the Site from Mills Gap Road. A temporary fence with a gate will be installed to create a ‘holding area’ before entering the area where ERH installation and operation activities will be conducted. The temporary gate to the Site will remain locked at all times to restrict entry to the Site by non-authorized persons when authorized personnel are on Site. When authorized personnel are not on Site, the main Site gate will be locked.

Security systems will be installed to interrupt the electrical flow to the electrodes in the case of a trespasser in the area of the electrical field. The security systems will be remotely monitored and continuously record for documentation purposes in the case of a trespasser.

Construction work will not be conducted on the surface of the off-Site property where the ERH treatment area extends. Angled borings will be extended from the Site to the target locations/depths. During drilling and construction of the electrodes below the ground surface of the off-Site property, caution tape will be used to mark the ERH treatment area as a “safety zone.” A temporary fence and gate will be installed approximately 10 feet east of the Site fence on the off-Site property to prevent non-Site personnel from contacting the electrode wellheads that will be located near the Site fence. Periodic voltage surveys will be conducted in the off-Site safety zone during ERH system operation.

5.3 WORK HOURS

Installation of the ERH system (e.g., drilling and system installation) will be conducted during daylight hours (generally 7:00 a.m. to 7:00 p.m.). The treatment system will operate automatically 24-hours per day, seven days per week, except during confirmation sampling or system down-time. Personnel will be on-Site during operation of the system generally during daylight hours. The system will be monitored remotely by TRS personnel and emergency contact phone numbers will be distributed to the project team at the beginning of the project. During operation, it is not anticipated to have personnel on Site over the weekends or holidays, but personnel will be available if a response at the Site is required.

5.4 LAND RESOURCES

Activities will primarily be limited to the fenced Site property boundaries. Significant grading is not anticipated. A steep slope is located in the southern portion of the ERH treatment area. If an electrode or TMP is to be located in a location on/adjacent to the slope which would limit drill rig access, an angled boring will be advanced to allow construction of the electrode or TMP at the specified location.

Clearing of trees and shrubs in the southeastern portion of the ERH treatment area is anticipated to provide clearances for drill rigs and piping construction.

5.5 EROSION AND SEDIMENTATION CONTROL

An erosion and sedimentation control plan will be prepared prior to conducting intrusive activities that will require the removal or grading of soil, which may have the potential to create or promote soil erosion at/off the Site. Best management practices (BMPs) will be implemented to reduce or eliminate erosion and promote sediment control. BMPs may include vegetation cover, soil stabilization, or silt fencing. Structural systems will be installed, if necessary, to divert water flows from exposed soils, temporarily store flows, or otherwise limit runoff and the potential discharges of pollutants from exposed areas of the Site.

Site runoff with visible and significant amounts of sediment will be diverted from entering surface waters. The majority of Site runoff is expected to originate from the concrete pad and asphalt driveway/parking area located in the ERH treatment area. Other Site runoff is expected from the asphalt parking area in the northern portion of the Site. Runoff will be dispersed to the extent possible to reduce erosion.

5.6 WATER RESOURCES

Best work practices will be implemented to prevent additional contamination from impacting groundwater. There is no surface water at the Site; however, groundwater discharge areas are located east and west of the Site and develop into tributaries. Application of pesticides, insecticides or other hazardous chemicals to the soil or vegetation is not anticipated.

5.6.1 Spill Response and Control

Aside from caustic soda (1,000-gallon storage tank) that will be used in the RTO scrubber, Amec Foster Wheeler and the primary contractors do not anticipate using chemicals that would require an immediate response if a spill or release occurred. Spill response measures for the caustic soda are described in the TRS Health and Safety Plan. A Spill Prevention, Control, and Countermeasures Plan is not applicable as oil products will not be stored or handled on Site above a quantity of 1,320 U.S. gallons (40 CFR Part 112). Surface waters are not located proximal to the areas of proposed Interim RA activities, such that releases of oil or other chemical products would be expected to impact the closest surface waters.

When spills or releases of hazardous materials or material that is suspected to be hazardous occurs, the following procedures will be implemented immediately:

- Work will be suspended in the area.
- The spill or leak source will be identified and controlled with the appropriate protective gear.
- Containment actions such as earthen beams, use of sorbent booms and/or pads, or excavating a shallow ditch to capture the release.
- Additional measures will be taken to minimize further movement and effect of the spill or leak on the surrounding area.

Actions or procedures addressing spills and leaks will be conducted in accordance with the Site Emergency Management Plan.

5.6.2 Liquid Treatment System

Containers and vessels that are part of the liquid treatment system will be equipped with secondary containment to contain liquids in the event of a release. The secondary containment equipment will be visually monitored periodically by TRS.

5.7 AIR RESOURCES

Remediation activities will be performed in a manner that minimizes the quantity of dust and gaseous vapors that may be released. Dust emissions and particulate will be controlled to the extent possible by implementing dust control measures, spraying water to minimize dust, and limiting the movement of vehicles and other dust suppression techniques, as necessary. Loads on trucks that could emit dust or falling debris will be covered. Containerized drill cuttings will be covered at the end of each day during drilling activities.

5.7.1 Particulates

Driving areas at the Site will be maintained so they are free from particulates which would cause applicable standards to be exceeded or which would cause a hazard or a nuisance. Minimizing vehicle speeds, wetting dry soils, covering loads, and similar measures will control particulates along Site driving areas. Particulate control will be performed as the work proceeds and whenever a particulate nuisance or hazard is identified. The majority of the surface in the area of the Site which will receive vehicle use is either paved with asphalt or concrete which will minimize particulate generation.

5.7.2 Odor and Vapors

Subsurface vapors will be controlled by vacuum blowers at all times during system operation. Vapors will be captured and removed through the extraction wells and treated. Air monitoring equipment will be used at the exhaust of the air/vapor treatment system and at the perimeter of the Site. Appropriate actions will be taken if excess vapor or odor concentrations are identified at the system or the Site perimeter. Vapors or odors are not expected to travel off-Site during construction or operation of the ERH system. If vapors or odors are identified off-Site, action similar to the spill notification will apply.

5.7.3 Noise

The ERH system is inherently a quiet technology. The electrical infrastructure generates a slight hum, like that found at standard electrical substations. To mitigate the noise generated by the vapor recovery blowers, each blower will be enclosed within a sound reducing enclosure. Further, each blower will have an effluent silencer to keep sound out of the piping. The enclosures are rated at 85 decibels at seven feet at full vacuum. The blowers are typically run at a reduced load, which produces significantly less noise than full power.

The drilling operations will produce noise typical of a construction site. Such drilling has occurred previously at the Site. Drilling will be performed during daylight hours when ambient noise is typically present in the Site area.

5.7.4 Water Vapor

An RTO emits water vapor via a discharge stack. The water vapor is warmer than the ambient air, so on colder days, the water vapor might appear as steam or ‘smoke’. An RTO is more efficient at cooling the water vapor than a standard thermal oxidizer, so the amount of visual vapor will be less. However, white water vapor might appear occasionally. The RTO will be equipped with an acid scrubber to neutralize the acid gas stream.

6.0 REFERENCES

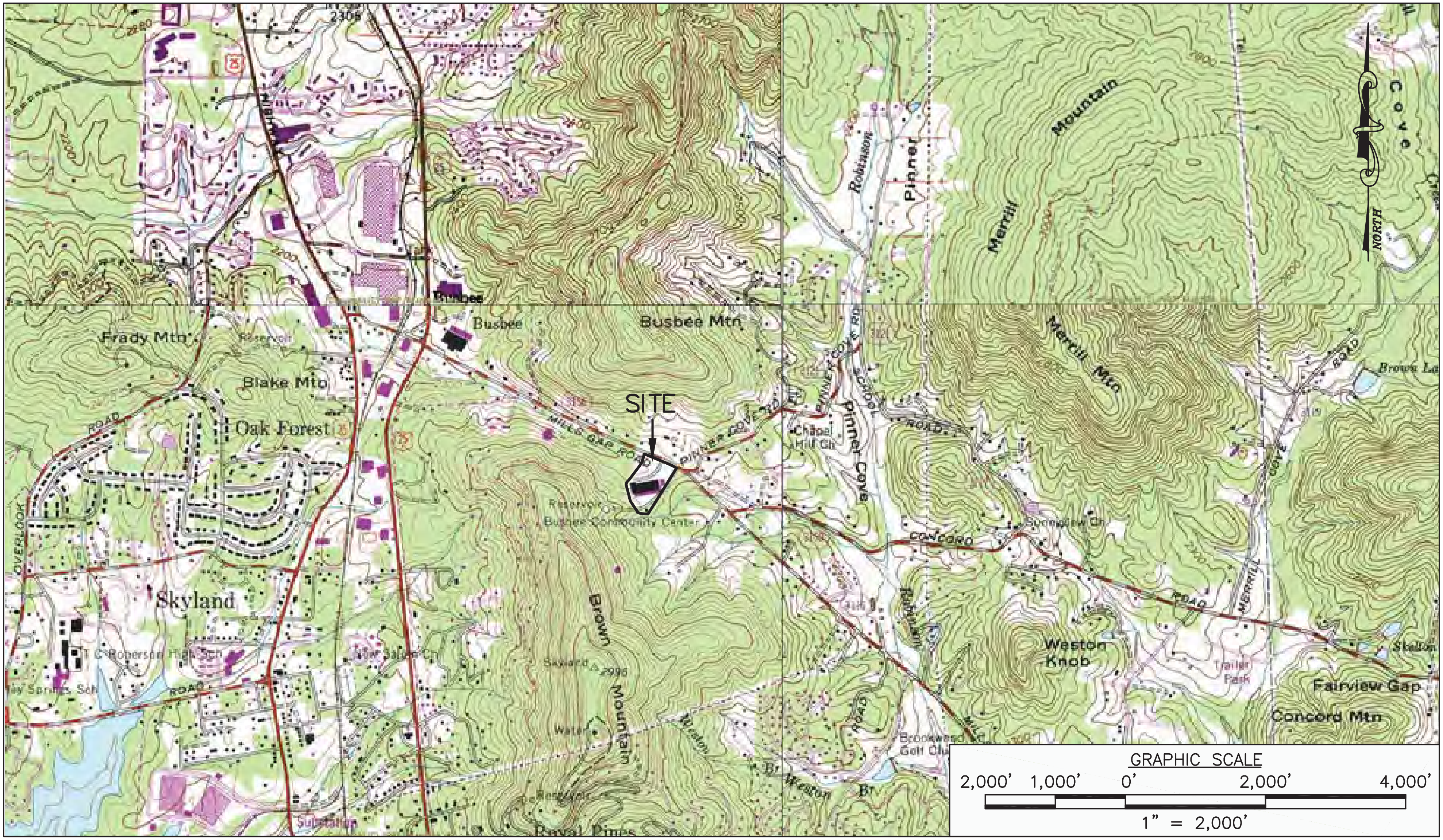
Amec Environment & Infrastructure, Inc., 2014a. NAPL Investigation Report, CTS of Asheville, Inc. Superfund Site (May 5, 2014).

Amec Environment & Infrastructure, Inc., 2014b. Report of Soil Vapor Extraction Confirmation Sampling and Analysis, CTS of Asheville, Inc. Superfund Site (May 5, 2014)

Amec Foster Wheeler, 2015a. Final NAPL Area Focused Feasibility Study Report, CTS of Asheville, Inc. Superfund Site, September 10, 2015.

Amec Foster Wheeler, 2015b. NAPL Area Focused Feasibility Study Report Addendum, CTS of Asheville, Inc. Superfund Site, November 25, 2015.

FIGURES



TOPOGRAPHIC SITE MAP
CTS OF ASHEVILLE, INC. SUPERFUND SITE
ASHEVILLE, NORTH CAROLINA

amec foster wheeler

DRAWN: SEK	ENG CHECK: --	DATE: APRIL 2017	PROJECT: 6252162012
DFT CHECK: MEW	APPROVAL: MEW	SCALE: 1" = 2,000'	FIGURE: 1

REFERENCE: USGS QUADRANGLES: ASHEVILLE (1961), OTEEN (1962), FRUITLAND (1978) AND SKYLAND (1978)

Prepared/Date: BRP 11/08/16
Checked/Date: SEK 11/08/16

Legend

- ⊙ Spring
- ✕—✕ Fence
- ▬ · ▬ Property Line

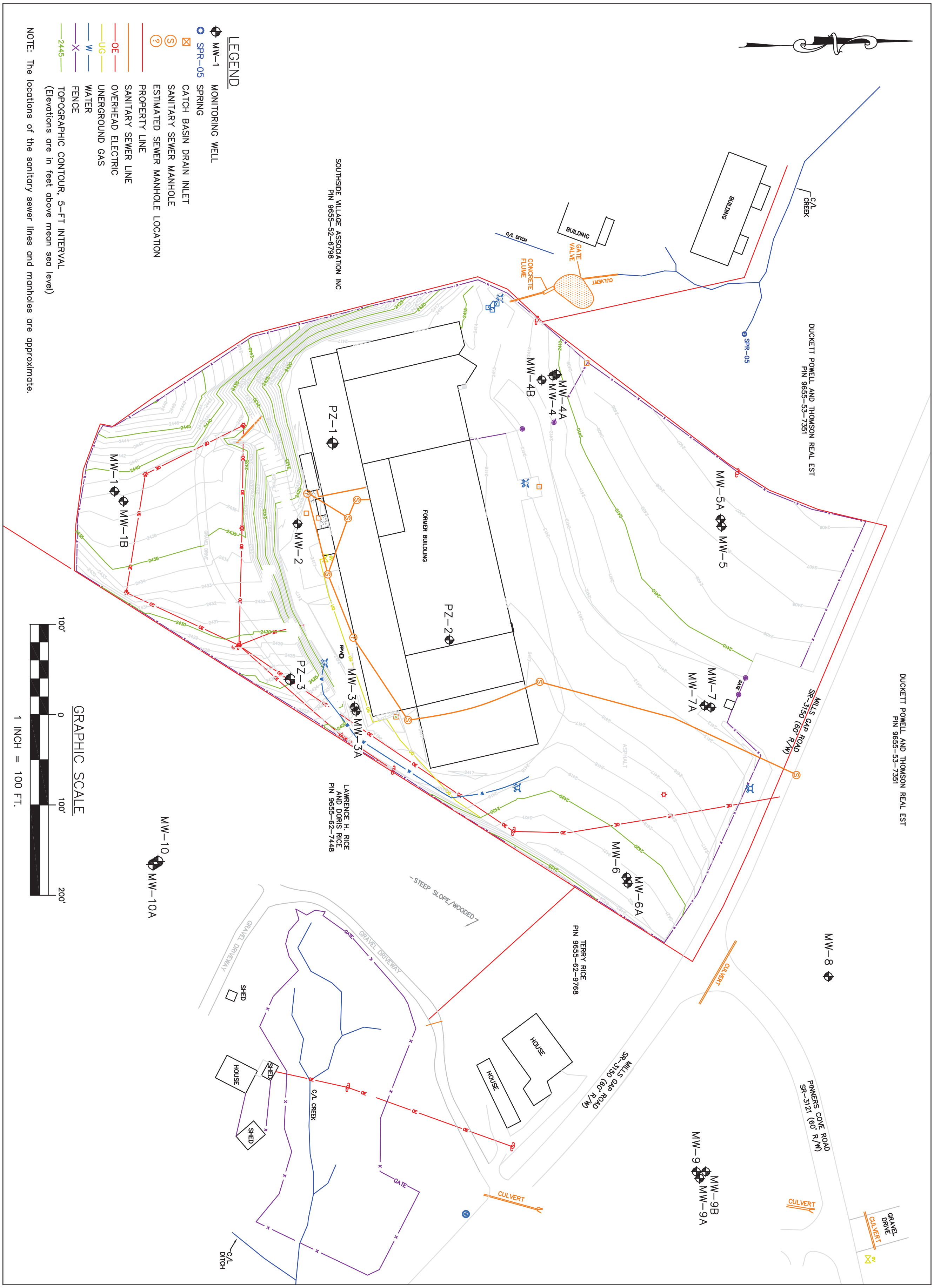
CTS of Asheville, Inc. Superfund Site
Asheville, North Carolina

Site Map

Project 6252162012

Figure 2

Document: P:\Projects\CTS Corporation\4.0 Project Deliverables\4.5 Databases\GIS\MapDocuments\Sep 2016\Sep2016_11x17LS.mxd PDF: P:\Projects\CTS Corporation\4.0 Project Deliverables\4.5 Databases\GIS\Figures\Sep 2016\Figure 2 - Site Map.pdf 11/08/2016 7:54 AM brian.peters



SITE MAP WITH FEATURES
CTS OF ASHEVILLE, INC. SUPERFUND SITE
ASHEVILLE, NORTH CAROLINA

amec foster wheeler

DRAWN: SEA	ENG CHECK: --	DATE: SEPTEMBER 2017	JOB: 6252-16-2012
DFT CHECK: MEW	APPROVAL: MEW	SCALE: 1"=100'	FIG: 3

REFERENCE: SURVEY PREPARED BY FREELAND & ASSOCIATES.

Legend

- ⊕ Proposed Monitoring Well Cluster
- ● Proposed Soil Boring
- ⊕ Existing Monitoring Well
- ERH Treatment Area
- Fence
- Property Line

Prepared/Date: BRP 11/21/17
Checked/Date: SEA 11/21/17

CTS of Asheville, Inc. Superfund Site
Asheville, North Carolina

Proposed Monitoring Well and Soil Boring Locations

Project 6252162012

Figure 4

Document: P:\Projects\CTS Corporation\4.0 Project Deliverables\4.5 Databases\GIS\MapDocuments\Remediation\ERH_Treatment_11x17LS.mxd PDF: P:\Projects\CTS Corporation\4.0 Project Deliverables\4.5 Databases\GIS\Figures\Remediation Nov 2017\Figure 4 - Proposed MW and SB Locations.pdf 11/21/2017 9:49 AM brian.peters

Prepared/Date: BRP 11/21/17
Checked/Date: SEA 11/21/17

N

0 60 120 Feet

Legend

⬢ Proposed Ambient Air Monitoring Location

⊙ Spring

×—× Fence

- - Property Line

amec foster wheeler

CTS of Asheville, Inc. Superfund Site
Asheville, North Carolina

Proposed Ambient Air Monitoring Locations

Project 6252162012

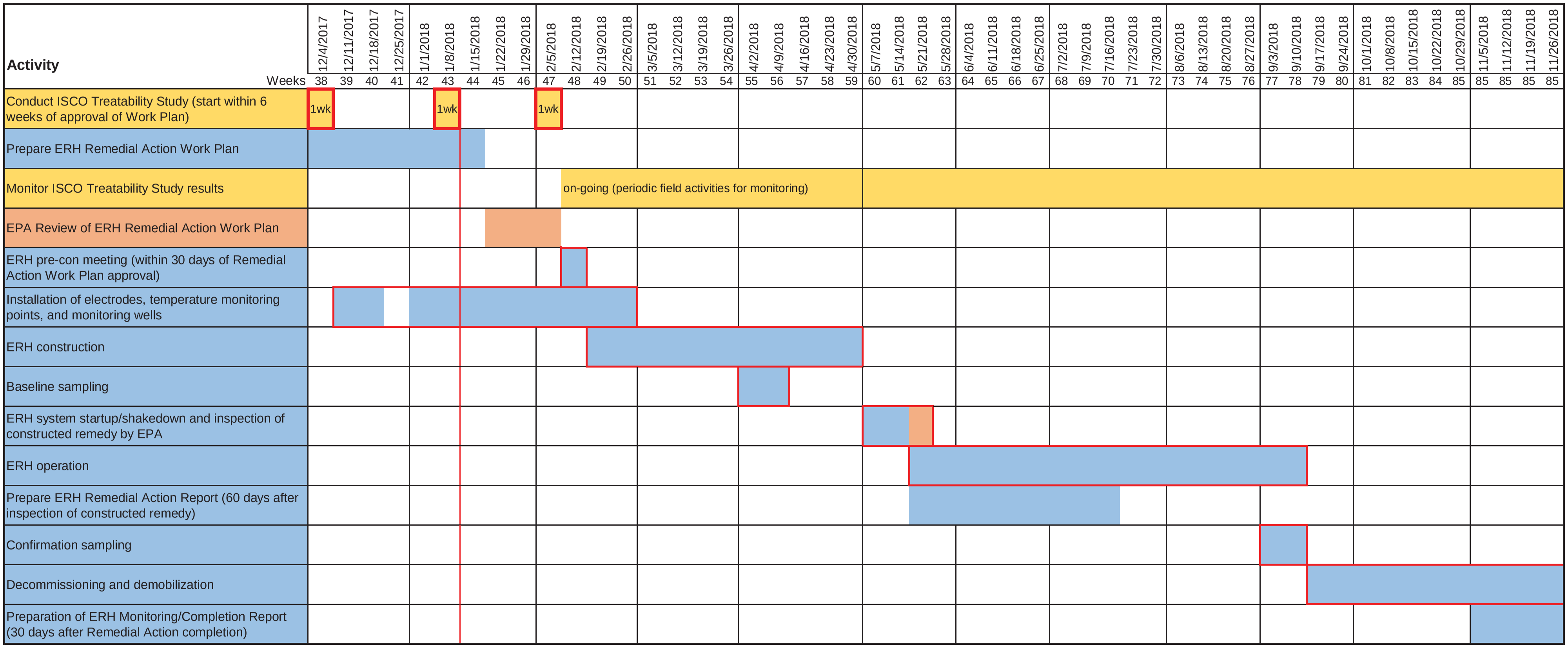
Figure 5

Document: P:\Projects\CTS Corporation\4.0 Project Deliverables\4.5 Databases\GIS\MapDocuments\Remediation\ERH_Treatment_11x17LS.mxd PDF: P:\Projects\CTS Corporation\4.0 Project Deliverables\4.5 Databases\GIS\Figures\Remediation Nov 2017\Figure 5 - Proposed AA Locations.pdf 11/21/2017 8:38 AM brian.peters

APPENDIX A

INTERIM REMEDIAL DESIGN/REMEDIAL ACTION SCHEDULE

CTS OF ASHEVILLE, INC. SUPERFUND SITE
SCHEDULE FOR INTERIM REMEDIAL DESIGN/REMEDIAL ACTION (Including ERH Remedial Action Construction)



Activity	12/4/2017	12/11/2017	12/18/2017	12/25/2017	1/1/2018	1/8/2018	1/15/2018	1/22/2018	1/29/2018	2/5/2018	2/12/2018	2/19/2018	2/26/2018	3/5/2018	3/12/2018	3/19/2018	3/26/2018	4/2/2018	4/9/2018	4/16/2018	4/23/2018	4/30/2018	5/7/2018	5/14/2018	5/21/2018	5/28/2018	6/4/2018	6/11/2018	6/18/2018	6/25/2018	7/2/2018	7/9/2018	7/16/2018	7/23/2018	7/30/2018	8/6/2018	8/13/2018	8/20/2018	8/27/2018	9/3/2018	9/10/2018	9/17/2018	9/24/2018	10/1/2018	10/8/2018	10/15/2018	10/22/2018	10/29/2018	11/5/2018	11/12/2018	11/19/2018	11/26/2018
Weeks	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	85	85	85	85
Conduct ISCO Treatability Study (start within 6 weeks of approval of Work Plan)	🟨 1wk					🟨 1wk				🟨 1wk																																										
Prepare ERH Remedial Action Work Plan	🟦	🟦	🟦	🟦	🟦	🟦	🟦																																													
Monitor ISCO Treatability Study results											🟨 on-going (periodic field activities for monitoring)	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨
EPA Review of ERH Remedial Action Work Plan								🟧	🟧	🟧																																										
ERH pre-con meeting (within 30 days of Remedial Action Work Plan approval)											🟦																																									
Installation of electrodes, temperature monitoring points, and monitoring wells		🟦	🟦		🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦																																							
ERH construction												🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦																														
Baseline sampling																		🟦	🟦																																	
ERH system startup/shakedown and inspection of constructed remedy by EPA																							🟦	🟦	🟧																											
ERH operation																									🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦											
Prepare ERH Remedial Action Report (60 days after inspection of constructed remedy)																									🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦																			
Confirmation sampling																																								🟦	🟦											
Decommissioning and demobilization																																										🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦
Preparation of ERH Monitoring/Completion Report (30 days after Remedial Action completion)																																																	🟦	🟦	🟦	🟦

Notes:
The schedule is based on indicated period for EPA approval or conditional approval of submittals without significant revisions, and is dependant on weather conditions and equipment availability, as applicable.
The project deliverable submittal dates shown above meet the stipulated schedules listed in the Consent Decree.
Date indicates the beginning of the week (period of work).

- 🟦 ERH - Electrical Resistance Heating
- 🟨 ISCO - In Situ Chemical Oxidation
- 🟧 EPA document review and finalization period
- 🟥 Field activities/site visits are in red outline

APPENDIX B

FIELD SAMPLING AND ANALYSIS PLAN

ELECTRICAL RESISTANCE HEATING REMEDIAL ACTION WORK PLAN: FIELD SAMPLING AND ANALYSIS PLAN

CTS OF ASHEVILLE, INC. SUPERFUND SITE

235 Mills Gap Road
Asheville, Buncombe County, North Carolina
EPA ID: NCD003149556
Consent Decree – Civil Action No. 1:16-cv-380

Prepared for:

CTS Corporation
4925 Indiana Avenue
Lisle, Illinois 60532

Prepared by:

Amec Foster Wheeler Environment & Infrastructure, Inc.
1308 Patton Avenue
Asheville, North Carolina 28806

Amec Foster Wheeler Project 6252-16-2012

January 17, 2018

TABLE OF CONTENTS

Page

APPENDICES

A	SESD Operating Procedures
B	TRS's Hot Soil Sampling Standard Operating Procedure
C	TRS's Hot Groundwater Sampling Standard Operating Procedure

ACRONYMS

CD	Consent Decree
DOT	Department of Transportation
DPT	direct-push technology
DO	dissolved oxygen
ERH	electrical resistivity heating
FDR	field data record
FOL	Field Operations Leader
FSAP	Field Sampling and Analysis Plan
GPS	Global Positioning System
IDW	investigation derived waste
ISCO	in-situ chemical oxidation
LNAPL	light non-aqueous phase liquid
ORP	oxidation-reduction potential
PID	photoionization detector
ppb	parts per billion
PPE	personal protective equipment
ppm	parts per million
QAPP	Quality Assurance Project Plan
RAO	remedial action objective
RAWP	Remedial Action Work Plan
RTD	resistance temperature detector
SESD	USEPA Science and Ecosystem Support Division
SOP	standard operating procedure
TCE	trichloroethene
TMP	temperature monitoring report
USEPA	United States Environmental Protection Agency
VOC	volatile organic compound

DOCUMENT REVISION LOG

Revision	Date	Description
0	1/17/2018	Initial Issuance

1.0 INTRODUCTION

On behalf of CTS Corporation, Amec Foster Wheeler Environment & Infrastructure, Inc. (Amec Foster Wheeler) has prepared this Electrical Resistance Heating (ERH) Remedial Action Work Plan (RAWP) Field Sampling and Analysis Plan (FSAP) for the CTS of Asheville, Inc. Superfund Site (Site) located in Asheville, Buncombe County, North Carolina. This FSAP has been prepared to comply with Paragraph 6.7(c) of the Statement of Work of the Consent Decree for Interim Remedial Design/Remedial Action (CD) at the Site between the United States of America and CTS Corporation, Mills Gap Road Associates, and Northrop Grumman Systems Corporation. The CD was entered by the United States District Court for the Western District of North Carolina on March 7, 2017.

The interim remedial activities will be conducted in two phases: ERH in the approximate 1.2-acre source area, and in-situ chemical oxidation (ISCO) in an approximate 1.9-acre downgradient dissolved-phase plume designated the Northern Area of the Site. This FSAP focuses on sample collection activities that will be conducted during implementation of the ERH Interim Remedial Action activities. Another FSAP will be prepared for the ISCO Interim Remedial Action activities after preparation and approval of the ISCO Remedial Design.

The overall remedial objective is a 95 percent reduction of trichloroethene (TCE) in the saturated soil above bedrock in the source area. In addition to TCE, the source area contains light non-aqueous phase liquid (LNAPL) from weathered fuel oil. In this area, TCE exists in three states: dissolved in groundwater, sorbed to saturated soil, and partitioned in the petroleum LNAPL. A remedial action objective (RAO) of a 95 percent reduction of TCE concentrations will be applied to saturated soil, groundwater and LNAPL samples collected in the ERH treatment area.

2.0 SAMPLING OBJECTIVES

The sampling objectives for the ERH Interim Remedial Action generally include system performance monitoring, remediation performance monitoring, and health and environmental protection-related monitoring, as follows:

- System performance monitoring includes collection of screening measurements and samples for chemical analysis to monitor the performance of the vapor and liquid treatment systems.
- Remediation performance monitoring includes collection of samples for chemical analysis to determine whether the remedial goal has been achieved.
- Health and environmental protection-related monitoring includes collection of air samples to monitor ambient conditions at the property boundary.

3.0 SAMPLE LOCATION AND FREQUENCY

System performance monitoring samples will be collected from ports on the treatment system equipment. The frequency and sample collection methods are described in Section 5.0.

Remediation performance monitoring will include collection of the following subsurface samples: saturated soil, groundwater, and LNAPL. Baseline samples will be collected prior to initiating ERH remediation and confirmation samples will be collected when system performance monitoring parameters generally indicate that the remedial goal has been achieved. The sample collection methods are described in Section 5.0.

Health and environmental protection-related monitoring samples will be collected at four locations along the property boundary. The frequency and sample collection methods are described in Section 5.0.

4.0 SAMPLE DESIGNATION, HANDLING, AND ANALYSIS

Procedures for sample designation, handling and analysis are included in the RAWP Quality Assurance Project Plan (QAPP).

5.0 INSTALLATION AND SAMPLING PROCEDURES

The following installation procedures and data collection/sampling methods are proposed for the ERH Remedial Action activities:

- Electrode installation
- Temperature monitoring point (TMP) installation
- Monitoring well installation
- Depth to groundwater measurement
- LNAPL thickness measurement
- Collection and chemical analysis of soil samples, including borehole abandonment
- Collection and chemical analysis of groundwater samples, including measurement of water quality parameters
- Collection and chemical analysis of LNAPL samples
- Collection and chemical analysis of ambient air samples
- Screening of volatile organic compounds (VOCs) in air and soil using a photoionization detector (PID)
- Collection and chemical analysis of influent and effluent air samples from the vapor extraction treatment system
- Collection and chemical analysis of influent and effluent water samples from the process water treatment system
- Surveying boring and monitoring well locations

5.1 ELECTRODE INSTALLATION

Electrode borings will be advanced using nominal 8.25-inch inner diameter hollow-stem augers to create approximate 12-inch diameter borings. The borings will be advanced until auger refusal is encountered. The ERH treatment zone is the interval from the approximate water table to auger refusal. This information will be transmitted to the ERH contractor, TRS Group (TRS), which will determine the construction details. One or two electrode elements attached to power supply cables will be installed in the borings, depending on the thickness of the treatment zone at a particular boring.

If two elements are located in a particular boring, the conductive backfill material will be placed in the borehole annulus around the bottom element via tremie pipe. Conductive backfill will placed in the borehole annulus around the upper element, or a single element, via backfilling through the augers. If two elements are installed in a boring, approximately three feet of No. 2 (i.e., coarse-grained) sand will be placed in the borehole annulus between the conductive backfill associated with each element. The augers will be incrementally lifted from the borehole as the conductive backfill and sand are placed.

A ‘drip tube’ consisting of slotted copper tubing attached to crosslinked high-density polyethylene (PEX) piping will be placed immediately above the top of the conductive backfill (Note: the drip tube will be used to inject water if determined to be needed during ERH treatment). A one-inch diameter, three-foot long stainless steel vapor recovery screen attached to vapor recovery piping will be installed with the bottom of the screen approximately four feet above the conductive backfill. No. 2 sand will be backfilled in the borehole annulus around drip tube and vapor recovery screen to approximately two feet above the top of the vapor recovery screen. Approximately one foot of extra-fine sand (i.e., 0.01 to 0.03-inch diameter) will be placed above the No. 2 sand. The borehole will be backfilled above the extra-fine sand to ground surface using neat Portland cement.

Upon completion of the ERH activities the drip tubes and vapor recovery screens will be abandoned in place using a Portland cement grout.

5.2 TEMPERATURE MONITORING POINT INSTALLATION

TMP borings will be installed using nominal 3.25-inch inner diameter hollow-stem augers to create approximate seven-inch borings. The borings will be advanced until auger refusal is encountered. A 1.5-inch diameter copper or steel pipe will be placed in the borings. The borehole annulus around the piping will be backfilled with neat Portland cement placed via tremie pipe.

Upon completion of the electrodes surrounding a particular TMP, TRS will determine where to place resistance temperature detectors (RTDs) inside of the piping to monitor the temperature in the treatment zone. The RTDs will be attached to electrical cabling and positioned at approximate five-foot intervals within the piping.

Upon completion of the ERH activities the RTDs will be removed and the copper/steel piping will be abandoned in place using a Portland cement grout.

5.3 MONITORING WELL INSTALLATION PROCEDURE

Groundwater will be monitored in the ERH treatment area to determine if/when the groundwater RAO has been met. Existing monitoring wells MW-2 and MW-3, which are located in the ERH treatment area, will be used for groundwater monitoring during the ERH remedial actions. Ten additional monitoring well pairs (one shallow and one deep at each location) will be installed and used for additional groundwater monitoring (Figure 4 in RAWP).

The following table presents screened intervals of the proposed and existing monitoring wells.

Shallow Monitoring Well	Screened Interval (feet bgs)	Deep Monitoring Well	Screened Interval (feet bgs)
MW-2[1]	18 – 28	N/A	N/A
MW-3[1]	26 – 36	N/A	N/A
MW-23	30 – 35	MW-23A	45 – 50
MW-24[2]	25 – 30	MW-24A[3]	50 – 55
MW-25	30 – 35	MW-25A	45 – 50
MW-26	25 – 30	MW-26A	40 – 45
MW-27[2]	20 – 25	MW-27A[3]	40 – 45
MW-28	25 – 30	MW-28A	40 – 45
MW-29[2]	20 – 25	MW-29A	30 – 35
MW-30	20 – 25	MW-30A[3]	35 – 40
MW-31	30 – 35	MW-31A[3]	45 – 50
MW-32[2]	20 – 25	MW-32A	40 – 45
Notes: 1 – existing monitoring well 2 – anticipated well screened at water table 3 – anticipated well screened near bottom of treatment zone			

The depths and screened intervals of the water table monitoring wells will be determined in the field based on the depth of the water table during drilling. The actual depths/screened intervals of the monitoring wells to be installed near the bottom of the treatment zone will be dependent upon the shallowest depth of the nearest three electrodes which are installed to auger drilling refusal (i.e., the treatment zone generally will not extend below the shallowest electrode).

An approximate eight-inch diameter borehole will be advanced using nominal 4.25-inch inner diameter hollow stem augers. The borings will be advanced to the target depth and a Type II monitoring well will be installed. A two-inch diameter stainless steel riser pipe and two-inch diameter, five-foot long, stainless steel 0.010-inch slotted screen will be installed in each of the borings. The annulus of each well will be filled with No. 1 filter sand to two feet above the top of the screen. Two feet of extra-fine sand will be placed above the filter sand and the annuls will be backfilled to ground surface using a neat Portland cement in accordance with North Carolina Well Construction Standards.

The new and existing monitoring wells will be fitted with a sealed wellhead that allows for groundwater samples to be collected via dedicated tubing and a pump (Note: if the groundwater level is less than 25 feet, only tubing will be installed for use with a peristaltic pump). A PVC cover will be placed over the wellhead to mitigate potential electrical exposure during sampling. An approximate four square-foot concrete pad will be placed around each wellhead in a manner that precludes surface runoff towards the well. Permanent well identification labels that include well construction details will be placed inside the wellheads.

5.4 DEPTH TO GROUNDWATER MEASUREMENT

Depth to groundwater measurements will be performed at 22 overburden monitoring wells prior to initiation of ERH heating. The purpose of these measurements is to obtain information on depth/elevation of the water table and potentiometric surface of the deeper partially weathered rock monitoring wells. The depth to groundwater measurement procedures have been developed in accordance with the United States Environmental Protection Agency (USEPA) Science and Ecosystem Support Division’s (SESD’s) Operating Procedure “Groundwater Level and Well Depth Measurement,” effective November 3, 2016 (Appendix A).

Depth to groundwater measurements will be made relative to the north side of the top of the monitoring well/piezometer casings. A water level meter with a measuring tape length of at least 50 feet and measurement accuracy of at least 0.01 feet will be used to measure the depth to groundwater. Depth to groundwater measurements will be recorded to the

0.01 foot on a field data record (FDR), such as the one included in Appendix D of the RAWP QAPP (“Depth to Water Measurement Record”).

It should be noted that prior to initiation of heating, the monitoring wells will be fitted with a wellhead sampling apparatus that allows for sample collection without opening the well. This configuration prevents steam from escaping the well and causing potential injury during sampling procedures. Therefore, measurement of depth to groundwater will not be possible during heating operations.

5.5 DEPTH/THICKNESS OF LNAPL MEASUREMENT

The thickness of LNAPL, if present, will be measured in 22 wells in the ERH treatment area prior to initiating ERH remediation. The LNAPL thickness will be measured with an oil-water interface probe with an accuracy of at least 0.01 feet.

If LNAPL is indicated by the interface probe (typically a buzzing or beeping sound), the depth of the indicated water/LNAPL interface will be recorded. The interface probe will slowly be raised or lowered to determine the LNAPL thickness (i.e., the difference between the LNAPL/groundwater interface and the LNAPL/air interface). The LNAPL measurements will be recorded on a FDR, such as the FDR included in Appendix D of the RAWP QAPP (“LNAPL Measurement Record”).

During ERH treatment, the depth/thickness of LNAPL will not be measured, due to the high temperature of the groundwater/LNAPL preventing the use of an oil-water interface probe.

5.6 PID SCREENING

A PID will be used to screen VOCs for several purposes, listed below, during the ERH Remedial Action, as described below.

5.6.1 Extracted Vapor Monitoring

A PID will be used to qualitatively measure total VOC concentrations in the influent vapor (pre-treatment) and the effluent vapor (post-treatment). The samples will be collected from ports located on the vapor treatment system piping. Because the vapor recovery system is under a vacuum, a ‘lung sampler’ or pump will be used to collect the air sample into a Tedlar® bag. The PID will then be connected to the Tedlar® bag for total VOC measurement. The PID to be used will measure total VOCs in the parts per million (ppm) range, with an accuracy of 0.1 to 10,000 ppm.

5.6.2 Ambient Air Monitoring

Continuous air monitoring will be conducted using a PID at four locations near the property line during the ERH operations. The PIDs will be programmed to calculate a 24-hour average of total VOCs. An individual PID will be used at each location. The PIDs to be used will measure total VOCs in the parts per billion (ppb) range, with an accuracy of 1 ppb to 10,000 ppm.

If a 24-hour average reading greater than 11 ppb is measured, an alarm will be sent to TRS and Amec Foster Wheeler, so that the source of the VOC readings can be identified and promptly mitigated.

5.6.3 Soil Screening

Soil borings advanced during baseline and confirmation sampling will be retrieved using a direct-push technology (DPT) macro-core sampler. The retrieved soil will be scanned at a minimum one-foot interval with a PID (PID “scan”). The soil core will be “pried” open and the tip of the PID will be placed within the freshly opened soil. A gloved hand will be “cupped” around the probe and atop the soil core to minimize volatilization. PID scan readings will be documented on a soil boring log, as described in the RAWP QAPP.

5.7 COLLECTION OF SOIL SAMPLES

Baseline and confirmation soil borings will be advanced at 15 locations within the ERH treatment area using DPT equipment (Figure 4 of the RAWP). Soil samples will be collected at approximate 10-foot intervals from below the top of the treatment zone to the bottom of the treatment zone. The treatment zone at a particular boring will be from the water table to the depth of the shallowest electrode or drilling refusal, whichever occurs first. Once the apparent water table is encountered, a soil sample will be collected at a depth of five feet below the water table, and at 10-foot intervals thereafter. A soil sample will not be collected in the bottom interval if the interval is five feet in length or less.

Confirmation soil borings will be located within three horizontal feet of the baseline soil boring and soil samples will be collected at approximately the same depth as the associated baseline soil sample.

Clean, non-powdered, disposable nitrile gloves will be worn when collecting soil samples. A new pair of gloves will be donned immediately prior to collecting a soil sample that will be submitted for analysis. Sample information (e.g., sample designation, depth, etc.) will be recorded on the soil boring log and sample summary log. The soil samples will be submitted for analysis of TCE according to USEPA Method 8260, as described in the RAWP QAPP.

5.7.1 Baseline Soil Sampling

Baseline soil samples will be collected in accordance with the SESD Operating Procedure "Soil Sampling," effective August 21, 2014 (Appendix A). Soil retrieved from the boring via the DPT macro-core sampler will be described in the field by a geologist. Information regarding moisture content, color, grain size, odor, PID measurement, etc. will be recorded on a soil boring log. Photographs of the soil core will be taken. Identification of the boring location and depth will be indicated in the photograph.

Soil samples will be collected from the desired interval of a select macro-core liner using a decontaminated stainless steel spoon, or similar device. The sample will be placed in the sample container, labeled with sample information and the lid securely closed. Soil samples will be placed on ice following collection.

5.7.2 Confirmation Soil Sampling

Confirmation soil samples will be collected in a manner similar to the baseline soil samples, with several modifications due to the elevated temperature of the retrieved soil. The macro-core liners will be made of stainless steel to withstand subsurface heat. The retrieved liner will be capped and placed in an ice bath. The ice bath will be fitted with a drain, so that the liner does not get submerged in water. The temperature of the soil will be monitored with a standard cooking thermometer inserted into the soil core from the capped end of the liner. When the soil temperature is approximately 70 degrees Fahrenheit, the liner will be cut and the soil removed and placed into labeled containers.

The soil samples will be placed on ice following collection. “Hot” soil sampling procedures are described in TRS’s “Hot Soil Sampling” Standard Operating Procedure (SOP; Appendix B).

5.7.3 Borehole Abandonment

After completion of a DPT borehole for soil sample collection, the borehole will be abandoned using a neat cement grout. The grout will be injected from the bottom of the borehole to the top of the borehole using the DPT rods. If the grout settles after placement, the grout will be “topped off” as needed to match the surrounding ground surface.

5.8 COLLECTION OF GROUNDWATER SAMPLES

Groundwater samples will be collected in accordance with the SESD Operating Procedure “Groundwater Sampling,” effective April 26, 2017 (Appendix A). Based on historical depth to groundwater measurements in the ERH treatment area, a peristaltic pump will be used to purge and collect groundwater samples. Dedicated Teflon tubing will be placed in each monitoring well at the approximate center of the five-foot screened interval.

Groundwater will be purged from the monitoring wells using low-flow purging techniques, in which groundwater drawdown is minimized. A flow-through cell will be utilized and water quality parameters (pH, temperature, conductivity, dissolved oxygen, and oxidation reduction potential) will be continuously monitored. Measurements will be recorded approximately every three minutes. Turbidity will be monitored using a turbidity meter. Groundwater samples will be collected after water quality parameters have stabilized.

Because the groundwater samples are not being submitted for trace VOC/TCE analysis, samples will be collected from the tubing (including the silicone pump head tubing) used to purge the groundwater, as the relative VOC loss via agitation at the pump head is expected to be minimal. New silicone pump head tubing and polyethylene tubing will be used for each sample location. Groundwater samples collected for analysis of VOCs will be placed in laboratory-prepared 40 milliliter volatile organic analysis sample containers preserved with hydrochloric acid. The samples will be collected with minimal agitation and the container should contain zero head space (e.g. no bubbles).

Groundwater samples will be placed on ice following collection. Groundwater samples will be packaged and shipped/delivered to the laboratory with appropriate chain-of-custody as described in the RAWP QAPP. Clean, non-powdered, disposable nitrile gloves will be worn when collecting groundwater samples. A new pair of gloves will be donned immediately prior to sampling. Information regarding the collected sample (e.g., sample designation, depth, etc.) will be recorded on the sample summary log.

5.8.1 Collection of Confirmation Groundwater Samples

Confirmation groundwater samples will be collected in a manner similar to the baseline groundwater samples, with several modifications due to the elevated temperature of the groundwater. The purged groundwater will flow through a copper coil that is submerged in an ice bath. A flow-through cell will be utilized and water quality parameters (pH, temperature, conductivity, dissolved oxygen, oxidation reduction potential, and turbidity) will be continuously monitored. A groundwater sample will be collected when the water quality parameters have stabilized. The groundwater samples will be placed on ice following collection. “Hot” groundwater sampling procedures are described in TRS’s “Hot Groundwater Sampling” SOP (Appendix C).

5.8.2 Measurement of Water Quality Parameters

Water quality parameters will be collected during purging of groundwater for sample collection. The following water quality parameters will be measured:

- pH
- Temperature
- Conductivity
- Dissolved oxygen (DO)
- Oxidation-reduction potential (ORP)
- Turbidity

A multi-parameter water quality meter that measures pH, temperature, conductivity, DO, and ORP will be used. A separate turbidity meter will be used to measure turbidity. The equipment will be calibrated each day prior to sample collection in accordance with the manufacturer’s specifications. Calibration data will be recorded on a Field Instrument Calibration Record FDR found in Appendix D of the RAWP QAPP. If drifting or erroneous readings occur during operation, the equipment will be checked for calibration, and re-calibrated if necessary. If the equipment cannot be re-calibrated, the Field Operations Leader (FOL) will be notified, and operable equipment will be identified/procured for use.

Water quality parameters will be measured in accordance with the most recent version of the following SESD Operating Procedures found in Appendix A:

- “Field pH Measurement,” effective December 16, 2016
- “Field Specific Conductance,” effective July 13, 2016
- “Field Temperature Measurement,” effective October 23, 2014
- “Field Measurement of Oxidation-Reduction Potential,” effective April 26, 2017
- “Field Measurement of Dissolved Oxygen,” effective April 12, 2017 (luminescent probe)
- “Field Turbidity Measurement,” effective July 27, 2017

5.9 COLLECTION OF LNAPL SAMPLES

LNAPL samples will be collected from monitoring wells where sufficient LNAPL has accumulated. Baseline and confirmation samples will be collected using the following procedures.

5.9.1 Baseline LNAPL Sample Collection

If the measured thickness of LNAPL is greater than 3 inches, a bottom-filling disposable bailer will be used to collect a sample of the LNAPL. The bailer will be slowly lowered to a depth where the bottom of the bailer reaches the base of the LNAPL. The bailer will be slowly retrieved and the LNAPL sample will be collected by pouring the contents of the bailer from the bottom of the bailer into the sample container.

If the LNAPL becomes mixed/emulsified with water, the sample will be poured into a new, clean glass jar and then the LNAPL will be decanted to the sample container for shipment to the laboratory. One LNAPL sample will be collected from each of up to five locations. The LNAPL samples will be analyzed for TCE according to USEPA Method 8260. Samples will be containerized, preserved, packaged and transported in accordance with the procedures contained in the RAWP QAPP.

5.9.2 Confirmation LNAPL Sample Collection

Confirmation LNAPL samples will be collected from up to five monitoring wells where baseline LNAPL samples were collected. Confirmation LNAPL samples will be collected in a manner similar to the baseline LNAPL samples, with several modifications due to the elevated temperature of the LNAPL. A stainless steel bailer will be slowly lowered into the monitoring well to the anticipated or judged/'observed' depth of the LNAPL/water table. The bailer will then be retrieved and a cap will be placed on the lower end of the bailer. The bailer will then be placed in an ice bath and allowed to cool for at least one hour, at which time a sample of LNAPL will be collected from the bailer and the temperature measured using a cooking thermometer. An LNAPL sample will be collected when the LNAPL is approximately 70 degrees Fahrenheit.

5.10 SURVEYING

Monitoring wells will be surveyed using by a North Carolina Licensed Surveyor. The elevation of the ground surface and top of casing will be recorded to the nearest 0.01 foot. The horizontal location of the monitoring wells will also be surveyed and recorded.

6.0 DECONTAMINATION PROCEDURES

The objective of this section is to provide procedures for the removal of contaminants from sampling, drilling, and other field equipment to concentrations that do not adversely impact the investigation objectives. The decontamination procedures have been developed in accordance with the SESD Operating Procedure "Field Equipment Cleaning and Decontamination," effective December 18, 2015 (Appendix A). Deviations from these procedures, if necessary, will be communicated to the FOL and documented in the field log book.

6.1 CLEANING SOLUTIONS

Specifications for standard cleaning materials referenced in this section are as follows:

- Potable water will be obtained from a drinking water tap and containerized in a clean plastic bucket or plastic spray/squeeze bottle. The container will be labeled as "potable water."
- Distilled water can be used in place of potable water, if necessary, and will be labeled as "distilled water."
- Soap will be a standard brand of phosphate-free laboratory detergent such as Alconox® or Liquinox®. Soap will be kept in a plastic or glass container until use, and dispensed directly from the container. The soap container will be labeled with its contents.
- Organic-free water will be stored in glass or plastic containers that can be closed between uses. The organic-free water container will be labeled as such.
- De-ionized water will be obtained from the laboratory and stored in glass or plastic containers that can be closed between uses. The de-ionized water container will be labeled as such.

6.2 EQUIPMENT DECONTAMINATION

During electrode and TMP installation, drilling equipment will not be decontaminated between locations. However, drilling equipment and associated tools will be decontaminated before leaving the Site at the end of the project.

During monitoring well installation, the augers will be decontaminated between locations. A decontamination pad will be constructed that consists of plastic sheeting surrounded by hay bales to form a containment 'pit'. The augers will be placed on sawhorses, or otherwise elevated, so that the inside and outside of the augers can be decontaminated. A steam cleaner will be used to removed soil/contamination from the augers. An industrial soap will be used, if needed, to remove the soil/contamination from the augers.

During soil sampling activities, a DPT rig equipped with a core sampler will be utilized. The direct sensing probe/equipment will be decontaminated between borings, as follows:

- As each DPT rod is removed from the borehole, it will be placed in a bucket that is placed on plastic sheeting and will be washed with hydrant or potable water and soap. A brush will be used to remove particulate matter and surface films.
- Decontamination fluid in the bucket will be transferred to a 55-gallon drum upon completion of the decontamination activities.
- Clean equipment will be placed on clean plastic sheeting or on a rack until needed.

The drill rigs and DPT rig and associated tools and equipment will be decontaminated before leaving the Site at the end of the project.

6.3 SAMPLING EQUIPMENT DECONTAMINATION

The following procedures will be used to decontaminate non-dedicated, non-disposable field sampling equipment (e.g., spoons, submersible pump, water level meter):

- Equipment will be cleaned prior to sampling, between sampling locations, and at the end of the project before equipment is removed from the Site.
- Equipment will be washed with potable water and soap, and rinsed with potable water.
- If samples are collected for trace organic compounds, the sampling equipment used during collection will be decontaminated as described above and then rinsed with isopropanol and then organic-free water. The equipment will be placed on aluminum foil to dry and then wrapped in aluminum foil.
- The wetted portion of a water level meter tape/probe and interface probe will be decontaminated using soap and potable water, and then rinsed with deionized water, before use and between measurements.
- The submersible pump will be disassembled to the extent possible and cleaned with potable water and soap, and rinsed with potable water and then organic-free water. The cable and reel will be cleaned in the same manner. Upon reassembly and reeling the cable, a final rinse over and through the pump with organic-free water will be conducted.
- Decontamination liquids will be contained in a bucket and transferred to a 55-gallon drum upon completion of the decontamination activities.

6.4 SAFETY PROCEDURES FOR FIELD CLEANING OPERATIONS

Field personnel will exercise caution and follow applicable safety procedures contained in the Site Health and Safety Plan when handling cleaning materials. At a minimum, the following precautions will be taken in the field during cleaning operations:

- Safety glasses and nitrile gloves will be worn during decontamination of sampling equipment.
- Eating, smoking, drinking, or any hand to mouth contact will not be permitted during the cleaning operations.

6.5 HANDLING OF CLEANED EQUIPMENT

After field cleaning, personnel wearing clean gloves will handle equipment to prevent re-contamination. In addition, equipment cleaned at the decontamination pad will be moved away from the cleaning area to prevent re-contamination. If the equipment is not to be immediately re-used it will be covered with plastic sheeting and stored in an area away from potential contaminants.

7.0 MANAGEMENT OF INVESTIGATION DERIVED WASTE

The procedures associated with the management of investigation derived waste (IDW) have been developed in accordance with the SESD Operating Procedure “Management of Investigation Derived Waste,” effective July 3, 2014 (Appendix A). IDW that will be generated during implementation of the PDI include:

- Soil cuttings
- Groundwater (purge water)
- Decontamination fluids
- Liners from soil sample collection via the DPT rig
- Tubing from groundwater sampling
- Decontamination pad materials
- Personal protective equipment (PPE)

Soil cuttings generated during installation of electrodes, TMPs, and monitoring wells will be transferred to ‘roll-off’ containers. Unsaturated soil will be segregated from saturated soil. Waste characterization samples will be collected from the soil cuttings and analyzed for total VOCs according to 8260. If required by the disposal facilities, additional analyses will be performed. The roll-offs will be transported off the Site for disposal at approved facilities as described in the RAWP. A roll-off management log will be completed by the FOL to track the soil type (non-hazardous or hazardous), date of generation, and associated manifest number provided by the disposal contractor.

Soil from DPT soil sampling, purged water, and decontamination fluids will be stored in Department of Transportation (DOT)-approved 55-gallon drums. Liquid IDW will be accumulated separately from soil IDW and each drum will be labeled as to the drum’s contents. Disposable items, including PPE and liners, are not considered hazardous and will be placed in trash bags and disposed of in a municipal solid waste dumpster. If the disposable items are heavily soiled and cannot be cleaned via the decontamination procedures described in Section 6.0, the items will be transferred to a DOT-approved 55-gallon drum and appropriately labeled pending disposal.

The drums will be transported off the Site for disposal at approved disposal facilities. A drum management log will be completed by the FOL to track the waste type, date of generation, and source of the waste material.

8.0 REFERENCES

USEPA, 2014. Management of Investigation Derived Waste, Science and Ecosystem Support Division, Athens, GA; SESDPROC-202-R3, July 3, 2014.

USEPA, 2014. Soil Sampling, Science and Ecosystem Support Division, Athens, GA; SESDPROC-300-R3, August 21, 2014.

USEPA, 2014. Field Temperature Measurement, Science and Ecosystem Support Division, Athens, GA; SESDPROC-102-R4, October 23, 2014.

USEPA, 2015. Field Equipment Cleaning and Decontamination, Science and Ecosystem Support Division, Athens, GA; SESDPROC-205-R3, December 18, 2015.

USEPA, 2016. Field Specific Conductance Measurement, Science and Ecosystem Support Division, Athens, GA; SESDPROC-101-R6, July 13, 2016.

USEPA, 2016. Groundwater Level and Well Depth Measurement, Science and Ecosystem Support Division, Athens, GA; SESDPROC-105-R3, November 3, 2016.

USEPA, 2016. Field pH Measurement, Science and Ecosystem Support Division, Athens, GA; SESDPROC-100-R4, December 16, 2016.

USEPA, 2017. Field Measurement of Dissolved Oxygen, Science and Ecosystem Support Division, Athens, GA; SESDPROC-106-R4, April 12, 2017.

USEPA, 2017. Field Measurement of Oxidation-Reduction Potential, Science and Ecosystem Support Division, Athens, GA; SESDPROC-113-R2, April 26, 2017.

USEPA, 2017. Groundwater Sampling, Science and Ecosystem Support Division, Athens, GA; SESDPROC-301-R4, April 26, 2017.

USEPA, 2017. Field Turbidity Measurement. Science and Ecosystem Support Division, Athens, GA; SESDPROC-103-R4, July 27, 2017.

APPENDIX A

SESD OPERATING PROCEDURES

SESD PROCEDURE SESDPROC-105-R3:

GROUNDWATER LEVEL AND WELL DEPTH MEASUREMENT

COPY

Region 4
U.S. Environmental Protection Agency
Science and Ecosystem Support Division
Athens, Georgia

OPERATING PROCEDURE

Title: **Groundwater Level and Well Depth Measurement**

Effective Date: November 3, 2016	**Number:** SESDPROC-105-R3

Authors

Name: Brian Striggow
Title: Environmental Engineer
Signature:
Date: 11/1/16

Approvals

Name: John Deatrick
Title: Chief, Field Services Branch
Signature: John Deatrick
Date: 11/2/16

Name: Hunter Johnson
Title: Field Quality Manager, Science and Ecosystem Support Division
Signature:
Date: 11/1/16

Revision History

The top row of this table shows the most recent changes to this controlled document. For previous revision history information, archived versions of this document are maintained by the SESD Document Control Coordinator on the SESD local area network (LAN).

History	Effective Date
SESDPROC-105-R3, *Groundwater Level and Well Depth Measurement*, replaces SESDPROC-105-R2 **General:** Corrected any typographical, grammatical, and/or editorial errors. **Title Page:** Author changed from Tim Simpson to Brian Striggow. Changed the Field Quality Manager from Bobby Lewis to Hunter Johnson. Updated cover page to represent SESD reorganization. John Deatrick was not listed as the Chief of the Field Services Branch **Section 4:** Added section on the Establishment of Well Top of Casing Elevations.	November 3, 2016
SESDPROC-105-R2, *Groundwater Level and Well Depth Measurement*, replaces SESDPROC-105-R1	January 29, 2013
SESDPROC-105-R1, *Groundwater Level and Well Depth Measurement*, replaces SESDPROC-105-R0	November 1, 2007
SESDPROC-105-R0, Groundwater Level and Well Depth Measurement, Original Issue	February 05, 2007

COPY

TABLE OF CONTENTS

1 General Information

1.1 Purpose

This document describes general and specific procedures, methods and considerations to be used and observed when determining water levels and depths of wells.

1.2 Scope/Application

The procedures contained in this document are to be used by field investigators to measure water levels and depths of wells. On the occasion that SESD field investigators determine that any of the procedures described in this section are either inappropriate, inadequate or impractical and that another procedure must be used for water level or depth determination, the variant procedure(s) will be documented in the field log book and the subsequent investigation report, along with a description of the circumstances requiring its use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and has been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD Local Area Network. The Document Control Coordinator is responsible for ensuring the most recent version of the procedure is placed on the LAN and for maintaining records of review conducted prior to its issuance.

1.4 References

SESD Operating Procedure for Equipment Inventory and Management, SESDPROC-108, Most Recent Version

SESD Operating Procedure for Field Equipment Cleaning and Decontamination, SESDPROC-205, Most Recent Version

SESD Operating Procedure for Logbooks, SESDPROC-010, Most Recent Version

US EPA. Safety, Health and Environmental Management Program Procedures and Policy Manual. Region 4 SESD, Athens, GA, Most Recent Version

1.5 General Precautions

1.5.1 Safety

Proper safety precautions must be observed when measuring water levels in wells and determining their depths. Refer to the SESD Safety, Health and Environmental Management Program Procedures and Policy Manual and any pertinent site-specific Health and Safety Plans (HASPs) for guidelines on safety precautions. These guidelines, however, should only be used to complement the judgment of an experienced professional. Address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate.

1.5.2 Procedural Precautions

The following precautions should be considered when measuring water levels and depths of wells:

- Special care must be taken to minimize the risk of cross-contamination between wells when conducting water level and depth measurements. This is accomplished primarily by decontaminating the sounders or other measuring devices between wells, according to SESD Operating Procedure for Field Equipment Cleaning and Decontamination, (SESDPROC-205) and maintaining the sounders in clean environment while in transit between wells.
- Water levels and well depths measured according to these procedures should be recorded in a bound logbook dedicated to the project as per SESD Operating Procedure for Logbooks (SESDPROC-010). Serial numbers, property numbers or other unique identification for the water level indicator or sounder must also be recorded.

2 Quality Control Issues

There are several specific quality control issues pertinent to conducting water level and depth measurements at wells. These are:

- Devices used to measure groundwater levels should be verified annually against a National Institute of Standards and Technology (NIST) traceable measuring tape.. These devices should check to within 0.01 feet per 10 feet of length with an allowable error of 0.03 feet in the first 30 feet. Before each use, these devices should be prepared according to the manufacturer's instructions (if appropriate) and checked for obvious damage. All verification and maintenance data should be documented electronically or recorded in a logbook maintained at the Field Equipment Center (FEC) as per the SESD Operating Procedure for Equipment Inventory and Management (SESDPROC-108). The functional check and tape length verification should be performed according to the instructions included in SESDFORM-043, *Well Sounder Function Check and Verification,* which also includes the form for recording the required information.

- These devices should be decontaminated according to the procedures specified in SESD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205) prior to use at the next well.

3 Water Level and Depth Measurement Procedures

3.1 General

The measurement of the groundwater level in a well is frequently conducted in conjunction with ground water sampling to determine the "free" water surface. This potentiometric surface measurement can be used to establish ground water direction and gradients. Groundwater level and well depth measurements are needed to determine the volume of water or drawdown in the well casing for proper purging.

All groundwater level and well depth measurements should be made relative to an established reference point on the well casing and should be documented in the field records. This reference point is usually identified by the well installer using a permanent marker for PVC wells, or by notching the top of casing with a chisel for stainless steel wells. By convention, this marking is usually placed on the north side of the top of casing. If no mark is apparent, the person performing the measurements should take both water level and depth measurements from the north side of the top of casing and note this procedure in the field log book.

To be useful for establishing groundwater gradient, the reference point should be tied in with the NGVD (National Geodetic Vertical Datum) or a local datum. For an isolated group of wells, it is acceptable to use an arbitrary datum common to all wells in that group..

Water levels should be allowed to equilibrate prior to measurement after removing sealing caps. There are no set guidelines and appropriate equilibration times can range from minutes to hours depending on well recharge, local geology and topography, and project objectives.

3.2 Specific Groundwater Level Measurement Techniques

Measuring the depth to the free ground water surface can be accomplished by the following methods. Method accuracies are noted for each of the specific methods described below.

- Electronic Water Level Indicators – These types of instruments consist of a spool of dual conductor wire, a probe attached to the end and an indicator. When the probe comes in contact with the water, the circuit is closed and a meter light and/or audible buzzer attached to the spool will signal contact. Penlight or 9-volt batteries are normally used as a power source. Measurements should be made and recorded to the nearest 0.01 foot.

- Other Methods – There are other types of water level indicators and recorders available on the market, such as weighted steel tape, chalked tape, sliding float method, air line pressure method and automatic recording methods. These methods are primarily used for closed systems or permanent monitoring wells. Acoustic water level indicators are also available which measure water levels based on the measured return of an emitted acoustical impulse. Accuracies for these methods vary and should be evaluated before selection. Any method not capable of providing measurements to within 0.1 foot should not be used.

3.3 Special Considerations for Water Level Measurements at Sites with Shallow Groundwater Gradient

Groundwater gradients at some sites can be very shallow and if gradient and groundwater flow pattern (gradient direction) determination are part of the project objectives, it is critical that groundwater level measurements obtained from wells are as accurate as possible. Special care should be taken to allow the water level to equilibrate after removing sealing caps and the same sounder should be used for all measurements, if possible. The sounding activity should be coordinated to allow all wells to be sounded within the minimum possible time. This is particularly important in areas with potential tidal influences.

3.4 Total Well Depth Measurement Techniques

The well sounder, weighted tape or electronic water level indicators can be used to determine the total well depth. This is accomplished by lowering the tape or cable until the weighted end is felt resting on the bottom of the well. Because of tape buoyancy and weight effects encountered in deep wells with long water columns, it may be difficult to determine when the tape end is touching the bottom of the well and sediment in the bottom of the well can also make it difficult to determine total depth. Care must be taken in these situations to ensure accurate measurements. The operator may find it easier to allow the weight to touch bottom and then detect the ‘tug’ on the tape while lifting the weight off the well bottom. All total depth measurements must be made and recorded to the nearest 0.1 foot. As a cautionary note, when measuring well depths with the electronic water level indicators, the person performing the measurement must measure and add the length of the probe beneath the circuit closing electrodes to the depth measured to obtain the true depth. This is necessary because the tape distance markings are referenced to the electrodes, rather than the end of the probe. For electronic sounders maintained at the SESD FEC, the sounder reel will be marked with the appropriate additional length identified as the ‘TD adder’.

3.5 Equipment Available

The following equipment is available for ground water level and total depth measurements:

- Weighted steel measuring tapes
- Electronic water level indicators

4 Establishment of Top of Casing Elevations

To establish groundwater surface elevations, the measured distance from the top of casing to the water surface is subtracted from the well top of casing (TOC) elevation. Obtaining accurate TOC elevations is crucial to developing an accurate groundwater surface elevation map and determination of groundwater flow direction.

The only acceptable means of surveying well TOC elevations is differential leveling conducted to third order standards. Third order differential leveling has allowable error defined by the following formula:

$$Allowable\ Error\ (ft) = 0.05 \times \sqrt{Survey\ loop\ length\ (miles)}$$

This work must be conducted with an auto level as the leveling instrument. Surveying TOC elevations with a total station or survey-grade GPS will not provide the requisite accuracy.

When adding wells to a monitoring network, it is permissible to tie the new well elevations to the known TOC elevations of existing wells in the network. The elevations of several wells in the existing network should be checked to assure that the relative differences in elevation match the recorded elevation data.

Generally, the ground surface elevations at each well should be surveyed at the same time.

SESD PROCEDURE SESDPROC-300-R3:

SOIL SAMPLING

COPY

Region 4
U.S. Environmental Protection Agency
Science and Ecosystem Support Division
Athens, Georgia

OPERATING PROCEDURE

Title: **Soil Sampling**

Effective Date: August 21, 2014

Number: SESDPROC-300-R3

Authors

Name: Kevin Simmons
Title: Environmental Scientist, Regional Expert
Signature:
Date: 8/18/2014

Approvals

Name: John Deatrick
Title: Acting Chief, Enforcement and Investigations Branch
Signature:
Date: 8/18/14

Name: Bobby Lewis
Title: Field Quality Manager, Science and Ecosystem Support Division
Signature: for Bobby Lewis
Date: 8/20/14

Revision History

The top row of this table shows the most recent changes to this controlled document. For previous revision history information, archived versions of this document are maintained by the SESD Document Control Coordinator on the SESD local area network (LAN).

History	Effective Date
SESDPROC-300-R3, *Soil Sampling*, replaces SESDPROC-300-R2. **General:** Corrected any typographical, grammatical and/or editorial errors. **Title Page:** Updated the author from Fred Sloan to Kevin Simmons. Updated the Enforcement and Investigations Branch Chief from Archie Lee to Acting Chief, John Deatrick. Section 1.5.1: Added "The reader should" to last sentence of the paragraph. Section 1.5.2: Omitted "When sampling in landscaped areas," from first sentence of eighth bullet. Section 3.2.4: In the first paragraph, first sentence, added "(rapidly form bubbles)." Omitted "(rapidly form bubbles)" from second paragraph, second sentence. Any reference to "Percent Moisture and Preservation Compatibility (MOICA)" or "Percent Moisture" was changed to "Percent Solids", both in the text and in Table 1.	August 21, 2014
SESDPROC-300-R2, *Soil Sampling*, replaces SESDPROC-300-R1.	December 20, 2011
SESDPROC-300-R1, *Soil Sampling*, replaces SESDPROC-300-R0.	November 1, 2007
SESDPROC-300-R0, Soil Sampling, Original Issue	February 05, 2007

COPY

TABLE OF CONTENTS

TABLES

1 General Information

1.1 Purpose

This document describes general and specific procedures, methods and considerations to be used and observed when collecting soil samples for field screening or laboratory analysis.

1.2 Scope/Application

The procedures contained in this document are to be used by field personnel when collecting and handling soil samples in the field. On the occasion that SESD field personnel determine that any of the procedures described in this section are inappropriate, inadequate or impractical and that another procedure must be used to obtain a soil sample, the variant procedure will be documented in the field logbook and subsequent investigation report, along with a description of the circumstances requiring its use. Mention of trade names or commercial products in this operating procedure does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and have been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD local area network (LAN). The Document Control Coordinator (DCC) is responsible for ensuring the most recent version of the procedure is placed on the LAN, and for maintaining records of review conducted prior to its issuance.

1.4 References

International Air Transport Authority (IATA). Dangerous Goods Regulations, Most Recent Version

SESD Operating Procedure for Field Equipment Cleaning and Decontamination, SESDPROC-205, Most Recent Version

SESD Operating Procedure for Field Equipment Cleaning and Decontamination at the FEC, SESDPROC-206, Most Recent Version

SESD Operating Procedure for Field Sampling Quality Control, SESDPROC-011, Most Recent Version

SESD Operating Procedure for Field X-Ray Fluorescence (XRF) Measurement, SESDPROC-107, Most Recent Version

SESD Operating Procedure for Logbooks, SESDPROC-010, Most Recent Version

SESD Operating Procedure for Sample and Evidence Management, SESDPROC-005, Most Recent Version

Title 49 Code of Federal Regulations, Pts. 171 to 179, Most Recent Version

US EPA Test Methods for Evaluating Solid Waste, Physical/Chemical Methods SW-846, Most Recent Version (Method 5035)

US EPA. Safety, Health and Environmental Management Program (SHEMP) Procedures and Policy Manual. Region 4 SESD, Athens, GA, Most Recent Version

1.5 General Precautions

1.5.1 Safety

Proper safety precautions must be observed when collecting soil samples. Refer to the SESD Safety, Health and Environmental Management Program (SHEMP) Procedures and Policy Manual and any pertinent site-specific Health and Safety Plans (HASP) for guidelines on safety precautions. These guidelines, however, should only be used to complement the judgment of an experienced professional. The reader should address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate.

1.5.2 Procedural Precautions

The following precautions should be considered when collecting soil samples:

- Special care must be taken not to contaminate samples. This includes storing samples in a secure location to preclude conditions which could alter the properties of the sample. Samples shall be custody sealed during long-term storage or shipment.
- Collected samples are in the custody of the sampler or sample custodian until the samples are relinquished to another party.
- If samples are transported by the sampler, they will remain under his/her custody or be secured until they are relinquished.
- Shipped samples shall conform to all U.S. Department of Transportation (DOT) rules of shipment found in Title 49 of the Code of Federal Regulations (49 CFR parts 171 to 179), and/or International Air Transportation Association

(IATA) hazardous materials shipping requirements found in the current edition of IATA's Dangerous Goods Regulations.

- Documentation of field sampling is done in a bound logbook.
- Chain-of-custody documents shall be filled out and remain with the samples until custody is relinquished.
- All shipping documents, such as air bills, bills of lading, etc., shall be retained by the project leader in the project files.
- Sampling in landscaped areas: Cuttings should be placed on plastic sheeting and returned to the borehole upon completion of the sample collection. Any 'turf plug' generated during the sampling process should be returned to the borehole.
- Sampling in non-landscaped areas: Return any unused sample material back to the auger, drill or push hole from which the sample was collected.

2 Special Sampling Considerations

2.1 Special Precautions for Trace Contaminant Soil Sampling

- A clean pair of new, non-powdered, disposable gloves will be worn each time a different sample is collected and the gloves should be donned immediately prior to sampling. The gloves should not come in contact with the media being sampled and should be changed any time during sample collection when their cleanliness is compromised.
- Sample containers with samples suspected of containing high concentrations of contaminants shall be handled and stored separately.
- All background samples shall be segregated from obvious high-concentration or waste samples. Sample collection activities shall proceed progressively from the least suspected contaminated area to the most suspected contaminated area. Samples of waste or highly-contaminated media must not be placed in the same ice chest as environmental (i.e., containing low contaminant levels) or background samples.
- If possible, one member of the field sampling team should take all the notes and photographs, fill out tags, etc., while the other member(s) collect the samples.
- Samplers must use new, verified/certified-clean disposable or non-disposable equipment cleaned according to procedures contained in the SESD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205), for collection of samples for trace metals or organic compound analyses.

2.2 Sample Homogenization

1. If sub-sampling of the primary sample is to be performed in the laboratory, transfer the entire primary sample directly into an appropriate, labeled sample container(s). Proceed to step 4.

2. If sub-sampling the primary sample in the field or compositing multiple primary samples in the field, place the sample into a glass or stainless steel homogenization container and mix thoroughly. Each aliquot of a composite sample should be of the same approximate volume.

3. All soil samples must be thoroughly mixed to ensure that the sample is as representative as possible of the sample media. ***Samples for VOC analysis are not homogenized.*** The most common method of mixing is referred to as quartering. The quartering procedure should be performed as follows:

- The material in the sample pan should be divided into quarters and each quarter should be mixed individually.
- Two quarters should then be mixed to form halves.
- The two halves should be mixed to form a homogenous matrix.

  This procedure should be repeated several times until the sample is adequately mixed. If round bowls are used for sample mixing, adequate mixing is achieved by stirring the material in a circular fashion, reversing direction, and occasionally turning the material over.

4. Place the sample into an appropriate, labeled container(s) by using the alternate shoveling method and secure the cap(s) tightly. The alternate shoveling method involves placing a spoonful of soil in each container in sequence and repeating until the containers are full or the sample volume has been exhausted. Threads on the container and lid should be cleaned to ensure a tight seal when closed.

2.3 Dressing Soil Surfaces

Any time a vertical or near vertical surface is sampled, such as achieved when shovels or similar devices are used for subsurface sampling, the surface should be dressed (scraped) to remove smeared soil. This is necessary to minimize the effects of contaminant migration interferences due to smearing of material from other levels.

2.4 Quality Control

If possible, a control sample should be collected from an area not affected by the possible contaminants of concern and submitted with the other samples. This control sample should be collected as close to the sampled area as possible and from the same soil type. Equipment blanks should be collected if equipment is field cleaned and re-used on-site or if necessary to document that low-level contaminants were not introduced by sampling tools. SESD Operating Procedure for Field Sampling Quality Control (SESDPROC-011) contains other procedures that may be applicable to soil sampling investigations.

2.5 Records

Field notes, recorded in a bound field logbook, as well as chain-of-custody documentation will be generated as described in the SESD Operating Procedure for Logbooks (SESDPROC-010) and the SESD Operating Procedure for Sample and Evidence Management (SESDPROC-005).

3 Method 5035

The procedures outlined here are summarized from *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods SW-846, Method 5035.*

3.1 Soil Samples for Volatile Organic Compounds (VOC) Analysis

If samples are to be analyzed for VOCs, they should be collected in a manner that minimizes disturbance of the sample. For example, when sampling with an auger bucket, the sample for VOC analysis should be collected directly from the auger bucket (preferred) or from minimally disturbed material immediately after an auger bucket is emptied into the pan. The sample shall be containerized by filling an En Core® Sampler or other Method 5035 compatible container. ***Samples for VOC analysis are not homogenized.*** Preservatives may be required for some samples with certain variations of Method 5035. Consult the method or the principal analytical chemist to determine if preservatives are necessary.

3.2 Soil Sampling (Method 5035)

The following sampling protocol is recommended for site investigators assessing the extent of VOCs in soils at a project site. Because of the large number of options available, careful coordination between field and laboratory personnel is needed. The specific sampling containers and sampling tools required will depend upon the detection levels and intended data use. Once this information has been established, selection of the appropriate sampling procedure and preservation method best applicable to the investigation can be made.

3.2.1 Equipment

Soil for VOC analyses may be retrieved using any of the SESD soil sampling methods described in Sections 4 through 8 of this procedure. Once the soil has been obtained, the En Core® Sampler, syringes, stainless steel spatula, standard 2-oz. soil VOC container, or pre-prepared 40 mL vials may be used/required for sub-sampling. The specific sample containers and the sampling tools required will depend upon the data quality objectives established for the site or sampling investigation. The various sub-sampling methods are described below.

3.2.2 Sampling Methodology - Low Concentrations (<200 µg/kg)

When the total VOC concentration in the soil is expected to be less than 200 µg/kg, the samples may be collected directly with the En Core® Sampler or syringe. If using the syringes, the sample must be placed in the sample container (40 mL pre-prepared vial) immediately to reduce volatilization losses. The 40 mL vials should contain 10 mL of organic-free water for an un-preserved sample or approximately

10 mL of organic-free water and a preservative. It is recommended that the 40 mL vials be prepared and weighed by the laboratory (commercial sources are available which supply preserved and tared vials). When sampling directly with the En Core® Sampler, the vial must be immediately capped and locked.

A soil sample for VOC analysis may also be collected with conventional sampling equipment. A sample collected in this fashion must either be placed in the final sample container (En Core® Sampler or 40 mL pre-prepared vial) immediately or the sample may be immediately placed into an intermediate sample container with no head space. If an intermediate container (usually 2-oz. soil jar) is used, the sample must be transferred to the final sample container (En Core® Sampler or 40 mL pre-prepared vial) as soon as possible, not to exceed 30 minutes.

NOTE: After collection of the sample into either the En Core® Sampler or other container, the sample must immediately be stored in an ice chest and cooled.

Soil samples may be prepared for shipping and analysis as follows:

En Core® Sampler - the sample shall be capped, locked, and secured in the original foil bag. All foil bags containing En Core® samplers are then placed in a plastic bag and sealed with custody tape, if required.

Syringe - Add about 3.7 cc (approximately 5 grams) of sample material to 40-mL pre-prepared containers. Secure the containers in a plastic bag. Do not use a custody seal on the container; place the custody seal on the plastic bag. Note: When using the syringes, it is important that no air is allowed to become trapped behind the sample prior to extrusion, as this will adversely affect the sample.

Stainless Steel Laboratory Spatulas - Add between 4.5 and 5.5 grams (approximate) of sample material to 40 mL containers. Secure the containers in a plastic bag. Do not use a custody seal on the container; place the custody seal on the plastic bag.

3.2.3 Sampling Methodology - High Concentrations (>200 µg/kg)

Based upon the data quality objectives and the detection level requirements, this high level method may also be used. Specifically, the sample may be packed into a single 2-oz. glass container with a screw cap and septum seal. The sample container must be filled quickly and completely to eliminate head space. Soils\sediments containing high total VOC concentrations may also be collected as described in Section 3.2.2, Sampling Methodology - Low Concentrations, and preserved using 10 mL methanol.

3.2.4 Special Techniques and Considerations for Method 5035

Effervescence

If low concentration samples effervesce (rapidly form bubbles) from contact with the acid preservative, then either a test for effervescence must be performed prior to sampling, or the investigators must be prepared to collect each sample both preserved or un-preserved, as needed, or all samples must be collected unpreserved.

To check for effervescence, collect a test sample and add to a pre-preserved vial. If preservation (acidification) of the sample results in effervescence then preservation by acidification is not acceptable, and the sample must be collected un-preserved.

If effervescence occurs and only pre-preserved sample vials are available, the preservative solution may be placed into an appropriate hazardous waste container and the vials triple rinsed with organic free water. An appropriate amount of organic free water, equal to the amount of preservative solution, should be placed into the vial. The sample may then be collected as an un-preserved sample. Note: the amount of organic free water placed into the vials will have to be accurately measured.

Sample Size

While this method is an improvement over earlier ones, field investigators must be aware of an inherent limitation. Because of the extremely small sample size and the lack of sample mixing, sample representativeness for VOCs may be reduced compared to samples with larger volumes collected for other constituents. The sampling design and objectives of the investigation should take this into consideration.

Holding Times

Sample holding times are specified in the Analytical Support Branch *Laboratory Operations and Quality Assurance Manual* (ASBLOQAM), Most Recent Version. Field investigators should note that the holding time for an un-preserved VOC soil/sediment sample on ice is 48 hours. Arrangements should be made to ship the soil/sediment VOC samples to the laboratory by overnight delivery the day they are collected so the laboratory may preserve and/or analyze the sample within 48 hours of collection.

Percent Solids

Samplers must ensure that the laboratory has sufficient material to determine percent solids in the VOC soil/sediment sample to correct the analytical results to dry weight. If other analyses requiring percent solids determination are being performed upon the sample, these results may be used. If not, a separate sample (minimum of 2 oz.) for percent solids determination will be required. The sample collected for percent solids may also be used by the laboratory to check for preservative compatibility.

Safety

Methanol is a toxic and flammable liquid. Therefore, methanol must be handled with all required safety precautions related to toxic and flammable liquids. Inhalation of methanol vapors must be avoided. Vials should be opened and closed quickly during the sample preservation procedure. Methanol must be handled in a ventilated area. Use protective gloves when handling the methanol vials. Store methanol away from sources of ignition such as extreme heat or open flames. The vials of methanol should be stored in a cooler with ice at all times.

Shipping

Methanol and sodium bisulfate are considered dangerous goods, therefore shipment of samples preserved with these materials by common carrier is regulated by the U.S. Department of Transportation and the International Air Transport Association (IATA). The rules of shipment found in Title 49 of the Code of Federal Regulations (49 CFR parts 171 to 179) and the current edition of the IATA Dangerous Goods Regulations must be followed when shipping methanol and sodium bisulfate. Consult the above documents or the carrier for additional information. Shipment of the quantities of methanol and sodium bisulfate used for sample preservation falls under the exemption for small quantities.

The summary table on the following page lists the options available for compliance with SW846 Method 5035. The advantages and disadvantages are noted for each option. SESD's goal is to minimize the use of hazardous material (methanol and sodium bisulfate) and minimize the generation of hazardous waste during sample collection.

COPY

Table 1: Method 5035 Summary

OPTION	PROCEDURE	ADVANTAGES	DISADVANTAGES
1	Collect two 40 mL vials with ≈ 5 grams of sample, and one 2 oz. glass jar w/septum lid for screening, % moisture and preservative compatibility.	Screening conducted by lab.	Presently a 48-hour holding time for unpreserved samples. Sample containers must be tared.
2	Collect three En Core® samplers, and one 2 oz. glass jar w/septum lid for screening, % solids.	Lab conducts all preservation/preparation procedures.	Presently a 48- hour holding time for preparation of samples.
3	Collect two 40 mL vials with 5 grams of sample and preserve w/methanol or sodium bisulfate, and one 2-oz. glass jar w/septum lid for screening, % solids .	High level VOC samples may be composited. Longer holding time.	Hazardous materials used in the field. Sample containers must be tared.
4	Collect one 2-oz. glass jar w/septum lid for analysis, % solids (high level VOC only).	Lab conducts all preservation/preparation procedures.	May have significant VOC loss.

4 Manual Soil Sampling Methods

4.1 General

These methods are used primarily to collect surface and shallow subsurface soil samples. Surface soils are generally classified as soils between the ground surface and 6 to 12 inches below ground surface. The most common interval is 0 to 6 inches; however, the data quality objectives of the investigation may dictate another interval, such as 0 to 3 inches for risk assessment purposes. The shallow subsurface interval may be considered to extend from approximately 12 inches below ground surface to a site-specific depth at which sample collection using manual collection methods becomes impractical.

If a thick, matted root zone, gravel, concrete, etc. is present at or near the surface, it should be removed before the sample is collected. The depth measurement for the sample begins at the top of the soil horizon, immediately following any removed materials.

When compositing, make sure that each composite location (aliquot) consist of equal volumes, i.e., same number of equal spoonfuls.

4.2 Spoons

Stainless steel spoons may be used for surface soil sampling to depths of approximately 6 inches below ground surface where conditions are generally soft and non-indurated, and there is no problematic vegetative layer to penetrate.

4.2.1 Special Considerations When Using Spoons

- When using stainless steel spoons, consideration must be given to the procedure used to collect the volatile organic compound sample. If the soil being sampled is cohesive and holds its in situ texture in the spoon, the En Core® Sampler or syringe used to collect the sub-sample for Method 5035 should be plugged directly from the spoon. If, however, the soil is not cohesive and crumbles when removed from the ground surface for sampling, consideration should be given to plugging the sample for Method 5035 directly from the ground surface at a depth appropriate for the investigation Data Quality Objectives.

4.3 Hand Augers

Hand augers may be used to advance boreholes and collect soil samples in the surface and shallow subsurface intervals. Typically, 4-inch stainless steel auger buckets with cutting heads are used. The bucket is advanced by simultaneously pushing and turning using an attached handle with extensions (if needed).

4.3.1 Surface Soil Sampling

When conducting surface soil sampling with hand augers, the auger buckets may be used with a handle alone or with a handle and extensions. The bucket is advanced to the appropriate depth and the contents are transferred to the homogenization container for processing. Observe precautions for volatile organic compound sample collection found in Section 3, Method 5035.

4.3.2 Subsurface Soil Sampling

Hand augers are the most common equipment used to collect shallow subsurface soil samples. Auger holes are advanced one bucket at a time until the sample depth is achieved. When the sample depth is reached, the bucket used to advance the hole is removed and a clean bucket is attached. The clean auger bucket is then placed in the hole and filled with soil to make up the sample and removed.

The practical depth of investigation using a hand auger depends upon the soil properties and depth of investigation. In sand, augering is usually easily performed, but the depth of collection is limited to the depth at which the sand begins to flow or collapse. Hand augers may also be of limited use in tight clays or cemented sands. In these soil types, the greater the depth attempted, the more difficult it is to recover a sample due to increased friction and torqueing of the hand auger extensions. At some point these problems become so severe that power equipment must be used.

4.3.3 Special Considerations for Soil Sampling with the Hand Auger

- Because of the tendency for the auger bucket to scrape material from the sides of the auger hole while being extracted, the top several inches of soil in the auger bucket should be discarded prior to placing the bucket contents in the homogenization container for processing.
- Observe precautions for volatile organic compound (VOC) sample collection found in Section 3, Method 5035. Collect the VOC sample directly from the auger bucket, if possible.
- Power augers, such as the Little Beaver® and drill rigs may be used to advance boreholes to depths for subsurface soil sampling with the hand auger. They may not be used for sample collection. When power augers are used to advance a borehole to depth for sampling, care must be taken that exhaust fumes, gasoline and/or oil do not contaminate the borehole or area in the immediate vicinity of sampling.
- When moving to a new sampling location, the entire hand auger assembly must be replaced with a properly decontaminated hand auger assembly.

5 Direct Push Soil Sampling Methods

5.1 General

These methods are used primarily to collect shallow and deep subsurface soil samples. Three samplers are available for use within the Division's direct push tooling inventory. All of the sampling tools involve the collection and retrieval of the soil sample within a thin-walled liner. The following sections describe each of the specific sampling methods that can be accomplished using direct push techniques, along with details specific to each method. While SESD currently uses the sample tooling described, tooling of similar design and materials is acceptable.

If gravel, concrete, etc. is present at or near the surface, it should be removed before the sample is collected. The depth measurement for the sample begins at the top of the soil horizon, immediately following any removed materials. Turf grass is not typically removed prior to sampling with these devices.

5.2 Large Bore® Soil Sampler

The Large Bore® (LB) sampler is a solid barrel direct push sampler equipped with a piston-rod point assembly used primarily for collection of depth-discrete subsurface soil samples. The sample barrel is approximately 30-inches (762 mm) long and has a 1.5-inch (38 mm) outside diameter. The LB® sampler is capable of recovering a discrete sample core 22 inches x 1.0 inch (559 mm x 25 mm) contained inside a removable liner. The resultant sample volume is a maximum of 283 mL.

After the LB® sample barrel is equipped with the cutting shoe and liner, the piston-rod point assembly is inserted, along with the drive head and piston stop assembly. The assembled sampler is driven to the desired sampling depth, at which time the piston stop pin is removed, freeing the push point. The LB® sampler is then pushed into the soil a distance equal to the length of the LB® sample barrel. The probe rod string, with the LB® sampler attached, is then removed from the subsurface. After retrieval, the LB® sampler is then removed from the probe rod string. The drive head is then removed to allow removal of the liner and soil sample.

5.3 Macro-Core® Soil Sampler

The Macro-Core® (MC) sampler is a solid barrel direct push sampler equipped with a piston-rod point assembly used primarily for collection of either continuous or depth-discrete subsurface soil samples. Although other lengths are available, the standard MC® sampler has an assembled length of approximately 52 inches (1321 mm) with an outside diameter of 2.2 inches (56 mm). The MC® sampler is capable of recovering a discrete sample core 45 inches x 1.5 inches (1143 mm x 38 mm) contained inside a removable liner. The resultant sample volume is a maximum of 1300 mL. The MC® sampler may be used in either an open-tube or closed-point configuration. Although the MC® sampler can be used as an open-barrel sampler, in SESD usage, the piston point is always used to prevent the collection of slough from the borehole sides.

5.4 Dual Tube Soil Sampling System

The Dual Tube 21 soil sampling system is a direct push system for collecting continuous core samples of unconsolidated materials from within a sealed outer casing of 2.125-inch (54 mm) OD probe rod. The samples are collected within a liner that is threaded onto the leading end of a string of 1.0-inch diameter probe rod. Collected samples have a volume of up to 800 mL in the form of a 1.125-inch x 48-inch (29 mm x 1219 mm) core. Use of this method allows for collection of continuous core inside a cased hole, minimizing or preventing cross-contamination between different intervals during sample collection. The outer casing is advanced, one core length at a time, with only the inner probe rod and core being removed and replaced between samples. If the sampling zone of interest begins at some depth below ground surface, a solid drive tip must be used to drive the dual tube assembly and core to its initial sample depth.

5.5 Special Considerations When Using Direct Push Sampling Methods

- *Liner Use and Material Selection* – Direct Push Soil Samples are collected within a liner to facilitate removal of sample material from the sample barrel. The liners may only be available in a limited number of materials for a given sample tool, although overall, liners are available in brass, stainless steel, cellulose acetate butyrate (CAB), polyethylene terepthalate glycol (PETG), polyvinyl chloride (PVC) and Teflon®. For most SESD investigations, the standard polymer liner material for a sampling tool will be acceptable. When the study objectives require very low reporting levels or unusual contaminants of concern, the use of more inert liner materials such as Teflon® or stainless steel may be necessary.

- *Sample Orientation* – When the liners and associated sample are removed from the sample tubes, it is important to maintain the proper orientation of the sample. This is particularly important when multiple sample depths are collected from the same push. It is also important to maintain proper orientation to define precisely the depth at which an aliquot was collected. Maintaining proper orientation is typically accomplished using vinyl end caps. Convention is to place red caps on the top of the liner and black caps on the bottom to maintain proper sample orientation. Orientation can also be indicated by marking on the exterior of the liner with a permanent marker.

- *Core Catchers* – Occasionally the material being sampled lacks cohesiveness and is subject to crumbling and falling out of the sample liner. In cases such as these, the use of core catchers on the leading end of the sampler may help retain the sample until it is retrieved to the surface. Core catchers may only be available in specific materials and should be evaluated for suitability. However, given the limited sample contact that core-catchers have with the sample material, most standard core-catchers available for a tool system will be acceptable.

- *Decontamination* – The cutting shoe and piston rod point are to be decontaminated between each sample, using the procedures specified for the collection of trace organic and inorganic compounds found in Field Equipment and Decontamination – SESDPROC-205, most recent version. Within a borehole, the sample barrel, rods, and drive head may be subjected to an abbreviated cleaning to remove obvious and loose material, but must be cleaned between boreholes using the procedures specified for downhole drilling equipment in Field Equipment and Decontamination – SESDPROC-205, most recent version.

- *Decommissioning* – Boreholes must be decommissioned after the completion of sampling. Boreholes less than 10 feet deep that remain open and do not approach the water table may be decommissioned by pouring 30% solids bentonite grout from the surface or pouring bentonite pellets from the surface, hydrating the pellets in lifts. Boreholes deeper than 10 feet, or any borehole that intercepts groundwater, must be decommissioned by pressure grouting with 30% solids bentonite grout, either through a re-entry tool string or through tremie pipe introduced to within several feet of the borehole bottom.

- *VOC Sample Collection* – Observe precautions for volatile organic compound sample collection found in Section 3 of this procedure.

6 Split Spoon/Drill Rig Methods

6.1 General

Split spoon sampling methods are used primarily to collect shallow and deep subsurface soil samples. All split spoon samplers, regardless of size, are basically split cylindrical barrels that are threaded on each end. The leading end is held together with a beveled threaded collar that functions as a cutting shoe. The other end is held together with a threaded collar that serves as the sub used to attach the spoon to the string of drill rod. Two basic methods are available for use, including the smaller diameter standard split spoon, driven with the drill rig safety hammer, and the larger diameter continuous split spoon, advanced inside and slightly ahead of the lead auger during hollow stem auger drilling. The following sections describe each of the specific sampling methods, along with details specific to each method.

If gravel, concrete, etc. is present at or near the surface, it should be removed before the sample is collected. The depth measurement for the sample begins at the top of the soil horizon, immediately following any removed materials. Turf grass is not typically removed prior to sampling with these devices.

6.2 Standard Split Spoon

A drill rig is used to advance a borehole to the target depth. The drill string is then removed and a standard split spoon is attached to a string of drill rod. Split spoons used for soil sampling must be constructed of stainless steel and are typically 2.0-inches OD (1.5-inches ID) and 18-inches to 24-inches in length. Other diameters and lengths are common and may be used if constructed of the proper material. After the spoon is attached to the string of drill rod, it is lowered into the borehole. The safety hammer is then used to drive the split spoon into the soil at the bottom of the borehole. After the split spoon has been driven into the soil, filling the spoon, it is retrieved to the surface, where it is removed from the drill rod string and opened for sample acquisition.

6.3 Continuous Split Spoon

The continuous split spoon is a large diameter split spoon that is advanced into the soil column inside a hollow stem auger. Continuous split spoons are typically 3 to 5 inches in diameter and either 5 feet or 10 feet in length, although the 5-foot long samplers are most common. After the auger string has been advanced into the soil column a distance equal to the length of the sampler being used it is returned to the surface. The sampler is removed from inside the hollow stem auger and the threaded collars are removed. The split spoon is then opened for sampling.

6.4 Special Considerations When Using Split Spoon Sampling Methods

- Always discard the top several inches of material in the spoon before removing any portion for sampling. This material normally consists of borehole wall material that has sloughed off of the borehole wall after removal of the drill string prior to and during inserting the split spoon.
- Observe precautions for volatile organic compound sample collection found in Section 3, Method 5035.

7 Shelby Tube/Thin-Walled Sampling Methods

7.1 General

Shelby tubes, also referred to generically as thin-walled push tubes or Acker thin-walled samplers, are used to collect subsurface soil samples in cohesive soils and clays during drilling activities. In addition to samples for chemical analyses, Shelby tubes are also used to collect relatively undisturbed soil samples for geotechnical analyses, such as hydraulic conductivity and permeability, to support hydrogeologic characterizations at hazardous waste and other sites.

If gravel, concrete, etc. is present at or near the surface, it should be removed before the sample is collected. The depth measurement for the sample begins at the top of the soil horizon, immediately following any removed materials. Turf grass is not typically removed prior to sampling with this device.

7.2 Shelby Tube Sampling Method

A typical Shelby tube is 30 inches in length and has a 3.0-inch OD (2.875-inch ID) and may be constructed of steel, stainless steel, galvanized steel, or brass. They also typically are attached to push heads that are constructed with a ball-check to aid in holding the contained sample during retrieval. If used for collecting samples for chemical analyses, it must be constructed of stainless steel. If used for collecting samples for standard geotechnical parameters, any material is acceptable.

To collect a sample, the tube is attached to a string of drill rod and is lowered into the borehole, where the sampler is then pressed into the undisturbed material by hydraulic force. After retrieval to the surface, the tube containing the sample is then removed from the sampler head. If samples for chemical analyses are needed, the soil contained inside the tube is then removed for sample acquisition. If the sample is collected for geotechnical parameters, the tube is typically capped, maintaining the sample in its relatively undisturbed state, and shipped to the appropriate geotechnical laboratory.

7.3 Special Considerations When Using Split Spoon Sampling Methods

Observe precautions for volatile organic compound sample collection found in Section 3, Method 5035.

8 Backhoe Sampling Method

8.1 General

Backhoes may be used in the collection of surface and shallow subsurface soil samples. The trenches created by excavation with a backhoe offer the capability of collecting samples from very specific intervals and allow visual correlation with vertically and horizontally adjacent material. If possible, the sample should be collected without entering the trench. Samples may be obtained from the trench wall or they may be obtained directly from the bucket at the surface. The following sections describe various techniques for safely collecting representative soil samples with the aid of a backhoe.

The depth measurement for the sample begins at the top of the soil horizon.

8.2 Scoop-and-Bracket Method

If a sample interval is targeted from the surface, it can be sampled using a stainless steel scoop and bracket. First a scoop and bracket are affixed to a length of conduit and is lowered into the backhoe pit. The first step is to take the scoop and scrape away the soil comprising the surface of the excavated wall. This material likely represents soil that has been smeared by the backhoe bucket from adjacent material. After the smeared material has been scraped off, the original stainless steel scoop is removed and a clean stainless steel scoop is placed on the bracket. The clean scoop can then be used to remove sufficient volume of soil from the excavation wall to make up the required sample volume.

8.3 Direct-from-Bucket Method

It is also possible to collect soil samples directly from the backhoe bucket at the surface. Some precision with respect to actual depth or location may be lost with this method but if the soil to be sampled is uniquely distinguishable from the adjacent or nearby soils, it may be possible to characterize the material as to location and depth. In order to ensure representativeness, it is also advisable to dress the surface to be sampled by scraping off any smeared material that may cross-contaminate the sample.

8.4 Special Considerations When Sampling with a Backhoe

- Do not physically enter backhoe excavations to collect a sample. Use either procedure 8.2, Scoop-and-Bracket Method, or procedure 8.3, Direct-from-Bucket Method to obtain soil for sampling.
- Smearing is an important issue when sampling with a backhoe. Measures must be taken, such as dressing the surfaces to be sampled (see Section 2.3), to mitigate problems with smearing.

- Paint, grease and rust must be removed and the bucket decontaminated prior to sample collection.
- Observe precautions for volatile organic compound sample collection found in Section 3, Method 5035.

SESD PROCEDURE SESDPROC-301-R4:

GROUNDWATER SAMPLING

COPY

Region 4
U.S. Environmental Protection Agency
Science and Ecosystem Support Division
Athens, Georgia

OPERATING PROCEDURE

Title: **Groundwater Sampling**

Effective Date: April 26, 2017

Number: SESDPROC-301-R4

Authors

Name: Brian Striggow
Title: Environmental Engineer
Signature:
Date: 4-20-17

Approvals

Name: John Deatrick
Title: Chief, Field Services Branch
Signature: John Deatrick
Date: 4/24/17

Name: Hunter Johnson
Title: Field Quality Manager, Science and Ecosystem Support Division
Signature:
Date: 4/20/17

Revision History

The top row of this table shows the most recent changes to this controlled document. For previous revision history information, archived versions of this document are maintained by the SESD Document Control Coordinator on the SESD local area network (LAN).

History	Effective Date
SESDPROC-301-R4, Groundwater Sampling, replaces SESDPROC-301-R3. **General:** Corrected any typographical, grammatical, and/or editorial errors. **General:** An extensive rewrite and reorganization of material. Stronger support of low-flow methods while maintaining cautious view of minimal/no purge methods.	April 26, 2017
SESDPROC-301-R3, Groundwater Sampling, replaces SESDPROC-301-R2.	**March 6, 2013**
SESDPROC-301-R2, Groundwater Sampling, replaces SESDPROC-301-R1.	**October 28, 2011**
SESDPROC-301-R1, Groundwater Sampling, replaces SESDPROC-301-R0.	**November 1, 2007**
SESDPROC-301-R0, Groundwater Sampling, Original Issue	**February 05, 2007**

TABLE OF CONTENTS

1 General Information

1.1 Purpose

This document describes general and specific procedures, methods and considerations to be used and observed when collecting groundwater samples for field screening or laboratory analysis.

1.2 Scope/Application

The procedures contained in this document are to be used by field personnel when collecting and handling groundwater samples in the field. On the occasion that SESD field personnel determine that any of the procedures described are either inappropriate, inadequate or impractical and that another procedure must be used to obtain a groundwater sample, the variant procedure will be documented in the field logbook, along with a description of the circumstances requiring its use. Mention of trade names or commercial products in this operating procedure does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and has been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD Local Area Network (LAN). The Document Control Coordinator (DCC) is responsible for ensuring the most recent version of the procedure is placed on the LAN and for maintaining records of review conducted prior to its issuance.

1.4 References

International Air Transport Authority (IATA). Dangerous Goods Regulations, Most Recent Version

Interstate Technology & Regulatory Council, Technology Overview of Passive Sampler Technologies, Prepared by The Interstate Technology & Regulatory Council Diffusion Sampler Team, March 2006.

Nielsen, David. *Practical Handbook of Environmental Site Characterization and Ground-Water Monitoring*. 2nd ed. Boca Raton, FL: Taylor&Francis, 2006. Print.

Puls, Robert W., and Michael J. Barcelona. 1989. Filtration of Ground Water Samples for Metals Analysis. Hazardous Waste and Hazardous Materials 6(4), pp.385-393.

Puls, Robert W., Don A. Clark, and Bert Bledsoe. 1992. Metals in Ground Water: Sampling Artifacts and Reproducibility. Hazardous Waste and Hazardous Materials 9(2), pp. 149-162.

SESD Guidance Document, Design and Installation of Monitoring Wells, SESDGUID-001, Most Recent Version

SESD Operating Procedure for Control of Records, SESDPROC-002, Most Recent Version

SESD Operating Procedure for Sample and Evidence Management, SESDPROC-005, Most Recent Version

SESD Operating Procedure for Logbooks, SESDPROC-010, Most Recent Version

SESD Operating Procedure for Field Sampling Quality Control, SESDPROC-011, Most Recent Version

SESD Operating Procedure for Field pH Measurement, SESDPROC-100, Most Recent Version

SESD Operating Procedure for Field Specific Conductance Measurement, SESDPROC-101, Most Recent Version

SESD Operating Procedure for Field Temperature Measurement, SESDPROC-102, Most Recent Version

SESD Operating Procedure for Field Turbidity Measurement, SESDPROC-103, Most Recent Version

SESD Operating Procedure for Groundwater Level and Well Depth Measurement, SESDPROC-105, Most Recent Version

SESD Operating Procedure for Management of Investigation Derived Waste, SESDROC-202, Most Recent Version

SESD Operating Procedure for Pump Operation, SESDPROC-203, Most Recent Version

SESD Operating Procedure for Field Equipment Cleaning and Decontamination, SESDPROC-205, Most Recent Version

SESD Operating Procedure for Field Equipment Cleaning and Decontamination at the FEC, SESDPROC-206, Most Recent Version

SESD Operating Procedure for Potable Water Supply Sampling, SESDPROC-305, Most Recent Version

United States Environmental Protection Agency (US EPA). 1975. Handbook for Evaluating Water Bacteriological Laboratories. Office of Research and Development (ORD), Municipal Environmental Research Laboratory, Cincinnati, Ohio.

US EPA. 1977. Sampling for Organic Chemicals and Microorganisms in the Subsurface. EPA-600/2-77/176.

US EPA. 1978. Microbiological Methods for Monitoring the Environment, Water and Wastes. ORD, Municipal Environmental Research Laboratory, Cincinnati, Ohio.

US EPA. 1981. "Final Regulation Package for Compliance with DOT Regulations in the Shipment of Environmental Laboratory Samples," Memo from David Weitzman, Work Group Chairman, Office of Occupational Health and Safety (PM-273), April 13, 1981.

US EPA. 1995. Ground Water Sampling - A Workshop Summary. Proceedings from the Dallas, Texas November 30 – December 2, 1993 Workshop. ORD, Robert S. Kerr Environmental Research Laboratory. EPA/600/R-94/205, January 1995.

US EPA 1996. Ground Water Issue. Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures. ORD, Robert W. Puls and Micael Barcelona. EPA/540/S-95/504, April 1996

US EPA. Analytical Services Branch Laboratory Operations and Quality Assurance Manual. Region 4 SESD, Athens, GA, Most Recent Version

US EPA. Safety, Health and Environmental Management Program Procedures and Policy Manual. Region 4 SESD, Athens, GA, Most Recent Version

Varljen, M., Barcelona, M., Obereiner, J., & Kaminski, D. (2006). Numerical simulations to assess the monitoring zone achieved during low-flow purging and sampling. *Ground Water Monitoring and Remediation*, 26(1), 44-52.

1.5 General Precautions

1.5.1 Safety

Proper safety precautions must be observed when collecting groundwater samples. Refer to the SESD Safety, Health and Environmental Management Program (SHEMP) Procedures and Policy Manual and any pertinent site-specific Health and Safety Plans (HASP) for guidelines on safety precautions. These guidelines, however, should only be used to complement the judgment of an experienced professional. The reader should address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate.

1.5.2 Procedural Precautions

The following precautions should be considered when collecting groundwater samples.

- Special care must be taken not to contaminate samples. This includes storing samples in a secure location to preclude conditions which could alter the properties of the sample. Samples shall be custody sealed during long-term storage or shipment.
- Always sample from the anticipated cleanest, i.e., least contaminated location, to the most contaminated location. This minimizes the opportunity for cross-contamination to occur during sampling.
- Collected samples must remain in the custody of the sampler or sample custodian until the samples are relinquished to another party.
- If samples are transported by the sampler, they will remain under his/her custody or be secured until they are relinquished.
- Chain-of-custody documents shall be filled out and remain with the samples until custody is relinquished.
- Shipped samples shall conform to all U.S. Department of Transportation (DOT) rules of shipment found in Title 49 of the Code of Federal Regulations (49 CFR parts 171 to 179), and/or International Air Transportation Association (IATA) hazardous materials shipping requirements found in the current edition of IATA's Dangerous Goods Regulations.
- Documentation of field sampling is done legibly, completely, and neatly in a bound logbook.

2 Special Sampling Considerations

2.1 Volatile Organic Compounds (VOC) Analysis

Groundwater samples for VOC analysis must be collected in 40 ml glass vials with Teflon® septa. The vial may be either pre-preserved with concentrated hydrochloric acid or they may be unpreserved. Preserved samples have a two-week holding time, whereas unpreserved samples have only a seven-day holding time. In the majority of cases, the preserved vials are used to take advantage of the extended holding time. In some situations, however, it may be necessary to use the unpreserved vials. For example, if the groundwater has a high amount of dissolved limestone, i.e., is highly calcareous, there will likely be an effervescent reaction between the hydrochloric acid and the water, producing large numbers of fine bubbles and rendering the sample unacceptable. In this case, unpreserved vials should be used and arrangements confirmed with the laboratory to ensure that they can accept the unpreserved vials and meet the shorter sample holding times.

The samples should be collected with as little agitation or disturbance as possible. The vial should be filled so that there is a meniscus at the top of the vial and no bubbles or headspace should be present in the vial after it is capped. After the cap is securely tightened, the vial should be inverted and tapped on the palm or knuckle to check if any undetected bubbles are dislodged. If a bubble or bubbles are present, the vial should be topped off using a minimal amount of sample to re-establish the meniscus. Care should be taken not to flush any preservative out of the vial during topping off. If, after topping off and capping the vial, bubbles are still present, a new vial should be obtained and the sample re-collected. While the 8260 method allows for bubbles up to 6 mm at the time of analysis, dissolved or entrained gases can coalesce during shipment. Collecting VOC vials absent of bubbles is generally feasible and is a reasonable precaution.

2.2 Special Precautions for Trace Contaminant Groundwater Sampling

- Sampling equipment must be constructed of Teflon® or stainless steel materials. Bailers and pumps should be of Teflon® and stainless steel construction throughout.
- New Teflon® tubing should be used at each well, although tubing dedicated to a particular well may be reused, either after decontamination or storage in the well between sampling events. Caution is appropriate in reusing tubing where early sampling events report high concentrations of contaminants.
- A clean pair of new, non-powdered, disposable gloves will be worn each time a different location is sampled and the gloves should be donned immediately prior to sampling. The gloves should not come in contact with the media being sampled and should be changed any time during sample collection when their cleanliness is compromised.
- Sample containers for samples suspected of containing high concentrations of contaminants shall be stored separately.

- Sample collection activities shall proceed progressively from the least suspected contaminated area to the most suspected contaminated area if purging and sampling devices are to be reused. Samples of waste or highly contaminated media must not be placed in the same cooler as environmental (i.e., containing low contaminant levels) or background samples.
- If possible, one member of the field sampling team should take all the notes and photographs, fill out tags, etc., while the other members collect the samples.
- Clean plastic sheeting will be placed on the ground at each sample location to prevent or minimize contaminating sampling equipment by accidental contact with the ground surface.
- Samplers must use new, verified certified-clean disposable or non-disposable equipment cleaned according to procedures contained in SESD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205) or SESD Operating Procedure for Field Equipment Cleaning and Decontamination at the FEC (SESDPROC-206) for collection of samples for trace metals or organic compound analyses.

2.3 Sample Handling and Preservation Requirements

1. Groundwater samples will typically be collected from the discharge line of a pump or from a bailer. Efforts should be made to reduce the flow from either the pump discharge line or the bailer during sample collection to minimize sample agitation.

2. During sample collection, make sure that the pump discharge line or the bailer does not contact the sample container.

3. Place the sample into appropriate, labeled containers. Samples collected for VOC, and alkalinity analysis must be collected without headspace. All other sample containers must be filled with an allowance for ullage.

4. All samples requiring preservation must be preserved as soon as practically possible, ideally immediately at the time of sample collection. If pre-preserved VOC vials are used, these will be preserved with concentrated hydrochloric acid by Analytical Services Branch (ASB) personnel prior to departure for the field investigation. For all other chemical preservatives, SESD will use the appropriate chemical preservative generally stored in an individual single-use vial as described in the SESD Operating Procedure for Field Sampling Quality Control (SESDPROC-011). The adequacy of sample preservation will be checked after the addition of the preservative for all samples except for the samples collected for VOC analysis. If additional preservative is needed, it should be added to achieve adequate preservation. Preservation requirements for groundwater samples are found in the USEPA Region 4 Analytical Services Branch Laboratory Operations and Quality Assurance Manual (ASBLOQAM), most recent version.

5. Sample containers should be placed in an ice-filled cooler as soon as possible after filling. Ice in coolers should be in bags with minimal pooled water and the cooler should be periodically checked and replenished to maintain sample storage temperature.

2.4 Quality Control

Equipment blanks should be collected if equipment is field cleaned and re-used on-site or if necessary to document that low-level contaminants were not introduced by pumps, bailers, tubing, or other sampling equipment.

Where appropriate, a background sample upgradient of all known influences or a control sample upgradient of site influences may be indicated. Background and control samples should be collected as close to the sampled area as possible and from the same water-bearing formation as the site samples.

2.5 Records

Information generated or obtained by SESD personnel will be organized and accounted for in accordance with SESD records management procedures found in SESD Operating Procedure for Control of Records, SESDPROC-002. Field notes, recorded in a bound field logbook, will be generated, as well as chain-of-custody documentation in accordance with SESD Operating Procedure for Logbooks, SESDPROC-010 and SESD Procedure for Sample and Evidence Management, SESDPROC-005.

3 Groundwater Purging and Sampling

3.1 Overview of Purging and Sampling Strategies

Purging is the process of removing stagnant water from a well, immediately prior to sampling, causing its replacement by groundwater from the adjacent formation that is representative of aquifer conditions. Sampling is the process of obtaining, containerizing, and preserving (when required) a ground water sample after the purging process is complete. There are several approaches to well purging and sampling that may be appropriate in various circumstances or for various combinations of available equipment. They are briefly summarized below and in *Table 1, Purge and Sample Strategies with Equipment Considerations.*

The M**ultiple-Volume Purge** method involves removing a minimum of three well volumes of water from the top of the water column and then sampling when the well has achieved stability of water quality parameters and adequately low turbidity. This is a traditional method and consistent results are generally obtained with samplers of varying skill. A drawback is that large volumes of purge water may be produced for large diameter or deep wells.

The **Low-Flow** method involves purging the well at a relatively low flow rate that minimizes drawdown, with the pump or tubing inlet located within the screened interval of the well. The well is sampled when water quality parameters are stable, adequately low turbidity is achieved, and the water level has achieved a stable drawdown (an unchanging water level). This method is often faster than Multiple-Volume Purge and generates less purge water. The method requires more skill and judgment on the part of the samplers.

The **Multiple-Volume Purge** method and the **Low-Flow** method can be considered equivalent for conventionally screened and filter-packed wells in that they both sample a flow-weighted average of water entering the well during pumping. However, other variables can result in differences between results with the two methods. In repeat sampling events, the sampling design should not change from one method to the other without appropriate cause. The transition should be noted in the report.

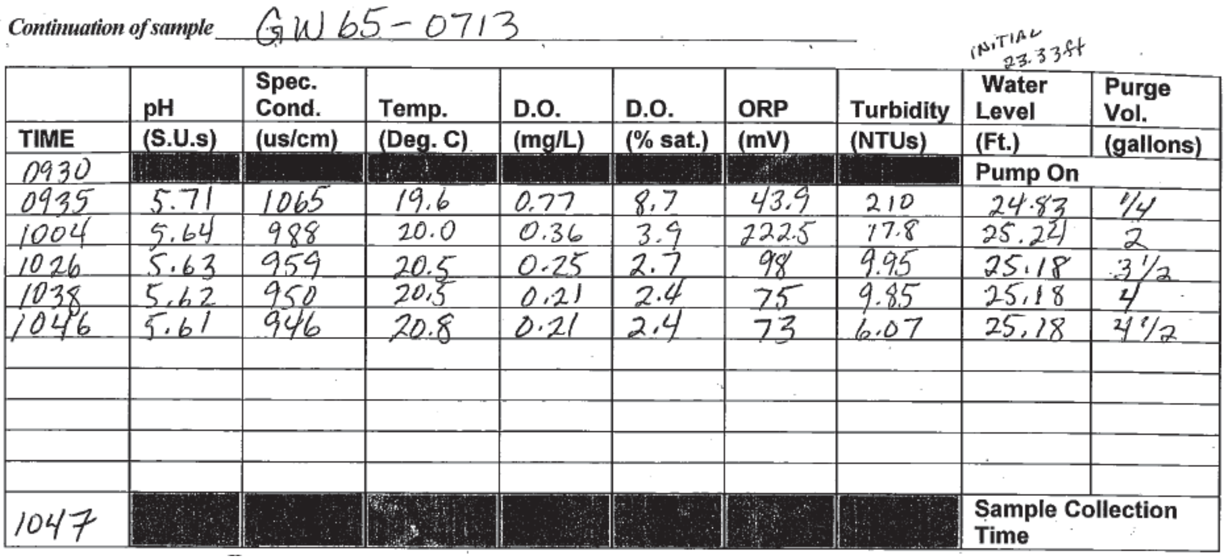
Minimum-Purge and **No-Purge** methods are based on the assumption that water within the screened interval of the well is at equilibrium with the water in the surrounding aquifer. This assumption should be carefully considered in the use of these methods and various cautions are discussed in sections below. The minimal-purge and no-purge methods are most useful for long-term monitoring and are generally inappropriate for the early stages of investigation. In some cases the methods might be used to gather screening-level data from wells that are too large to practically purge or have other sampling complications.

The **Minimum-Purge** and **No-Purge** methods collect water in the vicinity of the device under near-static conditions and are not equivalent to the multiple-volume purge and Low-Flow methods. Stratification of horizontal flow or vertical flow conditions within the well can result in non-intuitive and deceptive results. A comparison study should be conducted before transitioning a sampling program to the minimal-purge or no-purge methods.

3.2 Purging

Wells are purged to eliminate stagnant water residing in the casing and/or screen that has undergone geochemical changes or loss of VOCs. At the conclusion of purging, the desired flow-weighted average of water entering the well under pumping conditions will be available for sampling. Turbidity is often elevated during purging by the disturbance of formation materials at the borehole walls. As many contaminants (metals and many organics) will sorb to the formation particles, a sample including these particles will not represent the dissolved concentrations of the contaminants. Thus, a secondary goal of purging is to reduce the turbidity to the point that the sample will represent the dissolved concentration of contaminants.

In order to determine when a well has been adequately purged, field investigators should monitor, at a minimum, the pH, specific conductance and turbidity of the groundwater removed and the volume of water removed during purging. The measurements should be recorded in a purge table in the field logbook that includes the start time of purging, the parameter measurements at intervals during purging, estimated pumped volumes, depths to water for Low-Flow sampling, and any notes of unusual conditions. A typical purge table used for Low-Flow sampling is reproduced below.



Continuation of sample GW 65-0713

INITIAL 23.33 ft

TIME	pH (S.U.s)	Spec. Cond. (us/cm)	Temp. (Deg. C)	D.O. (mg/L)	D.O. (% sat.)	ORP (mV)	Turbidity (NTUs)	Water Level (Ft.)	Purge Vol. (gallons)
0930								Pump On	
0935	5.71	1065	19.6	0.77	8.7	43.9	210	24.83	1/4
1004	5.64	988	20.0	0.36	3.9	222.5	17.8	25.24	2
1026	5.63	959	20.5	0.25	2.7	98	9.95	25.18	3 1/2
1038	5.62	950	20.5	0.21	2.4	75	9.85	25.18	4
1046	5.61	946	20.8	0.21	2.4	73	6.07	25.18	4 1/2
1047								Sample Collection Time	

3.3 Parameter Stabilization Criteria

With respect to the ground water chemistry, an adequate purge is achieved when the pH and specific conductance of the ground water have stabilized and the turbidity has either stabilized or is below 10 Nephelometric Turbidity Units (NTUs) (twice the Secondary Drinking Water Standard of 5 NTUs).

Stabilization occurs when, for at least three consecutive measurements, the pH remains constant within 0.1 Standard Unit (SU) and specific conductance varies no more than 5 percent. Other parameters, such as dissolved oxygen (DO) or oxidation-reduction potential (ORP), may also be used as a purge adequacy parameter. Normal stability goals for DO are 0.2 mg/L or 10% change in saturation, whichever is greater. DO and ORP measurements must be conducted using either a flow-through cell or an over-topping cell to minimize oxygenation of the sample during measurement. A reasonable ORP stability goal is a range of 20 mV, although ORP is rarely at equilibrium in environmental media and often will not demonstrate enough stability to be used as a purge stabilization parameter. Determining the frequency of measurements has generally been left to ‘Best Professional Judgement’. Care is in order, as measurements recorded at frequent intervals with low flow rates can falsely indicate stability of parameters. Several measurements should be made early in the well purge to establish the direction and magnitude of trends, which can then inform the stability decision. Stability parameters should either be not trending, or approaching an asymptote, when a stability determination is made. As a matter of practice, parameter measurements are generally made at 5-10 minute intervals.

Because the measured groundwater temperature during purging is subject to changes related to surface ambient conditions and pumping rates, its usefulness is subject to question for the purpose of determining parameter stability. As such, it has been removed from SESD’s list of parameters used for stability determination. Even though temperature is not used to determine stability, it is still advisable to record the temperature of purge water as it is often used in the interpretation of other parameters.

Information on conducting the stability parameter measurements is available in the SESD Operating Procedures for Field pH Measurement (SESDPROC-100), Field Specific Conductance Measurement (SESDPROC-101), Field Temperature Measurement (SESDPROC-102), Field Turbidity Measurement (SESDPROC-103), Field Measurement of Dissolved Oxygen (SESDPROC-106) and Field Measurement of Oxidation-Reduction Potential (SESDPROC-113).

Table 1, Purge and Sample Strategies with Equipment Considerations

Purging Strategy	Purge Eqpt	Sample Eqpt	Comments
Multi-Volume Purge	-------------------------------	-------------------------------	Overall Method Comments- Advantages: Consistent results can be achieved with minimal skill level required. Common, simple equipment can be used. Disadvantages: Can result in large volumes of purge water. Can take extended periods of time with large diameter wells or long water columns.
In this traditional method, 3-5 well volumes of water are removed from the top of the water column while verifying the stability of water quality parameters. Following the well purge, the well is sampled from the top of the water column.	Bailer	Bailer	Bailers are rarely used for purging due to the effort required, the difficulty of lowering turbidity adequately, and the possibility of aerating the upper water column.
	Electric Submersible Pump	Bailer	Common multiple-volume setup when depth to water exceeds 25 feet. Abbreviated pump decontamination procedure can be used between wells.
	Electric Submersible Pump	Electric Submersible Pump	Requires full pump decontamination and new tubing at each well. In most cases the pump would be deployed to the screened interval instead to perform Low-Flow sampling.
	Peristaltic Pump	Peristaltic Pump	Common, multi-volume setup when depth to water is less than 25 feet. Special sampling techniques are required for the collection of SVOCs and VOCs.
Low-Flow methods	-------------------------------	-------------------------------	Overall Method Comments- Advantages: Lower volumes of purge water. May be faster, especially with longer water columns. Disadvantages: Requires greater skill for consistent results. Higher tubing costs than multi-volume method.
The pump or tubing inlet is placed within the screened interval and the well is purged to stable water quality parameters while maintaining stable drawdown of the water level.	Electric Submersible Pump	Electric Submersible Pump	Commonly used when depth to water exceeds 25 feet. Pump is cleaned to sample equipment standards prior to sampling each well and new or dedicated tubing used for each well. Concerns have been raised concerning VOC loss from agitation in the turbine section or from sample heating.
	Peristaltic Pump	Peristaltic Pump	Commonly used where depth to water is less than 25 feet. Special sampling techniques required for the collection of SVOCs and VOCs. Concerns have been raised concerning VOC loss from vacuum created in sample tubing.
	Bladder Pump	Bladder Pump	Least danger of VOC loss as entire sample train is under positive pressure and little sample heating occurs. Difficult to remove large volumes of water in reasonable time. Mild surging effect may keep turbidity elevated in sensitive wells.
Minimum-Purge, No-Purge Methods	-------------------------------	-------------------------------	Overall Method Comments- Advantages: Very little or no waste water. Well suited to repeat sampling events. Likely faster with lower costs. Disadvantages: Not directly equivalent to other methods. Vertical stratification or vertical flow conditions in the screened interval can result in deceptive or non-intuitive analytical results.
Predicated on the assumption that aquifer flow through the well maintains the water in the screened interval in a state equivalent to that in the aquifer. This assumption should be proven or the data qualified. Sampling is conducted with little or no purge, or by equilibrating a sampler in screened interval.	Pumps, various	Pumps, various	In the minimum-purge method, the internal volume of the sample tubing and pump is calculated. One volume of the pump and tubing is purged to flush the equipment and the well is then sampled.
	na	Passive Diffusion Bags	In most common form, a sealed water-filled polyethylene bag is allowed to equilibrate in the water column. Suitable primarily for VOCs. Generally require 2 week minimum in-situ residence time.
	na	Hydrasleeves	Collect a fixed volume of water from a specific interval. Requires duplicate samplers or redeployment for larger volumes. Sorbtion issues may bias results.
	na	Snap sampler	Deploys a sample container in the sampling interval where it is allowed to equilibrate (commonly for two weeks) before being sealed insitu by the sampler mechanism and retrieved. Limited to specific containers.

3.4 Multiple-Volume Purge

In the traditional Multiple-Volume Purge method, water is removed from the top of the water column, causing water to enter the screen and flush stagnant casing water upward to be subsequently removed. In recognition of the mixing of fresh and stagnant water in the casing section, a minimum of three well volumes is removed, at which time purging can be terminated upon parameter stabilization. Wells can be assumed to be adequately purged when five well volumes have been removed, although further purging may be conducted to meet specific goals, such as further reduction of turbidity.

3.4.1 Purge Volume Determination

Prior to initiating the purge, the amount of water standing in the water column (water inside the well riser and screen) should be determined The diameter of the well is determined and the water level and total depth of the well measured and recorded prior to inserting a pump or tubing into the well. The water level is subtracted from the total depth, providing the length of the water column. Specific methodology for obtaining these measurements is found in SESD Operating Procedure for Groundwater Level and Well Depth Measurement (SESDPROC-105).

Once this information is obtained, the volume of water to be purged can be determined using one of several methods. The well volume can be calculated using the equation:

$$V = 0.041\ d^2h$$

Where:
h = length of water column in feet
d = diameter of well in inches
V = one well volume in gallons

Alternatively, the volume of standing water in the well and the volume of three water columns may be determined using a casing volume per foot factor for the appropriate diameter well, such as *Table 2 Well Casing Diameter Volume Factors*. The water column length is multiplied by the appropriate factor in the Table 2 to determine the single well volume, three well volumes, or five well volumes for the well in question. Other acceptable methods include the use of nomographs or other equations or formulae.

TABLE 2, WELL CASING DIAMETER VOLUME FACTORS

		Reference	Minimum purge	Maximum purge*
		1 Well Volume (gallons/ft)	3 Well Volumes (gallons/ft)	5 Well Volumes (gallons/ft)
Well Casing Diameter (in)	0.5	0.01	0.03	0.05
	0.75	0.02	0.07	0.11
	1	0.04	0.12	0.20
	2	0.16	0.49	0.82
	3	0.37	1.1	1.8
	4	0.65	2.0	3.3
	5	1.0	3.1	5.1
	6	1.5	4.4	7.3
	7	2.0	6.0	10.0
	8	2.6	7.8	13.1
	9	3.3	9.9	16.5
	10	4.1	12.2	20.4
	11	4.9	14.8	24.7
	12	5.9	17.6	29.4
	13	6.9	20.7	34.5
	14	8.0	24.0	40.0
	15	9.2	27.5	45.9
	16	10.4	31.3	52.2
	18	13.2	39.7	66.1
	24	23.5	70.5	118
	36	52.9	159	264
	48	94.0	282	470

*** See text for discussion on terminating purge at five well volumes**

An adequate purge is normally achieved when three to five well volumes have been removed. The field notes should reflect the single well volume calculations or determinations, according to one of the above methods, and a reference to the appropriate multiplication of that volume, i.e., a minimum three well volumes, clearly identified as an initial purge volume goal.

3.4.2 Pumping Conditions

The pump or tubing inlet should be located at the top of the water column. If the pump is placed deep into the water column, the water above the pump may not be removed, and the subsequent samples, particularly if collected with a bailer, may not be representative of the aquifer conditions. If the recovery rate of the well is faster than the pump rate and no observable draw down occurs, the pump should be raised until the intake is as close as possible to the top of the water column for the duration of purging. If the pump rate exceeds the recovery rate of the well, the pump or tubing will have to be lowered to accommodate the drawdown.

3.4.3 Stability of Chemical Parameters

In the multiple-volume purge method, a stability determination may be made after three well volumes have been removed. If the chemical parameters have not stabilized according to the above criteria, additional well volumes (up to a total of five well volumes) should be removed. If the parameters have not stabilized after the removal of five well volumes, it is at the discretion of the project leader whether or not to collect a sample or to continue purging. If, after five well volumes, pH and conductivity have stabilized and the turbidity is still decreasing and approaching an acceptable level, additional purging should be considered to obtain the best sample possible.

3.4.4 Sample Collection

There are several means by which sampling can proceed after adequate volume has been purged and water quality parameters have stabilized. If a submersible pump and tubing are of suitable material and cleanliness for sample collection, sampling can proceed immediately by directly filling bottles from the tubing outlet. Commonly with the multiple-volume purge method, the pump is set up and cleaned in a manner suitable only for purging. In these cases, the pump is stopped and removed from the well and sampling proceeds with a bailer per the procedure described in Section 3.6.3. The pump should have a check valve to prevent water in the pump tubing from discharging back into the well when the pump is stopped. If a peristaltic pump is used, sampling can proceed as described in Section 3.6.1.

3.5 Low-Flow Method

This method involves placing the pump or tubing inlet within the screened interval of the well and purging at a low enough rate to achieve stable drawdown and minimal depression of the water level. The well is sampled without interruption after field parameters are stable and low turbidity is achieved. In general, only water in the screened interval of the well is pumped and the stagnant water in the well casing above the screen is not removed. Wells can generally be sampled in less time with less purge volume than with the multi-volume purge method. More attention is required in the assessment of stability criteria than the multi-volume method.

3.5.1 Nomenclature

A variety of terminology has been used to describe this method by SESD and others, including: ‘low flow’, ‘low-flow/low-volume’, ‘tubing-in-screen method’, ‘low flow/ minimal drawdown’, and ‘micropurge’. The current preferred SESD terminology for this method is ‘Low-Flow’. As the term ‘micropurge’ is sometimes used to refer to minimal-purge methods and has been trademarked by a vendor, the use of ‘micropurge’ to describe the Low-Flow method generally introduces ambiguity and confusion and thus the use of the term is discouraged.

3.5.2 Placement of Pump Tubing or Intake

The inlet of the pump tubing or intake of the submersible pump is placed in the approximate mid-portion of the screened interval of the well. While it is often thought that particular aquifer zones can be targeted by specific pump or intake placement, for conventionally constructed screened and filter-packed monitoring wells the zone monitored is only weakly dependent on the intake placement (Varljen, Barcelona, Obereiner & Kaminski, 2006).

The pump or tubing can be placed by carefully lowering them to the bottom of the well and then withdrawing half of the screen length, plus the length of any sump sections at the bottom of the well. A drawback of this approach is that it may stir up sediment at the well bottom. An alternate approach is to lower the pump or tubing a measured distance to place it at mid-screen without touching the bottom of the well. In the case of pumps, special care should be used in lowering them slowly, especially in the screened interval, to prevent elevating turbidity needlessly by the surging action of the pump.

3.5.3 Conditions of Pumping

Prior to initiation of pumping, a properly decontaminated well sounder should be lowered into the well to measure the water level prior to and during the purging process. Ideally, there should be only a slight and stable drawdown of the water column after pumping begins. In some cases, it will be necessary for the well to drawdown a considerable distance (10 ft or more in extreme cases) to maintain a minimal usable pumping rate for sampling (100-200 ml/min). Excessive pump rates and drawdown can result in increased turbidity, or aeration of the sample if the screen is exposed. Stable drawdown is an essential condition of the Low-Flow method. If the stable drawdown condition cannot be met, then one of the other methods should be employed.

3.5.4 Stability of Chemical Parameters

As with the Multiple-Volume Purging method described, it is important that all chemical parameters be stable prior to sampling. It is common for wells to require the removal of one of more screened-interval volumes (~2 gal for a 10 ft screen in a 2” dia. well) to achieve stability. Although it is possible for wells to achieve stability with lower purge volumes, the sampler should exercise caution in making an early stability determination.

3.5.5 Sample Collection

Low-Flow sampling is implemented using a pump and tubing suitable for sampling. After making the determination of parameter stability with stable drawdown, sampling can proceed immediately. Where submersible or bladder pumps are used, sampling can proceed by directly filling bottles from the tubing outlet. Where peristaltic pumps are used, sampling can proceed per the procedure described in Section 3.6.3.

3.6 Minimum-Purge and No-Purge Sampling

The Minimum-Purge and No-Purge sampling methods are employed when it is necessary to keep purge volumes to an absolute minimum, where it is desirable to reduce long-term monitoring costs, or where large wells or other limitations prevent well purging. The underlying assumption when employing these methods is that the water within the well screen is equilibrated with the groundwater in the associated formation. This assumption should be demonstrated prior to use of these methods or the results suitably qualified. These methods are generally impractical for SESD to implement because of the common lack of hydrogeological information in early investigative phases and the necessity with some methods that the samplers be pre-deployed to allow equilibration.

Vertical flow conditions and stratification of the water column have also been known to result in deceptive and non-intuitive analytical results. The use of these methods in the early phases of investigation can easily result in misinterpretation of site conditions and plume boundaries.

Particular caution is in order in the use of these methods when any of the following conditions exist:

- Low hydraulic conductivity ($K<10^{-5}$ cm/sec)
- Low groundwater surface gradients
- Fractured bedrock
- Wells with long screened intervals
- Wells screened in materials of varying hydraulic conductivities

If it is desired to transition a long-term monitoring program to Minimum-Purge or No-Purge sampling, a pilot study should be conducted where the Minimum-Purge or No-Purge sample results are compared to the conventional methods in use. Multiple samplers may be deployed in the screened interval to help establish appropriate monitoring intervals.

These methods are in common use and for the purposes of the SESD quality system they can be considered standard, but unaccredited, procedures. Several Minimum-Purge or No-Purge procedures that might be employed are shown below. It is not the intention to recommend particular equipment or vendors, and other equipment that can accomplish the same goals may be suitable.

3.6.1 Minimum Purge Sampling

The pump or tubing inlet is deployed in the screened interval. A volume of water equal to the internal pump and tubing volume is pumped to flush the equipment. Sampling then proceeds immediately. While superficially similar to Low-Flow sampling, the results obtained in this method will be sensitive to the vertical pump or tubing inlet placement and are subject to the limitations described above.

3.6.2 Passive Diffusion Bags

The no-purge Passive Diffusion Bag (PDB) typically consists of a sealed low-density polyethylene (LDPE) bag containing deionized water. They are deployed in the screened interval of a well and allowed to equilibrate, commonly for two weeks, prior to retrieval and decanting of the water into sample containers. Many volatile organic compounds will reach equilibrium across the LDPE material, including BTEX compounds and many chlorinated solvents. Compounds showing poor equilibration across LDPE include acetone, MTBE, MIBK, and styrene. PDBs have been constructed of other materials for sampling other analytes, but the vast majority of PDB samplers are of the LDPE material. Various vendors and the Interstate Technology and Regulatory Council (ITRC) can provide additional information on these devices.

3.6.3 HydraSleevesTM

HydraSleeeves^{TM} are no-purge grab sampling devices consisting of a closed-bottom sleeve of low-density polyethylene with a reed valve at the top. They are deployed in a collapsed state to the desired interval and fill themselves through the reed valve when pulled upward through the sampling interval. The following is a summary of their operation:

> Sampler placement – A reusable weight is attached to the bottom of the sampler or the sampler is clipped to a weighted line. The HydraSleeve^{TM} is lowered on the weighted line and placed with the top of the sampler at the bottom of the desired sampling interval. In-situ water pressure keeps the reed valve closed, preventing water from entering the sampler. The well is allowed to return to equilibrium.
>
> Sample collection - The reed valve opens to allow filling when the sampler is moved upward faster than 1 foot per second, either in one continuous upward pull or by cycling the sampler up and down to sample a shorter interval. There is no change in water level and only minimal agitation during collection.
>
> Sample retrieval - When the flexible sleeve is full, the reed valve closes and the sampler can be recovered without entry of extraneous overlying fluids. Samples are removed by puncturing the sleeve with the pointed discharge tube and draining the contents into containers for sampling or field parameter measurements.

Because the HydraSleeve™ is retrieved before equilibration can occur and they are constructed of non-Teflon® materials, there may be issues with sorbtion of contaminants in the use of this sampler.

3.6.4 Snap Samplers

The Snap Sampler is a patented no-purge groundwater sampling device that employs a double-end-opening bottle with “Snap” sealing end caps. The dedicated, device is deployed at the desired position in the screened interval with up to six Snap Samplers and six individual sampling bottles. The device is allowed to equilibrate in the screened interval and retrieved between 3 and 14 days after deployment. Longer deployments are possible to accommodate sampling schedules.

To operate, Snap Samplers are loaded with Snap Sampler bottles and the "Snap" caps are set into an open position. Samplers are deployed downhole with an attachment/trigger line and left to equilibrate downhole. To collect samples, the Snap Sampler bottles seal under the water surface by pulling a mechanical trigger line, or using an electric or pneumatic trigger system. The trigger releases Teflon® "Snap Caps" that seal the double-ended bottles. The end caps are designed to seal the water sample within the bottles with no headspace vapor. After the closed vial is retrieved from the well, the bottles are prepared with standard septa screw caps and labeled for laboratory submittal.

The manufacturer of the Snap Sampler provides considerable additional information on the validation and use of the device.

3.7 Equipment Considerations

Equipment choices are dictated by the purging and sampling method used, the depth to water, the quantity of water to be pumped, and quality considerations. The advantages and disadvantages of various commonly used pumps are discussed in the sections below and summarized in *Table 1, Purge and Sample Strategies with Equipment Considerations.* Additional information on the use of individual pumps is available in SESD Operating Procedure for Pump Operation, SESDPROC-203.

3.7.1 Use of Peristaltic Pumps

Peristaltic pumps are simple, inexpensive, and reliable equipment for purging and sampling where the limit of suction is not exceeded (approximately 25-30 vertical feet from the groundwater surface to the pump). When used for sampling, they should be equipped with new Teflon® tubing for each well. The flexible peristaltic pump-head tubing should also be changed between wells.

Samples for organic analyses cannot be exposed to the flexible peristaltic pump-head tubing, both due to the risk that the tubing would sorb contaminants and the propensity of this tubing to contribute organic compounds to the sample. Samples can be collected without contact with the pump-head tubing by the use of vacuum transfer caps for analyses requiring 1 liter glass containers and the use of the 'soda-straw' method for the filling of VOC vials.

The sample containers for the more turbidity-sensitive analyses are filled first, as filling the VOC vials (and to a lesser extent the glass bottles) may disturb the well and increase turbidity. The most appropriate order of sampling with a peristaltic pump is generally to fill poly containers for metals and classical analyses, followed by glass bottles for SVOCs and associated analyses, and finally to fill 40 ml VOC vials.

The following step-by-step procedure assumes that the pump has been set up per SESD Operating Procedure for Pump Operation (SESDPROC-203) and that containers for a typical full suite of analyses will be filled. The procedure is suitable for use with either multi-volume Purge and Low-Flow methods with minor differences in the collection of VOCs:

1. Deploy the lower end of the tubing to the desired point in the well. This would be the top-of-water for the multi-volume purge method or to the mid-screen for the Low-Flow method. Connect the well tubing to the flexible pump-head tubing and connect a short piece of tubing from the pump-head tubing to a measuring bucket.

2. Turn on the pump and establish a suitable pumping rate. For the multi-volume purge method, the rate will generally be a relatively fast rate that the well will sustain without elevating turbidity. For the low-flow method the pump rate is established at a slower rate to maintain a minimal and stable drawdown level.

3. Proceed with the measurement of water quality parameters and adjust the pump rate as needed to achieve low turbidity and stable drawdown.

4. When the well purge has been determined to be sufficient, fill containers for metals and classical analyses directly from the pump outlet. There is no need to interrupt pumping. The tubing should be held at the opening of the container and should not touch the container during filling. Protect caps from dust and debris during filling.

5. After filling the containers for metals and classical analyses stop the pump. Make sure that the tubing leading into the well is secured against movement during the following operations.

6. Create a crimp in the well tubing approximately one foot from the pump and grasp the crimped tubing in one hand. It is generally most effective to create a double 'Z' crimp.

7. Cut the sample tubing between the crimp and the pump. The tightly-held crimped tubing should keep water from running back into the well. In lieu of

cutting the tubing, the well tubing can be disconnected from the pump and a short piece of tubing connected in its place.

8. Insert both free ends of the tubing into the ferrule-nut fittings of a pre-cleaned Teflon® transfer cap assembly and tighten the nuts. Attach the transfer cap assembly to the first glass container for semi-volatile analysis and securely tighten the threaded ring.

9. Turn the pump on. Very slowly release the 'Z' crimp in the sample tubing. As vacuum builds up in the sample container, water should begin to move up the sample tubing instead of back into the well. If after several minutes water has not begun moving up the tubing, check the tightness of fittings and the attachment of the cap to the bottle. Allowing water to rush back down the tubing from the 'Z' crimp can surge the well and elevate turbidity.

10. Fill the container to about halfway between the shoulder and the neck. Crimp the well tubing. Move the transfer cap to any additional bottles and repeat the filling process.

11. When finished filling bottles with the transfer cap, again crimp the tubing. Remove the well tubing from the transfer cap and reattach it to the pump. Slowly run the pump and release the crimp until water is approaching the flexible peristaltic tubing.

12. Make a kink or otherwise mark the tubing at the top of the casing in case the tubing needs to be reinserted for additional sample volume. Slowly remove the tubing from the well and coil it in one hand in loose coils. With the top end of the tubing blocked, water is retained in the tubing as it is withdrawn, much as in a capped soda straw, hence the name for this method.

13. Remove the top from a 40 ml VOC vial and position the end of the sample tubing near the top of the vial. Reverse the pump direction and turn the speed knob to its slowest position. Turn on the pump and slowly increase speed until water slowly fills the vial. Fill the vial with a slow laminar flow that does not agitate the water in the vial or entrain bubbles. Continue to fill the vial until a convex meniscus forms on the top of the vial and turn off the pump.

14. Carefully screw the septum-lid to the vial and fasten firmly. Invert the vial and tap on your knuckles to check for bubbles. Carefully add additional volume to the vial if necessary. Small bubbles are undesirable but may be unavoidable with some media, especially when using pre-preserved vials.

15. Repeat the filling process for additional vials. Avoid partially filling vials as the available water in the tubing is used. If more volume is required than that contained in the tubing, purge the remaining water from the tubing and reinsert

the tubing in the well to the level marked previously. Run the pump to refill the tubing. If performing Low-Flow sampling, run additional volume through the pump to purge any water that may have been collected from the stagnant water column.

16. Fill additional vials as needed. Be sure that any water that has contacted the flexible peristaltic tubing is not pumped into a vial.

3.7.2 Use of Submersible Centrifugal Pumps

Submersible centrifugal pumps are used in wells of 2” diameter and larger. They are especially useful where large volumes of water are to be removed or when the groundwater surface is a large distance below ground surface. Commonly used pumps are the Grundfos® Redi-Flo2, the Geotech GeoSub, and the various ‘Monsoon’ style pumps. Other pumps are acceptable if constructed of suitable materials.

When used with the Multiple-Volume Purge method, the pump is generally used only to purge, with sampling performed with a bailer. In this use, the pump can be used with polyethylene or other tubing or hose that will not contribute contaminants to the well. The pump and tubing is decontaminated between wells per the relevant provisions of SESD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205). When used in this application the pump should be equipped with a check valve to prevent water in the discharge tubing or hose from running back down into the well.

When used for Low-Flow purging and sampling the pump must be constructed of stainless steel and Teflon®. Pump cleaning at each well follows the more stringent procedures described in SESD Operating Procedure for Field Equipment Cleaning and Decontamination SESDPROC-205) for this application. The sample tubing should be either new Teflon® tubing, or tubing dedicated to each well. Dedicated tubing would ideally be cleaned between uses, but tubing stored in the well casing between uses is acceptable, although caution should be exercised where very high concentrations of contaminants have been sampled in a well.

3.7.3 Use of Bailers

Bailers are a common means of sampling when the Multiple-Volume Purge method is used. They are occasionally used for purging when other equipment is not available or has failed. As bailers surge the well on each withdrawal, it is very difficult to lower turbidity adequately during a well purge, and when used for sampling they can elevate turbidity in a well before all sample volume is collected. If not lowered carefully into the top of the water column, the agitation may strip volatile compounds. Due to the difficulties and limitations inherent in their use, other sampling or purging means should generally be given preference.

Bailers should be closed-top Teflon® bailers with Teflon® coated stainless steel leaders used with new nylon haul rope. They are lowered gently into the top of the water column, allowed to fill, and removed slowly. It is critical that bailers be slowly and gently immersed into the top of the water column, particularly during final stages of purging and during sampling, to minimize turbidity and loss of volatile organic constituents.

If the well has previously been purged with a pump, there is likely stagnant water at the top of the well that was above the pump or tubing inlet. Several bailers of water should be retrieved and discarded to assure the upper stagnant water has been removed.

When sampling, containers are filled directly by pouring from the outlet at the top of the bailer. Containers for metals analysis should be filled first in case the bailing process increases well turbidity. VOC vials should be filled carefully and slowly with a laminar flow to reduce agitation and the stripping of VOCs.

3.7.4 Use of Bladder Pumps

Bladder pumps use a source of compressed gas to compress and release a bladder straddled by check valves within the pump body. As the bladder is compressed, water is expelled out the upper check valve to the surface. When gas pressure is released, the bladder refills as well water enters the lower pump inlet. A control unit is used to control the pressure and timing of the bladder inflation gas flow.

Bladder pumps are capable of pumping from moderate depths to water, but are not capable of high flow rates. As they operate cyclically, the well is surged slightly on each cycle and it may be difficult to lower turbidity in sensitive or poorly developed wells. As the entire sample train is under positive pressure and the pumps develop little heat, they are ideal for sampling VOCs.

Prior to sampling and between each well the pumps are cleaned internally and externally per the provisions of SESD Operating Procedure for Field Decontamination (SESDPROC-205) and a new Teflon® bladder installed. New (or dedicated) Teflon® sample tubing is used at each well, although polyethylene tubing can be used for the compressed gas drive line and cleaned between each well.

3.7.5 Use of Inertial Pumps

Inertial pumps consist of a check valve which is affixed to the lower end of semi-rigid tubing. The tubing and valve are cycled up and down, allowing water to alternately be drawn into the check valve inlet and then pulled up towards the surface. Two commonly used inertial pumps are the Waterrra® pump for wells 1arger than 1” and the Geoprobe® Tubing Check Valve for small diameter wells. The primary use of these pumps is in well development where their near-immunity to silt is an advantage. Inertial pumps should not be used for the final well purge or for sampling as there is a low likelihood of reducing turbidity to appropriate levels and they have the potential to strip volatiles from the water column through agitation.

To set up the pump, the check valve is screwed onto the discharge tubing where it will cut its own threads. In the case of the Waterra® pump, a surge block can also be pressed onto the check valve. The pump is lowered into the well to the screened interval and rapidly cycled up and down a distance of 3” -12”. The stroke length and speed are adjusted for pumping effect. Electric actuators can be used to reduce the effort involved. The pump should be moved to different levels in the screen to surge the entire screen. The pump can occasionally be lowered to the bottom of the well to vacuum out silt. Any silt that clogs the valve is usually quickly rinsed out by the pump cycling and if the clog remains the pump is easily retrieved and redeployed.

The surging activity is usually continued until turbidity is lowered to a measurable range and cannot easily be lowered further. Further development or purging is then conducted with other pumps.

3.8 Wells With In-Place Plumbing

Wells with in-place plumbing are commonly found at municipal water treatment plants, industrial water supplies, private residences, and in other applications. Many permanent monitoring wells at active facilities are also equipped with dedicated, in-place pumps.

A permanent monitoring well with an in-place pump may be treated as other monitoring wells without pumps. Since the in-place pump is generally “hard” mounted at a pre-selected depth, it cannot be moved up or down during purging and sampling. If the pump inlet is above the screened interval, the well should be sampled using the Multiple-Volume Purge method. If the pump intake is located within the screened interval, the well can be sampled using Low-Flow procedures. Known details of pump type and construction, tubing types, pump setting depths, and any other available information about the system should be recorded in the field logbook.

In the case of the other types of wells, e.g., municipal, industrial and residential supply wells, there is typically not enough known about the construction aspects of the wells to apply the same criteria as used for monitoring wells. The volume to be purged in these situations therefore depends on several factors: whether the pumps are running continuously or intermittently and whether or not any storage/pressure tanks are located between the sampling point and the pump. The following considerations and procedures should be followed when purging wells with in-place plumbing under the conditions described.

3.8.1 Continuously Running Pumps

If the pump runs more or less continuously, no purge (other than opening a valve and allowing it to flush for a few minutes) is necessary. If a storage tank is present, a spigot, valve or other sampling point should be found located between the pump and the storage tank. If no valve is present, locate and use the valve closest to the tank. Measurements of field parameters are recorded immediately prior to the time of sampling.

3.8.2 Intermittently or Infrequently Running Pumps

If the pump runs intermittently or infrequently, best judgment should be utilized to remove enough water from the plumbing to flush standing water from the piping and any storage tanks that might be present. Often under these conditions, 15 to 30 minutes of purging will be adequate. Measurements of pH, specific conductance, temperature and turbidity should be made and recorded at intervals during the purge and the final measurements made at the time of sampling should be considered the measurements of record for the event.

3.9 Temporary Monitoring Wells

3.9.1 General Considerations

As temporary wells are installed for immediate sample acquisition, the procedures used to purge temporary ground water monitoring wells may differ from those for permanent wells. Temporary wells include standard well screen and riser placed in boreholes created by hand augering or drilling, or they may consist of a drive rod and screen such as a direct-push Geoprobe® Screen Point that is driven into place at the desired sampling interval. As aquifer water enters the sampler immediately upon deployment, the requirement to remove several volumes of water to replace stagnant water does not necessarily apply. In practice, developing and purging the well to usable turbidity levels will remove many times the water that would be removed in a Multiple-Volume Purge with calculated well volumes. It is important to note, however, that the longer a temporary well is in place and not sampled, the more stagnant the water column becomes and the more appropriate it becomes to apply standard permanent monitoring well purging criteria to achieve representative aquifer conditions in the sample.

3.9.2 Development of Temporary Wells

In cases where the temporary well is to be sampled immediately after installation, purging is conducted primarily to mitigate the impacts of installation. In most cases, temporary well installation procedures disturb the existing aquifer conditions, causing extreme turbidity. The goal of purging is to reduce the turbidity and remove the volume of water in the area directly impacted by the installation procedure.

The following procedure has been found to be effective in developing and sampling small diameter temporary wells where a peristaltic pump can be used. Turbidity can generally be lowered to 50 NTU at the time of sampling and turbidity less than 10 NTU is often achieved.

1. Cut peristaltic tubing to reach to the bottom of the well. Connect to a peristaltic pump and begin pumping at a high rate.

2. Use the tubing to vacuum out sediment at the bottom of the well.

3. Aggressively surge the end of the tubing in the screened interval by cycling the tubing rapidly up and down. Periodically repeat vacuuming of the well bottom.

4. When a visible ‘break’ to a lower turbidity is observed, cease surging the well and begin lowering the pumping rate.

5. When the water clears (turbidity < 100-200 NTU) begin raising the end of the tubing to the top of the water column.

6. Continue purging from the top of the water column, lowering the pump speed as required to lower turbidity. When adequately low turbidity and stable water quality parameters have been achieved, sampling can proceed.

Where the water level is below the limit of suction in a small diameter temporary well, a Geoprobe® mechanical bladder pump can be used for purging and sampling. The well should first be developed with an inertial pump to remove the bulk of silt and suspended particles that could clog the check valves of the bladder pump. The inertial pump is used to vacuum out the bottom of the well and surged in the screened interval until a ‘break’ to lower turbidity is observed prior to deployment of the bladder pump. Since the mechanical bladder pump requires cumbersome redeployment to change its pumping level, it should be deployed low enough in the water column that the water level will not be lowered below the pump during purging and sampling. The mechanical bladder pump is generally deployed above the screened interval to facilitate the settling of particles, but below the top of the water column to alleviate the need to reset the pump. Detailed instructions on the deployment of the pump can be found in SESDPROC203, Pump Operation.

3.9.3 Decommissioning of Temporary Wells

After temporary wells have fulfilled their purpose, they should be properly decommissioned similar to permanent wells. In general, the casings and screens can be easily removed and the borehole should then be pressure grouted from the bottom of the original borehole to prevent surface contamination of the aquifer, cross-connection of aquifers, and to remove a potential vapor pathway.

Direct-push screen-point wells may be decommissioned by one of two methods.

1. A disposable screen is used. The sampling sheath is pulled off of the screen and a 30% solids bentonite grout is pumped down the tool string as the rods are withdrawn.

Grout volumes are measured during pumping to assure that the hole is completely filled. The disposable screen is left behind at the bottom of the borehole.

2. The screen is removed with the sampler sheath and tool string. The hole is immediately re-entered with an empty sample sheath with disposable point. Upon reaching the original total depth of the temporary well, 30% solids bentonite grout is pumped down the tool string with the pumped volume monitored during tool string withdrawal to assure that the hole is completely filled.

A system is available to insert a small diameter grouting tube down through the screen-point screen. Grout is pumped through the grouting tube while the tools are withdrawn. SESD does not use this system as grout denser than 20% solids cannot reliably be installed with this system.

Additional guidance on decommissioning may be found in SESDGUID-101, Design and Installation of Monitoring Wells.

3.9.4 Other Considerations for Direct-Push Groundwater Sampling

With certain direct push sampling techniques, such as the Hydropunch™ and other discrete samplers used with cone-penetrometer rigs, purging is either not practical or not possible. The sampling device is simply pushed or driven to the desired depth and opened, whereupon the sample is collected and retrieved. As a result, some samples collected in this way may not be satisfactory or acceptable for certain analyses, i.e., the sampler may collect a turbid sample inappropriate for metals analyses or the sample may have inadequate volume to achieve desired reporting levels.

3.10 Wells Purged to Dryness

In some situations, even with slow purge rates, a well may be purged dry in the Multiple-Volume Purge method or stable drawdown cannot be maintained in the Low-Flow method. In these cases, the well should be purged to dryness (evacuated) and sampled upon recovery of adequate volume for sampling. Sampling should occur as soon as adequate volume has recovered. The field parameters should be measured and recorded at the time of sample collection as the measurements of record for the sampling event.

Sampling under these conditions is not ideal and suitable qualifications of the data should be included in the report. Water cascading down the screen into the well may strip volatile compounds and elevate turbidity. Although suffering from other limitations, No-Purge methods may prove useful for these wells.

4 Additional Purging and Sampling Considerations

4.1 Field Care of Purging Equipment

New plastic sheeting should be placed on the ground surface around the well casing to prevent contamination of the pumps, hoses, ropes, etc., in the event they accidentally come into contact with the ground surface or, for some reason, they need to be placed on the ground during the purging event. It is preferable that hoses used in purging that come into contact with the ground water be kept on a spool or contained in a large wash tub lined with plastic sheeting, both during transportation and during field use, to further minimize contamination by the transporting vehicle or the ground surface.

Careful consideration shall be given to using submersible centrifugal or bladder pumps to purge wells which are excessively contaminated with oily compounds as it may be difficult to adequately decontaminate severely contaminated pumps under field conditions. When wells of this type are encountered, alternative equipment, such as bailers or peristaltic pumps, should be considered.

4.2 Investigation Derived Waste

Purging and field cleaning of equipment generates liquid investigation derived waste (IDW), the disposition of which must be considered. See SESD Operating Procedure for Management of Investigation Derived Waste (SESDPROC-202) for guidance on management or disposal of this waste.

4.3 Sample Preservation

After sample collection, all samples requiring preservation must be preserved as soon as practical. Consult the Analytical Services Branch Laboratory Operations and Quality Assurance Manual (ASBLOQAM) for the correct preservative for the particular analytes of interest. All samples preserved using a pH adjustment (except VOCs) must be checked, using pH strips, to ensure that they were adequately preserved. This is done by pouring a small volume of sample over the strip. Do not place the strip in the sample. Samples requiring reduced temperature storage should be placed on ice immediately.

4.4 Special Sample Collection Procedures

4.4.1 Trace Organic Compounds and Metals

Special sample handling procedures should be instituted when trace contaminant samples are being collected. All sampling equipment, including pumps, bailers, water level measurement equipment, etc., which contacts the water in the well must be cleaned in accordance with the cleaning procedures described in the SESD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205) or SESD Operating Procedure for Field Equipment Cleaning and Decontamination at the FEC (SESDPROC-

206). Pumps should not be used for sampling unless the interior and exterior portions of the pump and the discharge hoses are thoroughly cleaned. Rinse blank samples should be collected to verify the adequacy of cleaning when using a sampling pump other than a peristaltic pump.

4.4.2 Order of Sampling with Respect to Analytes

In many situations when sampling permanent or temporary monitoring wells, sufficiently low turbidity is difficult to achieve and maintain. Removal and insertion of equipment after the purge or during sampling may negate the low turbidities achieved during purging and elevate turbidity back to unacceptable levels. For this reason, it is important that special efforts be used to minimize any disturbance of the water column after purging and to fill sample containers for metals analysis first. The preferred order of sampling is metals first, followed by other inorganic analytes, extractable organic compounds, and finally volatile organic compounds.

4.5 Filtering

As many contaminants are known to sorb to soil particles, the normal goal of sampling is to reduce the presence of these particles (measured by turbidity) in order that the dissolved concentration of contaminants can be obtained. However, transport of sorbed contamination on colloidal particles can be a means of contaminant transport on some sites. For this reason, the SESD approach is to reduce turbidity through the careful purging of wells, rather than through filtering of samples, in order that the colloidal particles would be included in the sample.

As a standard practice, ground water samples will not be filtered for routine analysis. Filtering will usually only be performed to determine the fraction of major ions and trace metals passing the filter and used for flow system analysis and for the purpose of geochemical speciation modeling. Filtration is not acceptable to correct for improperly designed or constructed monitoring wells, inadequate well development, inappropriate sampling methods, or poor sampling technique.

When samples are collected for routine analyses and are filtered, both filtered and non-filtered samples will be submitted for analyses. Samples for organic compounds analysis should not be filtered. Prior to filtration of the ground water sample for any reason other than geochemical speciation modeling, the following criteria must be demonstrated to justify the use of filtered samples for inorganic analysis:

1. The monitoring wells, whether temporary or permanent, have been constructed and developed in accordance with the SESD Guidance Document, Design and Installation of Monitoring Wells (SESDGUID-001).

2. The ground water samples were collected using sampling techniques in accordance with this section, and the ground water samples were analyzed in accordance with USEPA approved methods.

3. Efforts have been undertaken to minimize any persistent sample turbidity problems. These efforts may consist of the redevelopment or re-installation of permanent ground water monitoring wells or the implementation of carefully conducted low flow rate sampling techniques.

If filtration is necessary for purposes of geochemical modeling or other **pre-approved** cases, the following procedures are suggested:

1. Accomplish in-line filtration through the use of disposable, high capacity filter cartridges (barrel-type) or membrane filters in an in-line filter apparatus. The high capacity, barrel-type filter is preferred due to the higher surface area associated with this configuration. If a membrane filter is utilized, a minimum diameter of 142 mm is suggested.

2. When using pumps for sampling, the filter can generally be attached directly to the pump outlet. When sampling with a bailer or when otherwise required, an initial unfiltered sample with extra volume will be collected, and a peristaltic pump with filter used to decant and filter the sample to the final sample container.

3. Use a 0.45 μm pore-size filter to remove most non-dissolved particles. A 5 μm or 10 μm pore-size filter should be used for the purpose of determining colloidal constituent concentrations.

4. Fill the filter and rinse with approximately one additional filter volume prior to filling sample bottles

Potential differences can result from variations in filtration procedures used to process water samples for the determination of trace element concentrations. A number of factors associated with filtration can substantially alter "dissolved" trace element concentrations; these include filter pore size, filter type, filter diameter, filtration method, volume of sample processed, suspended sediment concentration, suspended sediment grain-size distribution, concentration of colloids and colloidally-associated trace elements, and concentration of organic matter. Therefore, consistency is critical in the comparison of short-term and long-term results. Further guidance on filtration may be obtained from the following: 1) Metals in Ground Water: Sampling Artifacts and Reproducibility; 2) Filtration of Ground Water Samples for Metals Analysis; and 3) Ground Water Sampling - A Workshop Summary. See Section 1.4, References, for complete citation for these documents.

4.6 Bacterial Sampling

Whenever wells (normally potable wells) are sampled for bacteriological parameters, care must be taken to ensure the sterility of all sampling equipment and all other equipment entering the well. Further information regarding bacteriological sampling is available in the following: 1) Sampling for Organic Chemicals and Microorganisms in the Subsurface; 2) Handbook for Evaluating Water Bacteriological Laboratories; and 3) Microbiological Methods for Monitoring the Environment, Water and Wastes. See Section 1.4, References, for complete citation for these documents.

4.7 Specific Sampling Equipment Quality Assurance Techniques

All equipment used to collect ground water samples shall be cleaned as outlined in the SESD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205) or SESD Operating Procedure for Field Equipment Cleaning and Decontamination at the FEC (SESDPROC-206). Malfunctioning equipment should be labeled in the field and repaired, before being stored at the conclusion of field studies. Cleaning procedures utilized in the field or field repairs shall be thoroughly documented in field records.

4.8 Auxiliary Data Collection

During ground water sample collection, it is important to record a variety of ground water related data. Included in the category of auxiliary data are water levels measured according to the SESD Operating Procedure for Groundwater Level and Well Depth Measurement (SESDPROC-105), well volume determinations, pumping rates during purging, and, driller or boring logs. This information should be documented in the field records.

4.9 Well Development

Wells may be encountered that are difficult to sample effectively due to inadequate initial development or the need for redevelopment due to scaling, sedimentation, corrosion, or biofouling. These wells may produce water only at low flow rates or water with chronically elevated turbidity. Redevelopment of these wells should be considered as the process can improve sample quality and speed field operations. Well development procedures are described in Design and Installation of Monitoring Wells (SESDGUID-101).

SESD PROCEDURE SESDPROC-100-R4:

FIELD pH MEASUREMENT

COPY

Region 4
U.S. Environmental Protection Agency
Science and Ecosystem Support Division
Athens, Georgia

OPERATING PROCEDURE

Title: **Field pH Measurement**

Effective Date: December 16, 2016

Number: SESDPROC-100-R4

Author

Name: Timothy Simpson
Title: Environmental Scientist
Signature:
Date: 12/14/2016

Approvals

Name: John Deatrick
Title: Chief, Field Services Branch
Signature: John Deatrick
Date: 12/14/16

Name: Hunter Johnson
Title: Field Quality Manager, Science and Ecosystem Support Division
Signature:
Date: 12/14/2016

Revision History

The top row of this table shows the most recent changes to this controlled document. For previous revision history information, archived versions of this document are maintained by the SESD Document Control Coordinator on the SESD local area network (LAN).

History	Effective Date
SESDPROC-100-R4, *Field pH Measurement*, replaces SESDPROC-100-R3 **General:** Corrected any typographical, grammatical, and/or editorial errors. **Title Page:** Changed the Field Quality Manager from Bobby Lewis to Hunter Johnson. Updated cover page to represent SESD reorganization. John Deatrick was not listed as the Chief of the Field Services Branch	December 16, 2016
SESDPROC-100-R3, *Field pH Measurement*, replaces SESDPROC-100-R2	January 29, 2013
SESDPROC-100-R2, *Field pH Measurement*, replaces SESDPROC-100-R1	June 13, 2008
SESDPROC-100-R1, *Field pH Measurement*, replaces SESDPROC-100-R0	November 1, 2007
SESDPROC-100-R0, *Field pH Measurement*, Original Issue	February 05, 2007

TABLE OF CONTENTS

1 General Information

1.1 Purpose

This document describes procedures, methods and considerations to be used and observed when conducting field pH measurements in aqueous phase environmental media, including groundwater, surface water and certain wastewaters.

1.2 Scope/Application

The procedures contained in this document are to be used by field personnel when measuring the pH of aqueous phase environmental media in the field. On the occasion that SESD field personnel determine that any of the procedures described in this section cannot be used to obtain pH measurements of the media being sampled, and that another method must be used to obtain said measurements, the variant instrument and/or measurement procedure will be documented in the field logbook and subsequent investigation report, along with a description of the circumstances requiring its use. Mention of trade names or commercial products in this operating procedure does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and has been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on SESD's local area network (LAN). The Document Control Coordinator is responsible for ensuring that the most recent version of the procedure is placed on SESD's LAN and for maintaining records of review conducted prior to its issuance.

1.4 References

SESD Operating Procedure for Equipment Inventory and Management, SESDPROC-108, Most Recent Version

SESD Operating Procedure for Logbooks, SESDPROC-010, Most Recent Version

United States Environmental Protection Agency (US EPA). 2001. Environmental Investigations Standard Operating Procedures and Quality Assurance Manual. Region 4 Science and Ecosystem Support Division (SESD), Athens, GA

USEPA. Safety, Health and Environmental Management Program Procedures and Policy Manual. Region 4 SESD, Athens, GA, Most Recent Version.

1.5 General Precautions

1.5.1 Safety

Proper safety precautions must be observed when conducting field pH measurements. Refer to the SESD Safety, Health and Environmental Management Program Procedures and Policy Manual (Most Recent Version) and any pertinent site-specific Health and Safety Plans (HASPs) for guidelines on safety precautions. These guidelines, however, should only be used to complement the judgment of an experienced professional. Address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate.

1.5.2 Procedural Precautions

All field pH measurements pertinent to the sampling event should be recorded in the field logbook for the event. All records, including a unique, traceable identifier for the instrument, such as a property number or serial number, should be entered according to the procedures outlined in the SESD Operating Procedure for Logbooks (SESDPROC-010) and the SESD Operating Procedure for Equipment Inventory and Management, (SESDPROC-108).

Care should be taken not to contaminate standards and samples and verify the expiration date of all standards prior to use. All meters should be calibrated, operated and maintained according to the manufacturer's specifications.

2 Quality Control

All pH meters will be maintained and operated in accordance with the manufacturer's instructions and the SESD Operating Procedure for Equipment Inventory and Management (SESDPROC-108). Before a meter is taken to the field, it will be properly calibrated or verified, according to Section 3.2 of this procedure, to ensure it is operating properly. These calibration and verification checks will be documented and maintained in a logbook.

The ambient temperature in the immediate vicinity of the meter should be measured and recorded in the field logbook to insure the instrument is operated within the manufacturer's specified range of operating temperatures. For instruments that are deployed for *in-situ* measurements, the temperature of the medium being monitored should be measured and recorded in the logbook prior to deployment. *In-situ monitoring equipment may be utilized in unattended deployments where autonomous logging may preclude temperature measurement prior to deployment. Because in-situ instrumentation generally has a wide range of operating temperature, the field investigator may utilize professional judgment in determining if the operating environment is suitable for unattended deployment.*

If at any time during a field investigation, it appears that the environmental conditions could jeopardize the quality of the measurement results, the measurements will be stopped. This will be documented in the field logbook.

3 Field pH Measurement Procedures

3.1 General

pH is defined as the negative logarithm of the effective hydrogen-ion concentration. For routine work, a pH meter accurate and reproducible to within 0.2 Standard Unit (S.U.) is suitable. For NPDES compliance monitoring, the pH meter should be accurate and reproducible to within 0.1 S.U. Both meters should have a range of 0 to 14 S.U.s and be equipped with a temperature-compensation adjustment.

3.2 Instrument Calibration

Many brands of instruments are commercially available for the measurement of pH incorporating a wide variety of technologies. The manufacturer's instruction manual should be consulted for specific procedures regarding their calibration, maintenance and use. Calibration of any measurement instrument must be conducted and/or verified prior to each use or on a daily basis, whichever is most appropriate. At a minimum, a two-point calibration should be conducted to ensure the accuracy of the meter. The following are basic guidelines for calibration/verification and are provided as an example:

1. Verify the meter's internal temperature sensor (thermistor) against a National Institute of Standards and Technology (NIST) traceable thermometer and note any differences between the thermistor and the NIST-traceable thermometer in the logbook. If the temperatures do not agree within ± 4°C, the unit or probe must be repaired or replaced. Alternatively, if the meter can be used in a manual temperature compensation mode, the NIST-traceable thermometer may be used for temperature readings and the necessary corrections applied. Check and record the temperatures of the standards and the samples.

2. If the pH range of the sample is not known, the pH of the sample to be tested should be estimated either from historical data or by using a four-color pH indicator paper or equivalent. Using this information, calibrate the pH meter with the buffers that bracket the expected pH range. Buffer solutions are commonly pH 4, 7 and 10. It may be possible to configure the pH meter so that it can be standardized with buffers other than those in the default configuration.

3. Immerse the probe in the first buffer solution and calibrate the meter to read the correct pH. After the initial buffer calibration, calibrate the meter using other buffer solutions, as appropriate. Rinse the probe with de-ionized water and blot dry or otherwise remove excess rinse water

between the different buffer solutions. Record the buffer values and temperatures used to calibrate the meter.

4. Rinse the probe with de-ionized water, blot dry or otherwise remove excess rinse water and immerse it into the appropriate buffer and read as a sample. If the meter reads within ± 0.2 S.U. of the known value of the buffer (for general applications such as ecological studies) or ± 0.1 S.U. (for regulatory applications such as NPDES or drinking Water programs), record the value indicated by the meter. If the meter is outside of the acceptable accuracy range, it should be recalibrated. If it is still outside of the acceptable accuracy range after the second calibration, the electrode and/or meter should be replaced.

5. Once the meter has been properly calibrated and verified (steps 1-4 above), it is ready for use. Rinse the probe with de-ionized water and store it according to manufacturer's recommendations. Certain instruments may require being left on until all sample measurements are performed and the results are recorded. When collecting measurements from grab samples, certain instrument manufacturers recommend that an intermediate check(s) be performed by periodically checking the meter against a known calibration buffers if used for extended periods (> 4 hrs).

6. Unless the manufacturer indicates that the meter maintains its calibration after being turned off, meters must be re-calibrated if they are turned off during their period of use.

3.3 Sample Measurement Procedures

These procedures should be followed when conducting field pH measurements of grab samples:

1. Collect a sample. If the meter's thermistor is to be used for the temperature of record for the measurement activity, the temperature should be read as soon as the reading stabilizes and prior to measuring the pH.

   Note 1: When the pH meter response is slow, unstable, or non-reproducible, it may be necessary to check the conductivity. If the conductivity is lower than 20 to 30 μmhos/cm, it is permissible to add 1 ml of 1M potassium chloride solution per 100 ml of sample to improve response time for the probe. Recheck the pH and record.

   Note 2: If the pH measurements are to be used for RCRA regulatory purposes and when the pH approaches the alkaline end (pH

≥ 11.0) of the scale, the pH measurements should be made by a qualified analyst using laboratory quality equipment to control the sample at 25°C ± 1°C.

2. Immerse the probe in the sample keeping it away from the sides and bottom of the sample container. Allow ample time for the probe to equilibrate with the sample.

3. While suspending the probe away from the sides and bottom of the sample container, record the pH.

4. Rinse the probe with de-ionized water and store it in the manufacturer's recommended storage solution until the next sample is ready.

These procedures should be followed when conducting in-situ field pH measurements:

1. Place the probe into the media to be measured and allow the pH and temperature readings to stabilize. Once the readings have stabilized, record the measurements in the logbook.

2. When deploying meters for extended periods of time, insure the measurement location is representative of average media conditions.

3.4 Operational Check

Even though it is not necessary to re-calibrate pH meters at regular intervals during the day, depending on the instrument, it may be appropriate to occasionally perform operational checks to determine if site conditions, such as an increase in temperature, have impacted the meter's performance. If an operational check is warranted, the following procedure should be followed to ensure that the performance of the meter has not changed.

1. While in use, periodically check the pH by rinsing the probe with de-ionized water, blot dry or otherwise remove excess rinse water and immerse it into the appropriate buffer solution. If the measured pH differs by ≥ 0.2 S.U. or 0.1 S.U. (depending on the application) from the buffer solution, the meter must be re-calibrated.

A post-operation instrument verification check will be performed using the appropriate buffer(s) at the end of the day or after all measurements have been taken for a particular period of operation. These measurements must be recorded in the field logbook.

SESD PROCEDURE SESDPROC-101-R6:

FIELD SPECIFIC CONDUCTANCE MEASUREMENT

COPY

Region 4
U.S. Environmental Protection Agency
Science and Ecosystem Support Division
Athens, Georgia

OPERATING PROCEDURE

Title: **Field Specific Conductance Measurement**

Effective Date: July 13, 2016

Number: SESDPROC-101-R6

Authors

Name: Timothy Simpson
Title: Environmental Scientist
Signature:
Date: 07/07/2016

Approvals

Name: John Deatrick
Title: Chief, Ecological Assessment Branch
Signature: John Deatrick
Date: 7/7/16

Name: Hunter Johnson
Title: Field Quality Manager, Science and Ecosystem Support Division
Signature:
Date: 7/7/16

Revision History

The top row of this table shows the most recent changes to this controlled document. For previous revision history information, archived versions of this document are maintained by the SESD Document Control Coordinator on the SESD local area network (LAN).

History	Effective Date
SESDPROC-101-R6, *Field Specific Conductance Measurement*, replaces SESDPROC-101-R5 **General:** Corrected any typographical, grammatical, and/or editorial errors. Throughout the document mention of quality system or SESD quality system was replaced with Field Branches Quality System or FBQS. **Cover Page:** Omitted Hunter Johnson as an author. Updated cover page to represent SESD reorganization. John Deatrick was not listed as the Chief of the Field Services Branch.	July 13, 2016
SESDPROC-101-R5, *Field Specific Conductance Measurement*, replaces SESDPROC-101-R4	August 30, 2012
SESDPROC-101-R4, *Field Specific Conductance Measurement*, replaces SESDPROC-101-R3	January 13, 2012
SESDPROC-101-R3, *Field Specific Conductance Measurement*, replaces SESDPROC-101-R2	August 12, 2011
SESDPROC-101-R2, *Field Specific Conductance Measurement*, replaces SESDPROC-101-R1	June 13, 2008
SESDPROC-101-R1, *Field Specific Conductance Measurement*, replaces SESDPROC-101-R0	November 1, 2007
SESDPROC-101-R0, *Field Specific Conductance Measurement*, Original Issue	February 05, 2007

TABLE OF CONTENTS

1 General Information

1.1 Purpose

This document describes procedures, methods and considerations to be used and observed when conducting field specific conductance measurements in aqueous phase environmental media, including groundwater, surface water and certain wastewaters.

1.2 Scope/Application

The procedures contained in this document are to be used by field investigators when measuring the specific conductance of aqueous phase environmental media in the field. On the occasion that SESD field investigators determine that any of the procedures described in this section cannot be used to obtain specific conductance measurements of the media being sampled, and that another method must be used to obtain said measurements, the variant instrument and/or measurement procedure will be documented in the field logbook, along with a description of the circumstances requiring its use. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and has been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD local area network (LAN). The Document Control Coordinator is responsible for ensuring the most recent version of the procedure is placed on the LAN and for maintaining records of review conducted prior to its issuance.

1.4 References

SESD Operating Procedure for Equipment Inventory and Management, SESDPROC-108, Most Recent Version

SESD Operating Procedure for Logbooks, SESDPROC-010, Most Recent Version

United States Environmental Protection Agency (US EPA). 2001. Environmental Investigations Standard Operating Procedures and Quality Assurance Manual. Region 4 Science and Ecosystem Support Division (SESD), Athens, GA

US EPA. Safety, Health and Environmental Management Program Procedures and Policy Manual. Region 4 SESD, Athens, GA, Most Recent Version

1.5 General Precautions

1.5.1 Safety

Proper safety precautions must be observed when conducting field specific conductance measurements. Refer to the SESD Safety, Health and Environmental Management Program Procedures and Policy Manual and any pertinent site-specific Health and Safety Plans (HASPs) for guidelines on safety precautions. These guidelines, however, should only be used to complement the judgment of an experienced professional. Address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate.

1.5.2 Procedural Precautions

All field specific conductance measurements pertinent to the sampling event, including a unique, traceable identifier for the instrument, such as a property number or serial number, should be recorded in the field logbook for the event. All records should be entered according to the procedures outlined in the SESD Operating Procedure Logbooks (SESDPROC-010, most recent version).

Care should be taken to not contaminate standards and samples and verify the expiration date of all standards prior to use. All meters should be calibrated, operated and maintained according to the manufacturer's specifications.

2 Quality Control

All specific conductance meters will be maintained and operated in accordance with the manufacturer's instructions and the SESD Operating Procedure for Equipment Inventory and Management (SESDPROC-108, most recent version). Before a meter is taken to the field, it will be properly calibrated or verified, according to Section 3.2 of this procedure, to ensure it is operating properly. These calibration and verification checks will be documented and maintained in a logbook.

The ambient temperature in the immediate vicinity of the meter should be measured and recorded in the field logbook to ensure the instrument is operated within the manufacturer’s specified range of operating temperatures. For instruments that are deployed for in-situ measurements, the temperature of the medium being monitored should be measured and recorded in the logbook prior to deployment. *In-situ monitoring equipment may be utilized in unattended deployments where autonomous logging may preclude temperature measurement prior to deployment. Because in-situ instrumentation generally has a wide range of operating temperature, the field investigator may utilize professional judgment in determining if the operating environment is suitable for unattended deployment.*

If at any time during a field investigation it appears that the environmental conditions could jeopardize the quality of the measurement results, the measurements will be stopped. This will be documented in the field logbook.

3 Field Specific Conductance Measurement Procedures

3.1 General

Specific conductance is a measure of the ability of an aqueous solution to conduct an electric current and is customarily reported in microsiemens per centimeter (µS/cm) or micromhos per centimeter (µmhos/cm) at 25°C. It is important to note that if the specific conductance measurements are for NPDES reporting purposes, the meter and conductivity cell should be verified by comparing against a laboratory meter with a platinum-electrode type conductivity cell.

3.2 Instrument Calibration and Verification

Many brands of instruments are commercially available for the measurement of specific conductance incorporating a wide variety of technologies. The manufacturer's instruction manual should be consulted for specific procedures regarding their calibration, maintenance and use. Calibration of any measurement instrument must be conducted and/or verified prior to each use or on a daily basis, whichever is most appropriate.

Conductivity is affected by temperature; therefore, for instruments that do not automatically compensate for temperature, the user should document temperature first so that appropriate adjustments can be made in accordance with the manufacturer's instructions and/or method. The following are basic guidelines for calibration/verification and are provided as an example:

1. Verify the meter's internal temperature sensor (thermistor) against a National Institute of Standards and Technology (NIST) traceable thermometer and note any differences between the thermistor and the NIST-traceable thermometer in the logbook. If the temperatures do not agree within ± 4°C, the unit must be repaired or replaced. Alternatively, if the meter can be used in a manual temperature compensation mode, the NIST-traceable thermometer may be used for temperature readings and the necessary corrections applied. Check and record the temperatures of the standards and the samples.

2. Rinse the probe with de-ionized water and blot dry before conducting the following calibration and verification checks.

3. Immerse the probe in the first standard solution and calibrate or verify the meter against that solution. Fresh standards should be used for each calibration. After the initial standard, calibrate and/or verify the meter using additional standards, as appropriate. Rinse the probe with de-ionized water and blot dry or otherwise remove excess rinse water between the different standards. Record the standard values/temperatures used to calibrate or verify the meter.

Note: Some instruments require that calibration standards reflect the anticipated specific conductance of the media being measured.

4. Some meters will auto-recognize standards during calibration. For example, the Orion Star Series meter will auto-recognize standards 1413 µS/cm, 100 µS/cm and 12.9 mS/cm. If the meter is calibrated in a manner where it does not auto-recognize the standard, and the meter is not accurate to within ± 10 % of the standard solution(s) known values, the meter or probe should be repaired or replaced. If this condition can be corrected by adjusting the cell constant of the probe, refer to the instruction manual and make the adjustment.

5. After calibration is complete, place the probe back into the calibration standard used and record a post-calibration reading. Record a post calibration reading for each standard used. If the meter is not accurate to within ± 10 % of the standard solution(s) known values, it should be recalibrated. If it is still outside of the acceptable accuracy range after the second calibration, the probe and/or meter should be replaced.

6. Once the meter has been properly calibrated and verified (steps 1-5 above), it is ready for use. Rinse the probe with de-ionized water and store it in the manufacturer's recommended storage solution. Certain meters may require that the instrument be left on until all sample measurements are performed and the results are recorded. When collecting measurements from grab samples, certain instrument manufacturers recommend that an intermediate check(s) be performed by periodically checking the meter against the known calibration standards if used for extended periods (> 4 hrs).

3.3 Sample Measurement Procedures

The following procedures should be followed when conducting field specific conductance measurements of grab samples:

1. Collect the sample, check and record its temperature.

2. Correct the instrument's temperature adjustment to the temperature of the sample (if required).

3. Immerse the probe in the sample keeping it away from the sides and bottom of the container. It is important that the center portion of the probe be wetted by the sample.

4. Allow meter to stabilize. Record the results in a logbook.

5. Rinse probe with de-ionized water.

The following procedures should be followed when conducting in-situ field specific conductivity measurements:

1. Place the probe into the media to be measured and allow the specific conductivity and temperature readings to stabilize. Once the readings have stabilized, record the measurements in the logbook.

2. When deploying meters for extended periods of time, ensure the measurement location is representative of average media conditions.

3.4 Operational Checks

Even though it is not necessary to re-calibrate conductivity meters at regular intervals during the day, depending on the instrument, it may be appropriate to occasionally perform operational checks to determine if site conditions, such as an extreme temperature change, have impacted the meter's performance. If an operational check is warranted, the following procedures should be followed to ensure that the performance of the meter has not changed.

Check the conductivity meter with fresh conductivity standard. Rinse the conductivity probe with deionized water, blot dry or otherwise remove excess rinse water and immerse it into the appropriate conductivity standard. If the measured conductivity value is not with ± 10% of the standard, the probe should be re-calibrated. If the probe is still not within ± 10% of the standard, the probe should be repaired or replaced. These measurements must be recorded in the field logbook.

A post-operation instrument verification check should be performed using the appropriate standard(s) at the end of the day or after all measurements have been taken for a particular period of operation. These measurements must be recorded in the field logbook.

SESD PROCEDURE SESDPROC-102-R4:

FIELD TEMPERATURE MEASUREMENT

COPY

Region 4
U.S. Environmental Protection Agency
Science and Ecosystem Support Division
Athens, Georgia

OPERATING PROCEDURE

Title: **Field Temperature Measurement**

Effective Date: October 23, 2014 | **Number:** SESDPROC-102-R4

Authors

Name: Hunter Johnson
Title: Environmental Engineer
Signature: Date: 10/21/14

Approvals

Name: John Deatrick
Title: Chief, Enforcement and Investigations Branch
Signature: Date: 10/22/14

Name: Laura Ackerman
Title: Acting Chief, Ecological Assessment Branch
Signature: Laura Acke Date: 10/21/14

Name: Hunter Johnson
Title: Field Quality Manager, Science and Ecosystem Support Division
Signature: Date: 10/21/14

Revision History

The top row of this table shows the most recent changes to this controlled document. For previous revision history information, archived versions of this document are maintained by the SESD Document Control Coordinator on the SESD local area network (LAN).

History	Effective Date
SESDPROC-102-R4, *Field Temperature Measurement*, replaces SESDPROC-102-R3 **Cover Page:** The Enforcement and Investigations Branch Chief was changed from Archie Lee to John Deatrick. The Ecological Assessment Branch Chief was changed from Bill Cosgrove to Acting Chief Laura Ackerman. The FQM was changed from Liza Montalvo to Hunter Johnson. **Revision History:** Changes were made to reflect the current practice of only including the most recent changes in the revision history. **Section 2:** Omitted the following: "Data Sonde thermistors will be verified on a monthly basis to ensure accuracy. These verification checks are documented in the instrument's tracking logbook."	October 23, 2014
SESDPROC-102-R3, *Field Temperature Measurement*, replaces SESDPROC-102-R2	February 4, 2011
SESDPROC-102-R2, *Field Temperature Measurement*, Replaces SESDPROC-102-R1	June 13, 2008
SESDPROC-102-R1, *Field Temperature Measurement*, Replaces SESDPROC-102-R0	November 1, 2007
SESDPROC-102-R0, Field Temperature Measurement, Original Issue	February 05, 2007

TABLE OF CONTENTS

1 General Information

1.1 Purpose

This document describes general and specific procedures, methods and considerations to be used and observed when measuring the temperature of aqueous phase environmental media, including groundwater, surface water and certain wastewaters.

1.2 Scope/Application

The procedures contained in this document are to be used by field personnel when measuring the temperature of aqueous phase environmental media in the field. On the occasion that SESD field personnel determine that any of the procedures described in this section cannot be used to obtain temperature measurements of the media being sampled, and that another method or measurement instrument must be used to obtain said measurements, the variant instrument and measurement procedure will be documented in the field log book and subsequent investigation report, along with a description of the circumstances requiring its use. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and has been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD local area network (LAN). The Document Control Coordinator is responsible for ensuring the most recent version of the procedure is placed on the LAN and for maintaining records of review conducted prior to its issuance.

1.4 References

SESD Operating Procedure for Equipment Inventory and Management, SESDPROC-108, Most Recent Version

SESD Operating Procedure for Logbooks, SESDPROC-010, Most Recent Version

United States Environmental Protection Agency (US EPA). Most Recent Version. Environmental Investigations Standard Operating Procedures and Quality Assurance Manual. Region 4 Science and Ecosystem Support Division (SESD), Athens, GA

US EPA. Safety, Health and Environmental Management Program Procedures and Policy Manual. Region 4 SESD, Athens, GA, Most Recent Version

1.5 General Precautions

1.5.1 Safety

Proper safety precautions must be observed when conducting temperature measurements in the field. Refer to the SESD Safety, Health and Environmental Management Program Procedures and Policy Manual and any pertinent site-specific Health and Safety Plans (HASPs) for guidelines on safety precautions. These guidelines, however, should only be used to complement the judgment of an experienced professional. The field investigators will address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate.

2 Quality Control

All thermometers should be maintained and operated in accordance with the manufacturer's instructions and the SESD Operating Procedure for Equipment Inventory and Management (SESDPROC-108). Temperature measurement devices such as pH, conductivity and dissolved oxygen (DO) meter thermistors will be verified against a National Institute of Standards and Technology (NIST)-traceable thermometer before each use as described in Section 3.2.

If at any time during a field investigation, it appears that the environmental conditions could jeopardize the quality of the measurement results, the measurements will be stopped. This will be documented in the field logbook.

3 Field Temperature Measurement Procedures

3.1 General

Field temperature measurements may be made with a field thermometer, equipment thermistor, or NIST-traceable thermometer. At a minimum, the temperature measurement device should be capable of measuring in 0.1°C increments.

3.2 Instrument Verification

3.2.1 Field thermometers and thermistors

Temperature measurement devices such as field thermometers and equipment thermistors will be verified against a NIST-traceable thermometer prior to use and should agree within ± 4.0°C. Corrections may be applied for measurements up to ± 4.0°C depending on investigation objectives, but the instrument must be repaired or replaced beyond that range.

3.2.2 NIST-traceable thermometer

Verification of the NIST-traceable thermometers that are used to verify temperature measuring devices is accomplished by comparing temperature readings from the NIST-traceable thermometer to a thermometer that has an independent certification of accuracy traceable to the National Institute of Standards and Testing. Current certified thermometers are maintained by the SESD Analytical Support Branch and are called reference thermometers.

Each NIST-traceable thermometer is verified by comparing at least annually against a reference thermometer. If corrections need to be applied, they will be noted in the NIST-traceable thermometer. Depending on investigation objectives, project leaders may decide to apply the correction factor as necessary.

3.3 Inspections

All temperature measurement devices should be inspected for leaks, cracks, and/or function prior to each use.

3.4 Sample measurement procedures for thermometers/thermistors

(Make measurements in-situ when possible)

1. Clean the probe end with de-ionized water and immerse into sample.

2. If not measuring in-situ, swirl the instrument in the sample for mixing and

equilibration.

3. Allow the instrument to equilibrate with the sample for at least one minute.

4. Suspend the instrument away from the sides and bottom, if not in-situ, to observe the temperature reading.

5. Record the reading in the log book. For most applications, report temperature readings to the nearest 0.5°C or to the nearest 0.1°C depending on need.

   Note: Always clean the thermometer with de-ionized water or a detergent solution, if appropriate, prior to storage and/or use.

3.5 Units

Degrees Celsius (°C) or Degrees Fahrenheit (°F)

Conversion Formulas:

°F = (9/5 °C) + 32 or °C = 5/9 (°F - 32)

SESD PROCEDURE SESDPROC-113-R2:

FIELD MEASUREMENT OF OXIDATION-REDUCTION POTENTIAL

COPY

U.S. Environmental Protection Agency Region 4, Science and Ecosystem Support Division Athens, Georgia

OPERATING PROCEDURE

Title: **Field Measurement of Oxidation-Reduction Potential (ORP)**

Effective Date: April 26, 2017	**Number:** SESDPROC-113-R2

Author

Name: Brian Striggow
Title: Environmental Engineer

Signature: Date: 4-20-17

Approval

Name: John Deatrick
Title: Chief, Field Services Branch

Signature: John Deatrick Date: 4/24/17

Name: Hunter Johnson
Title: Field Quality Manager, Science and Ecosystem Support Division

Signature: Date: 4/20/17

Revision History

The top row of this table shows the most recent changes to this controlled document. For previous revision history information, archived versions of this document are maintained by the SESD Document Control Coordinator on the SESD local area network (LAN).

History	Effective Date
SESDPROC-113-R2, *Field Measurement of Oxidation-Reduction Potential (ORP)*, replaces SESDPROC-013-R1 **General:** Corrected any typographical, grammatical, and/or editorial errors. **Title Page:** Changed the EIB Chief from Danny France to the Field Services Branch Chief John Deatrick, and the Field Quality Manager from Bobby Lewis to Hunter Johnson. **Section 2.2**: Figure 6 modified for clarity. **Section 3.3**: Use of overtopping cell described consistent with current practice.	April 26, 2017
SESDPROC-113-R1, *Field Measurement of Oxidation-Reduction Potential (ORP)*, replaces SESDPROC-013-R0	January 29, 2013
SESDPROC-113-R0, *Field Measurement of Oxidation-Reduction Potential (ORP)*, Original Issue	August 7, 2009

TABLE OF CONTENTS

1 General Information

1.1 Purpose

This document describes procedures, methods and considerations to be used and observed when conducting field Oxidation-Reduction Potential (ORP) measurements in aqueous environmental media, including groundwater, surface water and certain wastewater. The measurement of soil ORP is a non-standard measurement and procedures should be developed on a project-specific basis.

1.2 Scope/Application

This document describes procedures generic to all ORP measurement methods to be used by Science and Ecosystem Support Division (SESD) field personnel when collecting and handling samples in the field. On the occasion SESD personnel determine that any of the procedures described in this section are inappropriate, inadequate or impractical and that another procedure must be used to obtain an ORP measurement, the variant procedure will be documented in the field logbook, along with a description of the circumstances requiring its use. Mention of trade names or commercial products in this operating procedure does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and has been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD local area network (LAN). The Document Control Coordinator (DCC) is responsible for ensuring the most recent version of the procedure is placed on the SESD LAN and for maintaining records of review conducted prior to its issuance.

1.4 References

Faulkner, S.P., W.H. Patrick, Jr., and R.P. Gambrell. 1989. Field techniques for measuring wetland soil parameters. Soil Sci. Soc. Am. J. 53:883-890.

Megonigal, J.P., W.H. Patrick, Jr., and S.P. Faulkner. 1993. Wetland identification in seasonally flooded forest soils: soil morphology and redox dynamics. Soil Sci. Soc. Am. J. 57:140-149.

D.K. Nordstrom and F.D. Wilde. 2005. National Field Manual, Chapter A6, Section 6.5: Reduction Oxidation Potential (Electrode Method). USGS.

Pankow, J.E. 1991. Aquatic chemistry concepts. Lewis Publishers, Inc. Cheleas, Michigan. USA.

Pruitt, B.A. 2001. Hydrologic and soil conditions across hydrogeomorphic settings. Dissertation. The University of Georgia, Athens, GA. USA.

Soil Survey Staff. 1998. Keys to soil taxonomy, 8th Edition. United States Department of Agriculture, Natural Resources Conservation Service, Washington, DC. USA.

Standard Methods. 1992. Standard Methods for the Examination of Water and Wastewater, 18th Edition. Prepared and published jointly by: American Public Health Association, American Water Works Association, Water Environment Federation. American Public Health Association, Washington, DC. USA.

Stumm, W. and J.J. Morgan. 1981. Aquatic chemistry: an introduction emphasizing chemical equilibra in natural waters, 2nd Ed. John Wiley & Sons, New York. USA.

USEPA. 2001. Environmental Investigations Standard Operating Procedures and Quality Assurance Manual. Region 4 Science and Ecosystem Support Division, Athens, GA.

USEPA. 2007. Safety, Health and Environmental Management Program Procedures and Policy Manual. Science and Ecosystem Support Division, Region 4, Athens, GA.

Wikipedia entry. Reduction Potential. http://en.wikipedia.org/wiki/Reduction_potential. Retrieved April 2, 2009.

1.5 General Considerations

1.5.1 Safety

Proper safety precautions must be observed when verifying or calibrating instruments for measurement of Oxidation-Reduction Potential. Refer to the SESD Safety, Health and Environmental Management Program Procedures and Policy Manual (most recent version) and any pertinent site-specific Health and Safety Plans (HASP) for guidelines on safety precautions. These guidelines should be used to complement the judgment of an experienced professional.

Reagents commonly used in the preparation of ORP calibration standards are toxic and require care when handling. When using this procedure, avoid exposure to these materials through the use of protective clothing, eye wear and gloves. Safety precautions when handling and preparing verification solutions should include gloves and eyewear to prevent dermal and eye contact, and a mask to avoid inhaling dust particles when handling dry materials. Vigorous flushing should be used if the reagents or solutions come in contact with skin or eyes. Following is specific information on commonly used solutions. The application of the solutions is described in detail in Section 3.1, Standard Solutions, of this procedure.

- Quinhydrone (CAS# 106-34-3) is a skin and respiratory irritant and is poisonous if ingested. Safety precautions when handling quinhydrone should include gloves to prevent dermal contact and a mask to avoid inhaling dust particles when mixing dry material to prepare calibration standards. Vigorous flushing should be used if concentrated material comes in contact with skin or eyes.

- Zobell's solution is also an irritant and toxic if ingested. The same handling precautions apply when mixing and using Zobell's solution as when using quinhydrone. Zobell's reacts with acid to form harmful byproducts, including hydrocyanide gas.

- Light's solution contains ferro- and ferric-cyanide compounds in sulfuric acid. The components are toxic and burns are possible from contact with this solution.

- Potassium iodide solutions have lower toxicity than most calibration solution options. General ingestion, skin contact, and eye contact precautions apply.

Unused quinhydrone, Zobell's, Light's or other calibration reagents and solutions should be returned to SESD for disposal in accordance with the SESD Safety, Health, and Environmental Management Plan (SHEMP).

1.5.2 Records

Documentation of field activities is done in a bound logbook. All records, including a unique, traceable identifier for the instrument, should be entered according to the procedures outlined in the SESD Operating Procedure for Logbooks (SESDPROC-010, most recent version) and the SESD Operating Procedure for Equipment Inventory and Management, (SESDPROC-108, most recent version).

All field ORP measurements pertinent to the sampling event should be recorded in the field logbook for the event as outlined in the SESD Operating Procedure for Logbooks (SESDPROC-010, most recent version), or managed electronically with appropriate backups as described in SESD Operating Procedure for Control of Records (SESDPROC-002, most recent version).

1.5.3 Shipping

Shipped material shall conform to all U.S. Department of Transportation (DOT) rules of shipment found in Title 49 of the Code of Federal Regulations (49 CFR parts 171 to 179), and/or International Air Transportation Association (IATA) hazardous materials shipping requirements found in the current edition of IATA's Dangerous Goods Regulations.

All shipping documents, such as bills of lading, will be retained by the project leader and stored in a secure place.

2 Background

2.1 General

Oxidation is the process of liberating electrons or gaining oxygen. Examples of oxidation include conversion of elemental iron to rust, elemental sulfur to sulfate, and elemental hydrogen to water (Pankow 1991). Reduction is the process of gaining electrons resulting in the charge on some atomic unit in the species to be reduced. Oxidation-reduction potential (ORP) or redox potential (hereafter, referred to as redox) is a measure of the intensity or activity of an aqueous environment or soil to mediate reactions of important elements in biological systems (e.g., O, N, Mn, Fe, S, and C) and other metallic elements.

Considerable confusion arises on the use of the terms oxidation and reduction as they apply to the media under study. The following introduction reproduced from an online ‘Wikipedia’ article on the topic lucidly explains their relationship in ORP measurement:

> **Reduction potential** (also known as **redox potential**, **oxidation / reduction potential** or **ORP**) is the tendency of a chemical species to acquire electrons and thereby be reduced. Each species has its own intrinsic reduction potential; the more positive the potential, the greater the species' affinity for electrons and tendency to be reduced.
>
> In aqueous solutions, the reduction potential is the tendency of the solution to either gain or lose electrons when it is subject to change by introduction of a new species. A solution with a higher (more positive) reduction potential than the new species will have a tendency to gain electrons from the new species (i.e. to be reduced by oxidizing the new species) and a solution with a lower (more negative) reduction potential will have a tendency to lose electrons to the new species (i.e. to be oxidized by reducing the new species). Just as the transfer of hydrogen ions between chemical species determines the pH of an aqueous solution, the transfer of electrons between chemical species determines the reduction potential of an aqueous solution. Like pH, the reduction potential represents an intensity factor. It does not characterize the capacity of the system for oxidation or reduction, in much the same way that pH does not characterize the buffering capacity.

In short, a numerically positive redox potential or ORP represents an environment conducive to the oxidation of an introduced substance by reduction of the original media.

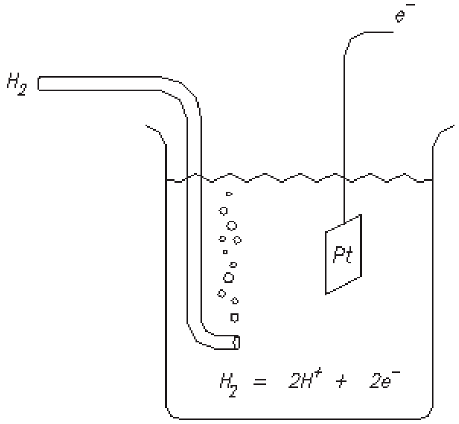
2.2 Instrumentation

ORP measurement systems are a practical implementation of electrochemical cells, which use metal electrodes in a solution to generate an electric current or voltage. If a platinum electrode is immersed in water with hydrogen bubbled into the solution, the H^2 is oxidized as follows:

$$H^2 = 2H^+ + 2e^-$$

In the electrochemical half-cell illustrated below in Fig.1, hydrogen gas oxidizes to hydrogen ions and free electrons, comprising an oxidation-reduction couple. This couple reaches an equilibrium state that maintains the reference potential of the electrode. The electric potential develops on the wire connected to the platinum electrode, but is difficult to measure in practice in the isolated half-cell. However, when used in a complete electrochemical cell, the cell illustrated is used as a reference to measure other half-cells against, and is called a Standard Hydrogen Electrode (SHE).

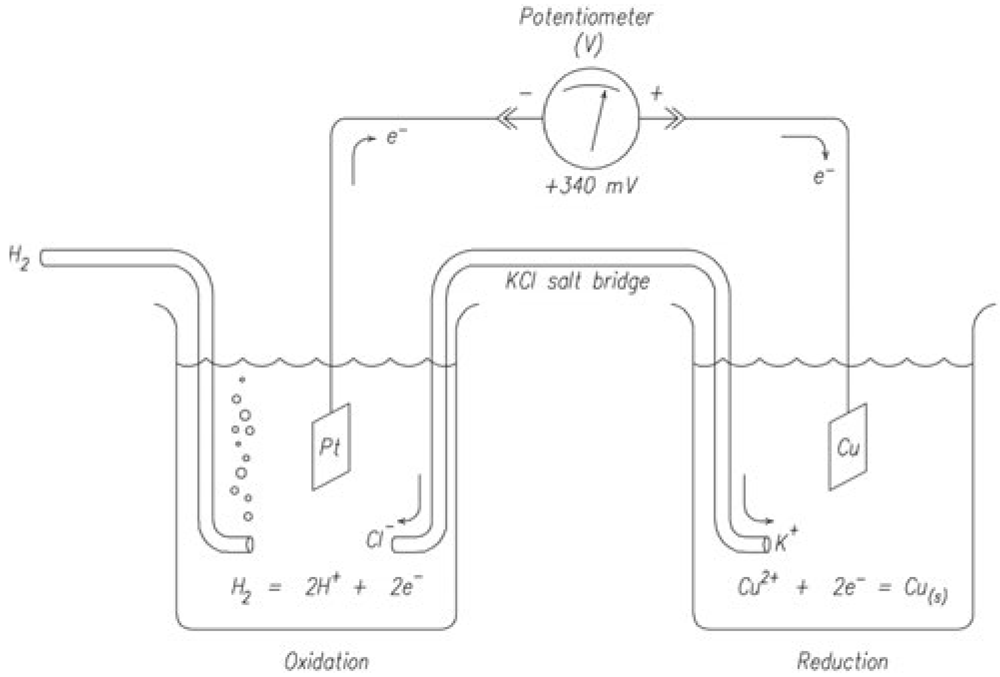
Figure 1



Hydrogen Half–Cell

If, as shown in Figure 2, a SHE is connected with a salt bridge to a second half-cell in which a reduction reaction is taking place, the electric potential between the two cells can be measured. In the case shown, the potential of the right cell will be +0.34 Volts in reference to the standard hydrogen electrode on the left. This would be represented as an Oxidation Reduction Potential (ORP) of +340mV on the hydrogen scale, or simply as Eh = +340mV.

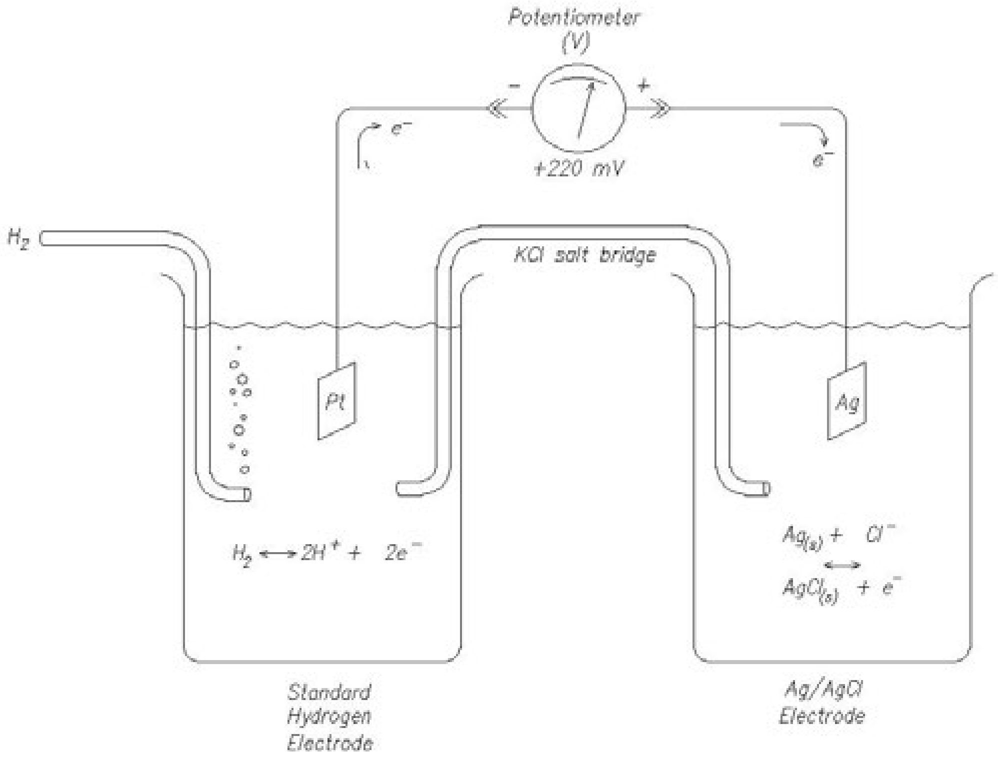
Figure 2



In field practice, the hydrogen electrode is difficult to reproduce. To conduct field measurements, a reference electrode is needed that is simple to maintain and will generate a potential that can be referenced to the standard hydrogen electrode. These requirements are met by the Saturated Calomel Electrode (SCE) and the Silver/Silver Chloride Electrode (SSCE - the SSCE is also commonly identified as an Ag/AgCl electrode). The SCE contains a small amount of elemental mercury, and while useful for certain applications, would rarely be used at SESD. The SSCE or Ag/AgCl electrode is generally used as the reference cell in SESD instrumentation.

In Figure 3 below, a SHE is connected to an Ag/AgCl electrode. In this example of an electrochemical cell, both cells reach an equilibrium potential. At that equilibrium state, the potential of the Ag/AgCl cell is 220mV more positive than the standard hydrogen electrode.

Figure 3



This half-cell potential of the Ag/AgCl electrode in reference to the SHE is used to convert measurements taken with an Ag/AgCl reference back to the hydrogen scale. While the laboratory Ag/AgCl half-cell shown has a potential of +220mV, practical reference cells have varying potentials based on temperature and filling solutions as shown in Table 1 below.

Table 1

Half-cell Potential of Ag/AgCl reference electrode

derived from USGS NFM, Table 6.5.2 (9/2005)

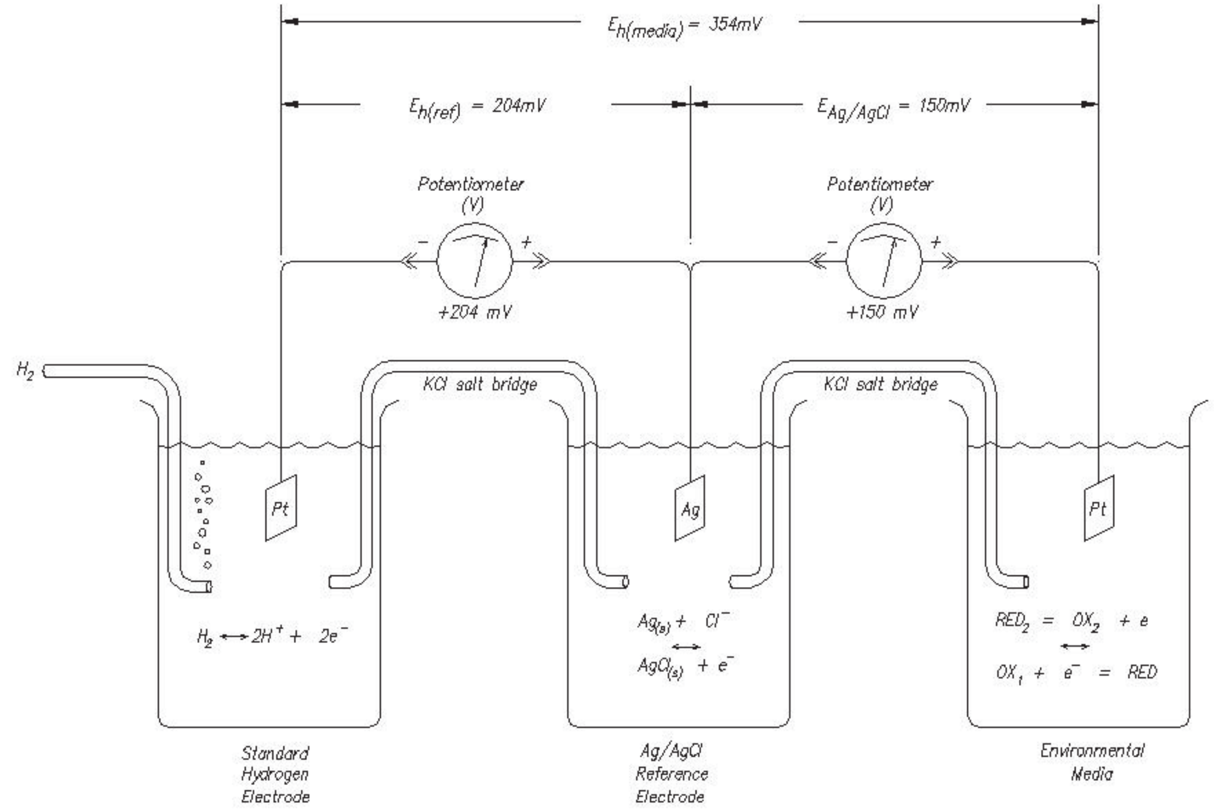
	Molarity of KCl filling solution			
T(°C)	3M	3.3M*	3.5M	Sat/4M
10	220	217	215	214
15	216	214	212	209
20	213	210	208	204
25	209	207	205	199
30	205	203	201	194
35	202	199	197	189
40	198	195	193	184

*interpolated value

Note: YSI sondes and Thermo electrodes typically use 4M KCl filling solutions. Eureka sondes typically use 3.3M KCl filling solutions.

In Figure 4, below, the relationship between a hydrogen electrode, a reference electrode, and a platinum sensing electrode in an arbitrary media is shown. In this case, the ORP of the media in reference to the silver/silver chloride electrode is 150mV. To obtain Eh, the potential of the reference electrode in relation to a hydrogen electrode is added to the potential of the sensing electrode in relation to the reference electrode. In practice, the potential of the reference electrode in relation to a hydrogen electrode is not measured, but obtained from Table 1 above.

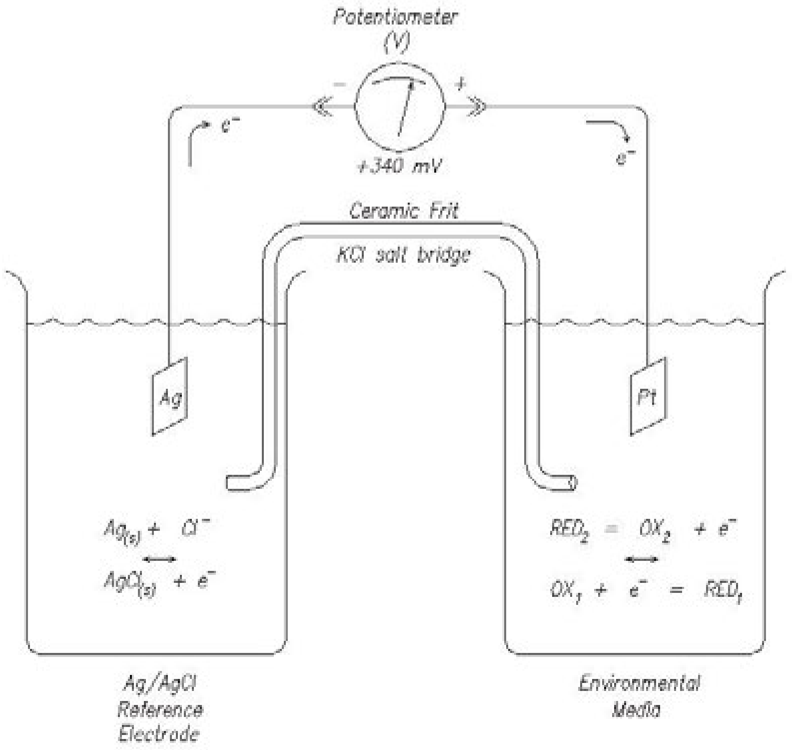
Figure 4



In Figure 5 below, a field instrument is represented as separate electrochemical cells. The

Ag/AgCl reference electrode uses a ceramic frit or other means to provide the essential salt bridge to the environmental media. The platinum sensing electrode is immersed in the environmental media and connected internally in the instrument to measure the potential (voltage) between the two electrodes.

Figure 5



In this illustration, the ORP is measured as 340 mV. This measurement is made in reference to the Ag/AgCl reference electrode and would be reported as such, or as $E_{Ag/AgCl}$ = 340mV.

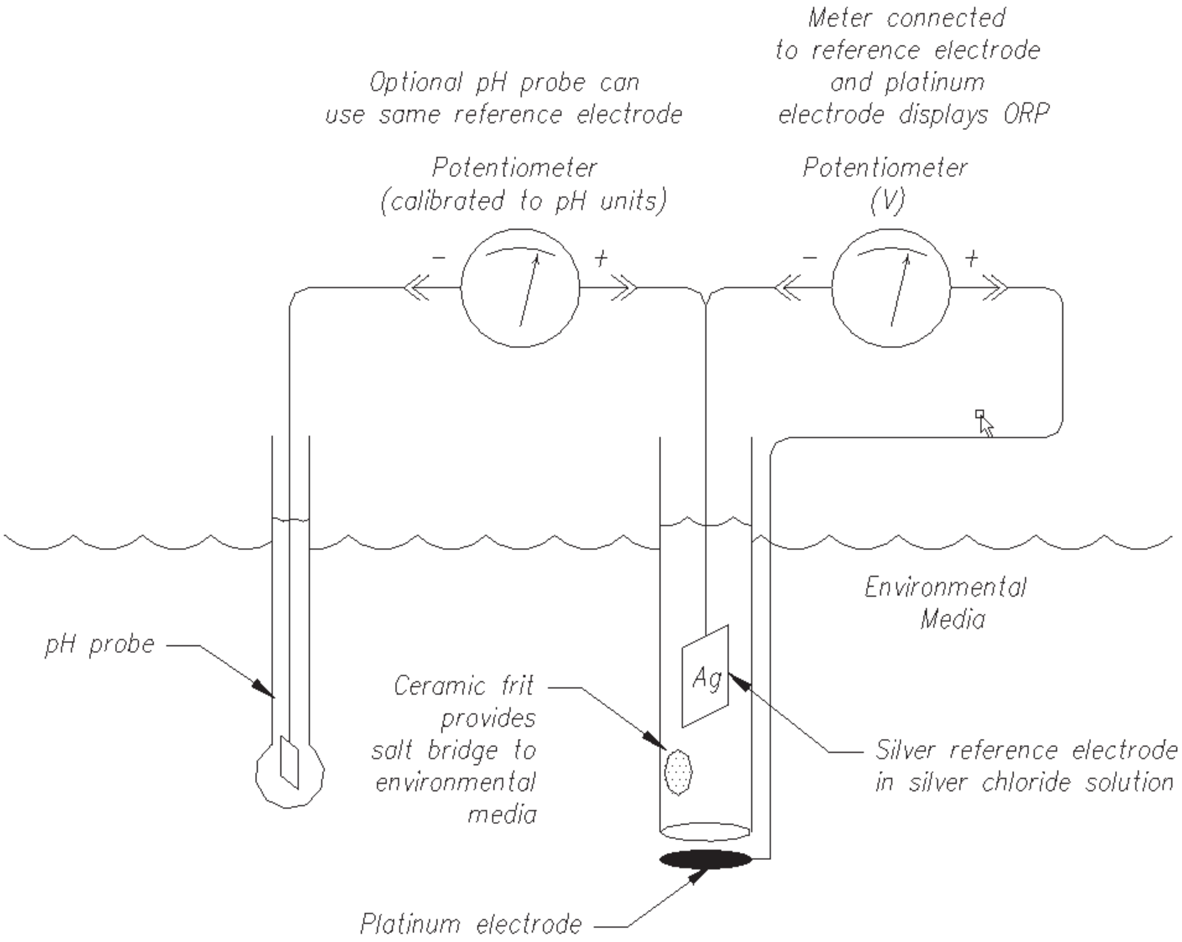
In some cases it will be desirable to report the reading on the hydrogen scale, or Eh. To do so, the potential of the reference electrode against the SHE, obtained from Table 1, is added to $E_{Ag/AgCl}$. For our example:

	340 mv	Measured ORP ($E_{Ag/AgCl}$) of sample
+	204 mV	Eh of Ag/AgCl electrode (ORP of Ag/AgCl electrode referenced to SHE)
	544 mV	Eh of sample

Both the +340 mV field reading and the adjusted +544 mV Eh can properly be referred to as ORP results. It is only through specifying the reference scale that the ambiguity can be eliminated.

In Figure 6, below, the theoretical cells shown above have been configured as a practical field instrument. The salt bridge is commonly provided by a ceramic frit connecting the environmental media to the reference electrode. In multi-parameter sondes, the pH probe commonly uses the same reference electrode as the ORP probe.

Figure 6



Redox Chemistry

In acid-base chemistry, the pH of a system is defined as the negative logarithm of the hydrogen ion activity (simplified in practice to the hydrogen ion concentration):

$$pH = -\log \{H^+\}$$

Similarly, Pankow (1991) described the negative logarithm of the electron activity (pe) as the master variable for describing the equilibrium position for all redox couples in a given system:

$$pe\ /\ -\log \{e^-\}$$

It can be shown (Pankow) that pe is related to Eh by

$$Eh = pe*(2.303*R*T)/F$$

Where:

R = gas constant = 8.314 J K^{-1} mol^{-1}
T = temperature, ^oK
F = Faraday constant = $96.485*10^3$ C mol^{-1}

At 25°C (298°K) this simplifies to

$$E_H = pe * 0.05916$$

And

$$pe = E_H / 0.05916$$

According to Faulkner et al. (1989) redox is a quantitative measure of electron availability and is indicative of the intensity of oxidation or reduction in both chemical and biological systems. When based on a hydrogen scale, redox (E_H) is derived from the Nernst Equation (Stumm and Morgan 1981):

$$E_H = E_H^o + 2.3\ H\ (R\ H\ T)/nF\ H \log (\vartheta_i \{ox\}^{ni}/\vartheta_j \{red\}^{nj})$$

Where:

E_H^o = potential of reference, mV
R = gas constant = 81.987 cal deg^{-1} $mole^{-1}$
T = temperature, ^oK
n = number of moles of electrons transferred
F = Faraday constant = 23.061 cal/mole-mv
{ox} and {red} = activity of the oxidants and reductants, respectively

2.4 Applications

When interpreted properly, redox combined with other conventional water quality parameters is useful in developing a more complete understanding of water chemistry. Several applications of redox are identified below:

1. Redox could be viewed as an extension of the oxygen scale. In this model, the DO probe spans the aerobic scale and the redox probe extends that scale to measure anaerobic conditions. Inferences to geochemistry and chemical speciation can be made from the oxidative state of the system. Application to metal sequestration, metal-iron, -sulfide, -methane complexation, and the subsequent bioaccumulation potential is possible.
2. Redox can be used to identify anaerobiosis at or near the water column and sediment interface in streams, lakes, and estuaries.
3. Redox may be useful in determination of stream jurisdiction and wetland delineation in that it can indicate conditions of soil saturation.

4. Based on redox, a pe (or EH) vs. pH stability diagram can be developed to aid in nutrient exchange studies including the timing, release, and partitioning of important water and sediment quality pollutants such as nitrogen and phosphorus species. Most importantly, redox can be used to address error associated with chamber-effect during closed chamber measurements of the water-sediment interface. Redox probes placed inside the contact chamber and inserted approximately ten centimeters into the underlying sediment can be used to monitor changes in sediment redox caused by the chamber, and steps can be taken to reduce chamber-effect.
5. Redox may be useful in establishing water and sediment quality standards applicable to wetlands.
6. Redox is used to assess the potential of a groundwater system to support various in situ reactions with contaminants, such as reductive dechlorination of chlorinated solvents.
7. Redox can provide a useful indicator of conditions that might compromise the performance of Clark-type dissolved oxygen (DO) probes. In general, anaerobic conditions occur at a redox range of +150 mV to +300 mV (pH-dependent and adjusted to hydrogen reference electrode). When redox drops below this level, DO measurements as determined with a Clarke-type probe are highly suspect as the semi-permeable membrane does not discriminate between partial O_2 and sulfides. Consequently, the meter may be reading sulfides.

2.5 Limitations

In most environmental media, redox reactions will not reach equilibrium due to low concentrations or multiple redox species. Consequently, redox measurements can generally be considered semi-quantitative in environmental media, unless certain conditions exist.

The USGS in the Interferences and Limitations Section 6.5.3A of their National Field Manual succinctly describe some of the issues encountered in the application of ORP measurements. This section is reproduced here, unedited:

> 6.5.3.A INTERFERENCES AND LIMITATIONS
>
> *Measurements should not be carried out without an awareness of the interferences and limitations inherent in the method.*
>
> - *Organic matter and sulfide may cause contamination of the electrode surface, salt bridge, or internal electrolyte, which can cause drift or erratic performance when reference electrodes are used (American Public Health Association and others, 2001).*
> - *Hydrogen sulfide can produce a coating on the platinum electrode that interferes with the measurement if the electrode is left in sulfide-rich water for several hours (Whitfield, 1974; Sato, 1960).*
> - *The platinum single and combination redox electrodes may yield unstable readings in solutions containing chromium, uranium, vanadium, or titanium ions and other ions that are stronger reducing agents than hydrogen or platinum (Orion Research Instruction Manual, written commun., 1991).*
> - *Do not insert redox electrodes into iron-rich waters directly after the electrode(s) contact ZoBell's. An insoluble blue precipitate coats the electrode surface because of an immediate reaction between ferro- and ferricyanide ions in ZoBell's with ferrous and ferric ions in the sample water, causing erratic readings.*
>
> *Many elements with more than one oxidation state do not exhibit reversible behavior at the platinum electrode surface and some systems will give mixed potentials, depending on the presence of several different couples (Barcelona and others, 1989; Bricker, 1982, p. 59–65; Stumm and Morgan, 1981, p. 490–495; Bricker, 1965, p. 65). Methane, bicarbonate, nitrogen gas, sulfate, and dissolved oxygen generally are not in equilibrium with platinum electrodes (Berner, 1981).*
>
> **TECHNICAL NOTE:**
>
> *Misconceptions regarding the analogy between Eh (pe) and pH as master variables and limitations on the interpretation of Eh measurements are explained in Hostettler (1984), Lindberg and Runnells (1984), Thorstenson (1984), and Berner (1981). To summarize:*

(1) Hydrated electrons do not exist in meaningful concentrations in most aqueous systems—in contrast, pH represents real activities of hydrated protons. Eh may be expressed as pe (the negative logarithm of the electron activity), but conversion to pe offers no advantage when dealing with measured potentials.

(2) Do not assume that redox species coexist in equilibrium. Many situations have been documented in which dissolved oxygen coexists with hydrogen sulfide, methane, and ferrous iron.

- *The practicality of Eh measurements is limited to iron in acidic mine waters and sulfide in waters undergoing sulfate reduction.*

- *Other redox species are not sufficiently electroactive to establish an equilibrium potential at the surface of the conducting electrode.*

(3) A single redox potential cannot be assigned to a disequilibrium system, nor can it be assigned to a water sample without specifying the particular redox species to which it refers. Different redox elements (iron, manganese, sulfur, selenium, arsenic) tend not to reach overall equilibrium in most natural water systems; therefore, a single Eh measurement generally does not represent the system.

3 Methodology

3.1 Standard Solutions

Care should be taken not to contaminate standards and samples and to verify the expiration date of all standards prior to use. All meters should be verified or calibrated according to the manufacturer’s procedures.

Standard solutions for calibration and verification should be selected to meet project requirements. SESD generally maintains a stock of Zobell’s solution suitable for most projects. The characteristics and use of the common standard solutions are described below.

- Zobell’s solution contains potassium ferri- and ferro- cyanide compounds. The solution is available as prepared solutions or premeasured reagents for mixing by the user. Zobell’s has moderate toxicity but will react with acid to form harmful byproducts, including hydrocyanide gas. It has a shelf life ranging from several days to several months depending on the manufacturer. Stock and working solutions of Zobell’s should be stored in dark bottles due to its light sensitivity.

- Quinhydrone solutions are mixed at the time of use by adding quinhydrone to pH 4 or pH 7 buffers. At 25°C, the E_h of quinhydrone pH 4 and pH 7 verification solutions are 462mV and 285mV respectively. An advantage of quinhydrone solutions is that they offer a span of calibration points that may be appropriate for particular applications. Quinhydrone is a lightly ‘poised’ solution in that it offers less driving force towards the calibration point: a compromised instrument is more likely to be revealed in a quinhydrone calibration. A quinhydrone calibration/verification solution is created by adding 10g of quinhydrone to 1L of pH 4 or pH 7 buffer solution (ASTM D1498). The solutions are mixed on a magnetic mixing plate for a minimum of 15 minutes to create a saturated solution with undissolved crystals remaining. Quinhydrone solutions are usable for 8 hrs from the time of mixing.

- Light’s solution consists of ferrous and ferric ammonium sulphate in sulphuric acid. The solution would rarely be used at SESD due to its high acidity and associated handling difficulty. Spent solutions with a pH<2 would be regulated as a hazardous waste. Light’s is a highly poised solution that may allow a marginally functioning electrode to pass calibration.

- A prepared potassium iodide solution is available which has low toxicity and a long shelf life. The solution may stain clothing or surfaces if spilled.

3.2 Verification and Calibration

ORP instruments may be **verified** or **calibrated**, depending on the application. The approach chosen should be selected based on project needs and information presented in Section 2.4., Limitations. Standard laboratory practice in making ORP measurements is to **verify** the accuracy of the instrument prior to use, and this practice should be followed when true quantitative results are required. In a **verification,** the instrument in its direct-reading mode is checked against a standard solution in a pass/no-pass test, and no corrections are applied to subsequent measurements. In most applications, the ORP information is used semi-quantitatively and for these applications, the instruments may be **calibrated** to the standard solutions. In an instrument **calibration**, the instrument probe is placed in the standard solution and the difference between the standard measurement and the known ORP value of the standard is used by the instrument to make adjustments to the subsequent measurements.

In **verification** of an ORP instrument, the instrument is set to absolute mV reading mode or the internal calibration offset is zeroed out. The instrument probe should then be placed in the standard solution and the reading verified to fall within +/-10mV of the predicted reading for the standard. Instruments with single-purpose electrodes are most suitable for this approach. If the instrument fails the verification, standard solution quality should be considered and instrument maintenance performed per the manufacturer's procedures.

In most SESD field practice, the end data use is semi-quantitative. In this case, the instruments can be **calibrated** to standard solutions appropriate for the project using the manufacturer's recommended procedure. One minute after the calibration, the instrument should display a stable reading within +/-10mV of the predicted reading. An instrument failing this test should be recalibrated to determine if the problem is inadequate equilibration time. In the event of continued instrument failure, aging or contamination of the standard solution should be considered. Subsequently the electrode should be serviced according to the manufacturer's procedures. Common service procedures include cleaning the platinum electrode with mild abrasives or acids and refilling or replacing the reference electrode.

Prior to a mobilization, all ORP instruments will be checked for proper operation and verified or calibrated against standard solutions. During the field mobilization, each instrument will be calibrated or verified prior to, and verified after, each day's use or deployment.

Even though it is not necessary to re-calibrate ORP instrument at regular intervals during the day, it may be appropriate to occasionally perform operational checks to determine if site conditions, such as an extreme temperature change or submersion of a filling solution port have impacted the instrument's performance. If an operational check is warranted, the field operator should follow the appropriate verification/calibration steps as described above.

The predicted ORP values of standard solutions will be obtained from the manufacturer of prepared solutions, literature, or appropriate values listed in this procedure. Care is in order, as the predicted ORP value is specific for the type of reference electrode used by the probe (either Ag/AgCl or calomel) and the molarity of the filling solution in the reference electrode. To use the solution with another electrode or filling solution, the expected ORP readings for the solution should be converted to Eh for the probes intended for the solution as per the Reporting section of this procedure. Then a table can be compiled for the electrode in use by subtracting the $E_{h,ref}$ for the electrode and filling solution in use. This will be done at the Field Equipment Center (FEC) for the solutions stocked.

Verification solutions should be managed per the manufacturer's directions regarding storage and handling. After instrument verification or calibration, the solution cannot be returned to the stock solution container, although a separate container of working solution can be maintained.

Spent solutions and working solutions should be returned from the field to the SESD laboratory for proper disposal by the SHEMP, or handled as directed by the SHEMP. Properly handled stock solutions may be returned to the FEC for use at that facility.

3.3 Measurement

ORP measurements should be conducted in a fashion that prevents the addition or loss of any potential oxidants or reductants. Results could be compromised by exposing the sample to air or allowing H_2S to off-gas from anoxic samples. Like dissolved oxygen measurements, ORP measurements should be conducted in situ or by using a flow-through cell evacuated of air (see the SESD Operating Procedure for Field Measurement of Dissolved Oxygen (SESDPROC-106, most recent version). Good results are commonly obtained with the use of an overtopping cell where the environmental media is pumped into the bottom of a narrow cup (generally field fabricated from a sample container) containing the instrument sensors. The sensors are continually flushed with fresh media as the cup is allowed to overflow. Caution should be exercised at very low flow rates where the media in the cup could potentially re-oxygenate.

When using multi-parameter probes for ORP measurements, the general guidelines for probe deployment described in the SESD Operating Procedure for Field Measurement of Dissolved Oxygen (SESDPROC-106, most recent version) and the SESD Operating Procedure for In situ Water Quality Monitoring (SESDPROC-111, most recent version) apply.

ORP probes must be operated and maintained in accordance with the manufacturer's instructions. Reference electrodes in multi-parameter probes may require regular filling or replacement. Single parameter ORP electrodes may require regular filling and operation in an upright position to assure that proper salt bridge flow is maintained. Platinum electrode surfaces are easily contaminated and polishing or cleaning of the electrodes should be performed as recommended by the manufacturer.

Measurements in field logbooks should be recorded to the nearest mV. The type of reference electrode in use and its filling solution should be recorded in at least one logbook as part of the field project records.

ORP is a temperature sensitive measurement, but ORP instruments are not temperature compensated. Consequently, the media temperature should always be recorded at the same time as the ORP is recorded. Likewise, as ORP is often pH dependent, pH should also be recorded at the time of ORP measurement.

3.4 Reporting

In the absence of a specified reference scale, ORP data has no meaning. Therefore, the reference scale used should always be specified in reporting or discussing the ORP data. ORP measurements converted to a hydrogen scale can be reported as "E_h". Data reported as the direct field measurement without correction might be described as "ORP referenced to Ag/AgCl electrode" or "$E_{Ag/AgCl}$". The expectations of the data user should be ascertained or the measurements should be reported in both systems.

To apply corrections to obtain E_h from the direct field measurement, the known half-cell potential of the reference electrode is added to the recorded field ORP value:

$$E_{h,sample} = ORP_{sample} + \text{half-cell potential of reference electrode}$$

The following table, reproduced from Section 2.2, presents the half-cell potential of a silver/silver chloride reference electrode at various temperatures and with various molarities of KCl filling solutions.

Table 1

Half-cell Potential of Ag/AgCl reference electrode

derived from USGS NFM, Table 6.5.2 (9/2005)

	Molarity of KCl filling solution			
T(°C)	3M	3.3M*	3.5M	Sat/4M
10	220	217	215	214
15	216	214	212	209
20	213	210	208	204
25	209	207	205	199
30	205	203	201	194
35	202	199	197	189
40	198	195	193	184

*interpolated value

Note: YSI sondes and Thermo electrodes typically use 4M KCl filling solutions. Eureka sondes typically use 3.3M KCl filling solutions

Example:

A multi-parameter probe with a silver/silver chloride reference electrode and 4M KCl filling solution is used to record a stream ORP measurement of 146mV. The stream temperature is recorded as 15°C.

From the above table, the half-cell potential of an Ag/AgCl reference electrode filled with 4M KCl is 209mV at 15°C. Then:

$$E_{h,sample} = ORP_{Ag/AgCl,sample} + \text{half-cell potential of Ag/AgCl reference electrode}$$

$$E_{h,sample} = 146mV + 209mV$$

$$E_{h,sample} = 355mV$$

As noted in Section 3.3, Measurement, ORP measurements are sensitive to temperature, and may be sensitive to pH. As the instruments do not compensate for these parameters, ORP data should always be reported with the temperature and pH of the media at the time of measurement.

Final reporting values of Eh or ORP should be rounded to the nearest 10mV. The following spreadsheet formula can perform the rounding of an interim result located in spreadsheet cell ‘A1’:

=INT(A1/10+0.5)*10

SESD PROCEDURE SESDPROC-106-R4:

FIELD MEASUREMENT OF DISSOLVED OXYGEN

COPY

Region 4
U.S. Environmental Protection Agency
Science and Ecosystem Support Division
Athens, Georgia

OPERATING PROCEDURE

Title: **Field Measurement of Dissolved Oxygen**

Effective Date: April 12, 2017

Number: SESDPROC-106-R4

Author

Name: Nathan Barlet
Title: Environmental Engineer
Signature:
Date: April 5, 2017

Approvals

Name: John Deatrick
Title: Chief, Field Services Branch
Signature: John Deatrick
Date: 4/11/17

Name: Hunter Johnson
Title: Field Quality Manager, Science and Ecosystem Support Division
Signature:
Date: 4/11/17

Revision History

The top row of this table shows the most recent changes to this controlled document. For previous revision history information, archived versions of this document are maintained by the SESD Document Control Coordinator on the SESD local area network (LAN).

History	Effective Date
SESDPROC-106-R4, *Field Measurement of Dissolved Oxygen*, replaces SESDPROC-106-R3 **General:** Corrected any typographical, grammatical, and/or editorial errors. In addition, any references to former Division organizational structure was updated to reflect current structure. **Title Page:** Changed the Author from Hunter Johnson to Nathan Barlet. Changed the Field Quality Manager from Bobby Lewis to Hunter Johnson. Updated cover page to represent SESD reorganization. **Table of Contents:** Added Sections 3.2.1 Water-Saturated Air Method, 3.2.2 Air-Saturated Water Method, and 3.2.3 Zero-DO Verification & 2-Point Calibration. Changed Section 3.5 from "Operational Check" to "Operational Verification." Updated page numbers. **Section 1.4:** Added the citations for Benson and Krause (1980), Benson and Krause (1984), USGS (2013*a*), and USGS (2013*b*) as references, **Section 3.1:** Changed "volume of oxygen contained in a volume of water" to "mass of molecular oxygen contained in a volume of water." Changed "pressure" in first paragraph and third bullet point to "atmospheric pressure." **Section 3.2:** Added "However, some optical DO meters are capable of a two-point calibration at 0% and 100% saturation, refer to Section 3.2.3 for applicability." Added Section 3.2.1 Water-Saturated Air Method, which includes information on the calibration procedure for the water-saturated air method. Added "Allow at least 10-15 minutes for the temperature and dissolved oxygen readings to equilibrate. Ensure that water droplets are removed from the luminescence cap or Clark cell membrane and thermistor before calibration. Refer to Section 3.5 for calibration verification procedure." Added Section 3.2.2 Air-Saturated Water Method, which includes information on the calibration procedure for the air-saturated water	April 12, 2017

method. Added “Refer to Section 3.5 for calibration verification procedure.” Added Section 3.2.3 Zero-DO Verification & 2-Point Calibration. Added “It is recommended that a zero-DO verification is conducted periodically or when concentrations are expected to be below 1 mg/l (USGS, 2013*a*). A zero-DO solution can be prepared by dissolving 1 gram of sodium sulfite in 1 liter of deionized water. This should be made fresh weekly or as needed. If the unit is equipped with a wiper, it should be removed before immersing in zero-DO solution. The reading should not exceed a concentration of 0.2 mg/l dissolved oxygen in the zero-DO solution. For Clark cells that exceed this concentration, replace the electrolyte and membrane before repeating the zero-DO verification process. For optical probes that read above 0.2 mg/l in zero-DO solution, replace the sensor cap if it is expired or perform a 2-point calibration if applicable. Some optical DO probes are capable of 2-point calibrations using a zero-DO solution and the air-saturated water method discussed in Section 3.2.2. Refer to the manufacturer’s instruction manual for the appropriate 2-point calibration procedure. Ensure that the probe is thoroughly rinsed of zero-DO solution after verification or calibration to avoid measurement interferences caused by residual sodium sulfite.” **Section 3.4:** Changed the fifth bullet point to read “The DO meter should be capable of auto-correcting for specific conductivity/salinity or a separate instrument should be used to measure specific conductivity/salinity so that the final DO measurement(s) can be corrected.” **Section 3.5:** Changed the title from “Operational Check” to “Operational Verification.” Changed first paragraph to read “A post-calibration and post-operation instrument verification check should be performed using one of the techniques described in Sections 3.2.1 and 3.2.2 or 3.2.3 (for 2-point calibrations) to quantify potential instrument drift during use. A verification check will be performed after a calibration and at the end of all measurements” Changed second paragraph to read “It may be appropriate to verify the calibration of a DO meter periodically during the course of a day’s measurements when conducting individual measurements. A DO probe may be re-calibrated throughout the day if drift is occurring. The verification DO concentration should be measured and recorded in the field logbook prior to any instrument adjustment.” Also added the sentence “For long-term deployments a post-operation verification should be performed at the end of the deployment.” Added third paragraph which reads “Verification is done by comparing a post-calibration or post-operation reading at 100% saturation conditions to a DO solubility table value at the ambient air/water	

temperature and barometric pressure. Post-calibration and post-operation readings should not exceed a maximum of ± 0.2 mg/l from the DO solubility table value. DO solubility tables can be accessed via the U.S. Geological Survey's DOTABLES software (USGS, 2013*b*) which are based on equations from Benson and Krause (1980; 1984)."	
SESDPROC-106-R3, *Field Measurement of Dissolved Oxygen*, replaces SESDPROC-106-R2 .	January 8, 2014
SESDPROC-106-R2, *Field Measurement of Dissolved Oxygen*, replaces SESDPROC-106-R1	February 12, 2010
SESDPROC-106-R1, *Field Measurement of Dissolved Oxygen*, replaces SESDPROC-106-R0	November 1, 2007
SESDPROC-106-R0, *Field Measurement of Dissolved Oxygen*, Original Issue	February 05, 2007

TABLE OF CONTENTS

1 General Information

1.1 Purpose

This document describes methods and considerations to be used and observed when conducting field measurements of dissolved oxygen in surface water, treated wastewater and in gas media for specific applications (e.g., reaeration measurement).

1.2 Scope/Application

On the occasion that SESD field investigators determine that any of the procedures described in this section are inappropriate, inadequate or impractical and that another method must be used to obtain a measurement of dissolved oxygen, the alternate procedure will be documented in the field log book, along with a description of the circumstances requiring its use. Mention of trade names or commercial products in this operating procedure does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and has been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD Local Area Network (LAN). The Document Control Coordinator (DCC) is responsible for ensuring the most recent version of the procedure is placed on the LAN and for maintaining records of review conducted prior to its issuance.

1.4 References

Benson, B.B., and Krause, D., Jr, 1980. The concentration and isotopic fractionation of gases dissolved in freshwater in equilibrium with the atmosphere—1. Oxygen: Limnology and Oceanography, v. 25, no. 4, p. 662–671.

Benson, B.B., and Krause, D., Jr, 1984. The concentration and isotopic fractionation of oxygen dissolved in freshwater and seawater in equilibrium with the atmosphere: Limnology and Oceanography, v. 29, no. 3, p. 620–632.

SESD Operating Procedure for Equipment Inventory and Management, SESDPROC-108, Most Recent Version

SESD Operating Procedure for Logbooks, SESDPROC-010, Most Recent Version

SESD Field Branches Quality Management Plan, SESDPLAN-001, Most Recent Version

USEPA. Safety, Health and Environmental Management Program Procedures and Policy Manual. Region 4 SESD, Athens, GA, Most Recent Version

USGS, 2013*a*. Dissolved Oxygen (ver. 3.0): U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A6, sec. 6.2, *http://water.usgs.gov/owq/FieldManual/Chapter*6/6.2_v3.0.pdf.

USGS, 2013*b*. DOTABLES (ver. 3.5): Dissolved Oxygen Solubility Tables, *https://water.usgs.gov/software/DOTABLES/*.

1.5 General Precautions

1.5.1 Safety

Refer to the SESD Safety, Health and Environmental Management Program Procedures and Policy Manual and any pertinent site-specific Health and Safety Plans (HASPs) for guidelines on safety precautions. These guidelines, however, should only be used to complement the judgment of an experienced professional. When using this procedure, minimize exposure to potential health hazards through the use of protective clothing, eye wear and gloves. Address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate.

Appropriate precautions should be observed when working in and around bodies of water and on boats. Be aware of fast flowing waters, waterway obstructions such as dams, and other vessels on the water.

2 Quality Control

All dissolved oxygen meters will be maintained and operated in accordance with the manufacturer's instructions and the SESD Operating Procedure for Equipment Inventory and Management (SESDPROC-108). Before a meter is utilized in the field, it will be calibrated and verified, according to Section 3.2 of this procedure, to ensure it is operating properly. These calibration and verification checks will be documented and maintained in a logbook.

For in-situ measurements, an instrument warm-up period appropriate for that instrument should be provided. Consult manufacturer's documentation for appropriate warm-up time.

The ambient temperature in the immediate vicinity of the meter should be measured and recorded in the field logbook to insure the instrument is operated within the manufacturer's specified range of operating temperatures. For instruments that are deployed for in-situ measurements, the temperature of the medium being monitored should be measured and recorded in the logbook prior to deployment. *In-situ monitoring equipment may be utilized in unattended deployments where autonomous logging may preclude temperature measurement prior to deployment. Because in situ instrumentation generally has a wide range of operating temperature, the field investigator may utilize professional judgment in determining if the operating environment is suitable for unattended deployment.*

Following instrument use, an end check should be performed using one of the techniques described in Section 3.2 to quantify potential instrument drift during use.

If at any time during a field investigation, it appears that the environmental conditions could jeopardize the quality of the measurement results, the measurements will be stopped. This will be documented in the field logbook.

3 Field Measurement of Dissolved Oxygen

3.1 General

Dissolved oxygen can be defined as the mass of molecular oxygen contained in a volume of water. The solubility of oxygen in water is dependent on the water temperature, salinity and atmospheric pressure.

- As the temperature of the water decreases, the solubility of oxygen increases.
- As salinity increases, the solubility of oxygen decreases.
- As atmospheric pressure decreases (altitude increases), the solubility of oxygen decreases.

Several methods for measurement of dissolved oxygen in water are available utilizing a variety of technologies. When measuring dissolved oxygen for compliance with the National Pollutant Discharge Elimination System (NPDES) Program, only approved methods will be used. Approved methods can be found in the Code of Federal Regulations (CFR) 40 CFR Part 136.

3.1.1 Clark Cell Probes

Clark cell probes utilize an oxygen permeable membrane that covers an electrolytic cell which consists of a cathode and an anode. The anode acts as a reference electrode. After passing through the permeable membrane, the oxygen is reduced by an applied potential voltage that is referenced to the anode. The reduction current at the cathode is directly proportional to the partial pressure of oxygen in liquid, expressed as %-air saturation. The concentration of oxygen, in mg/l, is calculated based on the %-air saturation reading and the solubility of oxygen in water at the sample temperature.

In general, sample collection using a DO probe requires only lowering the probe into the sample media and recording or logging the results. The probe should be lowered gently to prevent damage to the membrane and gently turned when initially lowered to remove any attached air bubbles. If the instrument requires the use of a stirrer, the stirrer should be turned on before recording any readings. Prior to use, the instrument should be calibrated and any manufacturer specified warm-up period should be observed.

3.1.2 Luminescent Probes

Luminescent dissolved oxygen probes employ a light emitting diode (LED) to provide incident light, which excites the oxygen-sensitive luminescent-dye molecule substrate of the sensor. After dissipation of the excitation energy, longer-wavelength light is emitted (luminescence). The magnitude of steady-state luminescence (intensity) is measured by the sensor and is inversely proportional to the dissolved oxygen concentration.

Sample collection with this type of probe should follow the sample procedures described in the second paragraph of Section 3.1.2 for Clark Cell probes.

3.2 Calibration

Many brands of instruments are commercially available for *in-situ* measurement of dissolved oxygen using Clark cell probes and luminescent probes. The manufacturer's instruction manual should be consulted for specific procedures regarding their calibration, maintenance and use. Calibration of any measurement instrument must be conducted and/or verified prior to each use or on a daily basis, whichever is most appropriate.

In general, calibrations should be conducted at temperatures and pressures as close as possible to those of the sample media for the most accurate measurements. Due to the sensitivity of dissolved oxygen measurements to changes in temperature, the temperature probe or thermistor should be verified using a NIST traceable thermometer prior to each calibration. Most dissolved oxygen meters utilize a one-point calibration which is generally performed using either water-saturated air or air-saturated water. However, some optical DO meters are capable of a two-point calibration at 0% and 100% saturation, refer to Section 3.2.3 for applicability.

3.2.1 Water-Saturated Air Method

When using the water-saturated air method, the probes should be placed in a 100% relative humidity environment open to ambient air temperature and barometric pressure. Allow at least 10-15 minutes for the temperature and dissolved oxygen readings to equilibrate. Ensure that water droplets are removed from the luminescence cap or Clark cell membrane and thermistor before calibration. Refer to Section 3.5 for calibration verification procedure.

3.2.2 Air-Saturated Water Method

When using air-saturated water for calibration, an aeration device such as an aquarium pump with a diffusion stone should be placed in a vessel containing tap water. The water in the vessel should be aerated for a minimum of one hour at a constant temperature. Saturation should be verified by placing the dissolved oxygen probe in the vessel and monitoring the temperature and dissolved oxygen readings for stabilization. Avoid placing the probe in the direct stream of air bubbles. Bubbles can accumulate on the probe surface and cause erroneous readings. Refer to Section 3.5 for calibration verification procedure.

3.2.3 Zero-DO Verification and 2-Point Calibration

It is recommended that a zero-DO verification is conducted periodically or when concentrations are expected to be below 1 mg/l (USGS, 2013*a*). A zero-DO solution can be prepared by dissolving 1 gram of sodium sulfite in 1 liter of deionized water. This should be made fresh weekly or as needed. If the unit is equipped with a wiper, it should be removed before immersing in zero-DO solution. The reading should not exceed a concentration of 0.2 mg/l dissolved oxygen in the zero-DO solution. For Clark cells that exceed this concentration, replace the electrolyte and membrane before repeating the zero-DO verification process. For optical probes that read above 0.2 mg/l in zero-DO solution, replace the sensor cap if it is expired or perform a 2-point calibration if applicable. Some optical DO probes are capable of 2-point calibrations using a zero-DO solution and the air-saturated water method discussed in Section 3.2.2. Refer to the manufacturer's instruction manual for the appropriate 2-point calibration procedure. Ensure that the probe is thoroughly rinsed of zero-DO solution after verification or calibration to avoid measurement interferences caused by residual sodium sulfite.

3.3 Maintenance

Maintenance procedures vary depending on the technology utilized by each instrument and the manufacturer. The manufacturer's instruction manual should be consulted for instrument specific procedures. Following are some general guidelines for maintaining dissolved oxygen meters:

- Inspect probes for damage prior to use.
- For Clark cell probes, membranes and electrolyte solution should be changed prior to each study, when feasible.
- Battery voltages should be checked. For meters that will be deployed unattended, new or fully charged batteries should be used for each study.
- All calibration and maintenance procedures performed should be thoroughly documented.

3.4 Conducting Field Measurement of Dissolved Oxygen

Following are guidelines for conducting field measurements of dissolved oxygen:

- Except as described in specific operating procedures, dissolved oxygen measurements should if possible be conducted *in-situ*.
- When measuring DO at distinct points in the water column, the probe should be allowed to equilibrate at each location prior to recording the measurement.
- In water bodies with a great deal of flow, a weight may be attached to the probe guard or support cable to insure the probe is maintained at the proper depth.
- Insure that the measurement location is representative of conditions within the water body or reach. Avoid measurements directly below turbulent sections or still water unless these conditions represent most of the water body or reach.
- The DO meter should be capable of auto-correcting for specific conductivity/salinity or a separate instrument should be used to measure specific conductivity/salinity so that the final DO measurement(s) can be corrected.

3.5 Operational Verification

A post-calibration and post-operation instrument verification check should be performed using one of the techniques described in Sections 3.2.1 and 3.2.2 or 3.2.3 (for 2-point calibrations) to quantify potential instrument drift during use. A verification check will be performed after a calibration and at the end of all measurements.

It may be appropriate to verify the calibration of a DO meter periodically during the course of a day's measurements when conducting individual measurements. A DO probe may be re-calibrated throughout the day if drift is occurring. The verification DO concentration should be measured and recorded in the field logbook prior to any instrument adjustment. For long-term deployments a post-operation verification should be performed at the end of the deployment.

Verification is done by comparing a post-calibration or post-operation reading at 100% saturation conditions to a DO solubility table value at the ambient air/water temperature and barometric pressure. Post-calibration and post-operation readings should not exceed a maximum of ± 0.2 mg/l from the DO solubility table value. DO solubility tables can be accessed via the U.S. Geological Survey's DOTABLES software (USGS, 2013*b*) which are based on equations from Benson and Krause (1980; 1984).

SESD PROCEDURE SESDPROC-103-R4:

FIELD TURBIDITY MEASUREMENT

COPY

Region 4
U.S. Environmental Protection Agency
Science and Ecosystem Support Division
Athens, Georgia

OPERATING PROCEDURE

Title: **Field Turbidity Measurement**

Effective Date: July 27, 2017

Number: SESDPROC-103-R4

Authors

Name: Timothy Simpson
Title: Environmental Scientist
Signature:
Date: 07/25/17

Approvals

Name: John Deatrick
Title: Chief, Field Services Branch
Signature: John Deatrick
Date: 7/25/17

Name: Hunter Johnson
Title: Field Quality Manager, Science and Ecosystem Support Division
Signature:
Date: 7/25/17

Revision History

The top row of this table shows the most recent changes to this controlled document. For previous revision history information, archived versions of this document are maintained by the SESD Document Control Coordinator on the SESD local area network (LAN).

History	Effective Date
SESDPROC-103-R4, *Field Turbidity Measurement*, replaces SESDPROC-103-R3 **General:** Added to Section 3.6 to include application of various turbidity units and associated methods relative to various applications. **Title Page:** Changed Enforcement and Investigations Branch to the Field Services Branch and changed the Chief from Danny France to John Deatrick. Changed Field Quality Manager from Bobby Lewis to Hunter Johnson. **Section 1.4:** Added new references cited in Section 3.5 **Section 3.2:** Added reference to Section 3.5 **Section 3.3.1:** Added Table 1 outlining reporting requirements. **Section 3.5:** Introduced different turbidity units associated with various methods and stated importance of using EPA approved methods for regulatory purposes. Also added Figure 1, a decision tree to assist project leaders in selecting the appropriate method to satisfy Data Quality Objectives, and Table 2, outlining technologies, associated units, application, and design.	July 27, 2017
SESDPROC-103-R3, *Field Turbidity Measurement*, replaces SESDPROC-103-R2	January 29, 2013
SESDPROC-103-R2, *Field Turbidity Measurement*, replaces SESDPROC-103-R1	June 13, 2008
SESDPROC-103-R1, *Field Turbidity Measurement*, replaces SESDPROC-103-R0	November 1, 2007
SESDPROC-103-R0, Field Turbidity Measurement, Original Issue	February 05, 2007

COPY

TABLE OF CONTENTS

TABLE OF FIGURES

TABLE OF TABLES

1 General Information

1.1 Purpose

This document describes general and specific procedures, methods and considerations to be used and observed when conducting field turbidity measurements in aqueous phase environmental media, including groundwater, surface water and certain wastewaters.

1.2 Scope/Application

The procedures contained in this document are to be used by field personnel when measuring turbidity of various, aqueous phase environmental media in the field. On the occasion that SESD field personnel determine that any of the procedures described in this section cannot be used to obtain turbidity measurements of the media being sampled, and that another method or turbidity measurement instrument must be used to obtain said measurements, the variant instrument and measurement procedure will be documented in the field logbook, along with a description of the circumstances requiring its use. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and has been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD local area network (LAN). The Document Control Coordinator is responsible for ensuring the most recent version of the procedure is placed on the LAN and for maintaining records of review conducted prior to its issuance.

1.4 References

APHA (1992). Turbidity: Method 2130B. Standard Methods for the Examination of Water and Wastewater, 18th Edition, pp. 2-11.

ASTM International (2012). D7315-12 Standard test method for determination of turbidity above 1 turbidity unit in static mode: ASTM International, Annual Book of Standards, Water and Environmental Technology, v. 11.01, West Conshohocken, Pennsylvania.

SESD Operating Procedure for Equipment Inventory and Management, SESDPROC-108, Most Recent Version

SESD Operating Procedure for Logbooks, SESDPROC-010, Most Recent Version

USEPA (1993). Method 180.1: Determination of Turbidity by Nephelometry. Rev. 2.0. Environmental Systems Monitoring Laboratory, Office of Research and Development, Cincinnati, Ohio.

USEPA (2001). Environmental Investigations Standard Operating Procedures and Quality Assurance Manual. Region 4 Science and Ecosystem Support Division (SESD), Athens, GA.

USEPA. Safety, Health and Environmental Management Program Procedures and Policy Manual. Region 4 SESD, Athens, GA, Most Recent Version

USGS (2004). Office of Water Quality Technical Memorandum 2004.03: Revision of NFM Chapter 6, Section 6.7- Turbidity, available online at: http://water.usgs.gov/admin/memo/QW/qw04.03.html

USGS (2005). National field manual for the collection of water-quality data: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chaps. A6.7, available online at http://pubs.water.usgs.gov/twri9A.

USGS (2012). Turbidity parameter and methods codes, available online at: https://water.usgs.gov/owq/turbidity/Turbidity_parameter_codes_and_methods_codes_(May2012)%20(2).xlsx

1.5 General Precautions

1.5.1 Safety

Proper safety precautions must be observed when conducting field turbidity measurements. Refer to the SESD Safety, Health and Environmental Management Program (SHEMP) Manual (Most Recent Version) and any pertinent site-specific Health and Safety Plans (HASPs) for guidelines on safety precautions. These guidelines, however, should only be used to complement the judgment of an experienced professional. When using this procedure, minimize exposure to potential health hazards through the use of protective clothing, eye wear and gloves. Address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate.

1.5.2 Procedural Precautions

All field turbidity measurements pertinent to the sampling event should be recorded in the field logbook for the event. All records should be entered according to the procedures outlined in the SESD Operating Procedure for Logbooks (SESDPROC-010).

2 Quality Control

All turbidity meters and probes shall be maintained and operated in accordance with the manufacturer's instructions and the SESD Operating Procedure for Equipment Inventory and Management (SESDPROC-108). Before a meter or probe is taken to the field, it shall be properly calibrated or verified, according to Sections 3.2 and 3.3 of this procedure, to ensure it is operating properly. These calibration and verification checks shall be documented and maintained in a logbook.

The ambient temperature in the immediate vicinity of the meter should be measured and recorded in the field logbook to insure the instrument is operated within the manufacturer’s specified range of operating temperatures. For instruments that are deployed for in-situ measurements, the temperature of the medium being monitored should be measured and recorded in the logbook prior to deployment. *In-situ monitoring equipment may be utilized in unattended deployments where autonomous logging may preclude temperature measurement prior to deployment. Because in situ instrumentation generally has a wide range of operating temperature, the field investigator may utilize professional judgment in determining if the operating environment is suitable for unattended deployment.*

If at any time during a field investigation, it appears that the environmental conditions could jeopardize the quality of the measurement results, the measurements will be stopped. This will be documented in the field logbook.

3 Field Turbidity Measurement Procedures

3.1 General

Turbidity is caused by suspended and colloidal matter such as clay, silt, organic and inorganic matter and microscopic organisms. Many methods are available for the measurement of turbidity including turbidimeters and optical probes. Turbidity is measured by determining the amount of scatter when a light is passed through a sample.

3.2 Instrument Calibration and Verification

Many brands of instruments are commercially available for the measurement of turbidity incorporating a wide variety of technologies (See Section 3.5 for further discussion). The manufacturer's instruction manual should be consulted for specific procedures regarding their calibration, maintenance and use. Calibration of any measurement instrument must be conducted and/or verified prior to each use or on a daily basis, whichever is most appropriate. Depending on the instrument, the verification and calibration can differ slightly. If the instrument readings do not agree within ± 10 % of the calibration standards, the unit must be recalibrated, repaired or replaced. The following are basic guidelines for calibration/verification of meters and are provided as an example:

3.2.1 Meter Calibration and Verification

HACH 2100Q Turbidimeter:

Portable turbidimeters are calibrated with Formazin Primary Standards. The manufacturer recommends calibration with a primary standard such as StablCal® Stabilized Standards or with formazin standards every three months.

Generally only a calibration verification measurement is required in the field; however, if a calibration is needed, record a post calibration reading for each calibration standard used.

Meter Verification:

1. Push **Verify Cal** to enter the Verify menu.
2. Gently invert the liquid standard several times prior to insertion into meter. Insert the 10.0 NTU (or other defined value) Verification Standard and close the Lid.
3. Push **Read**. The display shows "Stabilizing" and then shows the result and tolerance range.

4. Push **Done** to return to the reading display. Repeat the calibration verification if the verification failed. If a meter is unable to pass verification, then that meter will need to be calibrated.

Meter Calibration:

1. Push the **CALIBRATION** key to enter the Calibration mode. Follow the instructions on the display. **Note:** Gently invert each standard several times before inserting the standard and use a non-abrasive, lint-free paper or cloth to wipe off the standards.

2. Insert the 20 NTU StablCal Standard and close the lid. Push **Read**. The display shows "Stabilizing" and then shows the result. Record the result.

3. Repeat Step 2 with the 100 NTU and 800 NTU StablCal Standard. Record both results.

4. Push **Done** to review the calibration details.

5. Push **Store** to save the results. After a calibration is complete, the meter automatically goes into the Verify Cal mode.

3.2.2 Probe Calibration and Verification

The manufacturer's instruction manual should be consulted for specific procedures regarding probe's calibration, maintenance and use. Their calibration must be conducted and/or verified prior to each use or on a daily basis, whichever is most appropriate. The following are basic guidelines for calibration/verification of probes and are provided as an example:

1. Turn the meter "ON" and allow it to stabilize

2. Immerse the probe in the first standard solution and calibrate the probe against the solution.

3. Rinse the probe with de-ionized water, remove excess rinse water and calibrate the probe using additional standards as appropriate.

4. Record the standard values used to calibrate the meter.

3.3 Sample Measurement Procedures

Depending on the meter, the sample measurement procedure can differ slightly.

3.3.1 Grab Sample Measurement

These procedures should be followed when conducting turbidity measurements of grab samples:

1. Collect a representative sample and pour off enough to fill the cell to the fill line (about 15 mL) and replace the cap on the cell.

2. Gently wipe off excess water and any streaks from surface of sampling vial.

3. Turn instrument on. Place the meter on a flat, sturdy surface. Do not hold the instrument while making measurements.

4. Insert the sample cell in the instrument so the diamond or orientation mark aligns with the raised orientation mark in the front of the cell compartment. Close the lid.

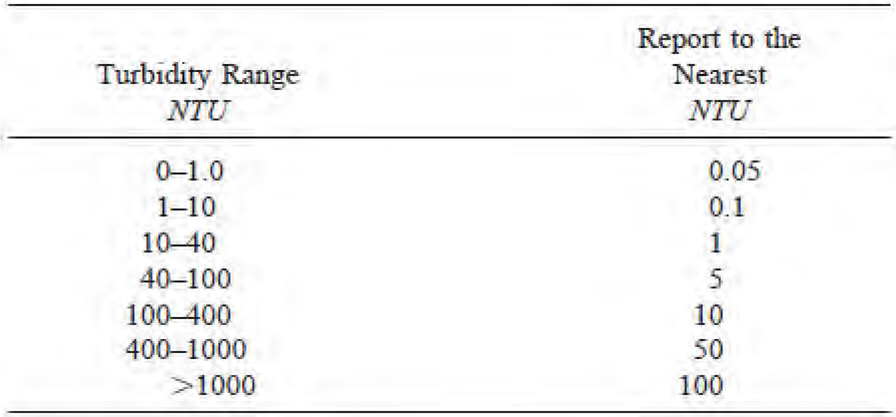
5. If appropriate, select manual or automatic range selection by pressing the range key.

6. If appropriate, select signal averaging mode by pressing the Signal Average key. Use signal average mode if the sample causes a noisy signal (display changes constantly).

7. Press Read. The display will show ---- NTU. Then the turbidity is displayed in NTU. Record the result to the correct range dependent significant digits as required by EPA Method 180.1 Rev. 2.0 (USEPA, 1993) and SM 2130B (APHA, 1992) (Table 1).

8. Rinse the cell with de-ionized water or rinse out with sample water prior to the next reading.

Table 1: Reporting Requirements (APHA, 1992)



Turbidity Range *NTU*	Report to the Nearest *NTU*
0–1.0	0.05
1–10	0.1
10–40	1
40–100	5
100–400	10
400–1000	50
>1000	100

3.3.2 In-Situ Measurement

These procedures should be followed when conducting in-situ turbidity measurements:

1. Place the probe into the media to be measured and allow the turbidity reading to stabilize. Once the reading has stabilized, record the measurement in the logbook.

2. When deploying meters for extended periods of time, ensure the measurement location is representative of average media conditions.

3.4 Operational check

Even though it is not necessary to re-calibrate turbidity meters at regular intervals during the day, depending on the instrument, it may be appropriate to occasionally perform operational checks to determine if site conditions, such as an increase in temperature, have impacted the meter’s performance. If an operational check is warranted, the following procedure should be followed to ensure that the performance of the meter has not changed.

While in use, periodically check the turbidity by rinsing the probe with de-ionized water, blot dry or otherwise remove excess rinse water and immerse it into the appropriate calibration standard. If the measured turbidity differs by ± 10 % (depending on the application) from the calibration standard, the meter must be re-calibrated.

A post-operation instrument verification check will be performed using the appropriate standard(s) at the end of the day or after all measurements have been taken for a particular period of operation. These measurements must be recorded in the field logbook.

3.5 Units and Application

Due to the availability of various technologies for measuring turbidity, the USGS (United States Geological Survey) in collaboration with ASTM International (American Society for Testing and Materials) has determined that data collected using different methods are not directly comparable and should be reported in units reflecting the specific technology used (USGS 2004; ASTM International 2012) (Table 2).

Measurements taken for regulatory purposes (i.e. National Primary Drinking Water Regulations (NPDWR) monitoring, National Pollution Discharge Elimination System (NPDES) reporting) must be in compliance with EPA approved methods. Approved methods for Clean Water Act programs and Safe Drinking Water Act programs can be found in 40 C.F.R. § 136.3 and 40 C.F.R. § 141.74(a)(1), respectively.

Project leaders should consult the decision tree depicted in Figure 1 to determine the appropriate turbidity method that will meet the project specific Data Quality Objectives. For more detailed information on the different methods and their associated units, refer to the USGS National Field Manual for the Collection of Water-Quality Data, Section 6.7 (USGS 2005) and ASTM designation D7315 (ASTM International 2012). A sensor specific spreadsheet detailing methods and associated units can be found on the USGS Field Manual website under turbidity parameter and methods codes (USGS 2012).

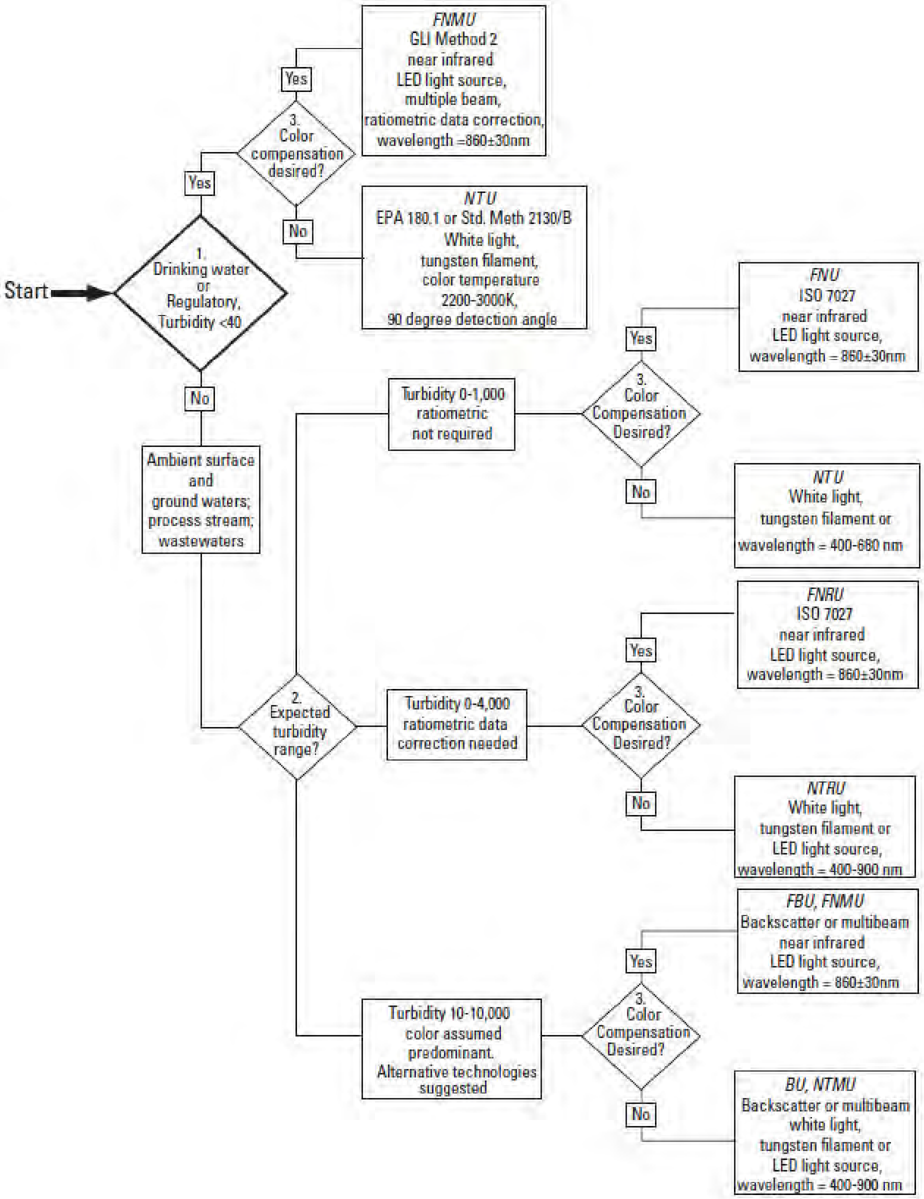
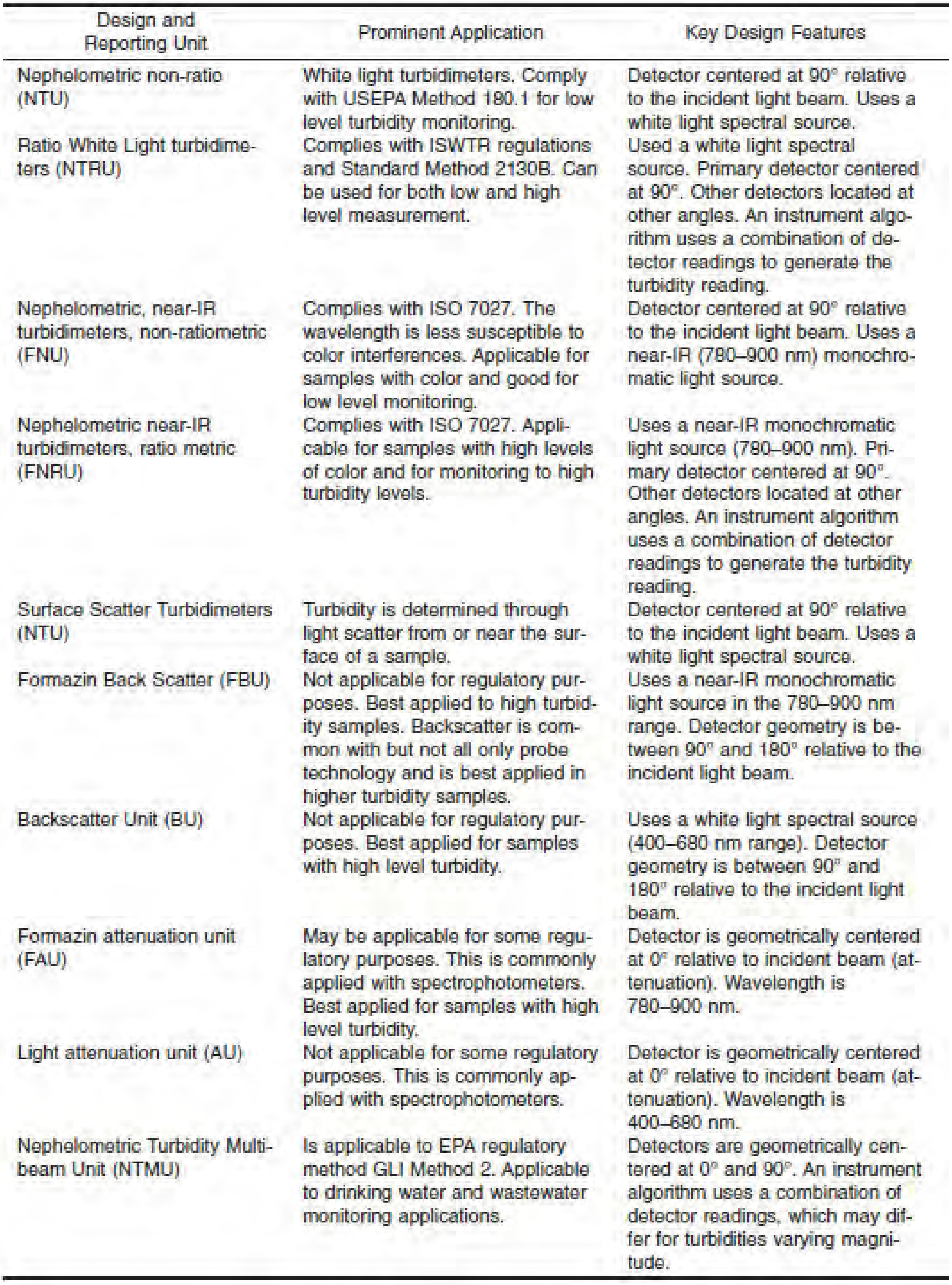


Figure 1: Turbidity Method Decision Tree, adapted from Figure 6.7-2 (USGS 2005)

Table 2: Turbidity Technology, Units, Application, & Design (adapted from ASTM International 2012)



Design and Reporting Unit	Prominent Application	Key Design Features
Nephelometric non-ratio (NTU)	White light turbidimeters. Comply with USEPA Method 180.1 for low level turbidity monitoring.	Detector centered at 90° relative to the incident light beam. Uses a white light spectral source.
Ratio White Light turbidimeters (NTRU)	Complies with ISWTR regulations and Standard Method 2130B. Can be used for both low and high level measurement.	Used a white light spectral source. Primary detector centered at 90°. Other detectors located at other angles. An instrument algorithm uses a combination of detector readings to generate the turbidity reading.
Nephelometric, near-IR turbidimeters, non-ratiometric (FNU)	Complies with ISO 7027. The wavelength is less susceptible to color interferences. Applicable for samples with color and good for low level monitoring.	Detector centered at 90° relative to the incident light beam. Uses a near-IR (780–900 nm) monochromatic light source.
Nephelometric near-IR turbidimeters, ratio metric (FNRU)	Complies with ISO 7027. Applicable for samples with high levels of color and for monitoring to high turbidity levels.	Uses a near-IR monochromatic light source (780–900 nm). Primary detector centered at 90°. Other detectors located at other angles. An instrument algorithm uses a combination of detector readings to generate the turbidity reading.
Surface Scatter Turbidimeters (NTU)	Turbidity is determined through light scatter from or near the surface of a sample.	Detector centered at 90° relative to the incident light beam. Uses a white light spectral source.
Formazin Back Scatter (FBU)	Not applicable for regulatory purposes. Best applied to high turbidity samples. Backscatter is common with but not all only probe technology and is best applied in higher turbidity samples.	Uses a near-IR monochromatic light source in the 780–900 nm range. Detector geometry is between 90° and 180° relative to the incident light beam.
Backscatter Unit (BU)	Not applicable for regulatory purposes. Best applied for samples with high level turbidity.	Uses a white light spectral source (400–680 nm range). Detector geometry is between 90° and 180° relative to the incident light beam.
Formazin attenuation unit (FAU)	May be applicable for some regulatory purposes. This is commonly applied with spectrophotometers. Best applied for samples with high level turbidity.	Detector is geometrically centered at 0° relative to incident beam (attenuation). Wavelength is 780–900 nm.
Light attenuation unit (AU)	Not applicable for some regulatory purposes. This is commonly applied with spectrophotometers.	Detector is geometrically centered at 0° relative to incident beam (attenuation). Wavelength is 400–680 nm.
Nephelometric Turbidity Multibeam Unit (NTMU)	Is applicable to EPA regulatory method GLI Method 2. Applicable to drinking water and wastewater monitoring applications.	Detectors are geometrically centered at 0° and 90°. An instrument algorithm uses a combination of detector readings, which may differ for turbidities varying magnitude.

SESD PROCEDURE SESDPROC-205-R3:

FIELD EQUIPMENT CLEANING AND DECONTAMINATION

COPY

Region 4
U.S. Environmental Protection Agency
Science and Ecosystem Support Division
Athens, Georgia

OPERATING PROCEDURE

Title: **Field Equipment Cleaning and Decontamination**	
Effective Date: December 18, 2015	**Number:** SESDPROC-205-R3

Authors

Name: Brian Striggow
Title: Environmental Engineer
Signature: Date: 12-18-15

Approvals

Name: John Deatrick
Title: Chief, Field Services Branch
Signature: John Deatrick Date: 12/18/15

Name: Hunter Johnson
Title: Field Quality Manager, Science and Ecosystem Support Division
Signature: Date: 12/18/15

Revision History

The top row of this table shows the most recent changes to this controlled document. For previous revision history information, archived versions of this document are maintained by the SESD Document Control Coordinator on the SESD local area network (LAN).

History	Effective Date
SESDPROC-205-R3, *Field Equipment Cleaning and Decontamination*, replaces SESDPROC-205-R2. **Cover Page:** The author was changed to Brian Striggow. SESD's reorganization was reflected in the authorization section by making John Deatrick the Chief of the Field Services Branch. The FQM was changed from Bobby Lewis to Hunter Johnson. **Revision History:** Changes were made to reflect the current practice of only including the most recent changes in the revision history. **General:** Corrected any typographical, grammatical and/or editorial errors. **Section 1.4:** Differentiate between Liquinox® and Luminox® detergents. **Section 3.4:** Restore solvent rinse as alternative cleaning method. **Section 3.7:** Added section on cleaning of 12 Volt electric submersible pumps. **Section 3.8:** Added section on cleaning of bladder pumps. **Section 3.9:** Added language on cleaning and transport of SP15/16 screens **Section 3.10:** Added section on cleaning of rental pumps	December 18, 2015
SESDPROC-205-R2, *Field Equipment Cleaning and Decontamination*, replaces SESDPROC-205-R1.	December 20, 2011
SESDPROC-205-R1, *Field Equipment Cleaning and Decontamination*, replaces SESDPROC-205-R0.	November 1, 2007
SESDPROC-205-R0, *Field Equipment Cleaning and Decontamination*, Original Issue	February 05, 2007

TABLE OF CONTENTS

1 General Information

1.1 Purpose

This document describes general and specific procedures, methods and considerations to be used and observed when cleaning and decontaminating sampling equipment during the course of field investigations.

1.2 Scope/Application

The procedures contained in this document are to be followed when field cleaning sampling equipment, for both re-use in the field, as well as used equipment being returned to the Field Equipment Center (FEC). On the occasion that SESD field investigators determine that any of the procedures described in this section are either inappropriate, inadequate or impractical and that other procedures must be used to clean or decontaminate sampling equipment at a particular site, the variant procedure will be documented in the field logbook, along with a description of the circumstances requiring its use. Mention of trade names or commercial products in this operating procedure does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and have been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD Local Area Network (LAN). The Document Control Coordinator (DCC) is responsible for ensuring the most recent version of the procedure is placed on LAN and for maintaining records of review conducted prior to its issuance.

1.4 Definitions

- Decontamination: The process of cleaning dirty sampling equipment to the degree to which it can be re-used, with appropriate QA/QC, in the field.

- Deionized water: Tap water that has been treated by passing through a standard deionizing resin column. At a minimum, the finished water should contain no detectable heavy metals or other inorganic compounds (i.e., at or above analytical detection limits) as defined by a standard inductively coupled Argon Plasma Spectrophotometer (ICP) (or equivalent) scan. Deionized water obtained by other methods is acceptable, as long as it meets the above analytical criteria. Organic-free water may be substituted for deionized water.

- Detergent shall be a standard brand of phosphate-free laboratory detergent such as Liquinox® or Luminox®. Liquinox® is a traditional anionic laboratory detergent and is used for general cleaning and where there is concern for the stability of the cleaned items in harsher cleaners. Luminox® is a specialized detergent with the capability of removing oils and organic contamination. It is used in lieu of a solvent rinse step in cleaning of equipment for trace contaminant sampling. Where not specified in these procedures, either detergent is acceptable.

- Drilling Equipment: All power equipment used to collect surface and sub-surface soil samples or install wells. For purposes of this procedure, direct push is also included in this definition.

- Field Cleaning: The process of cleaning dirty sampling equipment such that it can be returned to the FEC in a condition that will minimize the risk of transfer of contaminants from a site.

- Organic-free water: Tap water that has been treated with activated carbon and deionizing units. At a minimum, the finished water must meet the analytical criteria of deionized water and it should contain no detectable pesticides, herbicides, or extractable organic compounds, and no volatile organic compounds above minimum detectable levels as determined by the Region 4 laboratory for a given set of analyses. Organic-free water obtained by other methods is acceptable, as long as it meets the above analytical criteria.

- Tap water: Water from any potable water supply. Deionized water or organic-free water may be substituted for tap water.

1.5 References

SESD Operating Procedure for Management of Investigation Derived Waste, SESDPROC-202, Most Recent Version

SESD Operating Procedure for Equipment Cleaning and Decontamination at the FEC, SESDPROC-206, Most Recent Version

US EPA. Safety, Health and Environmental Management Program Procedures and Policy Manual. Region 4 SESD, Athens, GA, Most Recent Version

1.6 General Precautions

1.6.1 Safety

Proper safety precautions must be observed when field cleaning or decontaminating dirty sampling equipment. Refer to the SESD Safety, Health and Environmental Management Program (SHEMP) Procedures and Policy Manual and any pertinent site-specific Health and Safety Plans (HASPs) for guidelines on safety precautions. These guidelines, however, should only be used to complement the judgment of an experienced professional. Address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate. At a minimum, the following precautions should be taken in the field during these cleaning operations:

- When conducting field cleaning or decontamination using laboratory detergent, safety glasses with splash shields or goggles, and latex gloves will be worn.

- No eating, smoking, drinking, chewing, or any hand to mouth contact should be permitted during cleaning operations.

1.6.2 Procedural Precaution

Prior to mobilization to a site, the expected types of contamination should be evaluated to determine if the field cleaning and decontamination activities will generate rinsates and other waste waters that might be considered RCRA hazardous waste or may require special handling.

2 Introduction to Field Equipment Cleaning and Decontamination

2.1 General

The procedures outlined in this document are intended for use by field investigators for cleaning and decontaminating sampling and other equipment in the field. These procedures should be followed in order that equipment is returned to the FEC in a condition that will minimize the risk of transfer of contaminants from a site.

Sampling and field equipment cleaned in accordance with these procedures must meet the minimum requirements for the Data Quality Objectives (DQOs) of the study or investigation. If deviations from these procedures need to be made during the course of the field investigation, they will be documented in the field logbook along with a description of the circumstances requiring the use of the variant procedure.

Cleaning procedures for use at the Field Equipment Center (FEC) are found in SESD Operating Procedure for Equipment Cleaning and Decontamination at the FEC (SESDPROC-206).

2.2 Handling Practices and Containers for Cleaning Solutions

Improperly handled cleaning solutions may easily become contaminated. Storage and application containers must be constructed of the proper materials to ensure their integrity. Following are acceptable materials used for containing the specified cleaning solutions:

- Detergent must be kept in clean plastic, metal, or glass containers until used. It should be poured directly from the container during use.

- Tap water may be kept in tanks, hand pressure sprayers, squeeze bottles, or applied directly from a hose.

- Deionized water must be stored in clean, glass or plastic containers that can be closed prior to use. It can be applied from plastic squeeze bottles.

- Organic-free water must be stored in clean glass or Teflon® containers prior to use. It may be applied using Teflon® squeeze bottles, or with the portable system.

2.3 Disposal of Cleaning Solutions

Procedures for the safe handling and disposition of investigation derived waste (IDW); including used wash water and rinse water are in SESD Operating Procedure for Management of Investigation Derived Waste (SESDPROC-202).

2.4 Sample Collection Equipment Contaminated with Concentrated Materials

Equipment used to collect samples of concentrated materials from investigation sites must be field cleaned before returning from the study. At a minimum, this should consist of washing with detergent and rinsing with tap water. When the above procedure cannot be followed, the following options are acceptable:

1. Leave with facility for proper disposal;
2. If possible, containerize, seal, and secure the equipment and leave on-site for later disposal;
3. Containerize, bag or seal the equipment so that no odor is detected and return to the SESD.

It is the project leader's responsibility to evaluate the nature of the sampled material and determine the most appropriate cleaning procedures for the equipment used to sample that material.

2.5 Sample Collection Equipment Contaminated with Environmental Media

Equipment used to collect samples of environmental media from investigation sites should be field cleaned before returning from the study. Based on the condition of the sampling equipment, one or more of the following options must be used for field cleaning:

1. Wipe the equipment clean;
2. Water-rinse the equipment;
3. Wash the equipment in detergent and water followed by a tap water rinse.
4. For grossly contaminated equipment, the procedures set forth in Section 2.4 must be followed.

Under extenuating circumstances such as facility limitations, regulatory limitations, or during residential sampling investigations where field cleaning operations are not feasible, equipment can be containerized, bagged or sealed so that no odor is detected and returned to the FEC without being field cleaned. If possible, FEC personnel should be notified that equipment will be returned without being field cleaned. It is the project leader's responsibility to evaluate the nature of the sampled material and determine the most appropriate cleaning procedures for the equipment used to sample that material.

2.6 Handling of Decontaminated Equipment

After decontamination, equipment should be handled only by personnel wearing clean gloves to prevent re-contamination. In addition, the equipment should be moved away (preferably upwind) from the decontamination area to prevent re-contamination. If the equipment is not to be immediately re-used it should be covered with plastic sheeting or wrapped in aluminum foil to prevent re-contamination. The area where the equipment is kept prior to re-use must be free of contaminants.

3 Field Equipment Decontamination Procedures

3.1 General

Sufficient equipment should be transported to the field so that an entire study can be conducted without the need for decontamination. When equipment must be decontaminated in the field, the following procedures are to be utilized.

3.2 Specifications for Decontamination Pads

Decontamination pads constructed for field cleaning of sampling and drilling equipment should meet the following minimum specifications:

- The pad should be constructed in an area known or believed to be free of surface contamination.

- The pad should not leak.

- If possible, the pad should be constructed on a level, paved surface and should facilitate the removal of wastewater. This may be accomplished by either constructing the pad with one corner lower than the rest, or by creating a sump or pit in one corner or along one side. Any sump or pit should also be lined.

- Sawhorses or racks constructed to hold equipment while being cleaned should be high enough above ground to prevent equipment from being splashed.

- Water should be removed from the decontamination pad frequently.

- A temporary pad should be lined with a water impermeable material with no seams within the pad. This material should be either easily replaced (disposable) or repairable.

At the completion of site activities, the decontamination pad should be deactivated. The pit or sump should be backfilled with the appropriate material designated by the site project leader, but only after all waste/rinse water has been pumped into containers for disposal. See SESD Operating Procedure for Management of Investigation Derived Waste (SESDPROC-202) for proper handling and disposal of these materials. If the decontamination pad has leaked excessively, soil sampling may be required.

3.3 "Classical Parameter" Sampling Equipment

"Classical Parameters" are analyses such as oxygen demand, nutrients, certain inorganic compounds, sulfide, flow measurements, etc. For routine operations involving classical parameter analyses, water quality sampling equipment such as Kemmerers, buckets, dissolved oxygen dunkers, dredges, etc., may be cleaned with the sample water or tap water between sampling locations as appropriate.

Flow measuring equipment such as weirs, staff gages, velocity meters, and other stream gauging equipment may be cleaned with tap water between measuring locations, if necessary.

Note: The procedures described in Section 3.3 are not to be used for cleaning field equipment to be used for the collection of samples undergoing trace organic or inorganic constituent analyses.

3.4 Sampling Equipment used for the Collection of Trace Organic and Inorganic Compounds

For samples undergoing trace organic or inorganic constituent analyses, the following procedures are to be used for all sampling equipment or components of equipment that come in contact with the sample:

3.4.1 Standard SESD Method

1. An optional Liquinox® detergent wash step may be useful to remove gross dirt and soil.

2. Clean with tap water and Luminox® detergent using a brush, if necessary, to remove particulate matter and surface films.

3. Rinse thoroughly with tap water.
4. Rinse thoroughly with organic-free water and place on a clean foil-wrapped surface to **a**ir-dry.
5. Wrap the dry equipment with aluminum foil or bag in clean plastic. If the equipment is to be stored overnight before it is wrapped in foil, it should be covered and secured with clean, unused plastic sheeting.

3.4.2 Alternative Solvent Rinse Method

The historical solvent rinse method of cleaning equipment for trace contaminant sampling remains an acceptable method.

1. Clean with tap water and Liquinox® detergent using a brush, if necessary, to remove particulate matter and surface films. Equipment may be steam cleaned (Liquinox® detergent and high pressure hot water) as an alternative to

brushing. Sampling equipment that is steam cleaned should be placed on racks or saw horses at least two feet above the floor of the decontamination pad. PVC or plastic items should not be steam cleaned.

2. . Rinse thoroughly with tap water.

3. Rinse thoroughly with deionized water.

4. Rinse with an appropriate solvent (generally isopropanol).

5. Rinse with organic-free water and place on a clean foil-wrapped surface to **a**ir-dry.

4. Wrap the dry equipment with aluminum foil. If the equipment is to be stored overnight before it is wrapped in foil, it should be covered and secured with clean, unused.

3.5 Well Sounders or Tapes

The following procedures are recommended for decontaminating well sounders (water level indicators) and tapes. Unless conditions warrant, it is only necessary to decontaminate the wetted portion of the sounder or tape.

1. Wash with Liquinox® detergent and tap water.

2. Rinse with tap water.

3. Rinse with deionized water.

3.6 Redi-Flo2® Pump

CAUTION – Do not wet the controller. Always disconnect power from the pump when handling the pump body.

The Redi-Flo2® pump and any associated connected hardware (e.g., check valve) should be decontaminated between each monitoring well. The following procedures are required, depending on whether the pump is used solely for purging or used for purging and sampling.

3.6.1 Purge Only (Pump and Wetted Portion of Tubing or Hose)

1. Disconnect power and wash exterior of pump and wetted portion of the power lead and tubing or hose with Liquinox® detergent and water solution.

2. Rinse with tap water.

3. Final rinse with deionized water.

4. Place pump and reel in a clean plastic bag and keep tubing or hose contained in clean plastic or galvanized tub between uses.

3.6.2 Purge And Sample

Grundfos Redi-Flo2® pumps are extensively decontaminated and tested at the FEC to prevent contamination from being transmitted between sites. The relevant sections of SESDPROC-206, *Field Equipment Cleaning and Decontamination at the FEC,* should be implemented in the field where a high risk of cross-contamination exists, such as where NAPL or high-concentration contaminants occur. In most cases, the abbreviated cleaning procedure described below will suffice, provided that sampling proceeds from least to most contaminated areas.

1. Disconnect and discard the previously used sample tubing from the pump. Remove the check valve and tubing adapters and clean separately (See Section 3.6.3 for check valve). Wash the pump exterior with detergent and water.

2. Prepare and fill three containers with decontamination solutions, consisting of Container #1, a tap water/detergent washing solution. Luminox® is commonly used. An additional pre-wash container of Liquinox® may be used; Container #2, a tap water rinsing solution; and Container #3, a deionized or organic-free water final rinsing solution. Choice of detergent and final rinsing solution for all steps in this procedure is dependent upon project objectives (analytes and compounds of interest). The containers should be large enough to hold the pump and one to two liters of solution. An array of 2' long 2" PVC pipes with bottom caps is a common arrangement. The solutions should be changed at least daily.

3. Place the pump in Container #1. Turn the pump on and circulate the detergent and water solution through the pump and then turn the pump off.

4. Place the pump in Container #2. Turn the pump on and circulate the tap water through the pump and then turn the pump off.

5. Place the pump in Container #3. Turn the pump on and circulate deionized or organic-free water through the pump and then turn the pump off.

6. Disconnect power and remove pump from Container #3. Rinse exterior and interior of pump with fresh deionized or organic-free water.

7. Decontaminate the power lead by washing with detergent and water, followed by tap water and deionized water rinses. This step may be performed before washing the pump if desired.

8. Reassemble check valve and tubing adapters to pump. ALWAYS use Teflon® tape to prevent galling of threads. Firm hand-tightening of fittings or light wrench torque is generally adequate.

9. Place the pump and reel in a clean plastic bag.

3.6.3 Redi-Flo2® Ball Check Valve

1. Remove the ball check valve from the pump head. Check for wear and/or corrosion, and replace as needed. During decontamination check for free-flow in forward direction and blocking of flow in reverse direction.

2. Using a brush, scrub all components with detergent and tap water.

3. Rinse with deionized water.

4. Rethread the ball check valve to the Redi-Flo2® pump head.

3.7 Mega-Monsoon® and GeoSub® Electric Submersible Pump

As these pumps have lower velocities in the turbine section and are easier to disassemble in the field than Grundfos pumps, the outer pump housing should be removed to expose the impeller for cleaning prior to use and between each use when used as a sampling pump for trace contaminant sampling.

1. Remove check valves and adapter fittings and clean separately.
2. Remove the outer motor housing by holding the top of the pump head and unscrewing the outer housing from its O-ring sealed seat.
3. Clean all pump components per the provisions of section 3.4. Use a small bottle brush for the pump head passages
4. Wet the O-ring(s) on the pump head with organic-free water. Reassemble the outer pump housing to the pump head.
5. Clean cable and reel per Section 3.4.
6. Conduct final rinse of pump with organic-free water over pump and through pump turbine.

3.8 Bladder Pumps

Bladder pumps are presumed to be intended for use as purge-and-sample pumps. The Geotech® bladder pump and Geoprobe Systems® mechanical bladder pump can be cleaned similarly.

1. Discard any tubing returned with the pump.

2. Completely disassemble the pump, being careful to note the initial position of and retain any springs and loose ball checks.

3. Discard pump bladder.

4. Clean all parts as per the standard cleaning procedure in Section 3.4.

5. Install a new Teflon® bladder and reassemble pump.

3.9 Downhole Drilling Equipment

These procedures are to be used for drilling activities involving the collection of soil samples for trace organic and inorganic constituent analyses and for the construction of monitoring wells to be used for the collection of groundwater samples for trace organic and inorganic constituent analyses.

3.9.1 Introduction

Cleaning and decontamination of all equipment should occur at a designated area (decontamination pad) on the site. The decontamination pad should meet the specifications of Section 3.2 of this procedure.

Tap water brought on the site for drilling and cleaning purposes should be contained in a pre-cleaned tank.

A steam cleaner and/or high pressure hot water washer capable of generating a pressure of at least 2500 PSI and producing hot water and/or steam, with a detergent compartment, should be obtained.

3.9.2 Preliminary Cleaning and Inspection

Drilling equipment should be clean of any contaminants that may have been transported from off-site to minimize the potential for cross-contamination. The drilling equipment should not serve as a source of contaminants. Associated drilling and decontamination equipment, well construction materials, and equipment handling procedures should meet these minimum specified criteria:

- All downhole augering, drilling, and sampling equipment should be sandblasted before use if painted, and/or there is a buildup of rust, hard or caked matter, etc., that cannot be removed by steam cleaning (detergent and high pressure hot water), or wire brushing. Sandblasting should be performed <u>prior to arrival</u> on site, or well away from the decontamination pad and areas to be sampled.

- Any portion of the drilling equipment that is over the borehole (kelly bar or mast, backhoe buckets, drilling platform, hoist or chain pulldowns, spindles, cathead, etc.) should be steam cleaned (detergent and high pressure hot water) and wire brushed (as needed) to remove all rust, soil, and other material which may have come from other sites before being brought on site.

- Printing and/or writing on well casing, tremie tubing, etc., should be removed before use. Emery cloth or sand paper can be used to remove the printing and/or writing. Most well material suppliers can provide materials without the printing and/or writing if specified when ordered. Items that cannot be cleaned are not acceptable and should be discarded.

- Equipment associated with the drilling and sampling activities should be inspected to insure that all oils, greases, hydraulic fluids, etc., have been removed, and all seals and gaskets are intact with no fluid leaks.

3.9.3 Drill Rig Field Cleaning Procedure

Any portion of the drill rig, backhoe, etc., that is over the borehole (kelly bar or mast, backhoe buckets, drilling platform, hoist or chain pulldowns, spindles, cathead, etc.) should be steam cleaned (detergent and high pressure hot water) between boreholes.

3.9.4 Field Decontamination Procedure for Drilling Equipment

The following is the standard procedure for field cleaning augers, drill stems, rods, tools, and associated equipment. This procedure does <u>not</u> apply to well casings, well screens, or split-spoon samplers used to obtain samples for chemical analyses, which should be decontaminated as outlined in Section 3.4 of this procedure.

1. Wash with tap water and detergent, using a brush if necessary, to remove particulate matter and surface films. Steam cleaning (high pressure hot water with detergent) may be necessary to remove matter that is difficult to remove with the brush. Drilling equipment that is steam cleaned should be placed on racks or saw horses at least two feet above the floor of the decontamination pad. Hollow-stem augers, drill

rods, etc., that are hollow or have holes that transmit water or drilling fluids, should be cleaned on the inside with vigorous brushing.

2. Rinse thoroughly with tap water.

3. Remove from the decontamination pad and cover with clean, unused plastic. If stored overnight, the plastic should be secured to ensure that it stays in place.

3.9.5 Field Decontamination Procedure for Direct Push Technology (DPT) Equipment

1. Certain specific procedures for the decontamination of DPT tools are described in the various sampling procedures, but the following general guidelines apply:

2. Prior to return to the Field Equipment Center, all threaded tool joints should be broken apart and the equipment cleaned per the provisions of *Section 2.5, Sample Collection Equipment Contaminated with Environmental Media* of this procedure.

3. Equipment that contacts the sample media and is cleaned in the field for reuse should be cleaned per the provisions of *Section 3.4, Sampling Equipment used for the Collection of Trace Organic and Inorganic Compounds* of this procedure. This would include piston sampler points and shoes, screen point sampler screens and sheaths, and the drive rods when used for groundwater sampling.

4. Equipment that does not directly contact the sample media and is cleaned in the field for reuse can generally be cleaned per the provisions of Section *3.7.4, Field Decontamination Procedure for Drilling Equipment* of this procedure.

5. Stainless steel SP15/16 well screens require special care as the narrow slots are difficult to clean under even controlled circumstances and galvanic corrosion can release chrome from the screen surface. As soon as possible after retrieval, the screen slots should be sprayed from the outside to break loose as much material as possible before it can dry in place. To prevent galvanic corrosion, the screens must be segregated from the sampler sheaths, drive rods, and other carbon steel during return transport from the field.

3.10 Rental Pumps

Completing a groundwater sampling project may require the use of rental pumps. Rental pumps are acceptable where they are of suitable stainless steel and Teflon® construction. These pumps should be cleaned prior to use using the procedures specified herein and a rinse-blank collected prior to use.

SESD PROCEDURE SESDPROC-202-R3:

MANAGEMENT OF INVESTIGATION DERIVED WASTE

COPY

Region 4
U.S. Environmental Protection Agency
Science and Ecosystem Support Division
Athens, Georgia

OPERATING PROCEDURE

Title: **Management of Investigation Derived Waste**

Effective Date: July 3, 2014

Number: SESDPROC-202-R3

Authors

Name: Art Masters
Title: Environmental Scientist, Regional Expert
Signature: Date: 7/2/14

Approvals

Name: John Deatrick
Title: Acting Chief, Enforcement and Investigations Branch
Signature: John Deatrick Date: 7/2/14

Name: Mike Bowden
Title: Acting Chief, Ecological Assessment Branch
Signature: M Bowden Date: 7/2/14

Name: Bobby Lewis
Title: Field Quality Manager, Science and Ecosystem Support Division
Signature: Date: 7/2/14

Revision History

The top row of this table shows the most recent changes to this controlled document. For previous revision history information, archived versions of this document are maintained by the SESD Document Control Coordinator on the SESD local area network (LAN).

History	Effective Date
SESDPROC-202-R3, *Management of Investigation Derived Waste*, replaces SESDPROC-202-R2. **General:** Corrected typographical, grammatical and/or editorial errors. **Cover Page:** The Enforcement and Investigations Branch Chief was changed from Archie Lee to Acting Chief John Deatrick. The Ecological Assessment Branch Chief was changed from Bill Cosgrove to Acting Chief Mike Bowden. The FQM was changed from Liza Montalvo to Bobby Lewis. **Revision History:** Changes were made to reflect the current practice of only including the most recent changes in the revision history.	July 3, 2014
SESDPROC-202-R2, *Management of Investigation Derived Waste*, replaces SESDPROC-202-R1.	October 15, 2010
SESDPROC-202-R1, *Management of Investigation Derived Waste*, replaces SESDPROC-202-R0.	November 1, 2007
SESDPROC-202-R0, Management of Investigation Derived Waste, Original Issue	February 05, 2007

TABLE OF CONTENTS

TABLES

Contents

1 General Information

1.1 Purpose

This document describes general and specific procedures and considerations to be used and observed when managing investigation derived waste (IDW) generated during the course of hazardous waste site investigations.

1.2 Scope/Application

The procedures and management options for the different categories of IDW described in this document are to be used by SESD field personnel to manage IDW generated during site investigations. On the occasion that SESD field personnel determine that any of the procedures described in this section are inappropriate, inadequate or impractical and that another procedure must be used to manage IDW generated at a particular site, the variant procedure will be documented in the field logbook, along with a description of the circumstances requiring its use. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and have been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD Local Area Network (LAN). The Document Control Coordinator (DCC) is responsible for ensuring the most recent version of the procedure is placed on the LAN and for maintaining records of review conducted prior to its issuance.

1.4 References

SESD Operating Procedure for Field Equipment Cleaning and Decontamination, SESDPROC-205, Most Recent Version

United States Environmental Protection Agency (US EPA). 2001. Environmental Investigations Standard Operating Procedures and Quality Assurance Manual. Region 4 Science and Ecosystem Support Division (SESD), Athens, GA

US EPA. Safety, Health and Environmental Management Program Procedures and Policy Manual. Region 4 SESD, Athens, GA, Most Recent Version

1.5 General Precautions

1.5.1 Safety

Proper safety precautions must be observed when managing IDW. Refer to the SESD Safety, Health and Environmental Management Program (SHEMP) Procedures and Policy Manual and any pertinent site-specific Health and Safety Plans (HASP) for guidelines on safety precautions. These guidelines, however, should only be used to complement the judgment of an experienced professional. Address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate.

1.5.2 Procedural Precautions

The following precautions should be considered when managing IDW:

- Due to time limitations and restrictions posed by RCRA regulations on storage of hazardous waste, accumulation start dates should be identified on all drums, buckets or other containers used to hold IDW so that it can be managed in a timely manner.
- During generation of both non-hazardous and hazardous IDW, keep hazardous IDW segregated from non-hazardous IDW to minimize the volume of hazardous IDW that must be properly managed.

2 Types of Investigation Derived Waste

Materials which may become IDW include, but are not limited to:

- Personal protective equipment (PPE) - This includes disposable coveralls, gloves, booties, respirator canisters, splash suits, etc.
- Disposable equipment and items - This includes plastic ground and equipment covers, aluminum foil, conduit pipe, composite liquid waste samplers (COLIWASAs), Teflon® tubing, broken or unused sample containers, sample container boxes, tape, etc.
- Soil cuttings from drilling or hand augering.
- Drilling mud or water used for mud or water rotary drilling.
- Groundwater obtained through well development or well purging.
- Cleaning fluids such as spent solvents and wash water.
- Packing and shipping materials.

Table 1, found at the end of this procedure, lists the types of IDW commonly generated during field investigations and the current disposal practices for these materials.

For the purpose of determining the ultimate disposition of IDW, it is typically distinguished as being either hazardous or non-hazardous. This determination is based on either clear regulatory guidance or by subsequent analysis. This determination and subsequent management is the responsibility of the program site manager.

3 Management of Non-Hazardous IDW

Disposal of non-hazardous IDW should be addressed in the study plan or QAPP for the investigation. To reduce the volume of any IDW transported back to the Field Equipment Center (FEC), it may be necessary to compact the waste into a reusable container, such as a 55-gallon drum.

If the waste is from an active facility, permission should be sought from the operator of the facility to place the non-hazardous PPE, disposable equipment, and/or paper/cardboard into the facility's dumpsters. If necessary, these materials may be placed into municipal dumpsters, with the permission of the owner. These materials may also be taken to a nearby permitted landfill. On larger studies, waste hauling services may be obtained and a dumpster located at the study site.

Disposal of non-hazardous IDW such as drill cuttings, drilling mud, purge or development water, decontamination wash water, etc., should be specified in the approved study plan or QAPP. It is recommended that these materials be placed into a unit with an environmental permit, such as a landfill or sanitary sewer. These materials must not be placed into dumpsters. If the facility at which the study is being conducted is active, permission should be sought to place these types of IDW into the facility's treatment system. It may be feasible to spread drill cuttings around the borehole, or, if the well is temporary, to place the cuttings back into the borehole. Non-hazardous monitoring well purge or development water may also be poured onto the ground down gradient of the monitoring well when site conditions permit. Purge water from private potable wells which are in service may be discharged directly onto the ground surface.

The minimum requirements for this subsection are:

- Non-hazardous liquid and soil/sediment IDW may be placed on the ground or returned to the source if doing so does not endanger human health or the environment or violate federal or state regulations. Under no circumstances, however, should monitoring well purge water be placed back into the well from which it came.
- Soap and water decontamination fluids and rinsates of such cannot be placed in any water bodies and must be collected and returned to the FEC for disposition.
- The collection, handling and proposed disposal method must be specified in the approved study plan or QAPP.

4 Management of Hazardous IDW

Disposal of hazardous or suspected hazardous IDW must be specified in the approved study plan or QAPP for the study or investigation. Hazardous IDW must be disposed as specified in USEPA regulations. If appropriate, these wastes may be placed back in an active facility waste treatment system. These wastes may also be disposed in the source area from which they originated if doing so does not endanger human health or the environment.

If on-site disposal is not feasible, and if the wastes are suspected to be hazardous, appropriate tests must be conducted to make that determination. If they are determined to be hazardous wastes, they must be properly contained and labeled. They may be stored on the site for a maximum of 90 days before they must be manifested and shipped to a permitted treatment or disposal facility. Generation of hazardous IDW must be anticipated, if possible, to allow arrangements for proper containerization, labeling, transportation and disposal/treatment in accordance with USEPA regulations.

The generation of hazardous IDW should be minimized to conserve Division resources. Most routine studies should not produce any hazardous IDW, with the possible exception of spent solvents and, possibly, purged groundwater. The use of solvents during field cleaning of equipment should be minimized by using solvent-free cleaning procedures for routine cleaning and decontamination (see SESD Operating Procedure for Field Equipment Cleaning and Decontamination, SESDPROC-205). If solvents are needed, the volume should be minimized by using only the amount necessary and by capturing the residual solvent separately from the aqueous decontamination fluids (detergent/wash water mixes and water rinses).

At a minimum, the requirements of the management of hazardous IDW are as follows:

- Spent solvents must be left on-site with the permission of site operator and proper disposal arranged.
- All hazardous IDW must be containerized. Proper handling and disposal should be arranged prior to commencement of field activities.

COPY

Table 1: Disposal of IDW

TYPE	HAZARDOUS	NON - HAZARDOUS
PPE-Disposable	Containerize in plastic 5-gallon bucket with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise return to FEC for proper disposal.	Place waste in trash bag. Place in dumpster with permission of site operator, otherwise return to FEC for disposal in dumpster.
PPE-Reusable	Decontaminate as per SESD Operating Procedure for Field Equipment Cleaning and Decontamination, SESDPROC-205, if possible. If the equipment cannot be decontaminated, containerize in plastic 5-gallon bucket with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise return to FEC for proper disposal.	Decontaminate as per SESDPROC-205, and return to FEC.
Spent Solvents	Containerize in original containers. Clearly identify contents. Leave on-site with permission of site operator and arrange for proper disposal.	N/A
Soil Cuttings	Containerize in DOT-approved container with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with program site manager for testing and disposal.	Containerize in a 55-gallon steel drum with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with program site manager for testing and disposal. **
Groundwater	Containerize in DOT-approved container with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with program site manager for testing and disposal.	Containerize in an appropriate container with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with program site manager for testing and disposal. **
Decontamination Water	Containerize in DOT-approved container with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with program site manager for testing and disposal.	Containerize in an appropriate container with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with program site manager for testing and disposal. Decontamination water may also be disposed in a sanitary sewer system, with permission from the wastewater treatment plant representative, and if doing so does not endanger human health or the environment, or violate federal or state regulations.
Disposable Equipment	Containerize in DOT-approved container or 5-gallon plastic bucket with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with program site manager for testing and disposal.	Containerize in an appropriate container with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with program site manager for testing and disposal. If unfeasible, return to FEC for disposal in dumpster.
Trash	N/A	Place waste in trash bag. Place in dumpster with permission of site operator, otherwise return to FEC for disposal in dumpster.

**** These materials may be placed on the ground if doing so does not endanger human health or the environment or violate federal or state regulations.**

APPENDIX B

TRS's HOT SOIL SAMPLING STANDARD OPERATING PROCEDURE

TRS
Accelerating Value

STANDARD OPERATING PROCEDURE

PROCEDURE No: 3.2

Procedure Title:

HOT SOIL SAMPLING

Author:	TRS Team	**Issue Date:**	4/22/08

Revisions:

Date	Initials	Revision Description	Revision #
01-04-10	LS	Add Scope, responsibilities, training, definitions, recordkeeping	1
5-6-14	TP	Added caution concerning hot water, steam expulsion	2
2-22-16	TP	Review, revised power off requirement	3

Reviewed and Approved by (initial and date):

SOP/ Revision #	Health & Safety		Operations	
Original	4/22/08		4/22/08	
REV 1	1/4/10		1/4/10	
REV 2			Thomas Powell	5/6/14
REV 3		2/24/16	Thomas Powell	2/22/16

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to provide a procedure for the safe collection of representative soil samples during, or after, the application of Electrical Resistance Heating (ERH). This procedure specifically addresses sampling of soil that has been heated during the ERH process.

2.0 SCOPE

This SOP serves as a guideline for the collection of soil samples during, or after, the application of ERH. To minimize the risk due to electrical hazards, lockout/tagout (LOTO) procedures must be applied to the ERH power control unit (PCU) throughout the duration of the soil sampling effort. Only authorized persons trained in procedures and requirements described in SOP 1.1 are permitted to conduct LOTO on TRS equipment. Samples collected using this SOP are generally used for evaluating treatment effectiveness, and/or confirming treatment goals have been met.

TRS Group, Inc. (TRS) personnel shall use this procedure in conjunction with site-specific sample analysis plans and permit requirements. These are standard (i.e., typically applicable) operating procedures, which may be varied or changed as required, dependent on site conditions, equipment limitations, permit requirements or limitations imposed by the procedure. The ultimate procedures, including any deviations from this SOP, shall be documented in the soil sampling form.

3.0 DEFINITIONS

Authorized Employee – Any designated employee who locks out or tags out equipment in order to perform servicing or maintenance. This person must have completed the mandatory LOTO training described in SOP 1.1 LOTO to be qualified as an authorized worker. Only an authorized worker installs and removes his or her own lock and tag as required by this program.

Competent Person – Any designated employee who has been trained in proper procedures for the application of energy to the subsurface at ERH sites. This person must have completed the mandatory training outlined in Section 7.0 to be qualified as a competent person.

ERH – Electrical Resistance Heating is a process whereby soils and groundwater are heated by passing an electrical current through the subsurface volume to be remediated.

LOTO – Lockout/Tagout. The practice of using a tag for visibility and awareness in conjunction with placement of a keyed device ("lock") on an energy isolating device, in accordance with SOP 1.1, to prevent the unwanted activation of mechanical or electrical equipment. Lockout ensures the equipment being controlled cannot be operated until the lock is removed.

4.0 EQUIPMENT LIST

1) Soil Sampling Field Form and pen (recommend indelible).
2) Drill rig and related equipment. Soil sampling is best achieved using a direct push drill rig such as a Geoprobe®. Geoprobe® Dual Tube Sampling Systems are efficient methods of collecting continuous soil cores with the added benefit of a cased hole, especially at depths greater than 20 feet below ground surface (ft bgs).
3) Ice bath for soil samples. An example is a cooler filled with ice. The cooler (or container) must be equipped with an opening at the bottom to allow water from melting ice to drain.

4) Standard cooking thermometer. Calibrated to both 0 degrees Celsius (°C) and 100°C.
5) LOTO equipment as described in TRS SOP 1.1.
6) Sample containers, labels, and chain-of-custody forms (as required by the laboratory for the analysis).
7) Safety Glasses with side shields. Additional option: full face-shield (wear over safety glasses)
8) Hearing protection adequate for sampling equipment decibel level. Refer to site-specific Health and Safety Plan (HASP)..
9) Latex gloves. Additional option: cotton or leather outer gloves (wear over inner latex gloves).
10) Site-specific PPE requirements. Refer to site-specific HASP.
11) Packaging material, chain of custody forms, and shipping labels.

5.0 HOT SOIL SAMPLING PROCEDURES

A soil-sampling event begins with the shutdown and application of LOTO to the PCU. This is done to prevent any electrical hazards between the steel drill string and sampling personnel. The vapor recovery system should continue to operate to maintain capture of steam in the subsurface, rather than allowing it to exit through the sample borehole. Interim and final soil sampling is best achieved using a direct push drill rig such as a Geoprobe®. As the probe casing is extracted from the subsurface, it should be considered to be very hot, and handled with proper precaution and personal protective equipment.

Choose a sample sleeve consistent with the conditions being encountered. For example if sample location temperature is elevated above 100°C, then a steel sleeve will be a better choice than a Teflon sleeve as the Teflon sleeve will become soft and deform at elevated temperatures. Consult engineering for the appropriate sleeve.

5.1 Safety Considerations

There are certain hazards associated with ERH during the remediation of soil and groundwater. These hazardous include possible contact with hazardous voltage, steam, hot water, hot soil, other hot surfaces, or hazardous chemicals. Exposure to these hazardous can be mitigated through engineering controls and strict adherence to documented procedures and safety protocols such as the following restrictions:

- The ERH PCU system must be turned off and LOTO applied during soil sampling activities. <u>Only trained and authorized TRS personnel are allowed to perform LOTO of ERH equipment.</u>
- High temperatures, hot water and steam may be encountered when collecting subsurface soil samples; the use of the proper personal protective equipment (PPE) is mandatory and caution is advised.
- Contaminant vapors may be present at the borehole during sampling.
- Personnel shall be trained on hazards and engineering controls associated with drilling before beginning sampling operations. Potential hazards include rotating equipment, overhead loads, and slips trips and falls.

Refer to the site-specific Sampling and Analysis Plans (SAPs) and HASP for site-specific requirements and restrictions.

⚠ Caution: Exposure to hot groundwater and steam possible

The removal of water and soil from the sample borehole can change the temperature/pressure equilibrium conditions existing in the borehole prior to drilling and sampling by reducing the hydrostatic head in the borehole, allowing hot water and steam to eject from the borehole. Review the site conditions prior to commencing drilling or boring. If sampling soil beneath the groundwater surface level elevation, always remove the boring equipment and samples slowly from the boring to allow the borehole conditions to safely re-equilibrate.

Stop and complete the attached Site Sampling Evaluation Checklist before proceeding with this procedure.

5.2 Hot Soil Sampling Procedures

Sampling shall be completed in order from sample locations having the lowest anticipated concentrations of contaminants of concern (COC) to locations having highest anticipated COC concentrations (i.e.; outside treatment area, treatment area boundary, locations within the source area). The steps outlined below must be followed for both interim and final hot soil sampling.

1) Telephone the TRS Project Manager (PM) the day prior to sampling to schedule a remote shutdown. A shutdown period of at least 12 hours is preferred prior to soil sampling. Contact the TRS Health and Safety Officer if project conditions require sampling within 12 hours of shutdown for an activity hazard analysis.
2) An authorized person shall apply LOTO to the ERH PCU by site-specific instructions. Note: Only personnel who have been trained and certified by TRS in LOTO procedures can complete this procedure.
3) Position drill rig in the area to be sampled and perform a visual check for any safety concerns. Potential concerns include: high voltage lines, uneven terrain, underground utilities, and egress limitations with rig placement.

4) Hand auger, or air knife the first five feet of the boring to clear location for potential buried utilities.

5) Advance the push sampler to the depth required and collect samples. The sample sleeves used must be made of Teflon®, brass, or stainless steel. Sample sleeves made of other materials such as acrylic or other materials can melt and bias sample results.

6) The sample sleeves must be capped immediately and placed into the ice bath to begin the cool down process. Water from melting ice must be allowed to drain, as the sample sleeves should not be submerged at any time.

7) The sample sleeves should be cooled until the soil nears ambient temperature (approximately 20°C or 70 degrees Fahrenheit [°F]). A standard cooking thermometer can be inserted through the end cap for temperature monitoring. The sample sleeve may be opened and sampled once near-ambient temperatures have been reached. Soil samples including quality control (QC) samples are collected, labeled, preserved and shipped per the site-specific SAP.
8) Plugging/sealing of the soil borehole will be in accordance with Federal, State, and Local regulatory and client requirements.
9) Soil cuttings not consumed in the sampling process will be disposed of according to Federal, State, and Local regulatory and client requirements.

6.0 RESPONSIBILITIES

Role	Responsibility
VP Operations	• Develop and implement SOPs • Periodically review and update procedures based on project feedback • Provide training and maintain training documentation
TRS HSO	• Assist VP Operations with providing training and maintaining training documentation. • Assist Site Health and Safety Officer (SHSO) with modifying SOP to meet site-specific HASP requirements.
PM	• Review procedures in conjunction with site-specific sample requirements and scope of work (SOW). Coordinate changes to procedures as necessary. • Schedule and coordinate sampling effort. Ensure adequate supplies are available.
SHSO	• Conduct orientations for subcontractors and employees • Coordinate training needs with TRS HSO • Review procedures in conjunction with site-specific HASP. Coordinate changes to procedures as necessary to maintain safe working procedures.
Sampling Personnel	• Complete training to the level of competent person prior to initiating sampling activities. • Follow procedures and document information related to soil sampling effort as identified in this SOP, including and deviations from the SOP.

7.0 TRAINING

Training in SOPs is provided upon initial assignment and annually thereafter. Additional retraining is provided if there is a change in procedures or if inadequacies are observed in the individual's application of procedures. Subcontractors must train their own employees. LOTO training requirements for personnel are outlined in SOP 1.1.

8.0 RECORD KEEPING

These are standard (i.e., typically applicable) procedures, which may be varied or changed as required dependent on site conditions, equipment limitations, permit requirements, or limitations imposed by the procedure. The ultimate procedures used during any sampling event, including any deviations from these procedures, shall be documented in the sample logbook.

At a minimum, the following information shall be maintained in the sample logbook related to hot soil sampling at ERH project sites:

- Date;
- Sample identification and corresponding location;
- Sample time;
- Sample identifications and analysis to be performed;
- Chain of custody number;
- Shipping information;
- Deviations from this SOP, and;
- Any other information deemed relevant to the sample results.

Copies of chains of custody forms and shipping documentation shall be maintained and kept with the sample logbook.

9.0 REFERENCES

TRS Group, Inc., 2013. SOP 1.1, Lockout/Tagout (LOTO), Rev 3. Nov.

SOP 3.2 Hot Soil Sampling

Training Acknowledgment

All personnel that receive training on this procedure will review and sign the acknowledgement form contained in this section.

I have been trained by TRS Group, Inc. (TRS) to perform hot soil sampling at TRS ERH project sites. By signing this document, trainee acknowledges that SOP 3.2 Hot Soil Sampling has been read and the contents of the document are understood. Trainee has received hands-on training from a competent person who is authorized to use and instruct others on sampling procedures at TRS project sites.

Date	**Training Acknowledgement**	**TRS Trainer**

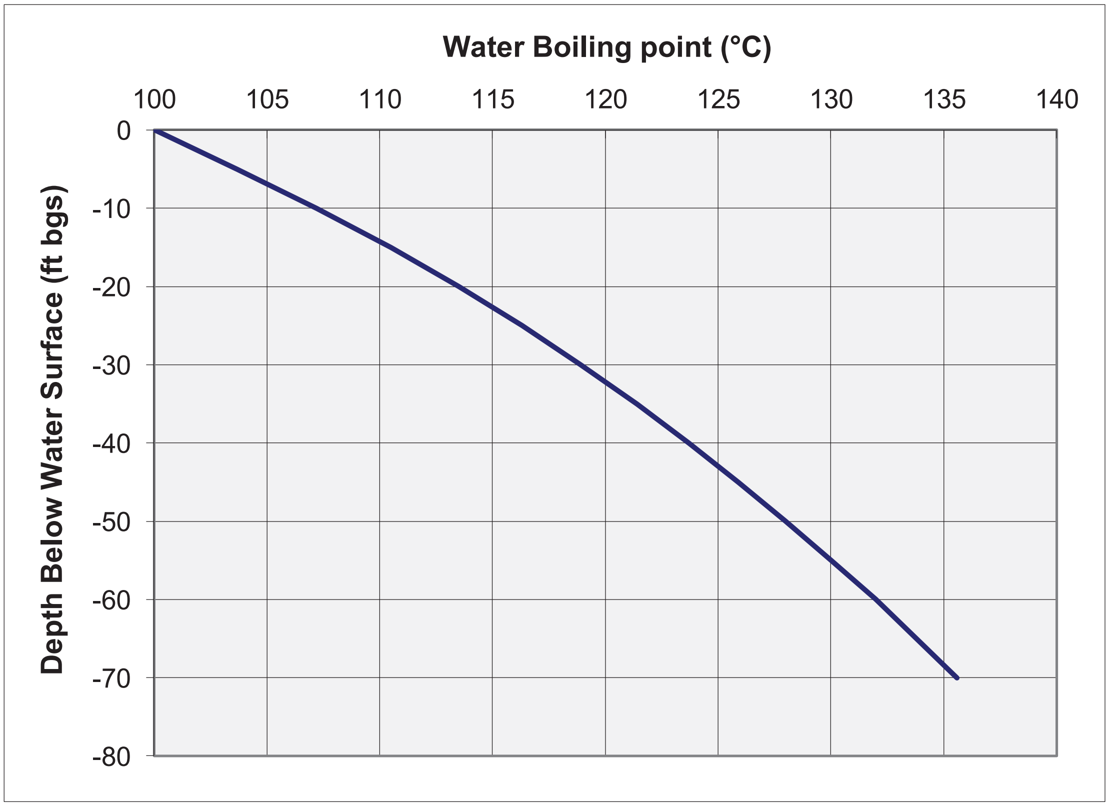
Site Sampling Evaluation Checklist

Project #: _________________

Date: _____________________

Subsurface Conditions

1) Are soil samples being recovered from beneath the groundwater surface?
2) What is the depth to groundwater at the time of sampling?
3) How deep below the groundwater surface elevation are we sampling?
4) What are the current temperatures at or near each boring location?
5) Are there confining layers on site? Clay or silt over saturated zone sand for example.
6) Use the figure below to determine where the sites actual temperatures fit on the boiling point curve.



7) Actual temperature for each depth elevation that is higher in value than the temperatures represented by this curve suggest a temperature value greater than the hydrostatic boiling point of water.

APPENDIX C

TRS's HOT GROUNDWATER SAMPLING STANDARD OPERATING PROCEDURE

TRS
Accelerating Value

STANDARD OPERATING PROCEDURE

PROCEDURE No: 3.1

Procedure Title:

Hot Groundwater Sampling

Author:	TRS Team	**Issue Date:**	4/22/08

Revisions:

Date	Initials	Revision Description	Revision #
04-14-09		Update Format, include pictures	2
06-27-09	LS	Add Scope, responsibilities, training, definitions, Recordkeeping, and new procedures	3
06-25-10	LS	Update Drawings	4
07-27-12	LS	Review and update SOP; changes to pump usage	5
12/15/14	TP	Annual Review, MW access caution	6

Reviewed and Approved by (initial and date):

SOP/ Revision #	Health & Safety		Operations	
Original	4/22/08		4/22/08	
REV 2	4/14/09		4/14/09	
REV 3	6/27/09		6/27/09	
REV 4	6/25/10		6/25/10	
REV 5	Lynette A Slauch	7/27/12	Thomas Powell	7/27/12
REV 6		1/9/15	Thomas Powell	1/9/15

1.0 PURPOSE

This standard operating procedure (SOP) provides uniform procedures for the safe collection of representative groundwater samples during or after the application of Electrical Resistance Heating (ERH). This procedure specifically addresses sampling of groundwater that has been heated due to the ERH process.

2.0 SCOPE

This SOP serves as a guideline for the collection of groundwater samples during the application of ERH using modified low-flow sampling procedures. This SOP draws information from the United States Environmental Protection Agency's (USEPA's) groundwater issue paper, Low-Flow (minimal drawdown) Ground-Water Sampling Procedure (Puls and Barcelona, 1996). Modifications to the EPA methodology have been made to accommodate groundwater temperatures that have been elevated as a result of ERH application. Only personnel trained to the minimum requirements outlined in Section 7.0 of this SOP are authorized to collect hot groundwater samples at TRS ERH project sites.

The USEPA guidance document recommends continual monitoring of water levels during the purge and sample process to ensure that minimal drawdown is occurring (Puls and Barcelona, 1996). Due to the safety hazards associated with opening wellheads at active ERH project sites, groundwater level measurements (depth to groundwater) will not be collected as part of hot groundwater sampling activities. If the TRS project site has been constructed with pressure transducers to monitor groundwater gradients, readings from the transducers will be monitored as feasible to minimize groundwater drawdown. If previous sampling records or hydrogeologic data is available, this information shall be used to develop target flow rates for the groundwater sampling effort.

These procedures assume that dedicated tubing and pumping systems, for each monitoring well, have been established prior to application of electrical energy to the subsurface.

Caution - Access to groundwater monitoring wells during an ERH application is prohibited without TRS management approval. If intrusive work is required to complete the sampling efforts, or minimally accessing a well cap, an additional activity hazard analysis (AHA) must be created and reviewed and approved by the TRS project manager (PM), TRS Health and Safety Officer (HSO), and, the TRS Senior Manager approving the Startup Checklist (SUCL).

Samples collected using this SOP are generally used for optimizing system performance. Samples collected using this procedure may also be used for regulatory compliance and/or site closure.

TRS Group, Inc. (TRS) personnel shall use this procedure in conjunction with site-specific sample analysis plans and permit requirements. These are standard (i.e., typically applicable) operating procedures that may be varied or changed as required, dependent on site conditions, equipment limitations, permit requirements or limitations imposed by the procedure. The ultimate procedures, including any deviations from this SOP, shall be documented on the groundwater sampling form.

Groundwater sampling typically is performed while the power application to the treatment area is shut off and locked out by a competent person in accordance with TRS SOP 1.1 Lockout/Tagout (LOTO; TRS 2009). The decision regarding the application of energy to the subsurface during groundwater sampling will be determined on a case-by-case basis dependent on specific site conditions and engineering controls. Refer to the site specific Health and Safety Plan (HASP) and consult with the PM and Site Health and Safety Officer (SHSO) for site-specific requirements and restrictions.

3.0 DEFINITIONS

Authorized employee – Any designated employee who locks out or tags out equipment in order to perform servicing or maintenance. This person must have completed the mandatory LOTO training described in SOP 1.1 LOTO to be qualified as an authorized worker. Only an authorized worker installs and removes his or her own lock and tag as required by this program.

Competent Person – Any designated employee who has been trained in proper procedures for the application of energy to the subsurface at ERH sites. This person must have completed the mandatory training outlined in Section 7.0 to be qualified as a competent person.

ERH – Electrical Resistance Heating. ERH is a process whereby soils and groundwater are heated by passing an electrical current through the subsurface volume to be remediated.

Bladder Pump – Submersible pump with external control unit used for pumping fluids at greater depths. The bladder pump consists of an internal flexible bladder that is positioned within a rigid pump body constructed of stainless steel. The inner bladder is equipped with one-way inlet and outlet valves and passively fills with water when the pump is at depth by virtue of hydrostatic pressure. Following the fill cycle, compressed air from a cylinder or compressor at the wellhead is delivered to the pump through tubing and is used to compress the bladder. The applied pressure then causes the flexible bladder to compress and closes the bottom check valve, forcing water from the bladder into the discharge tubing. During a vent cycle, the pressure is released from the drive tubing. The bladder returns to its initial state as water re-enters the pump, while the top check valve prevents water already in the discharge tubing from falling back into the bladder. The pumping sequence consists of repeated fill/compress cycles, using a pneumatic controller positioned at the wellhead.

LOTO – Lockout/Tagout. The practice of using a tag for visibility and awareness in conjunction with placement of a keyed device ("lock") on an energy isolating device, in accordance with SOP 1.1, to prevent the unwanted activation of mechanical or electrical equipment. Lockout ensures the equipment being controlled cannot be operated until the lock is removed.

Low-Flow Purging – A USEPA approved purge-and-sample method used to minimize stress on the formation (minimal drawdown) which results in less mixing of stagnant casing water with formation water. Additional advantages of using low-flow purging methods include the following:

- Samples are more representative of actual contaminant loading.
- Disturbance at the sampling point is minimal which minimizes sampling artifacts.
- Less operator variability occurs between sampling events.
- Decreased amount of investigation-derived waste (IDW) is produced.
- Need for filtration is reduced.
- Sample consistency is increased.

Flow-rates during low-flow purging/sampling are site-specific, based on hydrology, but are generally in the order of 0.1 to 0.5 L/min. Proper screen location, screen length, well construction and well development techniques may impact the effectiveness of low-flow purging. (Puls and Barcelona, 1996)

Multi-probe and Flow-Through Cell – The flow through cell allows for in-line sampling of water quality parameters with the Multi-probe to determine stabilization for water sampling. At a minimum, groundwater quality parameters include pH, conductivity, temperature, dissolved oxygen (DO), and turbidity. Examples of multiprobes used for collecting water quality parameters include the Horiba U-22 and YSI 556 (shown below).

Peristaltic Pump – A positive displacement pump used for pumping fluids. Generally, flexible tubing is fitted inside a circular pump casing. A rotor with a number of "rollers", "shoes" or "wipers" attached to the external circumference compresses the flexible tube. As the rotor turns, the part of tube under compression closes thus forcing the fluid to move through the tube.

SHSO – Site Health and Safety Officer

Trip Blank – The purpose of trip blanks it to identify any potential contamination of samples during sample handling and shipment. These blanks are prepared in the laboratory by filling a volatile organic analysis (VOA) bottle with distilled/deionized water. Trip blanks shall accompany shipment of empty bottles to the site and shipment of samples back to the laboratory.

VOA Vials – EPA recommended glass sample containers used to collect liquid samples for laboratory analysis. VOA vials have a nominal volume of 40 mL and are manufactured of clear or amber borosilicate glass. Depending on type of analysis being conducted, the VOA vials may contain small amounts of preservative when shipped from the laboratory. When collecting samples in VOA vials, fill the vial completely full (ensure that a meniscus has formed at the top of the vial before securing the cap) and check that there are no air bubbles in the closed sample. If there is a preservative present, use caution to not overfill the vial.

4.0 EQUIPMENT LIST

The required equipment for groundwater sampling may differ from this SOP based on the requirements set by the local regulatory oversight agency. Typically, the required equipment will be as follows:

1) Groundwater Sampling Field Form and indelible pen.
2) Safety Glasses with side shields. Additional option: full face-shield (wear over safety glasses)
3) Cotton Gloves with Latex over-gloves. Cotton gloves should be worn to protect against water having high temperatures (wear under outer latex gloves).
4) Site-specific personal protective equipment (PPE) requirements. Refer to site specific HASP.
5) Pump and operating components.
    - Peristaltic pump utilized when the depth to water is 20 feet below ground surface (ft bgs) or less. Dedicated tubing shall be installed prior to ERH application.
    - Dedicated bladder pump with compressed air for depth to groundwater greater than 20 feet. Dedicated pumps shall be installed prior to ERH application.
6) Tubing (installed prior to ERH application)
    - Disposable Teflon™ and Silicone tubing (Masterflex™) for use with the peristaltic pump. Silicone tubing should be used only above the ground surface at the pump head in order to minimize potential for degradation by contaminants. The silicone tubing is then connected to the Teflon™ tubing, which is lowered to depth within the well.
    - Dedicated bladder pumps and tubing if using a bladder pump. During installation, careful measurements need to be made to ensure that the pump inlet is located within the central portion of the screened interval of the monitoring well.

    Caution – Once ERH heating begins; wellhead access is prohibited without prior TRS management approval
7) Power supply (12 volt automotive battery or similar, or portable generator).
8) Cooler with ice.
9) 10-ft length of ¼-inch stainless steel or copper tubing.
10) One-ft length of four-inch diameter pipe
11) Tray or container for ice bath.
12) Field water quality measuring equipment w/flow-through cell or similar device for monitoring groundwater parameters (pH, conductivity, ORP, temperature, DO, etc.) and calibration standards.
13) Turbidity meter.

14) Buckets for purge water.

15) Sample containers (with preservative as required by the laboratory analytical method), labels, and chain-of-custody forms (as required by the laboratory for the analysis). Pre-printed labels are generally available from the laboratory if requested in advance.

16) Scissors or tubing cutter (for cutting tubing lengths).

17) Packaging material and shipping labels.

18) LOTO equipment as described in TRS SOP 1.1.

5.0 HOT GROUNDWATER SAMPLING PROCEDURES

Groundwater purging is generally accepted as a required component of groundwater sampling in order to remove non-representative water from the well casing (Puls and Barcelona, 1996). Low-flow purging and sampling techniques will be used to minimize the impact on groundwater chemistry and collect representative samples. This technique also reduces the amount of investigation-derived waste (IDW) produced from a well.

5.1 Safety Considerations

There are certain hazards associated with ERH during the remediation of soil and groundwater. These hazardous include possible contact with hazardous voltage, steam, hot water, or hazardous chemicals. Exposure to these hazards can be mitigated through engineering controls and strict adherence to documented procedures and safety protocols, such as the following restrictions:

Caution - At no time will a 110/120-volt extension cord from a line source be used in an energized electrode field.

- An alternative power source such as a 12-volt automotive battery or portable generator must be used when samples will be collected with electrical energy applied to the subsurface. Typically, ground water sampling is performed while the ERH is offline and locked out.
- Extreme temperatures and steam may be encountered when collecting groundwater samples; the use of the proper personal protective equipment (PPE) is mandatory and caution is advised.
- Dedicated tubing and pumping systems shall be established prior to application of electrical energy to the subsurface.
- The ERH PCU system should be turned off and LOTO applied during groundwater sampling activities.
- Refer to the site specific Sampling and Analysis Plans (SAPs) and HASP for site-specific requirements and restrictions.

5.2 Sampling Cautions and Evaluation

There are certain hazards associated with ERH during the remediation of soil and groundwater. These hazardous include possible contact with hazardous voltage, steam, hot water, hot soil, other hot surfaces, or hazardous chemicals. Exposure to these hazardous can be mitigated through engineering controls and strict adherence to documented procedures and safety protocols including the following restrictions:

- The ERH PCU system must be turned off and LOTO applied during soil sampling activities.
- High temperatures, hot water and steam may be encountered when collecting subsurface groundwater samples; the use of the proper PPE is mandatory and caution is advised.
- Contaminant vapors may be present at the borehole during sampling.
- Personnel shall be trained on hazards and engineering controls associated with drilling before beginning sampling operations. Potential hazards include rotating equipment, overhead loads, and slips trips and falls.

Refer to the site-specific Sampling and Analysis Plans (SAPs) and HASP for site-specific requirements and restrictions.

Caution: Exposure to hot groundwater and steam possible

The removal of water and soil from the sample borehole can change the temperature/pressure equilibrium conditions existing in the borehole prior to drilling and sampling by reducing the hydrostatic head in the borehole allowing hot water and steam to eject from the borehole. Review the site conditions prior to commencing drilling or boring. If sampling soil beneath the groundwater surface level elevation, always remove the boring equipment and samples slowly from the boring to allow the borehole conditions to safely re-equilibrate.

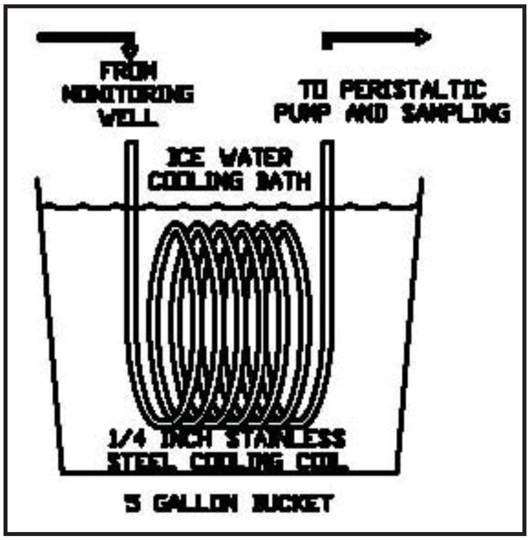
Stop and complete the Site Sampling Evaluation Checklist (attached) before proceeding with this procedure.

5.3 Ice Bath Construction

Groundwater heated through the ERH process presents both a potential safety hazard and a potential concern for collecting representative samples. If a boiling or near-boiling liquid is collected in a volatile organic analysis (VOA) vial, the formation of air bubbles as the sample cools within the VOA vial renders the sample non-representative. Additionally, hot liquids collected in the VOA vial may result in failure of the VOA septum.

The ice bath is designed to cool the groundwater prior to sampling while limiting the impact on groundwater chemistry and contaminant concentrations. Cooling the groundwater prior to sampling allows for both the safe handling of highly elevated water temperatures and prevents the formation of volatile organic compound (VOC) bubbles in the VOA vial after sample collection.

Prior to initial sampling, a cooling coil shall be constructed by wrapping a 10-ft length of ¼-inch stainless steel tubing 6 full turns around a 4-inch diameter pipe. The ends of the tubing shall be fashioned such that both ends of the tubing extend upward, as shown in the figure below.



5.4 Pumps

Peristaltic pumps are used for purging and sampling wells that have a depth to water of 20-ft bgs or less. During the construction of the ERH system, a dedicated 1/4-inch Teflon™ sample tube will be set within the well and a ¼-inch stainless steel sample valve will be installed in the surface well cap for sampling with a peristaltic pump. Prior to commencing any ERH operations, the well caps will be inspected for proper construction and installation and the well cap should not be removed during ERH operations and/or sampling without prior approval from TRS management. Installation of the sample valve is mandatory in order to prevent steam from escaping from the well during ERH application.

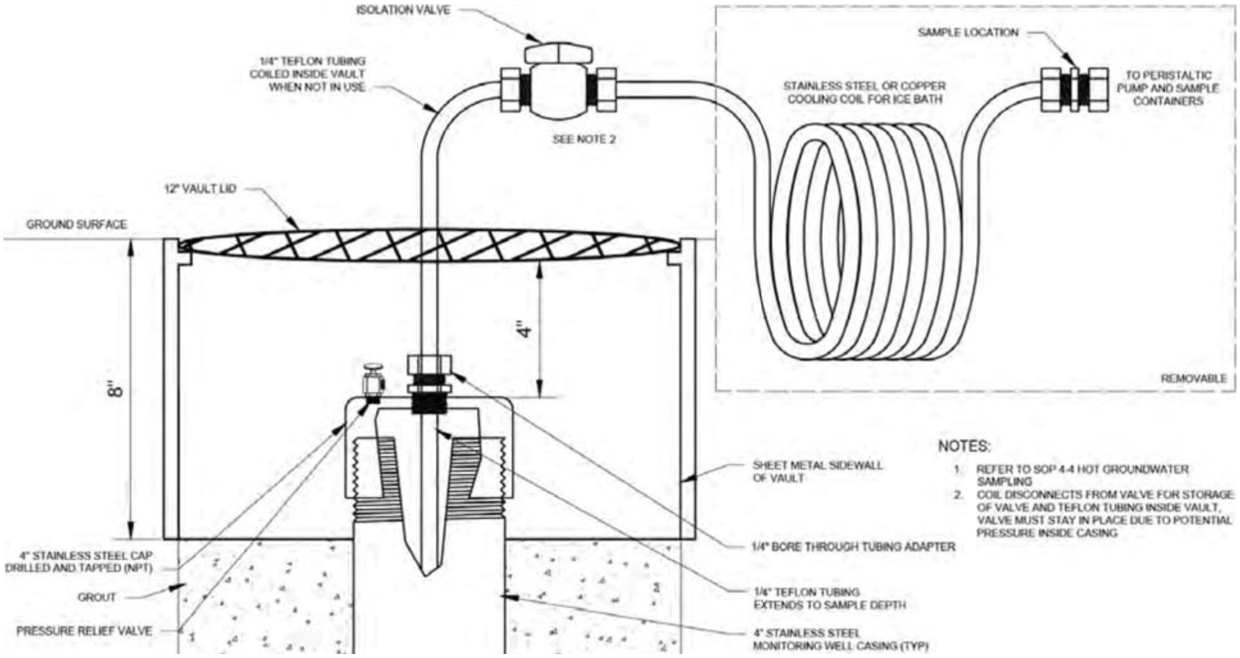
Pneumatically operated bladder pumps will be used for purging and sampling wells that with depth to water greater than 20 feet. The wellhead completion will be modified to allow for two tubes to pass independently through the sealed well head assembly. One tube will be used to deliver compressed air to the pump and the other tube will be used for sample recovery.

Either dedicated bladder pumps with Teflon™ tubing or dedicated Teflon™ tubing for use with a peristaltic pump will be installed prior to initiating heating of the ERH treatment volume. The use of pre-installed, dedicated sample equipment will reduce the risk of exposure to steam, hot water, or contaminants, since the wellhead will not have to be opened.

Regardless of which pumping system is used, the pump-intake shall be located in the middle or slightly above the middle of the screened interval. Placing the intake in the middle or near the middle of the screened interval, the amount of mixing between the overlaying stagnant casing water with the water within the screened interval is minimized. If the pump-intake is too close to the bottom of the well, increased entrainment of solids may occur. Pump-intake placement should only be used at the top of the water column in unconfined aquifers screened across the water table, where this is the required sampling point.

5.5 Well Head Construction

The TRS wellhead construction contains mandatory features that support the safe and representative collection of groundwater samples on a heated ERH site. The detailed features of the Groundwater Monitoring Well are shown below.



This well head design provides the ability to collect groundwater samples from a screened monitoring well without needing to open the well head increasing exposure to steam and hot water. Once heating has commenced, entry to the wellhead is prohibited without TRS senior management approval.

5.6 Groundwater Sampling

The TRS project team should coordinate, in advance, with all applicable parties to schedule an ERH system shutdown. The PM and SHSO shall determine a site-specific shutdown period. Sampling shall be completed in order from the wells having the lowest anticipated concentrations of contaminants of concern (COC) to wells having the highest anticipated COC concentrations (usually from exterior wells to boundary control wells to wells located within the source area).

The groundwater sampling procedure is as follows:

1) Calibrate probes used to monitor water quality parameters according to the manufacturer’s instructions (as necessary). Calibration frequencies should adhere to the manufacturer’s recommendations. Document all calibrations done to the probes used. Documentation should include: date, time, calibration solutions used, solution expiration dates, solution lot numbers, calibration results, outliers, and any illuminating comments.

2) Cease power application to the treatment area and perform LOTO procedures on the ERH PCU if required by site-specific protocols. Note: LOTO application shall only be completed by personnel who have been trained and certified by TRS according to SOP 1.1.

3) Confirm that the pump inlet (end of tubing for peristaltic pump or screened opening on the bladder pump) is located within the screened interval.

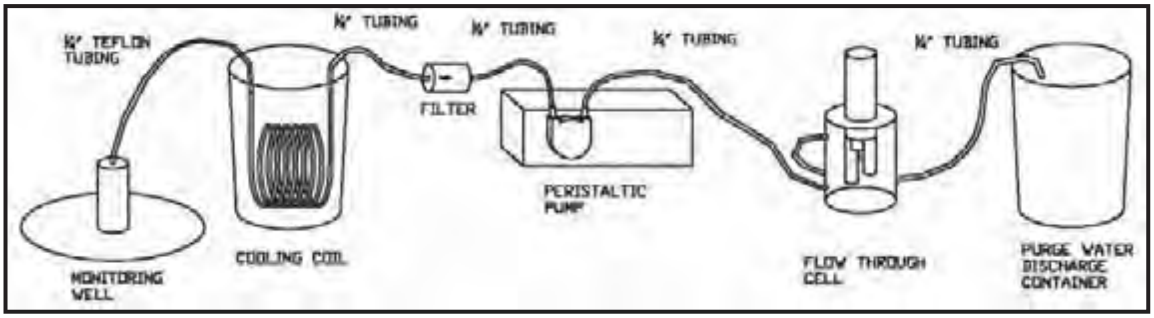
4) Connect ¼-inch sample tubing from the valve on the well to the cooling coil and place the coil in a bucket or cooler with ice to form the ice bath as described in Section 5.2.

5) Connect the pump to the cooling coil. For wells with a depth to water less than 20 feet, connect the cooling coil and peristaltic pump to the monitoring wellhead. For wells having a depth to water greater than 20-ft bgs, connect pump controls to the previously deployed bladder pump and connect the cooling coil and compressed air source.

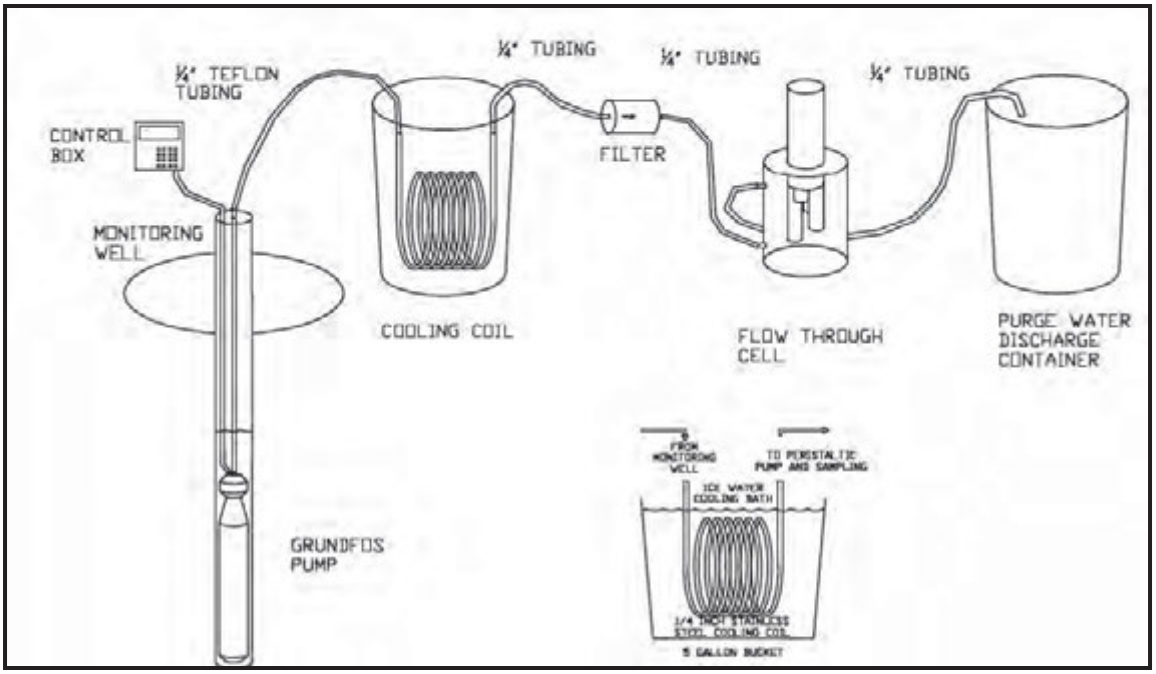
6) Connect the cooling coil discharge tubing to a flow-through cell with the calibrated meter probes/sensors securely held in the flow-through cell.

7) Connect tubing from the discharge of the flow-through cell to the purge water collection bucket.

PUMPING SET-UP WITH PERISTALTIC PUMP



PUMPING SET-UP WITH SUBMERSIBLE PUMP



8) Begin purging the well at a low- flow rate. Target pumping rates should generally be in the order of 0.1 to 0.5 liters per minute (L/min) to ensure stabilization of parameters and reduce mixing of formation water with stagnant well casing water. (Puls and Barcelona, 1996). Depending on site parameters and pumping method used, maintaining a steady low-flow rate may require pumping up to a rate of 1 L/min. Adjustments to the pumping rate are best made within the first 15 minutes of purging to minimize purging time.

9) The pumping rate is recorded on purge data sheets every 3 to 5 minutes during purging. Any adjustments to the pumping rate are recorded. At the initiation of well purging and after recording pumping rates, water quality parameters are measured and recorded with a multi-parameter water quality meter equipped with a flow-through cell. The measured water quality parameters are temperature, turbidity, specific conductance, pH, DO, and oxygen reduction potential (ORP or Redox). Pumping shall continue until the water quality parameters have stabilized (refer to Section 5.6.1) or the minimum purge volume has been removed (refer to Section 5.6.2).

10) After all water quality parameters have stabilized (refer to Section 5.6.1) and/or the minimum purge volume is purged (refer to Section 5.6.2), sampling may begin. If all parameters have stabilized, but turbidity remains above 10 NTUs, decrease the pump rate and continue monitoring. If the pump rate cannot be reduced and turbidity remains above 10 NTUs, the information will be recorded and sampling initiated. For low yield wells, sampling commences as soon as the well has recovered sufficiently to collect the appropriate volume for the anticipated samples. If well purging has caused the well to become dry, refer to Section 5.6.3 for sampling procedures.

11) Disconnect the tubing from the inlet side of the flow-through cell. The tubing from the pump outlet will be used to fill the groundwater sample bottles. Samples for VOCs shall be collected first followed by semi-volatile organic compounds (SVOCs). All other parameters should be collected in order from most volatile to least.

12) Groundwater samples including quality control (QC) samples are labeled and preserved per the site-specific Sampling and Analysis Plan (SAP).

13) All pertinent information will be documented in the sample log book and on the chain of custody forms including: date, time of sample, sample identification, analysis being completed, and any other information deemed relevant to the sample results. The following additional information shall be documented in the sample logbook: time at beginning and end of well purging, flow rate and any changes during the well purge, equipment used for well purge, and water quality parameter readings used to determine sample time.

14) Package and ship samples with a laboratory supplied trip blank to the offsite laboratory for analysis.

15) Meters used for groundwater sampling effort shall be decontaminated according to manufacturer recommendations. Dispose of decontamination liquids and purge water in accordance with site-specific documents.

5.6.1 Water Quality Parameters

Readings are recorded on the purge data sheets every 3 to 5 minutes. Field parameters are monitored until stabilization occurs. Unless local regulatory requirements differ, readings are generally considered stable when three consecutive readings are within the following criteria:

- Specific conductance readings within 3 percent
- Redox potential within 10mV
- pH within +/-0.1 standards units
- Turbidity and DO readings within 10 percent

5.6.2 Minimum Purge Volume

The purpose of micro purging is to reduce the amount of water generated during this procedure. Generally micro-purging is considered accomplished once the water quality parameters monitored have stabilized to within a 10% margin of error. However, if the water quality parameters will not stabilize a TRS established minimum purge volume will be used.

The minimum purge volume is three times the static saturated well volume. The equation to calculate the minimum purge volume is:

$$V = 7.48*rw2(td-dtw)$$

Where V = one purge volume in gallons; rw = radius of well casing in feet; td = total depth of well in feet; dtw = typical depth to groundwater in feet.

5.6.3 Dry Well Sampling

If well purging has caused the well to become dry, the following procedures will be used to sample the well and allow for recharge:

1) A column of water is drawn in the cooling coil tubing with the pump.
2) The well sample valve and the peristaltic pump inlet valve are closed and the pump shut off.
3) The cooling coil is disconnected from the well sample valve.
4) The cooling coil is carefully removed from the ice bath.
5) The pump inlet valve is opened.
6) The sample is decanted into the sample vials from the pump end of the tubing via gravity flow.

The process is repeated until the sample volume is collected. Any other sample fractions (cations, anions) are sampled from the well end of the cooling coil tubing.

6.0 RESPONSIBILITIES

Role	Responsibility
TRS Technical Group Lead	• Develop and implement SOPs • Periodically review and update procedures based on project feedback
TRS HSO	• Provide training and maintain training documentation. • Assist SHSO with modifying SOP to meet site specific HASP and SAP requirements. • Work with PM to develop AHA for any intrusive work required to complete groundwater sampling efforts.
PM	• Review procedures in conjunction with site specific SAP requirements and scope of work (SOW). Coordinate changes to procedures as necessary. • Schedule and coordinate sampling effort. Ensure adequate supplies are available. • Work with HSO to develop AHA for any intrusive work required to complete groundwater sampling efforts.
SHSO	• Conduct orientations for subcontractors and employees • Coordinate training needs with TRS HSO • Review procedures in conjunction with site specific HASP. Coordinate changes to procedures as necessary to maintain safe working procedures.
Sampling Personnel	• Complete training to the level of competent person prior to initiating sampling activities. • Follow procedures and document information related to groundwater sampling effort as identified in this SOP, including and deviations from the SOP.

7.0 TRAINING

Training in SOPs is provided upon initial assignment and annually thereafter. Practical training is provided on a project-specific basis. Additional retraining is provided if there is a change in procedures or if inadequacies are observed in the individual's application of procedures.

Competent persons in hot groundwater sampling are determined by the ERH PM and SHSO and must, at a minimum, complete the following requirements:

- Read this SOP (SOP 3.1) and understand the general process and the specific requirements of this SOP.
- Sign the training acknowledgement form.
- Obtain onsite instruction by a knowledgeable person on the task-specific hazards associated with hot groundwater sampling and the methods used to control these hazards.
- Obtain onsite instruction by a knowledgeable person on important technical components of the hot groundwater-sampling program to ensure the collection of representative samples.

8.0 RECORD KEEPING

These are standard (i.e., typically applicable) procedures that may be varied or changed as required, dependent on site conditions, equipment limitations, permit requirements or limitations imposed by the procedure. The ultimate procedures used during any sampling event, including any deviations from these procedures, shall be documented in the sample logbook. AHA's developed for any intrusive work conducted in conjunction with this SOP shall be maintained with the groundwater sample logbook.

Calibrations of water quality meters used to measure water quality readings shall be completed according to the manufacturer's recommendations. Calibration results shall be maintained in a written log kept at the site throughout the operational phase of the project.

At a minimum, the following information shall be maintained in the sample logbook related to well purging and groundwater sample collection:

1) Date;
2) Sample/purge location identification;
3) Type of pump used for well purge;
4) Duration of well purge;
5) Sample time;
6) Flow rate (including changes throughout purge);
7) Meter(s) used for collection of water quality parameters and calibration documentation;
8) Water quality parameter readings;
9) Volume of purge water collected prior to sampling;
10) Sample identifications and analysis to be performed;
11) Chain of custody number;
12) Shipping information;
13) Procedures used for equipment decontamination;
14) Deviations from this SOP; and
15) Any other information deemed relevant to the sample results.

Copies of chains of custody forms and shipping documentation shall be maintained and kept with the sample logbook.

9.0 REFERENCES

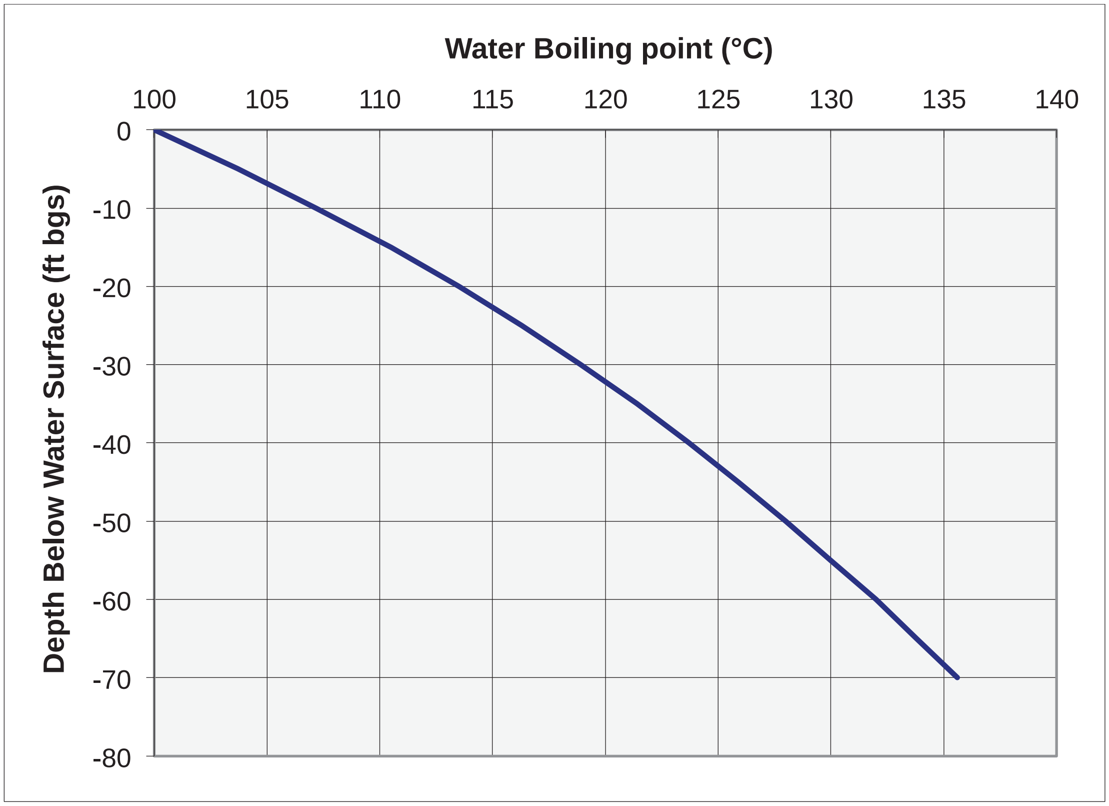
Puls, R.W. and M.J. Barcelona, 1996, Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedure, EPA/540/S-95/504.

Site Sampling Evaluation Checklist

Project #: ___________________
Date: ________________________

Subsurface Conditions

1) What is the depth to groundwater at the time of sampling?
2) How deep below the groundwater surface elevation are the screens?
3) What are the current temperatures at or near each boring location?
4) Are there confining layers on site? Clay or silt over saturated zone sand for example.
5) Use the figure below to determine where the sites actual temperatures fit on the boiling point curve.



6) Actual temperature for each depth elevation that is higher in value than the temperatures represented by this curve suggest a temperature value greater than the hydrostatic boiling point of water.

SOP 3.1 Hot Groundwater Sampling Training Acknowledgment

All personnel that receive training on this procedure will review and sign the acknowledgement form contained in this section.

I have been trained by TRS Group, Inc. (TRS) to perform non-intrusive hot groundwater sampling at ERH project sites. By signing this document, trainee acknowledges that SOP 3.1 Hot Groundwater Sampling has been read and the contents of the document are understood. Trainee has received hands-on training from a competent person who is authorized to use and instruct others on sampling procedures at TRS project sites.

Date	**Training Acknowledgement**	**TRS Trainer**

APPENDIX C

QUALITY ASSURANCE PROJECT PLAN

ELECTRICAL RESISTANCE HEATING REMEDIAL ACTION WORK PLAN: QUALITY ASSURANCE PROJECT PLAN

CTS OF ASHEVILLE, INC. SUPERFUND SITE

235 Mills Gap Road
Asheville, Buncombe County, North Carolina
EPA ID: NCD003149556
Consent Decree – Civil Action No. 1:16-cv-380

Prepared for:

CTS Corporation
4925 Indiana Avenue
Lisle, Illinois 60532

Prepared by:

Amec Foster Wheeler Environment & Infrastructure, Inc.
1308 Patton Avenue
Asheville, North Carolina 28806

Amec Foster Wheeler Project 6252-16-2012

January 17, 2018

Remedial Action Work Plan: Quality Assurance Project Plan

CTS of Asheville, Inc. Superfund Site
235 Mills Gap Road
Asheville, Buncombe County, North Carolina
EPA ID: NCD003149556
Consent Decree – Civil Action No. 1:16-cv-380

Prepared For: CTS Corporation
Prepared by: Amec Foster Wheeler Environment & Infrastructure, Inc.

January 17, 2018

Matthew G. Wallace

January 17, 2018

Matthew Wallace, P.E.
Amec Foster Wheeler
Environment & Infrastructure, Inc.
Project Manager

Date

Chris Ricardi

January 17, 2018

Christian Ricardi, NRCC-EAC
Amec Foster Wheeler
Environment & Infrastructure, Inc.
Quality Assurance Manager

Date

Craig Zeller, P.E.
USEPA Region 4
Remedial Project Manager

Date

Danny France
USEPA Region 4
Quality Assurance Manager

Date

TABLE OF CONTENTS

TABLES

APPENDICES

A	Organization Chart
B	Pace Analytical Services, LLC Quality Assurance Manual
C	ALS Environmental Quality Assurance Manual
D	Example Field Data Records

ACRONYMS

CD	Consent Decree
COC	chain-of-custody
CLP	Contract Laboratory Program
DPT	direct-push technology
DQI	data quality indicator
DQO	data quality objective
EDD	electronic data deliverable
ERH	electrical resistivity heating
FDR	field data record
FOL	Field Operations Leader
FSAP	Field Sampling and Analysis Plan
HASP	Health and Safety Plan
IATA	International Air Transport Association
IDW	investigative derived waste
LCS	laboratory control sample
LD	laboratory duplicate
LNAPL	light non-aqueous phase liquid
MDL	method detection limit
mL	milliliter
MS/MSD	matrix spike/matrix spike duplicate
NCDEQ	North Carolina Department of Environmental Quality
NELAP	National Environmental Laboratory Accreditation Program
OSHA	Occupational Safety and Health Act
PID	photoionization detector
PQL	practical quantitation limit
PM	Project Manager
ppm	parts per million
QA/QC	quality assurance/quality control
QAM	Quality Assurance Manager
QAPP	Quality Assurance Project Plan
R4DART	Region 4 Data Archival and ReTrieval
RAWP	Remedial Action Work Plan
RI/FS	Remedial Investigation/Feasibility Study
RPD	relative percent difference
SDG	sample delivery group
SESD	Science and Ecosystem Support Division
TCE	trichloroethene
TCL	Target Compound List
TED	Technical Environmental Database
USDOT	United States Department of Transportation
USEPA	United States Environmental Protection Agency
VOC	volatile organic compound

DISTRIBUTION LIST

Craig Zeller (1 electronic)
Remedial Project Manager
USEPA, Region 4
61 Forsyth Street, SW
Atlanta, Georgia 30303
404-562-8827
zeller.craig@epamail.epa.gov

Beth Hartzell (1 electronic)
Project Manager
NCDEQ, Superfund Section
3800 Barrett Drive
Raleigh, North Carolina 27609
919-707-8335
beth.hartzell@ncdenr.gov

Matthew Wallace (1 electronic)
Project Manager
Amec Foster Wheeler Environment & Infrastructure, Inc.
1308 Patton Avenue
Asheville, North Carolina 28806
828-252-8130
matthew.wallace@amecfw.com

Susan Avritt (1 paper, 1 electronic)
Field Operations Leader/Technical Lead
Amec Foster Wheeler Environment & Infrastructure, Inc.
1308 Patton Avenue
Asheville, North Carolina 28806
828-252-8130
susan.avritt@amecfw.com

Christian Ricardi (1 electronic)
Quality Assurance Manager
Amec Foster Wheeler Environment & Infrastructure, Inc.
511 Congress Street
Portland, Maine 04101
207-775-5401
christian.ricardi@amecfw.com

David Smoak (1 electronic)
Technical Reviewer
Amec Foster Wheeler Environment & Infrastructure, Inc.
1075 Big Shanty Road, NW, Suite 100
Kennesaw, Georgia 30144
770-421-3327
david.smoak@amecfw.com

Chris Blundy (1 electronic)
Senior Project Manager
TRS Group, Inc.
338 Commerce Avenue, Suite 304
Longview, Washington 98632
843-810-5310
cblundy@thermalrs.com

Michael Basel, PhD (1 electronic)
Technical Consultant
Haley & Aldrich, Inc.
11020 King Street, Suite 450
Overland Park, Kansas 66210
913-693-1900
mbasel@haleyaldrich.com

Taylor Ezell (1 electronic)
Project Manager
Pace Analytical Services, Inc.
9800 Kincey Avenue, Suite 100
Huntersville, North Carolina 28078
704-977-0943
taylor.ezell@pacelabs.com

DOCUMENT REVISION LOG

Revision	Date	Description
0	1/17/2018	Initial Issuance

1.0 INTRODUCTION

On behalf of CTS Corporation (CTS), Amec Foster Wheeler Environment & Infrastructure, Inc. (Amec Foster Wheeler) has prepared this Quality Assurance Project Plan (QAPP) for the CTS of Asheville, Inc. Superfund Site (Site) located in Asheville, Buncombe County, North Carolina. This QAPP has been prepared to comply with Paragraph 6.7(d) of the Statement of Work of the Consent Decree for Interim Remedial Design/Remedial Action (CD) at the Site between the United States of America and CTS Corporation, Mills Gap Road Associates, and Northrop Grumman Systems Corporation.

This QAPP has been designed to be a project document that is applicable to activities conducted during implementation of the Electrical Resistance Heating (ERH) Remedial Action Work Plan (RAWP). This QAPP, in conjunction with the Field Sampling and Analysis Plan (FSAP), are included in the RAWP and provide the framework upon which the ERH remedial action will be conducted. This QAPP has been prepared to document how the remedial activities will be completed and includes sampling methods, analytical methods, sample management, documentation procedures and Quality Assurance (QA) review procedures. This QAPP has been prepared following the criteria for quality assurance outlined in the following United States Environmental Protection Agency (USEPA) documents: *EPA Requirements for Quality Assurance Project Plans (*QA/R-5*)*; *Guidance for Quality Assurance Project Plans (*QA/G-5*)*; and *Uniform Federal Policy for Quality Assurance Project Plans, Parts 1 through 3*.

The overall interim remedial action project will be conducted under the Amec Foster Wheeler Environment & Infrastructure America’s *Quality Management Plan* (Revision No. 3, dated June 10, 2016). The Quality Management Plan follows the criteria for quality assurance outlined in the USEPA’s document *EPA Requirements for Quality Management Plans* (QA/R-2).

2.0 PROJECT MANAGEMENT

This section provides the overall approach to managing activities described in the RAWP, and includes the following:

- Project organization and responsibilities
- Problem definition
- Project description
- Data quality objectives
- Method performance objectives
- Special training, requirements, and certification
- Documentation and records management

2.1 PROJECT ORGANIZATION AND RESPONSIBILITIES

The various responsibilities of key project personnel are presented in this section and a project organizational chart is presented in Appendix A.

2.1.1 Regulatory Agencies

The United States Environmental Protection Agency (USEPA) is the lead agency overseeing design and implementation of the IRA. The USEPA will review/approve plans and reports related to design and implementation of the IRA. The USEPA Remedial Project Manager is Mr. Craig Zeller, P.E.

The North Carolina Department of Environmental Quality (NCDEQ) will consult with USEPA during design and implementation of the IRA. NCDEQ will review submittals and provide comments to USEPA.

2.1.2 Settling Defendants

The Settling Defendants are designated in the CD as CTS Corporation, Mills Gap Road Associates, and Northrop Grumman Systems Corporation. Mr. George Lytwynyshyn of CTS Corporation is the Settling Defendants’ Project Coordinator (PC), as defined in the CD, and will provide overall responsibility for procuring contractors/consultants, budgeting and assuring the requirements of the IRA are achieved. Mills Gap Road Associates is the owner of the property located at 235 Mills Gap Road, and will provide access to the Site.

Northrop Grumman Systems Corporation will provide additional review of project documents.

2.1.3 Amec Foster Wheeler Environment & Infrastructure, Inc.

Amec Foster Wheeler, as the Supervising Contractor, will execute the ERH RAWP from its Asheville, North Carolina office with support from other Amec Foster Wheeler offices. Project personnel and duties are described in the following sections. It should be noted that all personnel have a stop-work authority if they encounter adverse quality issues.

2.1.3.1 Project Manager

The Project Manager, Mr. Matthew Wallace, PE (North Carolina), will be responsible for the scope, cost, and technical considerations related to the project; staff and project coordination; and implementation of review of overall project quality related to the collection, completeness, and presentation of data. The Project Manager oversees the technical work conducted by the Field Operations Leader, quality assurance activities by the Quality Assurance Manager, review by the Technical Reviewer, and health and safety activities by the Site Health and Safety Supervisor.

2.1.3.2 Technical Lead/Field Operations Leader

The Technical Lead and Field Operations Leader (FOL), Ms. Susan Avritt, LG, PE (North Carolina), will be responsible for executing the planned work elements, issuing specific instructions for performing assigned work elements, and performing and directing the work so it is conducted in compliance with project-specific objectives and applicable QA procedures. The FOL will coordinate with the Project Manager and Quality Assurance Manager to review general work plans and specific work elements. The FOL maintains field documentation and deliverables in the project files during the performance of the assigned tasks. For field sampling activities, the FOL will be responsible for performing and/or overseeing the field work, preparing proper documentation, and ensuring proper handling of samples from sampling activities. The FOL has the authority to issue a stop work order if field sampling operations are not being conducted in accordance with the requirements specified in the RAWP/FSAP/QAPP or when worker safety becomes an issue.

2.1.3.3 Technical Reviewer

The Technical Reviewer, Mr. David Smoak, of Amec Foster Wheeler's Kennesaw, Georgia office, will provide technical review and support during implementation of the RAWP activities.

2.1.3.4 Quality Assurance Manager

The Quality Assurance Manager, Mr. Christian Ricardi, NRCC-EAC, of Amec Foster Wheeler's Portland, Maine office, will be responsible for reviewing the project QA program as it relates to the collection and completeness of data from field and laboratory operations. Mr. Ricardi's primary responsibilities include review of quality assurance/ quality control (QA/QC) protocols, ascertaining quality of environmental data collected to verify that it meets proposed data quality objectives, and identifying and verifying corrective actions, if any become necessary.

2.1.3.5 Project Chemist

The Project Chemist, Ms. Julie Ricardi of Amec Foster Wheeler's Portland, Maine office, will be responsible for reviewing laboratory reports for accuracy and completeness, and performing data validation according to the National Functional Guidelines (USEPA, 2016) modified for evaluation of USEPA SW-846 Methods. Ms. Ricardi will submit the validated laboratory reports with QA/QC evaluation sheets to the Quality Assurance Manager.

2.1.3.6 Data Manager

The Data Manager, Mr. Binks Colby-George of Amec Foster Wheeler's Portland, Maine office, will be responsible for entering data into Amec Foster Wheeler's database. Mr. Colby-George will also submit data to the USEPA in an electronic data deliverable (EDD) with relevant field information and laboratory data in the format specified for environmental data in the USEPA Region 4 Science and Ecosystem Support Division (SESD) R4DART (Data Archival and ReTrieval) database.

2.1.3.7 Site Health and Safety Supervisor

The Site Health and Safety Supervisor, Ms. Susan Avritt, LG, PE (North Carolina), is responsible for developing, implementing, and updating the Site Health and Safety Plan (HASP) to be consistent with anticipated conditions that may be encountered during field operations. Ms. Avritt will also serve as the FOL during implementation of the RAWP.

2.1.4 Analytical Laboratories

Chemical laboratory analysis of soil and water/groundwater samples will be performed by Pace Analytical Services, LLC (Pace) of Huntersville, North Carolina. Personnel organization, responsibility, and training for Pace can be found in Pace's Quality Assurance Manual, which is included in Appendix B.

Chemical laboratory analysis of air samples will be performed by ALS Environmental (ALS) of Simi Valley, California. Personnel organization, responsibility, and training for the ALS can be found in ALS's Quality Assurance Manual, which is included in Appendix C.

2.1.5 ERH Subcontractor

TRS Group, Inc. (TRS) is the ERH contractor responsible for design and implementation of the ERH IRA. TRS will contract with CTS, with technical support and oversight by Amec Foster Wheeler. The TRS Project Manager is Mr. Chris Blundy. TRS has a team of task managers, engineers, technicians and safety personnel to support the project, including a QC Manager.

2.1.6 ERH Technical Consultant

Haley & Aldrich, Inc. (H&A) is the ERH technical consultant responsible for providing additional technical review of the ERH remedial action. H&A will contract with CTS, and provide technical support to CTS and Amec Foster Wheeler. The H&A Principal Consultant is Dr. Michael Basel.

2.1.7 Drilling Subcontractors

Two drilling contractors, AE Drilling Services, LLC (Greenville, South Carolina) and Geologic Exploration, Inc. (Statesville, North Carolina) will be subcontracted to drill/install the electrodes and TMPs. Geologic Exploration will also drill/install the monitoring wells and drill soil borings for soil sampling.

2.1.8 Waste Disposal Subcontractor

A&D Environmental, Inc. is the waste disposal contractor for the project. A&D Environmental will coordinate waste profiling and transport to the appropriate waste disposal facilities. A&D Environmental will provide fully executed manifests to Amec Foster Wheeler after the waste has been accepted at the waste disposal facilities.

2.2 PROBLEM DEFINITION

2.2.1 Site Description

The Site is considered the approximate 8.7-acre property which formerly contained a manufacturing facility at 235 Mills Gap Road in Asheville, Buncombe County, North Carolina (Buncombe County tax parcel 9655-62-5706). However, it is understood that the Site also includes adjacent land containing other media that have become adversely impacted by processes/operations conducted at the former manufacturing facility.

The Site formerly contained an approximate 95,000-square foot, single-story brick and metal structure in the southern portion of the Site. The building was demolished in December 2011 and the concrete building pad remains intact. The northeastern portion of the Site contains an asphalt-paved parking area and asphalt-paved driveways are located parallel to the north (front) of the former building pad and southeast (rear) of the former building pad. A six-foot high chain-link fence surrounds the Site and a locked gate at the north end of the Site controls access to the Site from Mills Gap Road.

2.2.2 Site Operational History

Electronic components were manufactured at the former facility at the Site from 1953 until 1987, when the Site was bought by a developer who reportedly leased portions of the facility to various tenants, and otherwise utilized the building for business interests. The Site has been vacant/unoccupied since the mid-1990s.

Solvents, including trichloroethene (TCE) and acetone, were used in the process to clean and/or degrease metal objects prior to electroplating, and the spent solvents were disposed of accordingly. Disposal/recycling practices at the site prior to 1959 are not known. From 1959 to 1986, solvents and metals were reportedly reclaimed whenever possible. Between 1959 and 1980, metal-bearing rinse waters and alkaline cleaners that could not be reclaimed from the electroplating process were reportedly disposed of through the city sewer system, while concentrated metals and solvent wastes were placed in drums for off-site disposal/recycling. After 1980, all wastes were accumulated in drums on-site prior to off-site disposal or recycling.

2.2.3 Problem Definition

It is beyond the scope of this QAPP to describe the numerous investigations that have been conducted at the Site; however, the Final NAPL Area Focused Feasibility Report, dated September 10, 2015, contains a summary of previous investigations.

The objectives of the RAWP include:

- Describe procedures/actions that will be conducted during implementation of the ERH remediation.
- Describe how performance data will be used to determine if the system components are operating as designed.
- Describe how analysis of environmental samples from the ERH treatment area will be used to determine if interim remedial goals have been achieved and if ambient air concentrations are within applicable regulations/standards.

2.3 PROJECT DESCRIPTION

A NAPL investigation was conducted at the Site in 2013 and 2014. An approximate one-acre area containing light NAPL (LNAPL) with comingled TCE was identified. A Focused Feasibility Study was conducted to evaluate potential interim remedial alternatives for the one-acre LNAPL area and ERH was chosen as the recommended alternative. An additional approximate 0.2-acre area located adjacent and upgradient of the LNAPL area where elevated TCE concentrations had been detected was added to the proposed treatment area. This 1.2-acre area is considered the TCE source area.

ERH will be implemented in the approximate 1.2-acre source area. In this area, TCE contamination exists in three states: dissolved in groundwater, sorbed to saturated soil, and partitioned in the petroleum LNAPL. A remedial action objective (RAO) of a 95 percent reduction of TCE concentrations will be applied to soil, groundwater and LNAPL samples collected in the ERH treatment area.

The ERH Final Remedial Design was submitted to USEPA on November 27, 2017. USEPA provided notice to proceed with installation of subsurface components (e.g., electrodes and monitoring wells) on December 7, 2017, and the Final Remedial Design was approved by USEPA on December 18, 2017. The RAWP, which includes this QAPP, describes activities that will be undertaken to implement the Final Remedial Design.

2.3.1 Investigation Approach

The following methods are proposed for the RAWP:

- Depth to groundwater measurement
- LNAPL thickness measurement
- Collection and chemical analysis of soil samples
- Collection and chemical analysis of groundwater samples, including measurement of water quality parameters
- Collection and chemical analysis of LNAPL samples
- Collection and chemical analysis of ambient air samples
- Screening of volatile organic compounds (VOCs) in air and soil using a photoionization detector (PID)
- Collection and chemical analysis of influent and effluent air samples from the vapor extraction treatment system
- Collection and chemical analysis of influent and effluent water samples from the process water treatment system

2.3.2 Quality Objectives and Criteria

Qualitative and quantitative data will be collected during implementation of the RAWP. Qualitative data will generally be collected for monitoring purposes. Quantitative data will be collected to provide chemical concentration data for determination of when remedial objectives have been achieved and for determination of whether compliance standards are being met.

2.3.3 Schedule

The proposed schedule for the implementation of the RAWP is included in Appendix A of the RAWP. The USEPA will be notified at least 14 days prior to any sample collection activities.

2.4 DATA QUALITY OBJECTIVES

Data collected at a site needs to be of sufficient quality and quantity to support defensible decision making. Data quality objectives (DQOs) are identified before the sampling and analysis begin. DQOs will be used to ascertain the type, quality, and quantity of data necessary to address problems. The USEPA guidance document, Guidance on

Systematic Planning Using the Data Quality Objectives Process (USEPA, 2006), outlines the following seven-step process for establishing DQOs:

1. **State the Problem.** Concisely describe the problem to be studied.
2. **Identify the Goal of the Study.** State how environmental data will be used in meeting objectives and solving the problem, identify study questions, and define alternative outcomes.
3. **Identify Information Input.** Identify data and information needed to answer study questions.
4. **Define the Study Boundaries.** Specify the conditions (time periods, spatial areas, and situations) to which the decision will apply and within which the data will be collected.
5. **Develop the Analytical Approach.** Define the conditions by which the decision maker will choose among alternative risk management actions. This is usually specified in the form of an "if…then…" statement.
6. **Specify Performance or Acceptance Criteria.** Define in statistical terms the decision maker's acceptable error rate based on the consequence of making an incorrect decision.
7. **Develop the Plan for Obtaining Data.** Evaluate the results of the previous steps and develop the most resource-efficient design for data collection that meets all of the DQOs.

2.4.1 State the Problem

Past operations at the Site have resulted in releases of chlorinated solvents, primarily TCE. Remediation via ERH is proposed for this area to reduce TCE concentrations in saturated soil, groundwater, and LNAPL by 95 percent. Data will be collected to provide information regarding performance monitoring, remediation performance monitoring, and health and environmental protection-related monitoring

2.4.2 Identify the Goal of the Study

The principal study questions are:

- What are the baseline TCE concentrations in soil, groundwater, and LNAPL in the ERH treatment area?
- What are the TCE concentrations in soil, groundwater, and LNAPL after ERH treatment?
- Are regulatory compliance standards met during operation of the ERH treatment system?
- Approximately how much VOC mass was removed from subsurface via the ERH treatment system?

The principal study questions are for interim remedial purposes; therefore, alternative actions for the study questions include collecting additional data to answer the questions. The methods to answer the study questions are described in the following table.

Principal Study Questions	Information Inputs/Methods
What are the baseline TCE concentrations in soil, groundwater, and LNAPL in the ERH treatment area?	• Collect soil, groundwater, and LNAPL samples prior to initiating ERH remediation and submit the samples for TCE analysis.
What are the TCE concentrations in soil, groundwater, and LNAPL after ERH treatment? Was the RAO achieved?	• Collect soil, groundwater, and LNAPL samples after the ERH remediation and submit the samples for TCE analysis. • Compare the analytical results to the baseline sample results to determine if the 95 percent TCE removal objective has been met for each media.
Are regulatory compliance standards met during operation of the ERH treatment system?	• Collect influent and effluent samples from the vapor and water treatment systems and submit the samples for analysis of VOCs. Compare the analytical results to the compliance standards • Collect ambient air samples from locations near the property boundary and submit the samples for analysis of VOCs. Compare the analytical results to the compliance standards.
Approximately how much VOC mass was removed from subsurface via the ERH treatment system?	• Collect influent/effluent samples from the vapor and water recovery/treatment systems. Calculate the mass removed.

2.4.3 Identify Information Inputs

The data needed to answer the principal study questions include:

- Off-site laboratory analysis of soil, groundwater, and LNAPL samples for TCE
- Off-site laboratory analysis of ambient air samples for VOCs
- Off-site laboratory analyses of treatment system water and air samples for VOCs
- On-site screening of total VOCs

Limitations of the proposed methods are described below.

2.4.3.1 <u>Soil Sampling Limitations</u>

Soil samples will be collected from borings advanced with a direct-push technology (DPT) rig at 15 locations in the ERH treatment area and submitted for analysis of TCE. Limitations with soil sampling using a DPT rig equipped with a discrete sampler include: the DPT rig might encounter refusal by hard layers/zones above the target sample depth; dilution of the sample by the laboratory due to the elevated concentrations (baseline samples); and potential volatilization of constituents in the sample during collection.

2.4.3.2 Groundwater Sampling Limitations

Groundwater samples will be collected from monitoring wells installed in the ERH treatment area and submitted for analysis of TCE. Limitations with sampling groundwater from monitoring wells include: dilution of the sample due to the well screen not being a discrete sampling point; dilution of the sample by the laboratory due to the elevated concentrations (baseline samples); and potential volatilization of constituents in the sample during collection.

2.4.3.3 LNAPL Sampling Limitations

LNAPL samples will be collected from monitoring wells installed in the ERH treatment area and submitted for analysis of TCE. Limitations with sampling LNAPL monitoring wells include: mixing of the LNAPL with groundwater when collecting a sample; dilution of the sample by the laboratory due to the elevated concentrations; and potential volatilization of constituents in the sample during collection.

2.4.3.4 Ambient Air Sampling Limitations

Ambient air samples will be collected from four locations near the property boundary and submitted for analysis of VOCs. The primary limitation with ambient air sampling is the potential influence of other sources of contamination from what is actually being assessed. Other sources could include vehicular exhaust, effluent from a manufacturing facility, etc. If elevated concentrations of contaminants are detected, the sample could be diluted and could interfere with the results of the contaminants that are the primary contaminants of concern being monitored.

2.4.3.5 Vapor Treatment System Sampling Limitations

Influent and effluent air samples will be collected from the vapor treatment system and submitted for analysis of VOCs. The primary limitation is dilution of the influent samples due to the elevated concentrations.

2.4.3.6 Process Water Sampling Limitations

Influent and effluent water samples will be collected from the water treatment system and submitted for analysis of VOCs. The primary limitation is dilution of the influent samples due to the elevated concentrations.

2.4.3.7 On-site Screening Limitations

Air screening from locations around drilling and on-site operations will be conducted for total VOCs. The primary limitation with air screening is the potential influence of other sources of contamination from what is actually being assessed. Other sources could include vehicular/equipment exhaust, effluent from a manufacturing facility, etc.

2.4.4 Define the Study Boundaries

The target populations for the study include:

- Data to determine the baseline TCE concentrations in saturated soil, groundwater, and LNAPL
- Data to determine the confirmation TCE concentrations in saturated soil, groundwater, and LNAPL
- Data to determine if the vapor and water treatment systems are operating as designed and within compliance standards
- Data to determine if ambient air concentrations near the property boundary are within compliance standards

The horizontal spatial boundary is depicted in Figure 3 of the RAWP. The vertical spatial boundary is from ground surface to the depth of refusal with drilling equipment, which is expected to range from approximately 20 feet to 70 feet below ground surface. The boundary also includes ambient air to the property boundary. The treatment boundaries are based on an approximate 1.2-acre area identified in the Final NAPL Area Focused Feasibility Study Report.

Limited portions of the RAWP have been initiated based on USEPA’s approval of the Final ERH Remedial Design. Field activities will be conducted during the day, from approximately 7 a.m. to 7 p.m. from Monday through Friday. The ERH treatment system will be operated 24 hours a day for approximately three to four months. USEPA will be notified if field activities are necessary outside of the above day or time constraints. Work will be suspended when severe weather conditions, such as lightning, rain, or snow arise or are forecasted and pose a safety and/or quality control issue. The RAWP activities, including decommissioning and demobilization, are expected to take up to twelve months to complete, and the reporting is expected to take up to six weeks to complete.

Practical constraints that might interfere with the RAWP activities include:

- Hard zones/layers above competent bedrock that cannot be penetrated with drilling equipment
- Severe weather (thunder, lightning, heavy rain or snow, etc.)
- Availability of sufficient electricity for powering ERH system
- Ability to collect LNAPL samples (i.e., sufficient LNAPL no longer present in a monitoring well where a baseline LNAPL sample was collected)

2.4.5 Develop the Analytic Approach

The population parameters for the study are the individual measurements for the data collected (i.e., the concentration of a constituent in a groundwater sample determined by the groundwater analysis). The measurements will be used directly to answer the study questions or calculate a value that will be used to answer study questions.

2.4.6 Specify Performance or Acceptance Criteria

Data is subject to random and systematic errors at different stages of the collection process and typically include the following components:

- Sampling Error: Sometimes called Statistical Sampling Error, is influenced by the inherent variability of the population over space and time, the sample collection design, and the number of samples taken. It is usually impractical to measure the entire population space, and limited sampling may miss some features of the natural variation of the measurement of interest. Sampling design error occurs when the data collection design does not capture the complete variability within the population space, to the extent appropriate for making conclusions. Sampling error can lead to random error (i.e., random variability or imprecision) and systematic error (bias) in estimates of population parameters.
- Measurement Error: Sometimes called Physical Sampling Error, is influenced by imperfections in the measurement and analytical system. Random and systematic measurement errors are introduced in the measurement process during physical sample collection, sample handling, sample preparation, sample analysis, data reduction, transmission, and storage.

The RAWP implements a judgmental sampling approach and assessment of statistical error is not planned. Measurement error is addressed by establishing standardized methods of sample collection and through the validation of analytical data.

The methods proposed for the RAWP each have advantages and limitations. Several investigation methods are proposed, so that multiple lines of evidence can be evaluated to determine the treatment of TCE in the subsurface and monitoring of VOCs ambient air and influent/effluent vapor/water treatment system. Limitations to the proposed methods are described in Section 2.4.3 herein.

Data from off-Site laboratory analyses will be reviewed and validated as described in Section 5.0 herein. Standard analytical results (e.g., VOCs) will be evaluated based on criteria in the referenced analytical methods and USEPA validation guidelines. Results may be accepted without qualification or with validation qualifiers (J, UJ). Results that do not meet minimum criteria for acceptance (qualified as rejected, R, during validation) will be unacceptable for use.

2.4.7 Develop the Plan for Obtaining Data

Several sampling methods are proposed to provide information regarding ERH system operation, remediation effectiveness, and compliance with regulatory standards. The RAWP Work Plan describes the investigation strategy/methods and the FSAP describes the data/sample collection procedures.

To the extent practical, the design for collecting data presented in the RAWP has been optimized to achieve the stated DQOs. The scope of work and data collection process has been designed to provide near real-time data and off-Site laboratory testing. This data will be used to modify and expand the scope of field activities, as needed, to ensure the DQOs are met.

USEPA will be provided split and/or duplicate samples, if requested. USEPA can also collect additional samples that it deems necessary. USEPA will provide split/duplicate samples collected for oversight sampling to Amec Foster Wheeler, if performed and requested.

2.5 METHOD PERFORMANCE OBJECTIVES

Performance objectives are defined for field data and laboratory data. Method performance objectives for work performed are expressed in terms of precision, accuracy, representativeness, comparability, completeness, and sensitivity. Target analytes for VOCs and detection limits are summarized in Table 1. Sample collection, preservation, and holding time goals are summarized in Table 2. Measurement performance criteria for surrogates, spikes, and duplicate analyses are summarized in Table 3. The following sections describe the method performance parameters and calculations, as appropriate.

2.5.1 Precision

Precision is described as the agreement among a set of duplicate or replicate measurements.

2.5.1.1 Field Precision

For qualitative measurements, precision will be evaluated by the agreement of results. Field duplicates will be collected at a frequency of one per ten investigative samples per matrix/media per analytical parameter (Note: if sufficient LNAPL is not present in the monitoring wells, a duplicate LNAPL sample will not be collected). Precision will be measured through the calculation of relative percent difference (RPD) using the following equation:

$$RPD = \frac{|X_1 - X_2| x100}{(X_1 + X_2)/2}$$

where: RPD = relative percent difference between duplicate results
X_1 and X_2 = results of original sample and duplicate analyses
$|X_1 - X_2|$ = absolute difference between duplicates X_1 and X_2

The resulting information will be used to assess sample homogeneity, spatial variability of samples, sample collection reproducibility, and analytical variability. The field precision goals are presented in Table 3.

2.5.1.2 Laboratory Precision

The precision of laboratory analyses of VOCs can be inferred through one of the following: laboratory control sample duplicates (LCSDs), matrix spike (MS) and matrix spike duplicate (MSD) samples, or unspiked duplicate samples. The laboratory analyzes one or more of these duplicate samples at a rate of one per batch of 20 samples per matrix (Note: MS/MSD samples are not prepared/analyzed for air or LNAPL samples).

The MS/MSD samples provide information about the effect of the sample matrix on extraction and measurement methodology. A MS/MSD pair will be analyzed at a rate of one per batch of 20 or fewer investigative samples per matrix. The precision of laboratory analyses will be assessed by calculating the RPD for each pair of MS/MSD duplicate samples, laboratory control sample spike duplicates, unspiked duplicate samples, and field duplicate sets. The laboratory precision goals are presented in Table 3.

2.5.2 Accuracy

Accuracy is the degree of agreement between a measurement or observation and an accepted value.

2.5.2.1 Field Accuracy

Field accuracy, assessed through appropriate field equipment and trip blanks, is achieved by adhering to sampling, handling, preservation, and holding time requirements. Field blank samples will be analyzed to check for possible procedural contamination that could affect samples. Equipment rinsate blanks will be used to assess the adequacy of decontamination of sampling equipment between individual sample collections. Trip blanks will be used to assess the potential for contamination of samples due to migration of contaminants (e.g., VOCs) during sample shipment, handling, and/or storage. Accuracy of field instruments will be assessed by daily instrument calibration and calibration checks.

2.5.2.2 Laboratory Accuracy

Laboratory accuracy will be assessed by analyzing matrix spikes and laboratory control samples (LCS). The results will be expressed as a percent recovery. Surrogate recoveries will also be used to assess accuracy. Method blanks will be used to assess possible contamination from laboratory procedures. Laboratory control samples, method blanks, and preparation blanks will be analyzed at least once with each analytical batch, with a minimum of one for every 20 samples. The percent recovery (% R) is calculated with the following equation:

$$\%\ recovery = \left(\frac{X - B}{T} \right) x\, 100$$

where: X = measured amount in sample after spiking
B = background amount in sample

T = amount of spike added

The laboratory accuracy goals are presented in Table 3.

2.5.3 Representativeness

Representativeness is a qualitative measure of the degree to which sample data accurately and precisely represent a characteristic environmental condition. Representativeness is demonstrated in the project planning documents by providing full descriptions of the sampling techniques and the rationale used for selecting sampling locations. Representativeness of field data is dependent upon the proper design of the data collection procedures and will be evaluated by assessing whether this QAPP was followed during sample collection. In addition, the analytical results from method, trip and rinse blank samples will be used to evaluate the representativeness of field sampling procedures. The blank samples will be used during data validation to determine if contamination in the laboratory or field (from equipment or during transport) has potentially impacted the representativeness of the field samples (i.e., contamination in a blank sample could bias the field sample results). Laboratory data will be evaluated for representativeness by assessing whether the laboratory followed the analytical methods prescribed in this QAPP, evaluating holding time criteria, and evaluating the results of method, instrument, trip, and rinse blank samples and field duplicate samples.

For the ambient air samples, a 24-hour sample collection time will be used to obtain samples that are representative of daily conditions (i.e., the sample canisters will be deployed for a 24-hour period). Prior to deployment of the sample canisters, the air in the vicinity of the location intended for sampling will be screened with a calibrated PID to assess the potential presence of VOCs. The presence of elevated VOC concentrations could result in the collected sample to be diluted, which could adversely affect the analytical results of the sample (i.e., actual VOC concentrations might be too diluted to be detected by the analytical measurement equipment).

2.5.4 Completeness

Completeness is a measure of the quantity of valid data obtained from a measurement system compared to the quantity that was planned under normal conditions. Percent completeness is calculated with the following equation:

$$\%\ \text{Completeness} = \frac{\text{Valid Data Obtained}}{\text{Total Data Planned}} \times 100$$

Valid analytical results used to meet completeness objectives are those results that provide defensible estimates of the true concentration of an analyte in a sample. These valid results include data that is not qualified and data for which QC results indicate qualification is necessary but which may still be used to meet project objectives. Invalid results are those data for which there is an indication that the prescribed sampling or analytical protocol was not followed.

The baseline soil, groundwater, LNAPL samples to be submitted for analysis are anticipated to contain elevated concentrations of contaminants, which can result in qualified or rejected data due to compromised analytical procedures (e.g., significant dilution of samples). Therefore, a reasonable goal for completeness on this project is 95 percent. If insufficient valid data are obtained, the QA Manager will initiate corrective action.

2.5.5 Comparability

Comparability is the degree of confidence with which one data set can be compared to another. Throughout sampling on this project, standard methodologies as discussed in the FSAP and in this QAPP will be used for both sampling and analysis activities to ensure comparability. The intention is to use the same laboratories (Pace and ALS) for standard analyses (i.e., VOCs) throughout the duration of the ERH remedial action and there should not be a need to assess the comparability of data from different laboratories.

2.5.6 Sensitivity

Sensitivity is the measure of the concentration at which an analytical method can positively identify and report analytical results. The sensitivity of a given method commonly is referred to as the detection limit. Although there is no single definition of this term, the following definitions of detection limits will be used:

- Method detection limit (MDL) is a statistically determined concentration. It is the minimum concentration of an analyte that can be measured and reported with 99 percent confidence that the analyte concentration is greater than zero as determined in the same or a similar matrix. Because of the lack of analytical precision in this range, sample results greater than the MDL but less than the practical quantitation limit will be reported as estimated and flagged with a "J."

- Practical quantitation limit (PQL) is the concentration of the target analyte that the laboratory has demonstrated the ability to measure within specified limits of precision and accuracy during routine laboratory operating conditions. This value is variable and highly matrix-dependent. It is the minimum concentration that the laboratory will report as unqualified.

For sensitivity, the quality objective is to analyze data using a method that achieves PQLs that are less than or equal to the task-specific target analysis goals or concentrations. Target compounds and detection limits are listed in Table 1.

2.6 SPECIAL TRAINING/CERTIFICATION

Training of field personnel will be provided by the FOL. TRS will provide training related to operation of their equipment. Routine training will be completed at the beginning of each field event if required. The FOL will review applicable procedures with field personnel to verify that the project requirements and procedures are understood and implemented properly.

The drilling subcontractor will use personnel that have been trained and certified by the drilling equipment manufacturers. The drilling subcontractor will be trained and experienced in environmental drilling and a North Carolina Certified Well Contractor will conduct and/or oversee the drilling operations.

Pace will maintain a North Carolina Wastewater/Groundwater Laboratory Certification, which is applicable to the analytical methods (not including air) that will be performed during implementation of the RAWP. Field personnel will review and follow manufacturer's operating procedures for field equipment, such as the water level indicator and groundwater sampling equipment.

Personnel conducting work at the Site will be appropriately trained in health and safety procedures. If appropriate, personnel conducting work covered by this QAPP will have obtained at a minimum, the 40-hour hazardous waste-site worker training program and the 8-hour annual refresher course in compliance with regulations stated in 29 CFR Part 1910.120. Certificates or documentation representing completion of training shall be maintained in personnel files. The FOL will verify that personnel have the necessary training and certifications prior to the implementation of the project.

A Site HASP has been developed specific to the Site activities discussed in this QAPP. The HASP applies to Amec Foster Wheeler employees and Amec Foster Wheeler subcontractors, only. Each field team will have access to a copy of the HASP during field activities. Personnel working at the Site will be required to read, understand, and conform to the requirements of the HASP. As Site activities progress and if new information arises, the HASP will be updated, as necessary, to comply with the Occupational Safety and Health Act (OSHA) and safe working conditions.

2.7 DOCUMENTS AND RECORDS

Project records for the work will be maintained in Amec Foster Wheeler’s Asheville, North Carolina, office. File maintenance will be under the direct control of the Project Manager. Project records will be organized with a project-specific file and document numbering system in accordance with Amec Foster Wheeler protocols.

The anticipated hard copy project records related to this QAPP include:

- Project log book(s)
- Field data records (FDRs)
- Safety records, as specified in the Site HASP
- Chain of custody records

The anticipated electronic records related to this QAPP include:

- Laboratory reports
- Laboratory EDDs
- Final validated laboratory analytical results
- Surveying data
- Photographs (digital)
- Scanned hard copy information (e.g., log books, FDRs, etc.)

Hard copy records will be stored in Amec Foster Wheeler’s Asheville, North Carolina office and electronic records will be stored on Amec Foster Wheeler’s Asheville, North

Carolina office server, which is backed up daily. Electronic data will be available to other Amec Foster Wheeler office servers, as necessary for data validation, presentation, etc.; however, the original data documents will be stored on the Asheville server.

Pace and ALS will submit analytical results in electronic formats. The electronic analytical data from Pace will be submitted as laboratory reports and EDDs in accordance with the format described in Table 5. The analytical results will be imported into the Amec Foster Wheeler Technical Environmental Database (TED). The TED is an Oracle-based relational database designed with using Microsoft structured query language. The TED is used to manage and store a variety of records generated during field investigations, including sample location information and analytical data. The TED can provide output files, such as Excel, for use in data validation and subsequent importation of data qualification actions. The TED data are permanently stored on a secure Amec Foster Wheeler server that is backed up daily.

If this QAPP, or the associated RAWP or FSAP, is updated/modified, the updated version(s) will be distributed to those persons identified in the distribution list. If the modifications are minor, then only the portions of the document with the modifications will be disturbed; otherwise, the entire document(s) will be distributed. Data and document management is further discussed in Section 3.10.

Retention of files associated with this QAPP will be in accordance with the CD, which requires the preservation and retention of records and documents during the implementation of the CD and for a minimum of ten years after USEPA’s Certification of Work Completion.

3.0 MEASUREMENT AND DATA ACQUISITION

The following sections describe the design and implementation of measurement procedures and discuss the methods to be used for sampling, analysis, data handling, and QC in support of the tasks performed.

3.1 RAWP SAMPLING PROCESS DESIGN

The RAWP describes the proposed sampling plan, including planned sampling locations, rationale for the sampling locations and measurement methods, the media to be sampled, and measurements that will be taken during implementation of the ERH remedial action. The FSAP describes the field procedures associated with the RAWP. The sampling objectives for the ERH RAWP generally include system performance monitoring, remediation performance monitoring, and health and environmental protection-related monitoring, as follows:

- System performance monitoring includes collection of screening measurements and samples for chemical analysis to monitor the performance of the vapor and liquid treatment systems.
- Remediation performance monitoring includes collection of samples for chemical analysis to determine whether the remedial goal has been achieved.
- Health and environmental protection-related monitoring includes collection of air samples to monitor ambient conditions at the property boundary.

The following samples will be collected:

- Saturated soil samples will be collected to determine when the soil RAO has been achieved. Saturated soil samples will be collected from 15 soil borings at 10-foot intervals (approximately 45 soil samples are anticipated). Baseline (i.e., pre-remediation) and confirmation (i.e., post-remediation) saturated soil samples will be collected.
- Groundwater samples will be collected to determine when the groundwater RAO has been achieved. Groundwater samples will be collected from 22 Site monitoring wells (MW-2, MW-3 and 20 monitoring wells to be installed). Baseline and confirmation groundwater samples will be collected.
- LNAPL samples will be collected to determine when the LNAPL RAO has been achieved LNAPL samples will be collected from up to 5 monitoring wells where there is sufficient LNAPL to be collected. Baseline and confirmation LNAPL samples will be collected.
- Ambient air samples will be collected to determine if contaminant concentrations at the perimeter of the Site are within regulatory standards. Ambient air samples will be collected from 4 locations between the treatment system and nearby

residences. Baseline ambient air samples prior to initiating the ERH system. Ambient air samples will be collected after two weeks of initial ERH operation/heating, weekly during the period of greatest VOC mass removal (anticipated to be approximately 5 weeks), and monthly thereafter

- Influent and effluent air samples will be collected from the vapor treatment system to determine if contaminant concentrations in the effluent are within regulatory standards. The influent and effluent concentration data will also be used to determine the VOC mass removal rate. Influent/effluent vapor treatment system air samples will be collected from ports on the equipment. Air samples will be collected bi-weekly during initial operation, weekly during the period of greatest VOC mass removal, and every two weeks or monthly thereafter.
- Influent and effluent water samples will be collected from the water treatment system to determine if the treatment system is treating the process water to meet regulatory standards. Influent/effluent treatment system water samples will be collected from ports on the equipment. The frequency of sample collection will be based on requirements indicated by Metropolitan Sewerage District of Buncombe County.

3.1.1 Sampling Methods

The following sampling/measurement methods are proposed for the RAWP, and are described in the FSAP:

- Depth to groundwater measurement
- LNAPL thickness measurement
- Collection and chemical analysis of soil samples, including borehole abandonment
- Collection and chemical analysis of groundwater samples, including measurement of water quality parameters
- Collection and chemical analysis of LNAPL samples
- Collection and chemical analysis of ambient air samples
- Screening of VOCs in air and soil via a PID
- Collection and chemical analysis of influent and effluent air samples from the vapor extraction treatment system
- Collection and chemical analysis of influent and effluent water samples from the process water treatment system
- Surveying boring and monitoring well locations

Field equipment for the QAPP includes:

- Water level meter (depth to water)
- Oil-water interface probe

- Drilling rigs for electrode, TMP, and monitoring well installation
- Drilling rigs for soil sampling
- PIDs (including solar panels, batteries, and telemetry for continuous ambient air monitoring)
- Pumps for collecting groundwater samples
- Water quality meter
- Surveying equipment

Field supplies for the project include:

- FDRs and log books
- Personal protective equipment, as specified in the HASP
- Measuring tapes (engineers scale)
- Sample containers
- Stainless steel bailers
- Stainless steel spoons
- Shipping containers (coolers)
- Ice (shipment of samples to Pace)
- Ice bath materials
- Packing tape (shipment of samples)
- Black ink pens
- Digital camera
- Calibration solutions/gases
- Decontamination soap
- Organic-free water
- Sample containers
- Pump tubing
- Trash bags and Ziploc®-type bags

Support supplies/equipment include:

- Sampling table (portable)
- Vehicles for personnel and sample transport
- Safety supplies
- Drums for investigative derived waste (IDW)

- Roll-off containers for IDW
- Buckets for purge water or miscellaneous storage/transport of field supplies

Sample collection procedures are described in the FSAP. Sample information (e.g., analysis method, preservation, volume, hold time, etc.) is summarized in Table 3. Measurements made in the field will be recorded on FDRs or in the logbook.

3.1.2 Equipment Decontamination Procedures

Decontamination procedures will be employed to reduce the potential for cross contamination between sampling locations. Equipment decontamination procedures are described in Section 6.0 of the FSAP.

3.1.3 Management of Investigative Derived Waste

The management of investigative derived waste is described in Section 7.0 of the FSAP.

3.1.4 Field Sampling Documentation

Documentation of field activities will be completed using a combination of logbooks, FDRs, and sample custody records. A Site logbook will be completed to provide a general record of activities and events that occur during each field task. FDRs have been designed for exploration or sample collection tasks to provide a record of data obtained during the activity. Examples of FDRs that will be used during the RAWP are included as Appendix D.

Deviations from the procedures specified in the QAPP and the FSAP will be documented in the field logbook and applicable FDRs. Such deviations may be dictated by Site-specific conditions encountered during the sampling activity.

3.1.4.1 Field Logbooks

The field logbooks provide a daily hand-written account of all field activities. Logbooks will be permanently bound and entries will be made in permanent black or blue ink, and corrections will be made with a single line strikeout with the author's initials and date. Each page of the logbook will be dated and signed by the person completing the log. Partially completed pages will have a line drawn through the unused portion at the end of each day. The following information will generally be entered into the field logbooks:

- Project name and number
- Date and time of each entry
- Weather conditions anticipated for the day, or as weather conditions change
- Site personnel
- Descriptions of important tasks or subtasks
- A description of samples collected (if not documented on a FDR)
- Documentation of equipment maintenance and calibration activities (if not documented on a FDR)
- Documentation of equipment decontamination procedures
- A summary of problems encountered during the day, including cause of problem and corrective actions implemented, if appropriate

3.1.4.2 Field Data Records

Field data records contain sample collection and/or exploration details. Examples of FDR forms anticipated to be used during implementation of the Work Plan are contained in Appendix D. FDRs will be completed in the field by field personnel at the time testing/sampling is performed. The goal of the FDR is to document exploration and sample collection methods, materials, dates and times, and sample locations and identifiers. Field measurements and observations associated with a given exploration or sample collection task are recorded on the FDR. FDRs will be maintained throughout the field program in files that become a permanent record of field program activities. A listing of FDRs anticipated for the PDI is presented below. Additional FDRs may be developed to the RAWP.

- Depth to water measurement in monitoring wells
- Depth/thickness of LNAPL
- Groundwater purging/sampling record
- Soil boring record
- Instrument calibration record
- Electrode/TMP construction record
- Drum/roll-off management record
- Sample/boring record (summary for project)

3.2 SAMPLE HANDLING AND CUSTODY

The following sections describe how samples will be identified, contained, packaged, transported, and tracked during sampling and analysis activities. The FOL or designee will maintain the field log book and will be responsible for sample custody in the field.

3.2.1 Sample Designation

Groundwater samples collected from existing monitoring wells will be identified using the monitoring well identification (e.g., MW-2). New monitoring wells will begin with MW-23. At each well cluster, the deep monitoring well will be labeled with an ‘A’, beginning with MW-23A. LNAPL samples will be identified using the monitoring well identification, with the word ‘prod’ at the end (e.g., MW-2 (prod)).

Soil samples will be identified by boring location, depth (in feet), and sampling event. The boring location will begin with the next sequential number from the most recent Site sampling event, which will be SS-106. For example, a soil sample collected at 25 feet during the baseline sampling event at location 106 would be SS-106-25A. Confirmation samples collected at the same location/depth will be indicated by a ‘B’ (e.g., SS-106-25B).

Ambient air samples will be identified by the location, beginning with AAS-20. Influent and effluent air samples collected from the vapor treatment system will be labeled as VINF-01 and VEFF-01. Influent and effluent water samples collected from the water treatment system will be labeled as WINF-01 and WEFF-01.

The sample data will be recorded on FDRs or in the field logbook with sample designation information while in the custody of the sampling team. A sample label will be completed and attached to each sample container for every sample collected. Labels will consist of a waterproof material backed with a water-resistant adhesive. Labels will be completed using waterproof ink, and will contain at least the following information:

- Project name
- Date and time of sample collection
- Sample identification number
- Preservatives, if applicable
- Sampler’s initials

- Analysis to be conducted

Each sample submitted for analysis at the laboratory will be identified with a unique identification number (sample ID). These sample IDs will be tracked from collection through laboratory analysis and into the final reports. The sample ID will be cross-referenced with the sample location on the chain-of-custody (COC) form.

The field QC samples will be cross-referenced on the sample FDRs or in the field log book. The QC samples will have a prefix identifying their purpose, followed by a sequential number, as follows:

- FD-01 (field duplicate)
- EB-01 (equipment rinse blank)
- TB-01 (trip blank)

The numbering will begin at one number after the last sequential number used during the in-situ chemical oxidation Pre-design Investigation or the most recent ambient air sampling event.

3.2.2 Sample Collection and Preservation

Sample container and preservation requirements for samples submitted for analysis are summarized in Table 2. Sample container requirements are based on specifications from the referenced analytical methods. Samples for soil, water/groundwater, and LNAPL will be collected in laboratory-supplied containers.

Ambient air samples will be collected using Summa® canisters supplied by the laboratory. The canisters will be individually cleaned and leak checked by the laboratory. Flow controllers and vacuum gauges will also be supplied by the laboratory. The flow controller will be adjusted by the laboratory so that the canisters will collected a sample over a 24-hour period under vacuum. One-liter Tedlar® bags for influent and effluent air samples will be supplied by the laboratory.

3.2.3 Sample Packaging and Shipment

Sample containers for soil, groundwater, and LNAPL will be sealed in bubble-wrap and/or plastic sealable bags and placed into an iced cooler for shipment to the laboratory. The contents of the cooler will be placed in a plastic bag to minimize leakage of water from the cooler. Containers will be packed tightly so that movement of the containers is minimized. Appropriate packaging materials (e.g., Styrofoam, "bubble wrap") will be used if needed. Ice will be placed in the cooler, generally around the sample containers, so that the samples are maintained at 4 degrees Celsius (°C) [+/- 2°C]. The COC will be placed in a sealable plastic bag and affixed to the underside of the cooler lid, if the cooler is being shipped to the laboratory. The cooler will be securely closed with packaging tape to prevent the cooler from opening during transport.

Air samples and associated flow controllers and pressure gauges will be placed in boxes for shipment to the laboratory. The COC will be placed in the shipment box. The box will be securely closed with packaging tape to prevent the cooler from opening during transport.

Custody seals, which are adhesive-backed seals designed to break if disturbed, will be placed on the cooler/box prior to shipment to provide security. The custody seals will be signed and dated before leaving Amec Foster Wheeler's possession. Upon receipt by the laboratory, the sample custodian will confirm that the seals on coolers/boxes are intact or notify the Project Manager or FOL if any custody seals have been broken.

Regulations for packaging, marking/labeling and shipping hazardous waste materials and waste are issued by U.S. Department of Transportation (USDOT). Air carriers which transport hazardous material, such as Federal Express, may also require compliance with the current edition of the International Air Transport Association (IATA) Dangerous Goods Regulations. Current IATA Regulations will ensure compliance with USDOT protocol.

3.2.4 Chain-of-Custody Records

The chain-of-custody (COC) record will be placed inside the shipping container. An example of the Pace COC is included in Appendix B and an example of the ALS COC is included in Appendix C. The FOL will retain a copy of the COC. The custody record will include the following information:

- Name of person collecting the samples
- Date and time samples were collected
- The media sampled
- Type of sampling conducted (composite/grab)
- Sample ID
- Number and type of containers used
- Sample preservation notes
- Analyses requested
- Signature of the sampling person relinquishing samples to a non-sampling person (such as a Federal Express agent or laboratory courier), with the date and time of transfer

In addition, if samples are known to require expedited turnaround in the laboratory due to project time constraints or analytical concerns such as extraction time or sample retention period limitations, the person completing the COC record will note these constraints in the remarks section of the custody record and will notify the Laboratory Project Manager of the expedited turnaround requirement.

3.2.5 Laboratory Custody Procedures

Information regarding the laboratory's sample receipt, handling and custody procedures are presented in the Pace and ALS Quality Assurance Manuals. Below is a brief overview of lab custody procedures.

Upon arriving at the laboratory, samples are logged in by a designated sample custodian giving each sample a unique ID code. Sample receipt protocols and storage conditions include the following:

- Determine if the temperature requirement has been maintained during shipment, notifying the Laboratory Project Manager if the temperature requirements have not been maintained, and documenting on the cooler receipt form and COC.
- Verify samples received are listed in the COC. Notify Laboratory Project Manager if not listed.
- Verify appropriate sample preservation.
- Verify all sample holding times have not been exceeded. Notify Laboratory Project Manager if hold times have been exceeded.
- Examine shipping records for accuracy and completeness.

- Sign COC and attach the waybill.
- Note any other problems with the coolers and samples on the cooler receipt form, specifically with preservation and contact the Laboratory Project Manager if problems are identified.
- Log samples into the Master Logbook and into the Laboratory Information Management System, and attach the laboratory sample numbers to each sample bottle.
- Place the samples into proper laboratory storage.

The Laboratory Project Manager will send a copy of the laboratory sample receipt form via email to the Amec Foster Wheeler FOL, or an acceptable representative, and Amec Foster Wheeler will verify that the samples were received intact and properly preserved. The laboratory will also generate an intra-lab COC that will be maintained while the samples are being analyzed and remain in custody of the laboratory. This process ensures that the samples are maintained at the proper storage temperature, and that the sample integrity is maintained through adequate protection from contamination from outside sources or from highly contaminated samples.

Holding times are the responsibility of the laboratory for samples received within 48 hours of sampling or if less than half of the holding time has passed. If a holding time is exceeded, the laboratory will identify and document the root cause of the failure, and will contact the Laboratory Project Manager.

3.3 ANALYTICAL METHODS

Samples collected during the RAWP will be analyzed for Target Compound List (TCL) VOCs (or TCE only). The method analytes and associated laboratory reporting limits are contained in Table 1. The analytical method holding times, containers, and preservation requirements are summarized in Table 2. Table 3 contains a summary of the project quality control limits.

3.3.1 Soil/Water/LNAPL Samples

TCL VOCs in soil/water/LNAPL matrices and associated QC samples will be analyzed by USEPA Method 8260B or latest version. The VOCs are introduced into the gas chromatograph by purge-and-trap Method 5030 (aqueous samples) and Method 5035 (solid samples). Analytes eluted from the capillary column are introduced into the mass spectrometer. Identification of target analytes is accomplished by comparing their mass spectra with the electron impact spectra of certified standards. Quantitation is accomplished by comparing the response of a major (quantitation) ion relative to an internal standard with a five-point calibration curve.

3.3.2 Air Samples

VOCs in air samples and associated QC samples will be analyzed by USEPA Method TO-15. The laboratory's standard operating procedure for Method TO-15 is included as Appendix C. The ambient air samples are collected in specially-prepared stainless steel canisters. The influent/effluent air samples are collected in Tedlar® bags. A known volume of sample is directed from a canister/bag through a solid multi-sorbent concentrator where VOCs are trapped. VOCs are then released by thermal desorption and carried onto a gas chromatographic column for separation and identification using a mass spectrometer. Responses of detected analytes are compared to responses of standards with known concentrations to establish the analyte concentration present in the sample.

3.4 FIELD QUALITY CONTROL

The field quality control program ensures that samples collected are representative of the media being sampled and that the data generated are valid. Field quality control will be accomplished through:

- Accurate record keeping in the field logbooks and FDRs.
- Proper calibration of field equipment according to manufacturer's instructions.
- Proper cleaning of ambient air sampling equipment.
- Collection and analysis of QC samples potentially including field duplicates, equipment blanks, trip blanks, and matrix spike/matrix spike duplicate (MS/MSD) samples (Table 3).

Problems that require corrective action may be encountered in the field. Findings that require corrective action will be communicated to the Project Manager and documented in the field log book. The Project Manager will confirm that corrective actions have been implemented and that the problem has been resolved. If more easily addressed problems are encountered in the field, such problems will be addressed and the corrective action noted in the field log book. If an error is made on an accountable document assigned to one individual, that individual will make all corrections by crossing a line through the error, entering the correct information, and initialing and dating the correction. The erroneous information will not be obliterated. The person who made the entry will correct any subsequent error discovered on an accountable document.

The following sections describe quality control samples that will be collected during implementation of the RAWP.

3.4.1 Field Duplicates

Field duplicates are two samples taken from the same location and depth/interval, but submitted to the laboratory under blind identification protocol and analyzed separately. Soil duplicate samples for VOCs will be collected at the same location within the soil core and alternately filling the sample containers. Aqueous duplicates will be collected by alternately filling sample containers. LNAPL duplicates (if sufficient LNAPL is collected) will be collected by alternately filling sample containers. Duplicate ambient air samples will be collected by placing the air inlet within several inches of each other during sample collection. Duplicate influent/effluent air samples will be collected immediately after the initial/parent sample.

3.4.2 Equipment Blanks

A rinsate blank, commonly referred to as an equipment blank, is used to demonstrate the effectiveness of field cleaning/decontamination procedures. Contaminant-free water is poured over the equipment that has been cleaned in the field and is collected in the appropriate sample containers. One rinsate blank will be collected per week when non-dedicated sampling equipment is used (e.g., stainless steel bailer for collection of LNAPL samples).

3.4.3 Trip Blanks

A trip blank is utilized to detect possible VOC contamination of samples to be analyzed for VOCs. VOCs are susceptible to contamination by introduction or migration of contaminants through the vial septum. Trip blanks will be prepared by filling volatile vials with purged organic-free water. The trip blanks will be prepared in the laboratory and will accompany the sample containers during transit, during sampling activities, and during storage with the collected samples prior to analysis. Trip blanks will be shipped with each cooler containing samples collected for VOC analysis. LNAPL samples will be placed in coolers separate from other samples to prevent cross-contamination in the event of container breakage.

3.4.4 Matrix Spike and Matrix Spike Duplicate Samples

Matrix spike and matrix spike duplicate (MS/MSD) samples are additional samples collected with the field samples, and spiked by the laboratory and analyzed according to standard laboratory procedures. They are collected at a frequency of one MS/MSD pair per twenty environmental samples of the same matrix. MS/MSD samples also provide field precision data. MS/MSD samples will only be collected/submitted for soil and water/groundwater analyses.

3.5 LABORATORY QUALITY CONTROL

Laboratory performance for VOC analyses will be monitored by the inclusion of various internal QC checks that allow an evaluation of method control (batch QC) and the effect of the sample matrix on the data being generated (matrix-specific QC). The overall data quality indicators (DQIs) are to implement procedures for the laboratory analysis and reporting of the data that are indicative of the degree of quality consistent with their intended use. Laboratory batch QC samples consist of method and instrument blanks, LCSs, and calibration verification samples. Matrix specific QC samples consist of MS/MSDs, sample duplicates, and the use of surrogate compounds and internal standards.

3.6 INSTRUMENT/EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE

Maintenance and inspection of field and laboratory equipment are described in the following sections.

3.6.1 Field Equipment

Preventative maintenance of field measurement instrumentation and equipment will be performed according to the procedures presented in the manufacturer’s instructions. The field staff and/or subcontractors are responsible for ensuring instrumentation is operating properly prior to use. If problems are encountered, they will be communicated to the FOL and documented in the field logbook. The faulty instrumentation/equipment will be scheduled for repair and then sequestered and tagged until repaired and qualified for re-use.

3.6.2 Laboratory Equipment

Testing, inspection, and maintenance of laboratory instruments/equipment will be conducted in accordance with the procedures specified in the Pace and ALS Quality Assurance Manuals.

3.7 INSTRUMENT/EQUIPMENT CALIBRATION AND FREQUENCY

General guidance regarding calibration and frequency of calibration of field and laboratory equipment are described in the following sections.

3.7.1 Field Equipment

Equipment that requires field calibration during the RAWP include PID and water quality meters. Proper maintenance, calibration, and operation of each instrument will be the responsibility of the sampling personnel assigned/subcontractor to a particular field activity. Instruments and equipment used during the field investigations will be maintained, calibrated, and operated according to the manufacturer’s guidelines and recommendations. Relevant manuals will be kept with field sampling team personnel during the performance of field activities. Equipment will receive routine maintenance checks to minimize equipment breakdown in the field. Any items found to be inoperable will be taken out of use and a note stating the time and date of this action will be made in the daily field records.

A water level meter and oil-water interface will also be used during RAWP. The meters will be rented from an environmental supply company that will conduct a verification check on the instrument prior to shipping for use. The verification records will be reviewed to ensure that the instrument is operating to within the specified accuracy of the instrument.

3.7.1.1 PID Meter Calibration

A PID meter will be used to scan soil cores that are retrieved during soil sampling; monitor total VOCs in ambient air; and monitor influent/effluent vapor concentrations (conducted by TRS). The PIDs for soil scanning and influent/effluent monitoring will be calibrated prior to use when being utilized. A post-operation verification check will be conducted at the end of the day after use, or more frequently if erroneous readings are suspected. If the verification check indicates the PID meter is out of calibration (within 10 percent of the standard, as described below) the PID will be recalibrated.

The PIDs will be calibrated using a two-point calibration. One point will be ambient air that contains no detectable VOCs (i.e., zero parts per million; ppm) and the second point is a standard reference gas (isobutylene) of known concentration (i.e., 10 or 100 ppm). The PID’s computer has a set of known/pre-programmed gases and concentrations, so isobutylene will be selected for calibration. The calibration will be verified after the two-point procedure. The calibration will be acceptable when the fresh air concentration is within 5 ppm of zero, and the gas concentration is within 10 percent of the standard gas concentration. Calibration information will be recorded on the Field Instrument Calibration Record included for reference in Appendix D.

The PIDs used for continuous perimeter ambient air monitoring will only be re-calibrated when determined to be necessary. At least four times per week, a ‘bump test’ using a known concentration of isobutylene will be used to verify that the PID is within calibration (10 percent of the standard gas). If a PID is out of calibration, the PID will be taken off-line and re-calibrated. It will then be put back on-line for continuous ambient air monitoring.

3.7.1.2 Water Quality Meter Calibration

Water quality meters will be used to monitor water quality parameters during groundwater purging prior to collection of a groundwater sample. The objective of the purging is to collect a groundwater sample that is representative of groundwater at that location, as described in the FSAP. The water quality meters will be calibrated daily prior to use. A post-operation verification check will be conducted at the end of the day after use, or more frequently if erroneous readings are suspected. If the verification check indicates the water quality meters are out of calibration (as described below) the water quality meters will be recalibrated.

A water quality meter that measures pH, conductivity, temperature, dissolved oxygen, and oxygen reduction potential will be used. A separate water quality meter that measures turbidity will also be used. The water quality meters will be calibrated in accordance with the manufacturer’s instructions. Calibration information will be recorded on the Field Instrument Calibration Record included for reference in Appendix D.

3.7.2 Laboratory Equipment

The calibration of laboratory instruments and support equipment is necessary to ensure that the analytical system is operating correctly and functioning within the guidelines of precision, accuracy, and sensitivity. The frequency and type of calibration for laboratory equipment/procedures and control limits/acceptance criteria are presented the Pace and ALS Quality Assurance Manuals.

Reference standards are used to calibrate the equipment. Physical reference standards include weights for scales and balances, and certified thermometers for calibrating working thermometers. Chemical reference standards include reference materials traceable to recognized standards suppliers, and are generally associated with normal instrument calibrations. The standards must be verified by quantitation against a second known standard before the data is reported, and must meet specified QC criteria for calibration verification.

At minimum, the laboratory equipment must be calibrated and maintained at intervals prescribed by the analytical method. An instrument is said to be calibrated when an instrument response can be directly related to the concentration of an analyte graphically through the use of a calibration curve. The low standard of the curve shall be established by the laboratory as the PQL. Results above the highest standard will be diluted into the calibration range and reanalyzed.

3.8 INSPECTION/ACCEPTANCE OF SUPPLIES AND CONSUMABLES

Supplies and consumables that are anticipated to be used during implementation of the RAWP program are described in Section 3.1.1 herein. Sample containers will have certification papers for each lot that is used. The field samplers will inspect containers to verify that containers are not broken and the correct preservative is in the container where necessary. If dirt or foreign material is observed in the container, they will be replaced with a new container. The remaining supplies (i.e., those presented in Section 3.1.1 herein) will be accepted based on the judgment of the field personnel.

Project team members obtaining supplies and consumables are responsible for confirming that the materials meet the required specifications, are intact and in good condition, are available in adequate supply, and are stored appropriately until use. Project team members will direct any questions or any identified problems regarding supplies and consumables to the FOL for resolution.

Environmental equipment (water level meter, oil-water interface probe, water quality meters, PIDs, and pumps) will be rented from an environmental equipment supplier, and calibration solutions will be requested with the rented equipment that requires field calibration (e.g., water quality meter and PID). Calibration solution certifications will be reviewed to ensure that they are at the concentration ranges specified for the project and that they are within their expiration dates. Certification records will be maintained in the project files. Calibration acceptance criteria are indicated on the calibration record in Appendix D.

3.9 NON-DIRECT MEASUREMENTS

For the purposes of the RAWP, non-direct measurements will include information/data from previous investigations. This information will be appended to non-direct measurements to ensure data quality is communicated and understood before use.

3.10 DATA MANAGEMENT

The objective of data management is to establish procedures to be used during field investigations for documenting, tracking, and presenting investigative data. Data generated during the field investigations, as well as previously existing data, form the basis for developing conclusions and recommendations. Efficient utilization and comprehensive consideration of available data requires that the data be properly organized for review. Organization of the data will be planned prior to collection to assure the generation of identifiable and useable data. This section describes procedures necessary to provide for collecting sufficient data to accurately validate raw data and to transfer validated data to a data management system through which it can be evaluated with minimal effort. This section also describes the operating practices to be followed by personnel while collecting and reporting data.

3.10.1 Field Investigation Data

The following data will be collected in the field and maintained in the project file:

- A summary spreadsheet of data collected for each boring/location
- Monitoring well construction details
- Depth to water measurement
- Depth/thickness of LNAPL
- Soil boring logs containing:
  - Soil descriptions
  - PID measurements
  - Identification of soil samples collected
- Instrument calibration records
- Groundwater sampling and water quality records
- Air sampling records
- Photographs
- COC records

The flow of data for the project will be as follows:

- Field data records, including COCs, will be forwarded to the FOL, if collected by others.
- Samples will be sent directly from the field to the selected laboratory.
- Laboratory results, including EDDs and hard copies, will be sent to the FOL; the FOL will forward the laboratory results, including EDDs to the Quality Assurance Manager.
- The Project Chemist will perform data validation with oversight by the Quality Assurance Manager. The validated data will be transferred in electronic format to the FOL.

3.10.2 Off-Site Laboratory Data

The laboratories will provide electronic analytical reports to document the chemical testing and report analytical results. Data deliverables will include sample result and QC summary forms and all supporting raw data needed to verify sample results. For USEPA SW-846 methods used in this investigation, forms similar to those defined under the

USEPA Contract Laboratory Program (CLP) deliverables will be required. The laboratory can use customized reporting forms providing they contain equivalent information as CLP forms.

At a minimum, the data packages will include the following:

- Data package narrative
    - summary of analytical methods used
    - correlation of field sample identifications and laboratory sample identifications
    - data qualifier definitions
    - deviations from established QA/QC procedures with corrective action
- Sample results
    - project name
    - field sample identification
    - lab ID
    - unit of measurement
    - batch number
    - collection/extraction/analysis dates
    - detection limits
    - dilution factors
    - percent moisture
- Sample documentation
    - original chain-of-custody
    - shipping documents
    - cooler receipt forms
- Quality Assurance/Quality Control
    - spike recoveries (surrogates/deuterated monitoring compounds, MS/MSDs, LCSs)
    - internal standard summary
    - initial calibration summaries
    - GC/MS tuning summaries
    - continuing calibration summaries
    - QC blank summaries
    - CLP Form 10 – dual column summary (applicable GC methods)
    - measures of precision (laboratory duplicates, MS/MSDs)
    - control limits for accuracy and precision
- Raw data including instrument printouts (analytical sequence/acquisition files, chromatograms and quantitation reports), instrument logbook pages, and sample preparation logs (this data will not be provided for influent effluent vapor/water samples collected from the treatment system)

Sample results will be provided by the laboratory in electronic format. Laboratory reports and EDDs from the laboratory will be transmitted to the Amec Foster Wheeler Data Manager and Project Chemist. The electronic data will be provided in a format described in Table 4. Electronic lab results will be imported into the Amec Foster Wheeler TED. Files of the unvalidated electronic data are provided to the Project Chemist for use during data validation. The project chemist will make any necessary data qualification and changes based on the data validation review, and qualified results are entered back into the TED database. During data validation, a quality assurance review of sample results will be completed to ensure that the data in the database match the hard copy provided by the laboratory.

Final validated laboratory data will be maintained in the TED database to allow easy retrieval of information and electronic transfer of the data to other parties. Once final data are entered into the TED and validation is completed, data reports will be generated as needed to support contamination assessments and report preparation. A data validation report will be prepared and will be organized by sample collection task and might include multiple sample delivery groups (SDGs). The validation report(s) will include the following information:

- Introduction
  - description of sampling task
  - identity of the laboratory used for analysis
  - a summary of analytical methods
  - a table summarizing summary of SDGs and samples are included in the report
  - a description of the data validation process
  - a table summarizing project QC limits

- Validation actions and observations
  - a discussion of data validation actions, qualifications, and observations
  - a table summarizing all data qualification actions
  - a tabulation of validated samples results

- References cited

Upon completion of the field investigation and subsequent validation of off-Site laboratory data, an EDD will be prepared with relevant field information and laboratory data in the format specified for environmental data in the USEPA Region 4 SESD R4DART database. This database is the USEPA Region 4 repository for storing Superfund data, which includes location, geological, and analytical data. Data will be submitted in accordance with the Environmental Data Submission Guideline SESDGUID-106-RO (USEPA, 2010).

4.0 ASSESSMENT AND OVERSIGHT

Internal and external checks (assessments) have been built into this project to assure the following:

- Elements of this QAPP have been properly implemented as prescribed.
- The quality of the data generated is adequate and satisfies the DQOs and DQIs that have been identified in this QAPP.
- Corrective actions, when needed, are implemented in a timely manner and their effectiveness is confirmed.

Formal audits are not planned for this project. The FOL will provide training and oversight to field crews and review field records on a daily basis to verify that sample collection procedures and record keeping steps are being completed in accordance with the FSAP and QAPP. The USEPA may complete reviews and audits of the field sampling events at any time during the monitoring program.

If deviations from the RAWP, this QAPP, or the FSAP are identified, the information will be verbally reported to the Project Manager and noted in the field logbook. Based on the severity of the deviation, the Project Manager might request formal documentation of the deviation in the form of a memorandum to the project file. The Project Manager will determine the timeframe required for corrective action, if corrective action is necessary. Corrective actions will be completed and an assessment of the potential impact on data quality will be made. Project reviews and summaries of issues requiring corrective actions will be summarized in the Site logbook. If potential impact to data quality is identified, a summary of the issues, corrective actions, and impacts to data will be provided to the Quality Assurance Manager for use during the validation of the analytical data.

5.0 DATA VALIDATION AND USABILITY

Data validation involves reviewing and accepting, qualifying, or rejecting data based on requirements in the referenced analytical methods, data validation guidelines, and QC goals established for this project in Section 2.5 herein. Data validation for VOC analyses will be based on procedures in the USEPA Region 4 guidelines (USEPA, 2016). Validation guidelines will be modified based on USEPA SW-846 methods used in this investigation. Project QC limits identified in Table 3 will be used to evaluate sample results during validation. Validation will be performed by the Project Chemist, under the direction of the Quality Assurance Manager.

Data validation will consist of a systematic review of the analytical results and associated QC methods and results. In any area not specifically addressed by USEPA guidelines, best professional judgment will be utilized and described in the Usability Assessment portion of the data validation report.

In general, data validation will include a check of data completeness for data in each data package, a transcription check for sample results, and a thorough review of laboratory reporting forms. Specifically, this review will include the following:

- Data package completeness
- Required reporting summary forms to determine whether the QC requirements were met and to determine the effect of QC requirements on the precision, accuracy, and/or sensitivity of the data
- Additional QA/QC parameters, such as field duplicates and rinsate blanks to assess the technical usability of the data
- Application of standard data quality qualifiers to the data

In addition, each data validation effort will include a comprehensive review of the following data quality indicators:

- Sample collection, preservation, and holding times (to assess potential for degradation that could affect accuracy)
- Blanks (to assess cross-contamination)
- System monitoring compounds (to assess method accuracy)
- Laboratory Control Samples and MS/MSD samples to assess accuracy of a method and precision of the method relative to the specific sample matrix, if applicable)

- Instrument tuning and calibration
- Compound quantitation limits and method detection limits (to assess sensitivity compared to project-specific requirements)
- Field duplicate relative percent differences (to assess precision of the method relative to field sampling techniques, the specific sample matrix, and representativeness of the sample aliquot to the area sampled, if applicable)

Full validation including raw data verification and calculation checks will be completed on ten percent of the samples, not including influent/effluent vapor and water samples from the treatment system. If during full validation, significant errors are discovered in the QC summary forms, calculations, or data reporting, full validation will be performed on a larger subset of data packages and raw data will be examined.

Analytical results may be qualified by the data validator based on actions described in the USEPA validation guidelines or professional judgment. Results may be accepted without qualification or with validation qualifiers (e.g., U, J, UJ, N). Results that don't meet minimum criteria for acceptance (i.e., qualified as rejected during validation) will be unacceptable for decision making purposes. At a minimum, data rejection criteria identified in the USEPA validation documents will be applied to results.

The following validation qualifiers may be applied to sample results:

- U = target analyte is not detected above the associated detection limit
- J = the reported sample concentration is an estimate value
- UJ = the reported quantitation limit is an estimated value
- N = there is uncertainty in the identification of the reported analyte
- R = constituent rejected and unusable for detect and non-detects

The results of the data validation and any corrective actions implemented will be recorded on a QA/QC worksheet, which will be initialed and dated by the data reviewer. The Quality Assurance Manager or appropriate designee will provide secondary review of the QA/QC worksheet and will also initial and date the worksheet. The initialed and dated QA/QC worksheet will be attached to the final analytical laboratory report that is retained in the project files.

Results will be qualified using general procedures described in the USEPA validation guideline and the judgment of the project chemist. Upon completion of the validation task, a report will be prepared. Validation reports will be organized by sample collection task and may include multiple sample delivery groups. The validation report(s) will include the following information:

- Identity of the laboratory used for analysis
- A summary of analytical methods
- A summary of samples that are included in the sample set
- A discussion of data validation actions, qualifications, and observations
- A tabulation of validated samples results

Qualifiers applied to the data during validation will be entered into the electronic data deliverables in the database.

6.0 RECONCILIATION OF DATA TO PROJECT OBJECTIVES

At the end of the project there will be an assessment of field records, field data, laboratory analytical data usability, and project completeness to determine if project objectives defined in the FSAP and QAPP have been met. The FOL and Project Manager will review field records and reports to verify completeness of field records and identify any issues regarding project procedures, collection of field data that did not meet quality objectives, the completeness of the samples collected, or corrective actions. A review of the data validation report associated with the laboratory data will also be completed by the Quality Assurance Manager in cooperation with the FOL and Project Manager to identify data that is qualified. An assessment of impacts from field issues or data qualification actions will be performed and documented in a data usability report. Impacts might include identification of entire samples or a subset of analytes where data are considered unusable. In other cases, uncertainties in the accuracy of usable data might be identified.

In the EHR Monitoring/Completion Report, a data quality and completeness summary will be provided that identifies data gaps or analytical data quality issues that are identified in field operation reports or analytical data validation reports. The following items will be included in the data usability summary:

- Field investigation scope modifications
- Field investigation data quality issues
- Field investigation data gaps (data that was planned for collection and not obtained)
- Field and analytical data completeness
- Analytical data validation qualification actions and impacts on data usability
- Analytical detection limits and impacts on data usability

The need for recollection of sample or other actions related to the data usability will be determined on a case by case basis with input from the USEPA Project Manager.

7.0 REFERENCES

Amec Foster Wheeler, 2014. NAPL Investigation Report, CTS of Asheville, Inc. Superfund Site, EPA ID: NCD003149556 May 5, 2014.

Amec Foster Wheeler, 2015. Final NAPL Area Focused Feasibility Study, CTS of Asheville, Inc. Superfund Site, EPA ID: NCD003149556 September 10, 2015.

USEPA, 2006. Guidance on Systematic Planning Using the Data Quality Objectives Process (EPA QA-G4), EPA/240/B-06/001, February 2006.

USEPA, 2010. Environmental Data Submission Guideline, Science and Ecosystem Support Division, Athens, GA; SESDGUID-106-RO, December 17, 2010.

USEPA, 2016. USEPA Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review, USEPA 540-R-2016-02, OLEM 9355.0-134, September 2016.

TABLES

TABLE 1
Laboratory Reporting Limits for VOCs
CTS of Asheville, Inc. Superfund Site
Asheville, North Carolina
Amec Foster Wheeler Project 6252-16-2012

Analyte	Water			Soil			Air		
	PQL	MDL	Units	PQL	MDL	Units	PQL	MDL	Units
Acetone	25	10	ug/L	100	10	ug/kg	5	0.77	µg/m^3
Benzene	1	0.25	ug/L	5	1.6	ug/kg	0.5	0.16	µg/m^3
Bromochloromethane	1	0.17	ug/L	5	1.7	ug/kg	NA	NA	µg/m^3
Bromodichloromethane	1	0.18	ug/L	5	1.9	ug/kg	0.5	0.15	µg/m^3
Bromoform	1	0.26	ug/L	5	2.3	ug/kg	0.5	0.15	µg/m^3
Bromomethane	2	0.29	ug/L	10	2.5	ug/kg	0.5	0.19	µg/m^3
2-Butanone (MEK)	5	0.96	ug/L	100	2.9	ug/kg	5	0.21	µg/m^3
Carbon disulfide	2	1.15	ug/L	10	3	ug/kg	5	0.15	µg/m^3
Carbon tetrachloride	1	0.25	ug/L	5	2.6	ug/kg	0.5	0.15	µg/m^3
Chlorobenzene	1	0.23	ug/L	5	1.9	ug/kg	0.5	0.16	µg/m^3
Chloroethane	1	0.54	ug/L	10	2.4	ug/kg	0.5	0.17	µg/m^3
Chloroform	1	0.14	ug/L	5	1.6	ug/kg	0.5	0.17	µg/m^3
Chloromethane	1	0.11	ug/L	10	2.4	ug/kg	0.5	0.15	µg/m^3
Cyclohexane	1	0.36	ug/L	5	1.6	ug/kg	1	0.29	µg/m^3
1,2-Dibromo-3-chloropropane	2	2	ug/L	5	3.6	ug/kg	0.5	0.099	µg/m^3
Dibromochloromethane	1	0.21	ug/L	5	1.8	ug/kg	0.5	0.16	µg/m^3
1,2-Dibromoethane (EDB)	1	0.27	ug/L	5	1.8	ug/kg	0.5	0.16	µg/m^3
1,2-Dichlorobenzene	1	0.30	ug/L	5	1.9	ug/kg	0.5	0.15	µg/m^3
1,3-Dichlorobenzene	1	0.24	ug/L	5	2	ug/kg	0.5	0.15	µg/m^3
1,4-Dichlorobenzene	1	0.33	ug/L	5	1.7	ug/kg	0.5	0.14	µg/m^3
Dichlorodifluoromethane	1	0.21	ug/L	10	3.6	ug/kg	0.5	0.17	µg/m^3
1,1-Dichloroethane	1	0.32	ug/L	5	1.5	ug/kg	0.5	0.16	µg/m^3
1,2-Dichloroethane	1	0.24	ug/L	5	2.2	ug/kg	0.5	0.16	µg/m^3
1,1-Dichloroethene	1	0.56	ug/L	5	1.8	ug/kg	0.5	0.17	µg/m^3
cis-1,2-Dichloroethene	1	0.19	ug/L	5	1.4	ug/kg	0.5	0.16	µg/m^3
trans-1,2-Dichloroethene	1	0.49	ug/L	5	1.9	ug/kg	0.5	0.19	µg/m^3
1,2-Dichloropropane	1	0.27	ug/L	5	1.7	ug/kg	0.5	0.16	µg/m^3
cis-1,3-Dichloropropene	1	0.13	ug/L	5	1.8	ug/kg	0.5	0.14	µg/m^3
trans-1,3-Dichloropropene	1	0.26	ug/L	5	1.5	ug/kg	0.5	0.16	µg/m^3
1,4-Dioxane (p-Dioxane)	150	78.36	ug/L	150	120	ug/kg	0.5	0.16	µg/m^3
Ethylbenzene	1	0.30	ug/L	5	1.8	ug/kg	0.5	0.16	µg/m^3
2-Hexanone	5	0.46	ug/L	50	3.9	ug/kg	0.5	0.16	µg/m^3
Isopropylbenzene (Cumene)	1	0.40	ug/L	5	1.9	ug/kg	0.5	0.15	µg/m^3
Methyl acetate	10	0.82	ug/L	10	1.4	ug/kg	NA	NA	µg/m^3
Methylcyclohexane	10	1.87	ug/L	10	1.5	ug/kg	NA	NA	µg/m^3
Methylene Chloride	2	0.97	ug/L	20	3	ug/kg	0.5	0.17	µg/m^3
4-Methyl-2-pentanone (MIBK)	5	0.33	ug/L	50	3.7	ug/kg	0.5	0.16	µg/m^3
Methyl-tert-butyl ether	1	0.21	ug/L	5	1.5	ug/kg	0.5	0.17	µg/m^3
Napththalene	1	0.24	ug/L	5	1.2	ug/kg	NA	NA	µg/m^3
Styrene	1	0.26	ug/L	5	1.8	ug/kg	0.5	0.15	µg/m^3
1,1,2,2-Tetrachloroethane	1	0.40	ug/L	5	1.9	ug/kg	0.5	0.15	µg/m^3
Tetrachloroethene	1	0.46	ug/L	5	1.7	ug/kg	0.5	0.14	µg/m^3
Toluene	1	0.26	ug/L	5	1.8	ug/kg	0.5	0.17	µg/m^3
1,2,3-Trichlorobenzene	1	0.33	ug/L	5	2.2	ug/kg	0.5	0.18	µg/m^3

TABLE 1
Laboratory Reporting Limits for VOCs
CTS of Asheville, Inc. Superfund Site
Asheville, North Carolina
Amec Foster Wheeler Project 6252-16-2012

Analyte	Water			Soil			Air		
	PQL	**MDL**	**Units**	**PQL**	**MDL**	**Units**	**PQL**	**MDL**	**Units**
1,2,4-Trichlorobenzene	1	0.35	ug/L	5	1.6	ug/kg	0.5	0.16	µg/m^3
1,1,1-Trichloroethane	1	0.48	ug/L	5	1.8	ug/kg	0.5	0.17	µg/m^3
1,1,2-Trichloroethane	1	0.29	ug/L	5	2.1	ug/kg	0.5	0.16	µg/m^3
Trichloroethene	1	0.47	ug/L	5	2.1	ug/kg	0.5	0.14	µg/m^3
Trichlorofluoromethane	1	0.20	ug/L	5	2.2	ug/kg	0.5	0.17	µg/m^3
1,1,2-Trichlorotrifluoroethane	1	0.19	ug/L	5	1.9	ug/kg	0.5	0.17	µg/m^3
1,2,4-Trimethylbenzene	1	0.31	ug/L	5	2.0	ug/kg	0.5	0.15	µg/m^3
1,3,5-Trimethylbenzene	1	0.36	ug/L	5	1.8	ug/kg	0.5	0.16	µg/m^5
Vinyl chloride	1	0.62	ug/L	10	1.8	ug/kg	0.5	0.17	µg/m^3
m&p-Xylene	2	0.66	ug/L	10	3.6	ug/kg	1.0	0.30	µg/m^3
o-Xylene	1	0.23	ug/L	5	1.9	ug/kg	0.5	0.15	µg/m^3

Notes:
PQL - Pratical Quantitative Limit
MDL - Method Detection Limit
NL - not analyzed with TO-15
µg/L - micrograms per liter
µg/kg - micrograms per kilogram
µg/m^3 - micrograms per cubic meter

Prepared By: MRG 1/16/18
Checked By: SEA 1/17/18

TABLE 2
Sample Container, Preservation, and Holding Time Requirements
CTS of Asheville, Inc. Superfund Site
Asheville, North Carolina
Amec Foster Wheeler Project 6252-16-2012

Media	Analysis	Preparation Method	Analysis Method	Container	Sample Volume	Preservative	Hold Time
Saturated Soil	VOCs (TCE only)	EPA 5035	EPA 8260B	Terra Core™ kit	3 x 5 grams 1 x 100 grams	2 vials with $NaHSO_4$; 1 vial with MeOH; 1 vial/jar unpreserved; $4^{o}C$	14 days
Groundwater	VOCs (TCE only)	EPA 5030	EPA 8260B	VOA with Teflon®-lined septum	3 x 40 mL	HCl to pH<2; $4^{o}C$	14 days
Process Water	VOCs	EPA 5030	EPA 8260B	VOA with Teflon®-lined septum	3 x 40 mL	HCl to pH<2; $4^{o}C$	14 days
LNAPL	VOCs (TCE only)	EPA 5030	EPA 8260B	VOA with Teflon®-lined septum	1 x 40 mL	None	7 days
Ambient Air	VOCs	None	TO-15	Summa® canister	6 L	None	30 days
Influent/ Effluent Air	VOCs	None	TO-15	Tedlar® bag	1 L	None	3 days

Notes:
VOCs - volatile organic compounds
mL - milliliter
^{o}C - degrees Celsius
L - liter

$NaHSO_4$ - sodium bisulphate
MeOH - methanol
HCl - hydrochloric acid

Prepared By: SEA 1/15/18
Checked By: MEW 1/16/18

TABLE 3
Measurement Performance Criteria for Laboratory and Field Samples
CTS of Asheville, Inc. Superfund Site
Asheville, North Carolina
Amec Foster Wheeler Project 6252-12-2012

QC Sample	Analytical Group	Frequency	Data Quality Indicators	Measurement Performance Criteria	QC Sample Assesses Error for Sampling (S) or Analytical (A) or both
Method Blank	VOCs - EPA 8260 and TO-15	One per preparation batch	Accuracy/ Bias-Contamination (verify system is contaminant free)	Analytes ND above one-half the PQL and 1/10 the amount measured in a sample. No common laboratory contaminants detected greater than PQL.	A
LCS/LCD	VOCs - EPA 8260 and TO-15	One LCS/LCD pair per preparation batch per matrix	Precision and accuracy	Recovery: 70 - 130% RPD ≤ 30%	A
Surrogate Recovery	VOCs - EPA 8260 and TO-15	Every field and QC sample	Accuracy	Recovery: 70 - 130%	A
MS/MSD	VOCs - EPA 8260	One MS/MSD pair per 20 field samples collected per matrix	Precision and accuracy	Recovery: 70 - 130% RPD ≤ 30% (water) RPD ≤ 50% (soil)	A
Field Duplicate	VOCs - EPA 8260 and TO-15	One per 10 field samples collected per matrix	Precision	RPD ≤ 30% (water) RPD ≤ 50% (soil and air)	S & A
Equipment Blank	VOCs - EPA 8260	When non-dedicated sampling equipment used, one equipment blank will be collected per week.	Accuracy/ Bias-Contamination (verify decontamination procedure)	Analytes ND above one-half the PQL; acetone and methylene chloride ND above PQL	S
Temperature Blank	VOCs - EPA 8260	Each cooler shipped to laboratory	Accuracy (verify correct temperature maintained during transport)	0 to 4 degrees Celcius	S
Trip Blank	VOCs - EPA 8260	One per cooler containing samples for VOC analysis	Accuracy/ Bias-Contamination (verify that cross-contamination has not occurred during transport)	Analytes ND above one-half the PQL; acetone and methylene chloride ND above PQL	S

Notes:
LCS - laboratory control sample
LCSD - laboratory control sample duplicate
MS - matrix spike
MSD - matrix spike duplicate
RPD - relative percent difference
VOCs - volatile organic compounds
ND - not detected
PQL - practical quantitation limit

Prepared By: SEA 1/15/18
Checked By: CSR 1/16/18

TABLE 4
Laboratory Electronic Data Deliverable Format
CTS of Asheville, Inc. Superfund Site
Asheville, North Carolina
Amec Foster Wheeler Project 6252-16-2012

Equis "EZEDD01" Field Name	data type	Required for "EDD"	Description	"TED" Table	"TED" Column
project_code	1 Text20	X	This field contains the internal project_code used by TED to identify a unique site. This will be provided to the lab on a per project basis.	Location	Site_id
sample_name	2 Text30	X	This field contains the sample number as written in the Analysis Request and Chain of Custody (AR/COC) form sent to the laboratory with the field samples for analysis. This is a unique number assigned to each sample by sampling personnel. For laboratory samples enter "LAB QC".	sample_collection	field_sample_id
sys_sample_code	3 Text20				
sample_date	4 Date	X	mm/dd/yyyy. Date sample was collected in the field. Date information must be identical with the date from the AR/COC form. Leave blank for lab samples. Year may be entered as yyyy.	sample_collection	field_sample_date
sample_time	5 Time				
analysis_location	6 Text2				
lab_name_code	7 Text10	X	Laboratory that performed the analysis.	sample_analysis	lab_id
lab_sample_id	8 Text20	X	Unique sample ID internally assigned by the laboratory.	sample_analysis	lab_sample_id
sample_type_code	9 Text10	X	Specifies sample type. For field samples, enter FS (regular environmental sample), otherwise, use values listed in the LOV. For example, normal field samples must be distinguished from laboratory method blank samples, etc.	sample_collection	qc_code
Lab_Del_Group	10 Text20	X	Tracking code used by the laboratory. Commonly called Sample Delivery Group (SDG).	sample_analysis	lab_sample_delivery_group
Lab_Batch_Number	11 Text20		Tracking number used by the laboratory to identify a group of samples analyzed in the same batch. This field, in conjunction with laboratory blank ID, is used to link the relationship between field samples and laboratory blank and other QC samples.		
lab_anl_method_name	12 Text35	X	Test method used in the analysis of the analyte.	sample_analysis	analysis_method

TABLE 4
Laboratory Electronic Data Deliverable Format
CTS of Asheville, Inc. Superfund Site
Asheville, North Carolina
Amec Foster Wheeler Project 6252-16-2012

Equis "EZEDD01" Field Name	data type	Required for "EDD"	Description	"TED" Table	"TED" Column
cas_rn	13 Text15	X	Unique analyte identifier. Use assigned CAS number when one is identified for an analyte. Tentatively Identified Compounds (TICs) and a number of other analytes are not assigned a standard CAS number. The laboratory is required to assign a UNIQUE identifier for all chemical_names.	sample_analysis_results	casno
chemical_name	14 Text60	X	Name of analyte or parameter analyzed.		
result_value	15 Text20	X	Must only be a numeric value. It is stored as a string of characters so that significant digits can be retained. Must be identical with values presented in the hard copy. Analytical result is reported left justified. Reported as the reporting_detection_limit for non-detects.	sample_analysis_results	lab_result
lab_qualifiers	16 Text7	X	Qualifier flags assigned by the laboratory.	sample_analysis_results	lab_qualifier
result_unit	17 Text15	X	This format assumes that the result value and detect limit have the same units.	sample_analysis_results	result_uom
result_type_code	18 Text10	X	Parameter list type. Valid Values = Targer analytes (TCL, TAL or TRG); Surrogates (SUR); and TICs	sample_analysis_results	result_type
detect_flag	19 Text2	X	Enter “Y” for detected analytes or “N” for non-detected analytes.	sample_analysis_results	report_hit_flag
reporting_detection_limit	20 Text20	X	Must only be a numeric value. Use the value of the Reported Detection Limit (RDL), Practical Quantitation Limit (PQL), or Contract Required Quantitation Limit. Value is stored as a string to retain significant figures. Unit of measure must be identical with result_unit value.	sample_analysis_results	detection_limit
dilution_factor	21 Text6	X	Must be a numeric entry. The factor by which the sample was diluted as part of the preparation process. If no dilution was done, enter the value 1. Value is stored as a string to retain significant figures.	sample_analysis	dilution_factor
sample_matrix_code	22 Text10	X	Code which distinguishes between different type of sample matrix. For example, soil samples must be distinguished from ground water samples, etc. Valid codes for HESE are "G" (gas), "L" (liquid), "S" (solid), and "P" (free or raw liquid product).	sample_collection	matrix

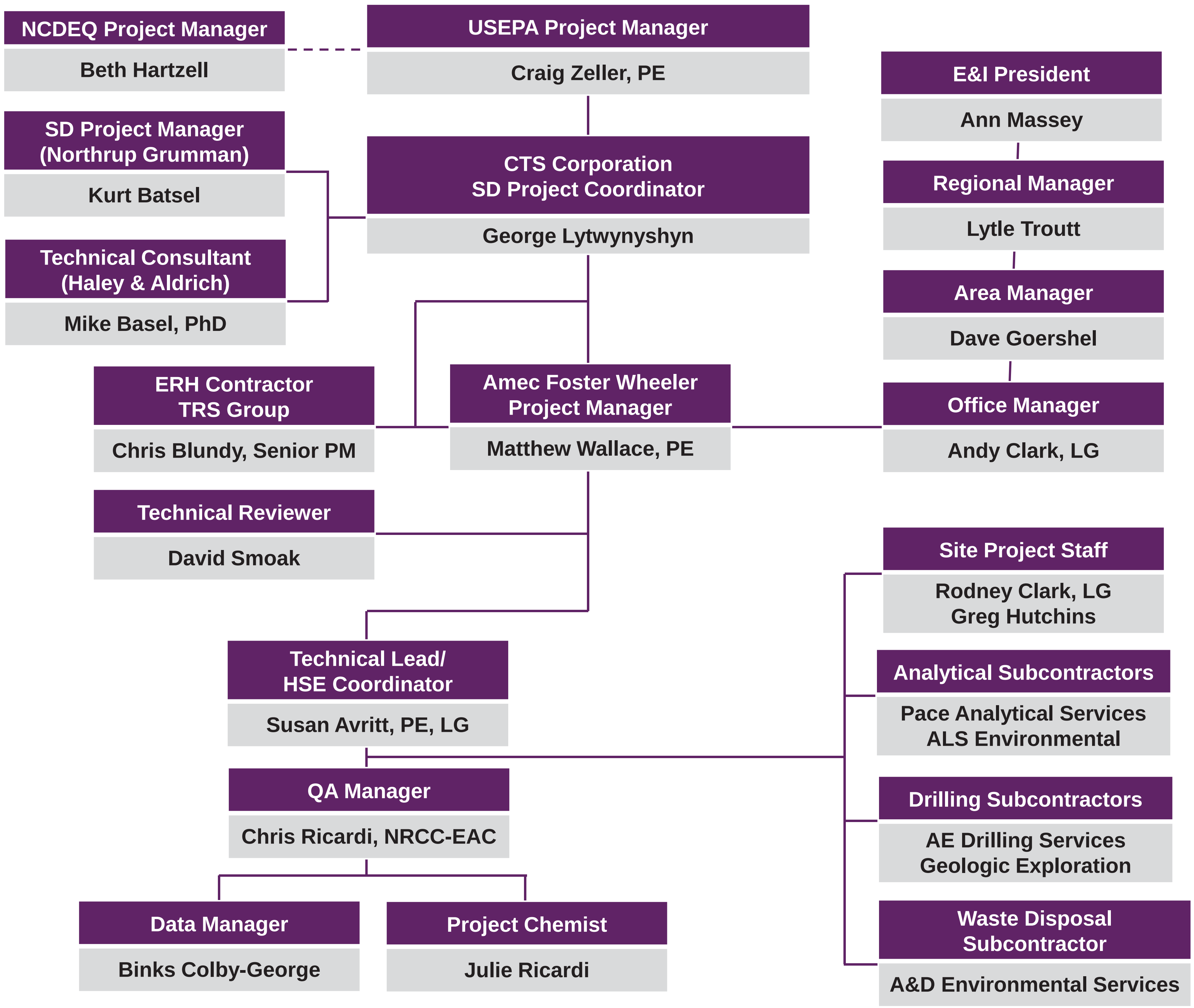
TABLE 4
Laboratory Electronic Data Deliverable Format
CTS of Asheville, Inc. Superfund Site
Asheville, North Carolina
Amec Foster Wheeler Project 6252-16-2012

Equis "EZEDD01" Field Name	data type	Required for "EDD"	Description	"TED" Table	"TED" Column
total_or_dissolved (or fraction)	23 Text1	X	Must be “T” for total metal concentration, “D” for dissolved or filtered metal concentration, or “N” for organic (or other) parameters for which neither “total” nor “dissolved” is applicable. Also, HESE requires "C" for TCLP and "S" for SPLP fractions.	sample_analysis	fraction
basis	24 Text10				
analysis_date	25 Date	X	mm/dd/yyyy. Date sample was analyzed.	sample_analysis	analysis_date
analysis_time	26 Time				
method_detection_limit	27 Text20				
lab_prep_method_name	28 Text35		Description of sample preparation or extraction method.	sample_analysis	prep_method_name
prep_date	29 Date	X	mm/dd/yyyy. This field is used to determine whether holding times for field samples have been exceeded.	sample_analysis	extraction_date
prep_time	30 Time				
test_batch_id	31 Text20	X	Default is 1 for primary results. Other valid values are 2, 3, 4, 5, and RE. Primary use is for reanalyses and dilutions where more than one result may be reported.	sample_analysis	run_id
result_error_delta	32 Text20				
TIC_retention_time	33 Text8				
qc_level	34 Text10		Laboratory QC level associated with the analysis	sample_analysis	qc_level
result_comment	35 Text255		Any comments related to the analysis.	sample_analysis_results	comments
sample_quantitation_limit (may be REQUIRED FIELD for certain projects)	36 Text20		Must only be a numeric value. Use the value of the Sample Quantitation Limit (SQL). Value is stored as a string to retain significant figures. Unit of measure must be identical with result_unit value.	sample_analysis_results	TBD

Note: All "X" marked fields are minimum data required to load data to "TED".

APPENDIX A

ORGANIZATION CHART


NCDEQ Project Manager
Beth Hartzell
USEPA Project Manager
Craig Zeller, PE
E&I President
Ann Massey
SD Project Manager
(Northrup Grumman)
Kurt Batsel
CTS Corporation
SD Project Coordinator
George Lytwynyshyn
Regional Manager
Lytle Troutt
Technical Consultant
(Haley & Aldrich)
Mike Basel, PhD
Area Manager
Dave Goershel
ERH Contractor
TRS Group
Chris Blundy, Senior PM
Amec Foster Wheeler
Project Manager
Matthew Wallace, PE
Office Manager
Andy Clark, LG
Technical Reviewer
David Smoak
Site Project Staff
Rodney Clark, LG
Greg Hutchins
Technical Lead/
HSE Coordinator
Susan Avritt, PE, LG
Analytical Subcontractors
Pace Analytical Services
ALS Environmental
QA Manager
Chris Ricardi, NRCC-EAC
Drilling Subcontractors
AE Drilling Services
Geologic Exploration
Data Manager
Binks Colby-George
Project Chemist
Julie Ricardi
Waste Disposal
Subcontractor
A&D Environmental Services

APPENDIX B

PACE ANALYTICAL SERVICES, LLC QUALITY ASSURANCE MANUAL

QUALITY ASSURANCE MANUAL

Quality Assurance/Quality Control Policies and Procedures

Pace Analytical Services, LLC – Carolinas

Asheville Laboratory
225 Riverside Dr
Asheville, NC 28808
(828) 254-7176

Charlotte Laboratory
9800 Kincey Ave, Suite 100
Huntersville, NC 28078
(704) 875-9092

Eden Laboratory
205 East Meadow Rd, Suite A
Eden, NC 27288
(336) 623-8921

Raleigh Laboratory
6701 Conference Drive
Raleigh, NC 27607
(919) 834-4984

Greenwood Laboratory
816 Durst Avenue East
Greenwood, SC 29649
(864)-229-4413

APPROVAL

5/18/2017

Jeff Graham
Senior Laboratory General Manager
704-977-0954
Date

Felicia Grogan

5/12/2017

Felicia Grogan
Laboratory General Manager
Technical Director - Eden
704-977-0955
Date

5/18/2017

Barry Johnson
Senior Laboratory Quality Manager
828-254-7176 ext 938301
Date

Cheryl Johnson

5/11/2017

Cheryl Johnson
Laboratory Quality Manager
704-977-0959
Date

Craig R Tronzo

5/15/2017

Craig Tronzo
Laboratory Technical Director - Asheville
828-254-7176
Date

This is **COPY#** _____ Distributed on ____________ by ________ and is ____ **CONTROLLED**

Elizabeth J. Culbertson

5/18/2017

Elizabeth Culbertson
Laboratory Technical Director - Greenwood
864-229-4413

Date

5/18/2017

Rob Hobson
Laboratory Technical Director - Charlotte
704-977-0963

Date

5/18/2017

Eric Setzer
Laboratory Supervisor – Raleigh
828-254-7176

Date

Effective Date is the date of the last signature

Table of Contents

1.0. INTRODUCTION AND ORGANIZATIONAL STRUCTURE

"Working together to protect our environment and improve our health"
Pace Analytical Services LLC - Mission Statement

1.1. Introduction to Pace

1.1.1. Pace Analytical Services, LLC is a privately held, full-service analytical testing firm operating a nationwide system of laboratories. Pace offers extensive services beyond standard analytical testing, including: bioassay for aquatic toxicity, air toxics, dioxins and coplanar PCB's by high resolution mass spectroscopy , radiochemical analyses, product testing, pharmaceutical testing, field services and mobile laboratory capabilities. This document defines the Quality System and Quality Assurance (QA)/Quality Control (QC) protocols.

1.1.2. Pace laboratories are capable of analyzing a full range of environmental samples from a variety of matrices, including air, surface water, wastewater, groundwater, soil, sediment, biota, and other waste products. Methods are applied from regulatory and professional sources including EPA, ASTM, USGS, NIOSH, Standard Methods, and State Agencies. Section 11 of this document is a representative listing of general analytical protocol references.

1.2. Statement of Purpose

1.2.1. To meet the business needs of our customers for high quality, cost-effective analytical measurements and services.

1.3. Quality Policy Statement and Goals of the Quality System

1.3.1. Pace management is committed to maintaining the highest possible standard of service and quality for our customers by following a documented quality system that is compliant with all current applicable state, federal, and industry standards, such as the NELAC Standard, the TNI Standard, and ISO standards and is in accordance with the stated methods and customer requirements. The overall objective of this quality system is to provide reliable data of known quality through adherence to rigorous quality assurance policies and quality control procedures as documented in this Quality Assurance Manual.

1.3.2. All personnel within the Pace network are required to be familiar with all facets of the quality system relevant to their position and implement these policies and procedures in their daily work.

1.4. Core Values

1.4.1. The following are the Pace Core Values:

- **Integrity**
- **Value Employees**
- **Know Our Customers**
- **Honor Commitments**

- **Flexible Response To Demand**
- **Pursue Opportunities**
- **Continuously Improve**

1.5. Code of Ethics and Standards of Conduct

1.5.1. Code of Ethics:

1.5.1.1. Each Pace employee is responsible for the propriety and consequences of his or her actions;

1.5.1.2. Each Pace employee must conduct all aspects of Company business in an ethical and strictly legal manner, and must obey the laws of the United States and of all localities, states and nations where Pace does business or seeks to do business;

1.5.1.3. Each Pace employee must reflect the highest standards of honesty, integrity and fairness on behalf of the Company with customers, suppliers, the public, and one another.

1.5.1.4. Each Pace employee must recognize and understand that our daily activities in environmental laboratories affect public health as well as the environment and that environmental laboratory analysts are a critical part of the system society depends upon to improve and guard our natural resources:

1.5.2. Standards of Conduct:

1.5.2.1. **Data Integrity**

1.5.2.1.1. The accuracy and integrity of the analytical results and its supporting documentation produced at Pace are the cornerstones of the company. Employees are to accurately prepare and maintain all technical records, scientific notebooks, calculations, and databases. Employees are prohibited from making false entries or misrepresentations of data for any reason.

1.5.2.1.2. Managerial staff must make every effort to ensure that personnel are free from any undue pressures that may affect the quality or integrity of their work including commercial, financial, over-scheduling, and working condition pressures.

1.5.2.1.3. The data integrity system includes in-depth, periodic monitoring of data integrity including peer data review and validation, internal raw data audits, proficiency testing studies, etc.

1.5.2.1.4. Any documentation related to data integrity issues, including any disciplinary actions involved, corrective actions taken, and notifications to customers must be retained for a minimum of five years.

1.5.2.2. **Confidentiality**

1.5.2.2.1. Pace employees must not use or disclose confidential or proprietary information except when in connection with their duties at Pace. This is effective over the course of employment and for an additional period of two years thereafter.

1.5.2.2.2. Confidential or proprietary information, belonging to either Pace and/or its customers, includes but is not limited to test results, trade secrets, research and development matters, procedures, methods, processes and standards, company-specific techniques and equipment, marketing and customer information, inventions, materials composition, etc.

1.5.2.3. **Conflict of Interest**

1.5.2.3.1. Pace employees must avoid situations that might involve a conflict of interest or could appear questionable to others. This includes participation in activities that conflict or appear to conflict with the employees' Pace responsibilities. This would also include offering or accepting anything that might influence the recipient or cause another person to believe that the recipient may be influenced to behave or in a different manner than he would normally (such as bribes, gifts, kickbacks, or illegal payments).

1.5.2.3.2. Employees are not to engage in outside business or economic activity relating to a sale or purchase by the Company. Other problematic activities include service on the Board of Directors of a competing or supplier company, significant ownership in a competing or supplier company, employment for a competing or supplier company, or participation in any outside business during the employee's work hours.

1.5.3. Strict adherence by each Pace employee to this Code of Ethics and to the Standards of Conduct is essential to the continued vitality of Pace and to continue the pursuit of our common mission to protect our environment and improve our health.

1.5.4. Failure to comply with the Code of Ethics and Standards of Conduct will result in disciplinary action up to and including termination and referral for civil or criminal prosecution where appropriate. An employee will be notified of an infraction and given an opportunity to explain, as prescribed under current disciplinary procedures.

1.5.5. Compliance: all employees undergo annual Data Integrity/Ethics training which includes the concepts listed above. All employees also sign an annual Ethic Policy statement.

1.6. Anonymous Compliance Alertline

1.6.1. An ethical and safe workplace is important to the long-term success of Pace and the well-being of its employees. Pace has a responsibility to provide a work environmental where employees feel safe and can report unethical or improper behavior in complete confidence. With this in mind, Pace has engaged Lighthouse Services, Inc. to provide all employees with access to an anonymous ethics and compliance alertline for reporting possible ethics and compliance violations. The purpose of this service is to ensure that any employee can report anonymously and without fear of retaliation.

1.6.2. Lighthouse Services provides a toll-free number along with several other reporting methods, all of which are available 24 hours a day, seven days a week for use by employees and staff.

1.6.3. Telephone: English speaking USA and Canada: (844)-970-0003.

1.6.4. Telephone: Spanish speaking North America: (800)-216-1288.

1.6.5. Website: www.lighthouse-services.com/pacelabs.

1.6.6. Email: reports@lighthouse-services.com (must include company name with report).

1.7. Laboratory Organization

1.7.1. Each laboratory within the system operates with local management, but all labs share common systems and receive support from the Corporate Office. See Attachment III for the Corporate Organizational structure.

1.7.2. A Senior General Manager (SGM) oversees all laboratories and service centers in their assigned region. Each laboratory or facility in the company is then directly managed by an SGM, a General Manager (GM), an Assistant General Manager (AGM), or an Operations Manager (OM). Quality Managers (QM) or Senior Quality Managers (SQM) at each laboratory report directly to the highest level of local laboratory management, however named, that routinely makes day-to-day decisions regarding that facility's operations. The QMs and SQMs will also receive guidance and direction from the corporate Director of Environmental Quality.

1.7.3. The SGM, GM, AGM or OM, or equivalent functionality in each facility, bears the responsibility for the laboratory operations and serves as the final, local authority in all matters. In the absence of these managers, the SQM/QM serves as the next in command, unless the manager in charge has assigned another designee. He or she assumes the responsibilities of the manager, however named, until the manager is available to resume the duties of their position. In the absence of both the manager and the SQM/QM, management responsibility of the laboratory is passed to the Technical Director, provided such a position is identified, and then to the most senior department manager until the return of the lab manager or SQM/QM. The most senior department manager in charge may include the Client Services Manager (CSM) or the Administrative Business Manager (ABM) at the discretion of the SGM/GM/AGM/OM.

1.7.4. A Technical Director who is absent for a period of time exceeding 15 consecutive calendar days shall designate another full-time staff member meeting the qualifications of the technical director to temporarily perform this function. The laboratory SGM/GM/AGM/OM or SQM/QM has the authority to make this designation in the event the existing Technical Director is unable to do so. If this absence exceeds 35 consecutive calendar days, the primary accrediting authority shall be notified in writing.

1.7.5. The SQM/QM has the responsibility and authority to ensure the Quality System is implemented and followed at all times. In circumstances where a laboratory is not meeting the established level of quality or following the policies set forth in this Quality Assurance Manual, the SQM/QM has the authority to halt laboratory operations should he or she deem such an action necessary. The SQM/QM will immediately communicate the halting of operations to the SGM/GM/AGM/OM and keep them posted on the progress of corrective actions. In the event the SGM/GM/AGM/OM and the SQM/QM are not in agreement as to the need for the suspension, the Chief Operating Officer (COO) and Director of Environmental Quality will be called in to mediate the situation.

1.7.6. The lab is required to appoint deputies for key managerial personnel. These deputies must be documented for auditing purposes. The deputies, by position, are the following:

1.7.7. The technical staff of the laboratory is generally organized into the following functional groups:

- Organic Sample Preparation
- Wet Chemistry Analysis
- Metals Analysis
- Volatiles Analysis
- Semi-volatiles Analysis
- Radiochemical Analysis

- Microbiological Analysis
- Bioassay Analysis

1.7.8. The organizational structure for Pace – Carolinas is listed in Attachment II. In the event of a change in SGM/GM/AGM/OM, SQM/QM, or any Technical Director, the laboratory will notify its accrediting authorities per their individual required timeframes, not to exceed 30 days. The QAM will remain in effect until the next scheduled revision.

1.8. Laboratory Job Descriptions

1.8.1. Senior General Manager

- Oversees all functions of all the operations within their designated region;
- Oversees the development of local GMs/AGMs/OMs within their designated region;
- Oversees and authorizes personnel development including staffing, recruiting, training, workload scheduling, employee retention and motivation;
- Oversees the preparation of budgets and staffing plans for all operations within their designated region;
- Ensures compliance with all applicable state, federal and industry standards;
- Works closely with Regional Sales Management.

1.8.2. General Manager

- Oversees all functions of their assigned operations;
- Authorizes personnel development including staffing, recruiting, training, workload scheduling, employee retention and motivation;
- Prepares budgets and staffing plans;
- Monitors the Quality Systems of the laboratory and advises the SQM/QM accordingly;
- Presents the Ethics/Data Integrity training annually to all employees in their facilities as an instructor-led training.
- Ensures compliance with all applicable state, federal and industry standards.

1.8.3. Assistant General Manager / Operations Manager

- In the absence of the GM, performs all duties as listed above for the GM;
- Oversees the daily production and quality activities of all departments;
- Manages all departments and works with staff to ensure department objectives are met;
- Works with all departments to ensure capacity and customer expectations are accurately understood and met;
- Works with SGM/GM to prepare appropriate budget and staffing plans for all departments;
- Responsible for prioritizing personnel and production activities within all departments;
- In the absence of a General Manager, presents the Ethics/Data Integrity training annually to all employees in their facilities as an instructor-led training.
- Performs formal and informal performance reviews of departmental staff.

1.8.4. Senior Quality Manager

- Provides quality oversight for multiple laboratories where there is not a local quality manager or for labs where there are multiple and separately distinct quality systems in the same facility;
- Responsible for implementing, maintaining and improving the quality system while functioning independently from laboratory operations. Reports directly to the highest level of local laboratory facility management, however named, that routinely makes day-to-day decisions regarding laboratory operations, but receives direction and assistance from the Corporate Director of Environmental Quality;
- Ensures that communication takes place at all levels within the lab regarding the effectiveness of the quality system and that all personnel understand their contributions to the quality system;
- Monitors QA/QC activities to ensure that the laboratory achieves established standards of quality (as set forth by the Corporate Environmental Quality office). The SQM is responsible for reporting the lab’s level of compliance to these standards to the Corporate Director of Environmental Quality on a quarterly basis;
- Maintains records of quality control data and evaluates data quality;
- Conducts periodic internal audits and coordinates external audits performed by regulatory agencies or customer representatives;
- Reviews and maintains records of proficiency testing results;
- Maintains the document control system;
- Assists in development and implementation of appropriate training programs;
- Provides technical support to laboratory operations regarding methodology and project QA/QC requirements;
- Maintains certifications from federal and state programs;
- Ensures compliance with all applicable state, federal and industry standards;
- Maintains the laboratory training records, including those in the Learning Management System (LMS), and evaluates the effectiveness of training;
- Monitors corrective and preventive actions;
- Maintains the currency of the Quality Manual.

1.8.5. Quality Manager

- Responsible for implementing, maintaining and improving the quality system while functioning independently from laboratory operations. Reports directly to the highest level of local laboratory facility management, however named, that routinely makes day-to-day decisions regarding laboratory operations, but receives direction and assistance from the Corporate Director of Environmental Quality. They may also report to a Senior Quality Manager (SQM);
- Ensures that communication takes place at all levels within the lab regarding the effectiveness of the quality system and that all personnel understand their contributions to the quality system;
- Monitors QA/QC activities to ensure that the laboratory achieves established standards of quality (as set forth by the Corporate Environmental Quality office). The QM is responsible for reporting the lab’s level of compliance to these standards to the Corporate Director of Environmental Quality on a quarterly basis;
- Maintains records of quality control data and evaluates data quality;
- Conducts periodic internal audits and coordinates external audits performed by regulatory agencies or customer representatives;
- Reviews and maintains records of proficiency testing results;

- Maintains the document control system;
- Assists in development and implementation of appropriate training programs;
- Provides technical support to laboratory operations regarding methodology and project QA/QC requirements;
- Maintains certifications from federal and state programs;
- Ensures compliance with all applicable state, federal and industry standards;
- Maintains the laboratory training records, including those in the Learning Management System (LMS), and evaluates the effectiveness of training;
- Monitors corrective and preventive actions;
- Maintains the currency of the Quality Manual.

1.8.6. Technical Director

- Monitors the standards of performance in quality assurance and quality control data;
- Monitors the validity of analyses performed and data generated;
- Reviews tenders, contracts and QAPPs to ensure the laboratory can meet the data quality objectives for any given project;
- Serves as the manager of the laboratory in the absence of the SGM/GM/AGM/OM and SQM/QM;
- Provides technical guidance in the review, development, and validation of new methodologies.

1.8.7. Administrative Business Manager

- Responsible for financial and administrative management for the entire facility;
- Provides input relative to tactical and strategic planning activities;
- Organizes financial information so that the facility is run as a fiscally responsible business;
- Works with staff to confirm that appropriate processes are put in place to track revenues and expenses;
- Provide ongoing financial information to the SGM/GM/AGM/OM and the management team so they can better manage their business;
- Utilizes historical information and trends to accurately forecast future financial positions;
- Works with management to ensure that key measurements are put in place to be utilized for trend analysis—this will include personnel and supply expenses, and key revenue and expense ratios;
- Works with SGM/GM/AGM/OM to develop accurate budget and track on an ongoing basis;
- Works with entire management team to submit complete and justified capital budget requests and to balance requests across departments;
- Works with project management team and administrative support staff to ensure timely and accurate invoicing.

1.8.8. Client Services Manager

- Oversees all the day to day activities of the Client Services Department which includes Project Management and, possibly, Sample Control;
- Responsible for staffing and all personnel management related issues for Client Services;

- Serves as the primary senior consultant to customers on all project related issues such as set up, initiation, execution and closure;
- Performs or is capable of performing all duties listed for that of Project Manager.

1.8.9. Project Manager

- Coordinates daily activities including taking orders, reporting data and analytical results;
- Serves as the primary technical and administrative liaison between customers and Pace;
- Communicates with operations staff to update and set project priorities;
- Provides results to customers in the requested format (verbal, hardcopy, electronic, etc.);
- Works with customers, laboratory staff, and other appropriate Pace staff to develop project statements of work or resolve problems of data quality;
- Responsible for solicitation of work requests, assisting with proposal preparation and project initiation with customers and maintain customer records;
- Mediation of project schedules and scope of work through communication with internal resources and management;
- Responsible for preparing routine and non-routine quotations, reports and technical papers;
- Interfaces between customers and management personnel to achieve customer satisfaction;
- Manages large-scale complex projects;
- Supervises less experienced project managers and provide guidance on management of complex projects;
- Arranges bottle orders and shipment of sample kits to customers;
- Verifies login information relative to project requirements and field sample Chains-of-Custody.

1.8.10. Department Manager/Supervisor

- Oversees the day-to-day production and quality activities of their assigned department;
- Ensures that quality assurance and quality control criteria of analytical methods and projects are satisfied;
- Assesses data quality and takes corrective action when necessary;
- Approves and releases technical and data management reports;
- Ensures compliance with all applicable state, federal and industry standards.

1.8.11. Additional job descriptions are available upon request from the laboratory ABM.

1.9. Training and Orientation

1.9.1. Training for Pace employees is managed through a web-based training system. Employees are provided with several training activities for their particular job description and scope of duties. These training activities may include:

- Hands-on training led by supervisors;
- Job-specific training checklists and worksheets;
- Lectures and instructor-led training sessions;
- Method-specific training;

- External conferences and seminars;
- Reading Standard Operating Procedures (SOPs);
- Reading the Quality Assurance Manual and Safety Manual/Chemical Hygiene Plan;
- Core training modules (basic lab skills, etc.);
- Quality system training modules (support equipment use, corrective actions/root causes, etc.);
- Data Integrity/Ethics training;
- Specialized training by instrument manufacturers;
- On-line courses.

1.9.2. All procedures and training records are maintained and available for review during laboratory audits. Additional information can be found in SOP S-ALL-Q-020 **Training and Employee Orientation** or its equivalent revision or replacement.

1.10. Laboratory Safety and Waste

1.10.1. It is the policy of Pace to make safety and waste compliance an integral part of daily operations and to ensure that all employees are provided with safe working conditions, personal protective equipment, and requisite training to do their work without injury. Each employee is responsible for his/her own safety as well as those working in the immediate area by complying with established company rules and procedures. These rules and procedures as well as a more detailed description of the employees’ responsibilities are contained in the local Safety Manual/Chemical Hygiene Plan.

1.11. Security and Confidentiality

1.11.1. Security is maintained by controlled access to laboratory buildings. Exterior doors to laboratory buildings remain either locked or continuously monitored by Pace staff.

1.11.2. Additional security is provided where necessary, (e.g., specific secure areas for sample, data, and customer report storage), as requested by customers, or cases where national security is of concern. These areas are lockable within the facilities, or are securely offsite. Access is limited to specific individuals or their designees.

1.11.3. All information pertaining to a particular customer, including national security concerns will remain confidential. Data will be released to outside agencies only with written authorization from the customer or where federal or state law requires the company to do so.

1.12. Communications

1.12.1. Management within each lab bears the responsibility of ensuring that appropriate communication processes are established and that communication takes place regarding the effectiveness of the management/quality system. These communication processes may include email, regular staff meetings, senior management meetings, etc.

1.12.2. Corporate management bears the responsibility of ensuring that appropriate communication processes are established within the network of facilities and that communication takes place at a company-wide level regarding the effectiveness of the management/quality systems of all Pace facilities. These communication processes may include email, quarterly continuous improvement conference calls for all lab departments, and annual continuous improvement meetings for all department supervisors, quality managers, client services managers, and other support positions.

2.0. SAMPLE CUSTODY

2.1. Project Initiation

2.1.1. Prior to accepting new work, the laboratory reviews its performance capability. The laboratory confirms that sufficient personnel, equipment capacity, analytical method capability, etc., are available to complete the required work. Customer needs, certification requirements, and data quality objectives are defined and the appropriate sampling and analysis plan is developed to meet the project requirements by project managers or sales representatives. Members of the management staff review current instrument capacity, personnel availability and training, analytical procedures capability, and projected sample load. Management then informs the sales and client services personnel whether or not the laboratory can accept the new project via written correspondence, email, and/or daily operations meetings.

2.1.2. Additional information regarding specific procedures for reviewing new work requests can be found in SOP S-CAR-C-006 **Review of Analytical Requests** or its equivalent revision or replacement.

2.2. Sampling Materials and Support

2.2.1. Each individual Pace laboratory provides shipping containers, properly preserved sample containers, custody documents, and field quality control samples to support field-sampling events. Guidelines for sample container types, preservatives, and holding times for a variety of methods are listed in Attachment VII. Note that all analyses listed are not necessarily performed at all Pace laboratories and there may be additional laboratory analyses performed that are not included in these tables. Customers are encouraged to contact their local Pace Project Manager for questions or clarifications regarding sample handling. Pace may provide pick-up and delivery services to their customers when needed

2.2.2. Some Pace facilities provide sampling support through a Field Services department. Field Services operates under the Pace Corporate Quality System, with applicable and necessary provisions to address the activities, methods, and goals specific to Field Services. All procedures and methods used by Field Services are documented in SOPs and Procedure Manuals.

2.3. Chain of Custody

2.3.1. A chain of custody (COC) provides the legal documentation of samples from time of collection to completion of analysis.

2.3.2. Field personnel or client representatives must complete a COC for all samples that are received by the laboratory. Samplers are required to properly complete a COC. This is critical to efficient sample receipt and to ensure the requested methods are used to analyze the correct samples. If sample shipments are not accompanied by the correct documentation, the Sample Receiving department notifies a Project Manager. The Project Manager then obtains the correct documentation/information from the customer in order for analysis of samples to proceed.

2.3.3. The COC is filled out completely and legibly with indelible ink. Errors are corrected by drawing a single line through the initial entry and initialing and dating the change. All transfers of samples are recorded on the chain of custody in the “relinquished” and “received by” sections. All information except signatures is printed.

2.3.4. Additional information can be found in SOP S-CAR-C-001 **Sample Management** or its equivalent revision or replacement.

2.4. Sample Acceptance Policy

2.4.1. In accordance with regulatory guidelines, Pace complies with the following sample acceptance policy for all samples received.

2.4.2. If the samples do not meet the sample receipt acceptance criteria outlined below, the laboratory is required to document all non-compliances, contact the customer, and either reject the samples or fully document any decisions to proceed with analyses of samples which do not meet the criteria. Any results reported from samples not meeting these criteria are appropriately communicated to the client.

2.4.3. Sample Acceptance Policy requirements:

- Sample containers must have unique client identification designations that are clearly marked with indelible ink on durable, water-resistant labels. The client identifications must match those on the chain-of-custody (COC).
- There must be clear documentation on the COC, or related documents that lists the unique sample identification, sampling site location, date and time of sample collection, and name of the sample collector.
- There must be clear documentation on the COC, or related documents that lists the requested analyses, the preservatives used, and any special remarks concerning the samples (i.e., data deliverables, samples are for evidentiary purposes, field filtration, etc.).
- Samples must be in appropriate sample containers. If the sample containers show signs of damage (i.e., broken or leaking) or if the samples show signs of contamination, the samples will not be processed without prior client approval.
- Samples must be correctly preserved upon receipt, unless the method requested allows for laboratory preservation. If the samples are received with inadequate preservation, and the samples cannot be preserved by the lab appropriately, the samples will not be processed without prior client approval.
- Samples must be received within required holding time. Any samples with hold times that are exceeded will not be processed without prior client approval.
- Samples must be received with sufficient sample volume or weight to proceed with the analytical testing. If insufficient sample volume or weight is received, analysis will not proceed without client approval.
- All samples that require thermal preservation are considered acceptable if they are received at a temperature within 2^{o}C of the required temperature, or within the method-specified range. For samples with a required temperature of 4^{o}C, samples with a temperature ranging from just above freezing to 6^{o}C are acceptable. Samples that are delivered to the lab on the same day they are collected are considered acceptable if the samples are received on ice.

Any samples that are not received at the required temperature will not be processed without prior client approval.

- Samples for **drinking water** analyses will be rejected at the time of receipt if they are not received in a secure manner, are received in inappropriate containers, are received outside the required temperature range, are received outside the recognized holding time, are received with inadequate identification on sample containers or COC, or are improperly preserved (with the exception of VOA samples- tested for pH at time of analysis and TOC- tested for pH in the field).
- Some specific clients may require custody seals. **For these clients**, samples or coolers that are not received with the proper custody seals will not be processed without prior client approval.

Note 1: Temperature will be read and recorded based on the precision of the measuring device. For example, temperatures obtained from a thermometer graduated to 0.1°C will be read and recorded to ± 0.1°C. Measurements obtained from a thermometer graduate to 0.5°C will be read to ± 0.5°C. Measurements read at the specified precision are not to be rounded down to meet the ≤ 6°C limit. Please reference the Support Equipment SOP for more information.

Note 2: Some microbiology methods allow sample receipt temperatures of up to 10°C. Consult the specific method for microbiology samples received above 6°C prior to initiating corrective action for out of temperature preservation conditions.

2.4.4. Upon sample receipt, the following items are also checked and recorded:

- Presence of custody seals or tapes on the shipping containers;
- Sample condition: Intact, broken/leaking, bubbles in VOA samples;
- Sample holding time;
- Sample pH and residual chlorine when required;
- Appropriate containers.

2.4.5. Additional information can be found in SOP S-CAR-C-001 **Sample Management** or its equivalent revision or replacement.

2.5. Sample Log-in

2.5.1. After sample inspection, all sample information on the COC is entered into the Laboratory Information Management System (LIMS). The lab's permanent records for samples received include the following information:

- Customer name and contact
- Customer number
- Pace Analytical project number
- Pace Analytical Project Manager
- Sample descriptions
- Due dates
- List of analyses requested
- Date and time of laboratory receipt
- Field ID code

- Date and time of collection
- Any comments resulting from inspection for sample rejection

2.5.2. If the time collected for any sample is unspecified and Pace is unable to obtain this information from the customer, the laboratory will use 00:00 am as the time sampled. All hold times will be based on this sampling time and qualified accordingly if exceeded.

2.5.3. The Laboratory Information Management System automatically generates a unique identification number for each sample created in the system. The LIMS sample number follows the general convention of BBXXXXXXYYY. The BB represents the laboratory identification within Pace's laboratory network. The six digit "X" number represents the project number. The project number is a sequential number that is assigned as a new project is created and may contain more or less than six digits. The three digit "Y" represents the sample number. The sample number corresponds to the number of samples submitted by the client. In addition to the unique sample ID, there is a sample container ID that consists of the sample number, the container type (ex. BP1U), and bottle 1 of Y where Y represents the total number of containers of that particular type. Together the sample LIMS number and sample container ID create a unique barcode encryption that can be linked to sample analysis as requested by the client. This unique identification number is placed on the sample container as a durable label and becomes the link between the laboratory's sample management system and the customer's field identification; it will be a permanent reference number for all future interactions.

2.5.4. Current division codes are noted below. These division codes are used primarily for accounting purposes and LIMS sample identifications. More division codes may be added without updating this document.

00 = Corporate
10 = Minnesota/Montana/Virginia MN
12 = Virginia/Duluth MN
20 = New Orleans/Puerto Rico
30 = Pittsburgh
35 = Florida/South Florida
36 = South Florida (accounting only)
40 = Green Bay
50 = Indianapolis/Columbus
51 = Columbus (accounting only)
55/56 = Pace Energy Labs
60 = Kansas
65 = New York (Schenectady)
70 = Long Island
75 = Dallas
92 = Carolinas

2.5.5. Sample labels are printed from the LIMS and affixed to each sample container.

2.5.6. Samples with hold times that are near expiration date/time may be sent directly to the laboratory for analysis at the discretion of the Project Manager and/or SGM/GM/AGM/OM.

2.5.7. Additional information can be found in SOP S-CAR-C-001 **Sample Management** or its equivalent revision or replacement.

2.6. Sample Storage

2.6.1. Additional information on sample storage can be found in SOP S-CAR-C-001 **Sample Management** or its equivalent revision or replacement and in SOP S-CHR-S-002 **Waste Handling and Management** (Charlotte laboratory), SOP S-ASV-S-002 **Waste Handling and Management** (Asheville, Eden, and Raleigh laboratories), or its equivalent revision or replacement.

2.6.2. Storage Conditions

2.6.2.1. Samples are stored away from all standards, reagents, or other potential sources of contamination. Samples are stored in a manner that prevents cross contamination. Volatile samples are stored separately from other samples. All sample fractions, extracts, leachates, and other sample preparation products are stored in the same manner as actual samples or as specified by the analytical method.

2.6.2.2. Storage blanks are stored with volatile samples and are used to measure cross-contamination acquired during storage. Laboratories must have documented procedures and criteria for evaluating storage blanks, appropriate to the types of samples being stored.

2.6.2.3. Insert specification for ensuring sample temperatures while outside of controlled storage conditions if needed. Additional information can be found in SOP S-CAR-Q-018 **Monitoring Temperature Controlled Units.**

2.6.3. Temperature Monitoring

2.6.3.1. Samples are taken to the appropriate storage location immediately after sample receipt and check-in procedures are completed.

2.6.3.2. The temperature of each refrigerated storage area is maintained at ≤ 6°C (but above freezing) unless state, method or program requirements differ. The temperature of each freezer storage area is maintained at ≤ -10°C unless state, method or program requirements differ. The temperature of each storage area is checked and documented each day of use (each calendar day). Additional information, including corrective actions for temperatures outside of acceptance limits, can be found in SOP S-CAR-Q-018 **Monitoring Temperature Controlled Units.**

2.6.4. Hazardous Materials

2.6.4.1. Samples designated by clients upon receipt as pure product or potentially heavily contaminated samples, or samples found to be designated as such following analysis, must be tagged as "hazardous" or "lab pack" and stored separately from other samples.

2.6.5. Foreign/Quarantined Soils

2.6.5.1. Foreign soils and soils from USDA regulated areas must be adequately segregated to enable proper sample disposal. The USDA requires these samples to be treated by an approved procedure. Additional information regarding USDA regulations and sample handling can be found in the laboratory’s SOP for **Regulated Soil Handling** S-CAR-L-006, or its equivalent revision or replacement.

2.7. Subcontracting Analytical Services

2.7.1. Every effort is made to perform all analyses for Pace customers within the laboratory that receives the samples. When subcontracting to a laboratory other than the receiving laboratory, whether inside or outside the Pace network, becomes necessary, a preliminary verbal communication with that laboratory is undertaken. Customers are notified in writing of the laboratory’s intention to subcontract any portion of the testing to another laboratory. Work performed under specific protocols may involve special considerations. When possible, subcontracting will be to a TNI-accredited laboratory.

2.7.2. Potential subcontract laboratories must be approved by Pace based on the criteria listed in SOP S-CAR-C-003 **Subcontracting Samples** or its equivalent revision or replacement. All sample reports from the subcontracted labs are appended to the applicable Pace final reports.

2.7.3. Any Pace Analytical work sent to other labs within the Pace network is handled as inter-regional work and all final reports are labeled clearly with the name of the laboratory performing the work. Any non-TNI work is clearly identified. Pace will not be responsible for analytical data if the subcontract laboratory was designated by the customer.

2.7.4. Additional information can be found in SOP S-CAR-C-003 **Subcontracting Samples** or its equivalent revision or replacement.

2.8. Sample Retention and Disposal

2.8.1. Samples, extracts, digestates, and leachates must be retained by the laboratory for the period of time necessary to protect the interests of the laboratory and the customer.

2.8.2. Unused portions of samples are retained by each laboratory based on program or customer requirements for sample retention and storage. The minimum sample retention time is 30 days from receipt of the samples. Samples requiring thermal preservation may be stored at ambient temperature when the hold time is expired, the report has been delivered, and/or allowed by the customer, program, or contract. Samples requiring storage beyond the minimum sample retention time due to special requests or contractual obligations may be stored at ambient temperature unless the laboratory has sufficient capacity and their presence does not compromise the integrity of other samples.

2.8.3. After this period expires, non-hazardous samples are properly disposed of as non-hazardous waste. The preferred method for disposition of **hazardous** samples is to return the excess sample to the customer. If it is not feasible to return samples, or the customer requires Pace to dispose of excess samples, proper arrangements will be made for disposal by an approved contractor.

2.8.4. Additional information can be found in SOP S-CHR-S-002 **Waste Handling and Management** (Charlotte laboratory), SOP S-ASV-S-002 **Waste Handling and Management** (Asheville, Eden, and Raleigh laboratories), and SOP S-CAR-C-001 **Sample Management** or the equivalent revisions or replacements.

3.0. QUALITY CONTROL PROCEDURES

3.1. Quality Control Samples

3.1.1. The quality control samples described in this section are analyzed per batch as applicable to the method used. Acceptance criteria must be established for all quality control samples and if the acceptance criteria are not met, corrective actions must be performed and samples reanalyzed, or final reports must be appropriately qualified.

3.1.2. Quality control samples must be processed in the same manner as associated client samples.

3.1.3. Please reference the glossary of this Quality Manual for definitions of all quality control samples mentioned in this section.

3.1.4. Any deviations to the policies and procedures governing quality control samples must be approved by the QM/SQM.

3.2. Method Blank

3.2.1. A method blank is a negative control used to assess the preparation/analysis system for possible contamination and is processed through all preparation and analytical steps with its associated client samples. The method blank is processed at a minimum frequency of one per preparation batch and is comprised of a matrix similar to the associated client samples. Method blanks are not applicable for certain analyses (i.e., pH, flash point, temperature, etc.).

3.2.2. Please reference method-specific SOPs for acceptance criteria and associated corrective actions for method blanks.

3.3. Laboratory Control Sample

3.3.1. The Laboratory Control Sample (LCS) is a positive control used to assess the performance of the entire analytical system including preparation and analysis. The LCS is processed at a minimum frequency of one per preparation batch and is comprised of a matrix similar to the associated client samples.

3.3.2. The LCS contains **all** analytes required by a specific method or by the customer or regulatory agency, which may include full list of target compounds, with certain exceptions. The lab must ensure that all target components are included in the spike mixture for the LCS over a two (2) year period. In the absence of specified components, the laboratory will spike the LCS with the following compounds:

- For multi-peak analytes (e.g. PCBs, technical chlordane, toxaphene), a representative standard will be processed.
- For methods with long lists of analytes, a representative number of target analytes may be chosen. The following criteria is used to determine the number of LCS compounds used:
  - For methods with 1-10 target compounds, the laboratory will spike with all compounds;
  - For methods with 11-20 target compounds, the laboratory will spike with at least 10 compounds or 80%, whichever is greater;
  - For methods with greater than 20 compounds, the laboratory will spike with at least 16 compounds.

3.3.3. Please reference method-specific SOPs for acceptance criteria and associated corrective actions for LCSs.

3.3.4. For LCSs containing a large number of analytes, it is statistically likely that a few recoveries will be outside of control limits. This does not necessarily mean that the system is out of control, and therefore no corrective action would be necessary (except for proper documentation). TNI has allowed for a minimum number of marginal exceedances, defined as recoveries that are beyond the LCS control limits (3X the standard deviation) but within the marginal exceedance limits (4X the standard deviation). The number of allowable exceedances depends on the number of compounds in the LCS. If more analyte recoveries exceed the LCS control limits than is allowed (see below) or if any one analyte exceeds the marginal exceedance limits, then the LCS is considered non-compliant and corrective actions are necessary. The number of allowable exceedances is as follows:

- >90 analytes in the LCS- 5 analytes
- 71-90 analytes in the LCS- 4 analytes
- 51-70 analytes in the LCS- 3 analytes
- 31-50 analytes in the LCS- 2 analytes
- 11-30 analytes in the LCS- 1 analyte
- <11 analytes in the LCS- no analytes allowed out)

Note: the use of marginal exceedances is not approved for work from the state of South Carolina.

3.3.5. A matrix spike (MS) can be used in place of a non-compliant LCS in a batch as long as the MS passes the LCS acceptance criteria (this is a TNI allowance). Note: the use of the MS to replace a non-compliant LCS is not approved for work from the state of South Carolina. When this happens, full documentation must be made available to the data user. If this is not allowed by a customer or regulatory body, the associated samples must be rerun with a compliant LCS (if possible) or reported with appropriate data qualifiers.

3.3.6. Deviations made from this policy must be approved by the SQM/QM prior to release of the data.

3.4. Matrix Spike/Matrix Spike Duplicate (MS/MSD)

3.4.1. A matrix spike (MS) is a positive control used to determine the effect of the sample matrix on compound recovery for a particular method. A matrix spike/matrix spike duplicate (MS/MSD) set or matrix spike/sample duplicate set is processed at a frequency specified in a particular method or as determined by a specific customer request. The MS and MSD consist of the sample matrix that is spiked with known concentrations of target analytes.

3.4.2. The MS and MSD contain all analytes required by a specific method or by the customer or regulatory agency. In the absence of specified components, the laboratory will spike the MS/MSD with the same number of compounds as previously discussed in the LCS section. However, the lab must ensure that all targeted components are included in the spike mixture for the MS/MSD over a two (2) year period.

3.4.3. Please reference method-specific SOPs for acceptance criteria and associated corrective actions for MS/MSDs.

3.5. Sample Duplicate

3.5.1. A sample duplicate is a second portion of sample that is prepared and analyzed in the laboratory along with the first portion. It is used to measure the precision associated with preparation and analysis. A sample duplicate is processed at a frequency specified by the particular method or as determined by a specific customer.

3.5.2. Please reference method-specific SOPs for acceptance criteria and associated corrective actions for sample duplicates.

3.6. Surrogates

3.6.1. Surrogates are compounds that reflect the chemistry of target analytes and are typically added to samples for organic analyses to measure the extraction or purge efficiency and to monitor the effect of the sample matrix on compound recovery.

3.6.2. Please reference method-specific SOPs for acceptance criteria and associated corrective actions for surrogates.

3.7. Internal Standards

3.7.1. Internal Standards are method-specific analytes that are added, as applicable, to every standard, QC sample, and client sample at a known concentration, prior to analysis for the purpose of adjusting the response factor used in quantifying target analytes..

3.7.2. Please reference method-specific SOPs for acceptance criteria and associated corrective actions for internal standards.

3.8. Limit of Detection (LOD)

3.8.1. Pace laboratories use a documented procedure to determine a limit of detection (LOD) for each analyte of concern in each matrix reported. Unless otherwise noted in a published method, the procedure used by Pace laboratories to determine LODs is based on the Method Detection Limit (MDL) procedure outlined in 40 CFR Part 136, Appendix B. All sample processing steps of the preparation and analytical methods are included in the LOD determination including any clean ups.

3.8.2. Additional information can be found in SOP S-CAR-Q-004 **Determination of LOD and LOQ** or its equivalent revision or replacement.

3.9. Limit of Quantitation (LOQ)

3.9.1. A limit of quantitation (LOQ) for every analyte of concern must be determined. For Pace laboratories, this LOQ is referred to as the RL, or Reporting Limit. Results reported below the reporting limit are not allowed to be reported without qualification. For methods with a determined LOD, results can be reported out below the LOQ but above the LOD if they are properly qualified (e.g., J flag).

3.9.2. Additional information can be found in SOP S-CAR-Q-004 **Determination of LOD and LOQ** or its equivalent revision or replacement.

3.10. Estimate of Analytical Uncertainty

3.10.1. Pace laboratories can provide an estimation of uncertainty for results generated by the laboratory. The estimate quantifies the error associated with any given result at a 95% confidence interval. This estimate does not include bias that may be associated with sampling. The laboratory has a procedure in place for making this estimation. In the absence of a regulatory or customer-specific procedure, Pace laboratories base this estimation on the recovery data obtained from the

Laboratory Control Samples. The uncertainty is a function of the standard deviation of the recoveries multiplied by the appropriate Student's t Factor at 95% confidence. Additional information pertaining to the estimation of uncertainty and the exact manner in which it is derived are contained in the SOP S-CAR-Q-031 **Estimation of Measurement Uncertainty** or its equivalent revision or replacement.

3.10.2. The measurement of uncertainty is provided only on request by the customer, as required by specification or regulation and when the result is used to determine conformance within a specification limit.

3.11. Proficiency Testing (PT) Studies

3.11.1. Pace laboratories participate in a defined proficiency testing (PT) program. PT samples are obtained from NIST approved providers and analyzed and reported at a minimum of two times per year for the relevant fields of testing per matrix.

3.11.2. Additional information can be found in SOP S-CAR-Q-010 **Proficiency Testing Program** or its equivalent revision or replacement.

3.12. Rounding and Significant Figures

3.12.1. In general, the Pace laboratories report data to no more than three significant figures. Therefore, all measurements made in the analytical process must reflect this level of precision. In the event that a parameter that contributes to the final result has less than three significant figures of precision, the final result must be reported with no more significant figures than that of the parameter in question. The rounding rules listed below are descriptive of the LIMS and not necessarily of any supporting program such as Excel.

3.12.2. **Rounding:** Pace-Carolinas follows the odd / even guidelines for rounding numbers:

- If the figure following the one to be retained is less than five, that figure is dropped and the retained ones are not changed (with three significant figures, 2.544 is rounded to 2.54).
- If the figure following the ones to be retained is greater than five, that figure is dropped and the last retained one is rounded up (with three significant figures, 2.546 is rounded to 2.55).
- If the figure following the ones to be retained is five and if there are no figures other than zeros beyond that five, then the five is dropped and the last figure retained is unchanged if it is even and rounded up if it is odd (with three significant figures, 2.525 is rounded to 2.52 and 2.535 is rounded to 2.54).

3.12.3. **Significant Figures**

3.12.3.1. Pace-Carolinas follows the following convention for reporting to a specified number of significant figures. Unless specified by federal, state, or local requirements or on specific request by a customer, the laboratory reports:

Values > 10 – Reported to 3 significant figures
Values ≤ 10 – Reported to 2 significant figures

3.13. Retention Time Windows

3.13.1. When chromatographic conditions are changed, retention times and analytical separations are often affected. As a result, two critical aspects of any chromatographic method are the determination and verification of retention times and analyte separation. Retention time windows must be established for the identification of target analytes. The retention times of all target analytes in all calibration verification standards must fall within the retention time windows. If an analyte falls outside the retention time window in an ICV or CCV, new absolute retention time windows must be calculated, unless instrument maintenance fixes the problem. When a new column is installed, a new retention time window study must be performed.

3.13.2. Additional information, such as requirements regarding time frames for reporting failures to states, makeup PTs, and notifications of investigations, can be found in SOP S-ALL-Q-010 **Proficiency Testing Program.**

3.14. Analytical Method Validation and Instrument Validation

3.14.1. In some situations, Pace develops and validates methodologies that may be more applicable to a specific problem or objective. When non-standard methods are required for specific projects or analytes of interest, or when the laboratory develops or modifies a method, the laboratory validates the method prior to applying it to customer samples. Method validity is established by meeting criteria for precision and accuracy as established by the data quality objectives specified by the end user of the data. The laboratory records the validation procedure, the results obtained and a statement as to the usability of the method. The minimum requirements for method validation include evaluation of sensitivity, quantitation, precision, bias, and selectivity of each analyte of interest.

3.15. Regulatory and Method Compliance

3.15.1. It is Pace policy to disclose in a forthright manner any detected noncompliance affecting the usability of data produced by our laboratories. The laboratory will notify customers within 30 days of fully characterizing the nature of the nonconformance, the scope of the nonconformance and the impact it may have on data usability.

4.0. DOCUMENT MANAGEMENT AND CHANGE CONTROL

4.0. Document Management

4.0.1. Additional information can be found in SOP S-CAR-Q-002 **Document Control and Management** or its equivalent revision or replacement. Information on Pace's policy for electronic signatures can also be found in this SOP.

4.0.2. Pace has an established procedure for managing documents that are part of the quality system.

4.0.3. A master list of all managed documents is maintained at each facility identifying the current revision status and distribution of the controlled documents.

4.0.4. Each managed document is uniquely identified to include the date of issue, the revision identification, page numbers, the total number of pages and the issuing authorities. For complete information on document numbering, refer to SOP S-ALL-Q-003 **Document Numbering**.

4.0.5. **Quality Assurance Manual (QAM):** The Quality Assurance Manual is the company-wide document that describes all aspects of the quality system for Pace. The base QAM template is distributed by the Corporate Environmental Quality Department to each of the SQMs/QMs. The local management personnel modify the necessary and permissible sections of the base template and then all applicable lab staff sign the Quality Assurance Manual. Each SQM/QM is then in charge of distribution to employees, external customers or regulatory agencies and maintaining a distribution list of controlled document copies. The Quality Assurance Manual template is reviewed on an annual basis and revised accordingly by the Corporate Quality office.

4.0.6. **Standard Operating Procedures (SOPs)**

4.0.6.1. SOPs are reviewed every two years at a minimum although a more frequent review may be required by some state or federal agencies or customers. If no revisions are made based on this review, documentation of the review itself is made by the addition of new signatures on the cover page. If revisions are made, documentation of the revisions is made in the revisions section of each SOP and a new revision number is applied to the SOP. This provides a historical record of all revisions.

4.0.6.2. All copies of superseded SOPs are removed from general use and the original copy of each SOP is archived for audit or knowledge preservation purposes. This ensures that all Pace employees use the most current version of each SOP and provides the SQM/QM with a historical record of each SOP.

4.0.6.3. Additional information can be found in SOP S-CAR-Q-001 **Preparation of SOPs** or its equivalent revision or replacement.

4.1. Document Change Control

4.1.1. Additional information can be found in SOP S-CAR-Q-002 **Document Control and Management** or its equivalent revision or replacement.

4.1.2. Changes to managed documents are reviewed and approved in the same manner as the original review. Any revision to a document requires the approval of the applicable signatories. After revisions are approved, a revision number is assigned and the previous version of the document is officially retired.

4.1.3. All copies of the previous document are replaced with copies of the revised document and the superseded copies are destroyed or archived. All affected personnel are advised that there has been a revision and any necessary training is scheduled.

5.0. EQUIPMENT AND MEASUREMENT TRACEABILITY

5.1. Standards and Traceability

5.1.1. Each Pace facility retains pertinent information for standards, reagents, and chemicals to assure traceability to a national standard. This includes documentation of purchase, receipt, preparation, and use.

5.1.2. Upon receipt, all purchased standard reference materials are recorded into a standard logbook or database and assigned a unique identification number. The entries include the facility's unique identification number, the chemical name, manufacturer name, manufacturer's identification numbers, receipt date, and expiration date. Vendor's certificates of analysis for all standards, reagents, or chemicals are retained for future reference.

5.1.3. Subsequent preparations of intermediate or working solutions are also documented in a standard logbook or database. These entries include the stock standard name and lot number, the manufacturer name, the solvents used for preparation, the solvent lot number and manufacturer, the preparation steps, preparation date, expiration dates, preparer's initials, and a unique Pace identification number. This number is used in any applicable sample preparation or analysis logbook so the standard can be traced back to the standard preparation record. This process ensures traceability back to the national standard.

5.1.4. All prepared standard or reagent containers include the Pace identification number, the standard or chemical name, the date of preparation, the date of expiration, the concentration with units, and the preparer's initials, unless the container is too small to hold all of this information. This ensures traceability back to the standard preparation logbook or database.

5.1.5. All initial calibrations must be verified with a standard obtained from a second manufacturer or a separate lot prepared independently by the same manufacturer, unless client-specific QAPP requirements state otherwise.

5.1.6. Additional information concerning the procurement of standards and reagent and their traceability can be found in the SOP S-CAR-Q-025 **Standard and Reagent Management and Traceability** or its equivalent revision or replacement.

5.2. General Analytical Instrument Calibration Procedures

5.2.1. All applicable instrumentation are calibrated or checked before use to ensure proper functioning and verify that laboratory, client and regulatory requirements are met. All calibrations are performed by, or under the supervision of, an experienced analyst at scheduled intervals against either certified standards traceable to recognized national standards or reference standards whose values have been statistically validated.

5.2.2. Calibration standards for each parameter are chosen to establish the linear range of the instrument and must bracket the concentrations of those parameters measured in the samples. The lowest calibration standard is the lowest concentration for which quantitative data may be reported. Data reported below this level is considered to have less certainty and must be reported using appropriate data qualifiers or explained in a narrative. The highest calibration standard is the highest concentration for which quantitative data may be reported. Data reported above this level is considered to have less certainty and must be reported using appropriate data qualifiers or explained in the narrative.

5.2.3. Instrumentation or support equipment that cannot be calibrated to specification or is otherwise defective is clearly labeled as out-of-service until it has been repaired and tested to demonstrate it meets the laboratory's specifications. All repair and maintenance activities including service calls are documented in the maintenance log. Equipment sent off-site for calibration testing is packed and transported to prevent breakage and is in accordance with the calibration laboratory's recommendations.

5.2.4. In the event that recalibration of a piece of test equipment indicates the equipment may have been malfunctioning during the course of sample analysis, an investigation is performed. The results of the investigation along with a summary of the information reviewed are documented and maintained by the quality manager. Customers must be notified within 30 days after the data investigation is completed and the impact to final results is assessed. This allows for sufficient investigation and review of documentation to determine the impact on the analytical results. Instrumentation found to be consistently out of calibration is either repaired and positively verified or taken out of service and replaced.

5.2.5. Raw data records are retained to document equipment performance. Sufficient raw data is retained to reconstruct the instrument calibration and explicitly connect the continuing calibration verification to the initial calibration.

5.3. Support Equipment Calibration and Verification Procedures

5.3.1. All support equipment is calibrated or verified at least annually using NIST traceable references over the entire range of use, as applicable. The results of calibrations or verifications must be within the specifications required or the equipment will be removed from service until brought back into control. Additional information regarding calibration and maintenance of support equipment can be found in SOP S-CAR-Q-013 **Support Equipment** or its equivalent revision or replacement.

5.3.2. On each day the support equipment is used, it is verified, as applicable, in the expected range of use with NIST traceable references in order to ensure the equipment meets laboratory specifications. These checks are documented appropriately. This applies mainly to thermometers within temperature-controlled units and balances.

5.3.3. **Analytical Balances**

5.3.3.1. Each analytical balance is calibrated or verified at least annually by a qualified service technician. The calibration of each balance is verified each day of use with weights traceable to NIST bracketing the range of use. Calibration weights are ASTM Class 1 or other class weights that have been calibrated against a NIST standard weight and are re-certified every 5 years at a minimum against a NIST traceable reference. Some accrediting agencies may require more frequent checks. If balances are calibrated by an external agency, verification of their weights must be provided. All information pertaining to balance maintenance and calibration is recorded in the individual balance logbook and/or is maintained on file in the local Quality department.

5.3.4. Thermometers

5.3.4.1. Certified, or reference, thermometers are maintained for checking calibration of working thermometers. Reference thermometers are provided with NIST traceability for initial calibration and are re-certified, at a minimum, every 3 years with equipment directly traceable to NIST.

5.3.4.2. Working thermometers are compared with the reference thermometers annually according to corporate metrology procedures (working digital thermometers are calibrated quarterly). Each thermometer is individually numbered and assigned a correction factor based on the NIST reference source. In addition, working thermometers are visually inspected by laboratory personnel prior to use and temperatures are documented.

5.3.4.3. Laboratory thermometer inventory and calibration data are maintained in the local Quality department.

5.3.5. pH/Electrometers

5.3.5.1. The meter is calibrated before use each day, using fresh buffer solutions.

5.3.6. Spectrophotometers

5.3.6.1. During use, spectrophotometer performance is checked at established frequencies in analysis sequences against initial calibration verification (ICV) and continuing calibration verification (CCV) standards.

5.3.7. Mechanical Volumetric Dispensing Devices

5.3.7.1. Mechanical volumetric dispensing devices including bottle top dispensers (those that are critical in measuring a required amount of reagent), pipettes, and burettes, excluding Class A volumetric glassware, are checked for accuracy on a quarterly basis.

5.3.7.2. Additional information regarding calibration and maintenance of laboratory support equipment can be found in SOP S-CAR-Q-013 **Support Equipment** or its equivalent revision or replacement.

5.4. Instrument/Equipment Maintenance

5.4.1. The objectives of the Pace Analytical maintenance program are twofold: to establish a system of instrument care that maintains instrumentation and equipment at required levels of calibration and sensitivity, and to minimize loss of productivity due to repairs.

5.4.2. The Operations Manager and/or department manager/supervisors are responsible for providing technical leadership to evaluate new equipment, solve equipment problems, and coordinate instrument repair and maintenance. Analysts have the primary responsibility to perform routine maintenance.

5.4.3. To minimize downtime and interruption of analytical work, preventative maintenance may be routinely performed on each analytical instrument. Up-to-date instructions on the use and maintenance of equipment are available to staff in the department where the equipment is used.

5.4.4. Department manager/supervisors are responsible for maintaining an adequate inventory of spare parts required to minimize equipment downtime. This inventory includes parts and supplies that are subject to frequent failure, have limited lifetimes, or cannot be obtained in a timely manner should a failure occur.

5.4.5. All major equipment and instrumentation items are uniquely identified to allow for traceability. Equipment/instrumentation is, unless otherwise stated, identified as a system and not as individual pieces. The laboratory maintains equipment records that include the following:

- The name of the equipment and its software
- The manufacturer's name, type, and serial number
- Approximate date received and date placed into service
- Current location in the laboratory
- Condition when received (new, used, etc.)
- Copy of any manufacturer's manuals or instructions
- Dates and results of calibrations and next scheduled calibration (if known)
- Details of past maintenance activities, both routine and non-routine
- Details of any damage, modification or major repairs

5.4.6. All instrument maintenance is documented in maintenance logbooks that are assigned to each particular instrument or system.

5.4.7. The maintenance log entry must include a summary of the results of that analysis and verification by the analyst that the instrument has been returned to an in-control status. In addition, each entry must include the initials of the analyst making the entry, the dates the maintenance actions were performed, and the date the entry was made in the maintenance logbook, if different from the date(s) of the maintenance.

5.4.8. Any equipment that has been subjected to overloading or mishandling, or that gives suspect results, or has been shown to be defective, is taken out of service and clearly identified. The equipment shall not be used to analyze customer samples until it has been repaired and shown to perform satisfactorily. In the event of instrumentation failure, to avoid hold time issues, the lab may subcontract the necessary samples to another Pace lab or to an outside subcontract lab if possible.

6.0. CONTROL OF DATA

Analytical results processing, verification, and reporting are procedures employed that result in the delivery of defensible data. These processes include, but are not limited to, calculation of raw data into final concentration values, review of results for accuracy, evaluation of quality control criteria and assembly of technical reports for delivery to the data user.

All analytical data undergo a documented multi-tier review process prior to being reported to the customer. This section describes procedures used for translating raw analytical data into accurate final sample reports as well as Pace data storage policies.

When analytical, field, or product testing data is generated, it is documented appropriately. These logbooks and other laboratory records are kept in accordance with each facility's SOP for documentation storage and archival In this case, the laboratory must ensure that there are sufficient redundant electronic copies so no data is lost due to unforeseen computer issues

6.1. Primary Data Review

6.1.1. The primary analyst is responsible for initial data reduction and data review. This includes confirming compliance with required methodology, verifying calculations, evaluating quality control data, noting non-conformances in logbooks or as footnotes or narratives, and uploading analytical results into the LIMS. Data review checklists, either hardcopy or electronic, are used to document the primary data review process. The primary analyst must be clearly identified in all applicable logbooks, spreadsheets, LIMS fields, and data review checklists.

6.1.2. The primary analyst compiles the initial data for secondary data review. This compilation must include sufficient documentation for secondary data review.

6.1.3. Additional information regarding data review procedures can be found in SOP S-CAR-Q-037 **Data Review** or its equivalent revision or replacement, as well as in SOP S-CAR-Q-016 **Manual Integration** or its equivalent revision or replacement.

6.2. Secondary Data Review

6.2.1. Secondary data review is the process of examining data and accepting or rejecting it based on pre-defined criteria. This review step is designed to ensure that reported data are free from calculation and transcription errors, that quality control parameters are evaluated, and that any non-conformances are properly documented.

6.2.2. The completed data from the primary analyst is sent to a designated qualified secondary data reviewer (this cannot be the primary analyst). The secondary data reviewer provides an independent technical assessment of the data package and technical review for accuracy according to methods employed and laboratory protocols. This assessment involves a quality control review for use of the proper methodology and detection limits, compliance to quality control protocol and criteria, presence and completeness of required deliverables, and accuracy of calculations and data quantitation. The reviewer validates the data entered into the LIMS and documents approval of manual integrations. Data review checklists, either hardcopy or electronic, are used to document the secondary data review process.

6.2.3. Additional information regarding data review procedures can be found in SOP S-CAR-Q-037 **Data Review** or its equivalent revision or replacement, as well as in SOP S-CAR-Q-016 **Manual Integration** or its equivalent revision or replacement.

6.3. Data Reporting

6.3.1. Data for each analytical fraction pertaining to a particular Pace project number are delivered to the Project Manager for assembly into the final report. All points mentioned during technical and QC reviews are included in data qualifiers on the final report or in a separate case narrative if there is potential for data to be impacted.

6.3.2. Final reports are prepared according to the level of reporting required by the customer and can be transmitted to the customer via hardcopy or electronic deliverable. A standard PASI final report consists of the following components:

6.3.2.1. A title which designates the report as “Final Report”, “Laboratory Results”, “Certificate of Results”, etc.;

6.3.2.2. Name and address of laboratory (or subcontracted laboratories, if used);

6.3.2.3. Phone number and name of laboratory contact to where questions can be referred;

6.3.2.4. A unique identification number for the report. The pages of the report shall be numbered and a total number of pages shall be indicated;

6.3.2.5. Name and address of customer and name of project;

6.3.2.6. Unique identification of samples analyzed as well as customer sample IDs;

6.3.2.7. Identification of any sample that did not meet acceptable sampling requirements of the relevant governing agency, such as improper sample containers, holding times missed, sample temperature, etc.;

6.3.2.8. Date and time of collection of samples, date of sample receipt by the laboratory, dates of sample preparation and analysis, and times of sample preparation and analysis when the holding time for either is 72 hours or less;

6.3.2.9. Identification of the test methods used;

6.3.2.10. Identification of sampling procedures if sampling was conducted by the laboratory;

6.3.2.11. Deviations from, additions to, or exclusions from the test methods. These can include failed quality control parameters, deviations caused by the matrix of the sample, etc., and can be shown as a case narrative or as defined footnotes to the analytical data;

6.3.2.12. Identification of whether calculations were performed on a dry or wet-weight basis;

6.3.2.13. Reporting limits used;

6.3.2.14. Final results or measurements, supported by appropriate chromatograms, charts, tables, spectra, etc.;

6.3.2.15. A signature and title, electronic or otherwise, of person accepting responsibility for the content of the report;

6.3.2.16. Date report was issued;

6.3.2.17. A statement clarifying that the results of the report relate only to the samples tested or to the samples as they were received by the laboratory;

6.3.2.18. If necessary, a statement indicating that the report must not be reproduced except in full, without the written approval of the laboratory;

6.3.2.19. Identification of all test results provided by a subcontracted laboratory or other outside source;

6.3.2.20. Identification of results obtained outside of quantitation levels.

In addition to the requirements listed above, final reports shall also contain the following items when necessary for the interpretation of results:

6.3.2.21. Deviations from, additions to, or exclusions from the test method, and information on specific test conditions, such as environmental conditions;

6.3.2.22. Where relevant, a statement of compliance/non-compliance with requirements and/or specifications (e.g., the TNI standard);

6.3.2.23. Where applicable, a statement on the estimated uncertainty of measurement; information on uncertainty is needed in test reports when it is relevant to the validity or application of the test results, when a customer’s instruction so requires, or when the uncertainty affects compliance to a specification limit;

6.3.3. Any changes made to a final report shall be designated as “Revised” or equivalent wording. The laboratory must keep sufficient archived records of all laboratory reports and revisions. For higher levels of data deliverables, a copy of all supporting raw data is sent to the customer along with a final report of results. Pace will provide electronic data deliverables (EDD) as required by contracts or upon customer request.

6.3.4. Customer data that requires transmission by telephone, telex, facsimile or other electronic means undergoes appropriate steps to preserve confidentiality.

6.3.5. The following positions are the only approved signatories for Pace final reports:

- Senior General Manager
- General Manager
- Assistant General Manager
- Senior Quality Manager
- Quality Manager
- Client Services Manager
- Project Manager
- Project Coordinator

6.4. Data Security

6.4.1. All data including electronic files, logbooks, extraction/digestion/distillation worksheets, calculations, project files and reports, and any other information used to produce the technical report are maintained secured and retrievable by the Pace facility.

6.5. Data Archiving

6.5.1. All records compiled by Pace are archived in a suitable, limited-access environment to prevent loss, damage, or deterioration by fire, flood, vermin, theft, and/or environmental deterioration. Records are retained for a minimum of five years unless superseded by federal, state, contractual, and/or accreditation requirements (seven years per some client requirements). TNI-related records will be made readily available to accrediting authorities. Access to archived data is documented and controlled by the SQM/QM or a designated Data Archivist.

6.5.2. Records that are computer-generated have either a hard copy or electronic backup copy. Hardware and software necessary for the retrieval of electronic data is maintained with the applicable records. Archived electronic records are stored protected against electronic and/or magnetic sources.

6.5.3. In the event of a change in ownership, accountability or liability, reports of analyses performed pertaining to accreditation will be maintained per the purchase agreement. In the event of bankruptcy, laboratory reports and/or records will be transferred to the customer and/or the appropriate regulatory entity upon request.

6.6. Data Disposal

6.6.1. Data that has been archived for the facility’s required storage time may be disposed of in a secure manner by shredding, returning to customer, or utilizing some other means that does not jeopardize data confidentiality. Records of data disposal will be archived for a minimum of five years unless superseded by federal, contractual, and/or accreditation requirements. Data disposal includes any preliminary or final reports that are disposed.

7.0. QUALITY SYSTEM AUDITS AND REVIEWS

7.1. Internal Audits

7.1.1. Responsibilities

7.1.1.1. The SQM/QM is responsible for managing and/or conducting internal audits in accordance with a predetermined schedule and procedure. Since internal audits represent an independent assessment of laboratory functions, the auditor must be independent from laboratory operations to ensure objectivity. The auditor must be trained, qualified, and familiar enough with the objectives, principles, and procedures of laboratory operations to be able to perform a thorough and effective evaluation. The SQM/QM evaluates audit observations and verifies the completion of corrective actions. In addition, a periodic corporate audit will be conducted. The corporate audits will focus on the effectiveness of the Quality System as outlined in this manual but may also include other quality programs applicable to an individual laboratory.

7.1.1.2. Additional information can be found in SOP S-CAR-Q-011 **Internal and External Audits** or its equivalent revision or replacement.

7.1.2. Scope and Frequency of Internal Audits

7.1.2.1. The complete internal audit process consists of the following four sections: 1) Raw Data Reviews, 2) traditional Quality Systems internal audits (including SOP and method compliance), 3) Final Report Reviews, and 4) Corrective Action Effectiveness Follow-up.

7.1.2.2. Internal systems audits are conducted yearly at a minimum. The scope of these audits includes evaluation of specific analytical departments or a specific quality related system as applied throughout the laboratory.

7.1.2.3. Where the identification of non-conformities or departures cast doubt on the laboratory’s compliance with its own policies and procedures, the lab must ensure that the appropriate areas of activity are audited as soon as possible.

7.1.2.4. Certain projects may require an internal audit to ensure laboratory conformance to site work plans, sampling and analysis plans, QAPPs, etc.

7.1.2.5. The laboratory, as part of their overall internal audit program, ensures that a review is conducted with respect to any evidence of inappropriate actions or vulnerabilities related to data integrity. Discovery and reporting of potential data integrity issues are handled in a confidential manner. All investigations that result in findings of inappropriate activity are fully documented, including the source of the problem, the samples and customers affected the impact on the data, the corrective actions taken by the laboratory, and which final reports had to be re-issued. Customers must be notified within 30 days after the data investigation is completed and the impact to final results is assessed.

7.1.3. Internal Audit Reports and Corrective Action Plans

7.1.3.1. A full description of the audit, including the identification of the operation audited, the date(s) on which the audit was conducted, the specific systems examined, and the observations noted are summarized in an internal audit report. Although other personnel may assist with the performance of the audit, the SQM/QM writes and issues the internal audit report identifying which audit observations are deficiencies that require corrective action.

7.1.3.2. When audit findings cast doubt on the effectiveness of the operations or on the correctness of validity of the laboratory's environmental test results, the laboratory will take timely corrective action and notify the customer in writing within three business days, if investigations show that the laboratory results may have been affected.

7.1.3.3. Additional information can be found in SOP S-CAR-Q-011 **Internal and External Audits** or its equivalent revision or replacement.

7.2. External Audits

7.2.1. Pace laboratories are audited regularly by regulatory agencies to maintain laboratory certifications and by customers to maintain appropriate specific protocols.

7.2.2. External audit teams review the laboratory to assess the effectiveness of quality systems. The SQM/QM host the external audit team and assist in facilitation of the audit process. After the audit, the external auditors will prepare a formalized audit report listing deficiencies observed and follow-up requirements for the laboratory. The laboratory staff and supervisors develop corrective action plans to address any deficiencies with the guidance of the SQM/QM, who provides a written response to the external audit team. The SQM/QM follows-up with the laboratory staff to ensure corrective actions are implemented and that the corrective action was effective.

7.3. Annual Managerial Review

7.3.1. A managerial review of Management and Quality Systems is performed on an annual basis at a minimum. This allows for assessing program effectiveness and introducing changes and/or improvements. Additional information can be found in SOP S-ALL-Q-015 **Review of Laboratory Management System** or its equivalent revision or replacement.

7.3.2. The managerial review must include the following topics of discussion:

- Suitability of quality management policies and procedures
- Manager/Supervisor reports
- Internal audit results
- Corrective and preventive actions
- External assessment results
- Proficiency testing studies
- Sample capacity and scope of work changes
- Customer feedback, including complaints
- Recommendations for improvement,
- Other relevant factors, such as quality control activities, resources, and staffing.

7.3.3. This managerial review must be documented for future reference by the SQM/QM and copies of the report are distributed to laboratory staff. Results must feed into the laboratory planning system and must include goals, objectives, and action plans for the coming year. The laboratory shall ensure that any actions identified during the review are carried out within an appropriate and agreed upon timescale.

8.0. CORRECTIVE ACTION

Additional information can be found in SOP S-CAR-Q-012 **Corrective and Preventive Actions** or its equivalent revision or replacement.

During the process of sample handling, preparation, and analysis, or during review of quality control records, or during reviews of non-technical portions of the lab, certain occurrences may warrant the necessity of corrective actions. These occurrences may take the form of analyst errors, deficiencies in quality control, method deviations, or other unusual circumstances. The Quality System of Pace provides systematic procedures for the documentation, monitoring, completion of corrective actions, and follow-up verification of the effectiveness of these corrective actions. This can be done using Pace's LabTrack system that lists at a minimum, the deficiency by issue number, the deficiency source, responsible party, root cause, resolution, due date, and date resolved.

8.1. Corrective and Preventive Action Documentation

8.1.1. The following items are examples of sources of laboratory deviations or non-conformances that may warrant some form of documented corrective action:

- Internal Laboratory Non-Conformance Trends
- Proficiency Testing Sample Results
- Internal and External Audits
- Data or Records Review
- Client Complaints
- Client Inquiries
- Holding Time violations

8.1.2. Documentation of corrective actions may be in the form of a comment or footnote on the final report that explains the deficiency (e.g., matrix spike recoveries outside of acceptance criteria) or it may be a more formal documentation (either paper system or computerized spreadsheet). This depends on the extent of the deficiency, the impact on the data, and the method or customer requirements for documentation.

8.1.3. The person who discovers the deficiency or non-conformance initiates the corrective action documentation on the Non-Conformance Corrective/ Preventive Action report and/or LabTrack. The documentation must include (as applicable): the affected projects and sample numbers, the name of the applicable Project Manager, the customer name, and the sample matrix involved. The person initiating the corrective action documentation must also list the known causes of the deficiency or non-conformance as well as any corrective/preventative actions that they have taken. Preventive actions must be taken in order to prevent or minimize the occurrence of the situation.

8.1.4. **Root Cause Analysis**: Laboratory personnel and management staff will start a root cause analysis by going through an investigative process. During this process, the following general steps must be taken into account: defining the non-conformance, assigning responsibilities, determining if the condition is significant, and investigating the root cause of the nonconformance. General non-conformance investigative techniques follow the path of the sample through the process looking at each individual step in detail. The root cause must be documented within the lab's corrective action system.

8.1.5. Based on the root cause(s) determined, the lab implements applicable corrective actions and verifies their effectiveness. In the event that analytical testing or results do not conform to documented laboratory policies or procedures Project Management will notify the customer of the situation and will advise of any ramifications to data quality if impacted (with the possibility of work being recalled).

8.2. Corrective Action Completion

8.2.1. Internal Laboratory Non-Conformance Trends

8.2.1.1. There are several types of non-conformance trends that may occur in the laboratory that would require the initiation of a corrective action report. Laboratories may choose to initiate a corrective action for all instances of one or more of these categories if they so choose, however the intent is that each of these would be handled according to its severity; one time instances could be handled with a footnote or qualifier whereas a systemic problem with any of these categories may require an official corrective action process. These categories, as defined in the Corrective Action SOP are as follows:

- Login error
- Preparation Error
- Contamination
- Calibration Failure
- Internal Standard Failure
- LCS Failure
- Laboratory accident
- Spike Failure
- Instrument Failure
- Final Reporting error

8.2.2. PE/PT Sample Results

8.2.2.1. Any PT result assessed as “not acceptable” requires an investigation and applicable corrective actions. The operational staff is made aware of the PT failures and they are responsible for reviewing the applicable raw data and calibrations and list possible causes for error. The SQM/QM reviews their findings and initiates another external PT sample or an internal PT sample to try and correct the previous failure. Replacement PT results must be monitored by the SQM/QM and reported to the applicable regulatory authorities.

8.2.2.2. Additional information, such as requirements regarding time frames for reporting failures to states, makeup PTs, and notifications of investigations, can be found in SOP S-CAR-Q-010 **Proficiency Testing Program** or its equivalent revision or replacement.

8.2.3. Internal and External Audits

8.2.3.1. The SQM/QM is responsible for documenting all audit findings and their corrective actions. This documentation must include the initial finding, the persons responsible for the corrective action, the due date for responding to the auditing body, the root cause of the finding, and the corrective actions needed for resolution. The SQM/QM is also responsible for providing any back-up documentation used to demonstrate that a corrective action has been completed.

8.2.4. Data Review

8.2.4.1. In the course of performing primary and secondary review of data or in the case of raw data reviews (e.g., by the SQM/QM), errors may be found which require corrective actions. Any finding that affects the quality of the data requires some form of corrective action, which may include revising and re-issuing of final reports.

8.2.5. Client Complaints

8.2.5.1. Project Managers are responsible for issuing corrective action forms, when warranted, for customer complaints. As with other corrective actions, the possible causes of the problem are listed and the form is passed to the appropriate analyst or supervisor for investigation. After potential corrective actions have been determined, the Project Manager reviews the corrective action form to ensure all customer needs or concerns are being adequately addressed.

8.2.6. Client Inquiries

8.2.6.1. When an error on the customer report is discovered, the Project Manager is responsible for initiating a formal corrective action form that describes the failure (e.g., incorrect analysis reported, reporting units are incorrect, or reporting limits do not meet objectives). The Project Manager is also responsible for revising the final report if necessary and submitting it to the customer.

8.2.7. Holding Time Violations

8.2.7.1. In the event that a holding time has been missed, the analyst or supervisor must complete a formal corrective action form. The Project Manager and the SQM/QM must be made aware of all holding time violations.

8.2.7.2. The Project Manager must contact the customer in order that appropriate decisions are made regarding the hold time excursion and the ultimate resolution is then documented and included in the customer project file.

9.0. GLOSSARY

The source of some of the definitions is indicated previous to the actual definition (e.g., TNI, DoD).

Terms and Definitions	
3P Program	The Pace continuous improvement program that focuses on Process, Productivity, and Performance. Best Practices are identified that can be used by all Pace labs.
Acceptance Criteria	TNI- Specified limits placed on characteristics of an item, process, or service defined in requirement documents.
Accreditation	TNI- The process by which an agency or organization evaluates and recognizes a laboratory as meeting certain predetermined qualifications or standards, thereby accrediting the laboratory. DoD- Refers to accreditation in accordance with the DoD ELAP.
Accreditation Body (AB)	TNI- The organization having responsibility and accountability for environmental laboratory accreditation and which grants accreditation under this program. DoD- Entities recognized in accordance with the DoD-ELAP that are required to operate in accordance with ISO/IEC 17011, *Conformity assessment: General requirements for accreditation bodies accrediting conformity assessment bodies*. The AB must be a signatory, in good standing, to the International Laboratory Accreditation Cooperation (ILAC) mutual recognition arrangement (MRA) that verifies, by evaluation and peer assessment, that its signatory members are in full compliance with ISO/IEC 17011 and that its accredited laboratories comply with ISO/IEC 17025.
Accuracy	TNI- The degree of agreement between an observed value and an accepted reference value. Accuracy includes a combination of random error (precision) and systematic error (bias) components that are due to sampling and analytical operations; a data quality indicator.
Activity, Absolute	TNI- Rate of nuclear decay occurring in a body of material, equal to the number of nuclear disintegrations per unit time. NOTE: Activity (absolute) may be expressed in becquerels (Bq), curies (Ci), or disintegrations per minute (dpm), and multiples or submultiples of these units.
Activity, Areic	TNI- Quotient of the activity of a body of material and its associated area.
Activity, Massic	TNI- Quotient of the activity of a body of material and its mass; also called specific activity.
Activity, Volumic	TNI- Quotient of the activity of a body of material and its volume; also called activity concentration. NOTE: In this module [TNI Volume 1, Module 6], unless otherwise stated, references to activity shall include absolute activity, areic activity, massic activity, and volumic activity.
Activity Reference Date	TNI- The date (and time, as appropriate to the half-life of the radionuclide) to which a reported activity result is calculated. NOTE: The sample collection date is most frequently used as the Activity Reference Date for environmental measurements, but different programs may specify other points in time for correction of results for decay and ingrowth.
Aliquot	DoD- A discrete, measured, representative portion of a sample taken for analysis.

American Society for Testing and Materials (ASTM)	An international standards organization that develops and publishes voluntary consensus standards for a wide range of materials, products, systems and services.
Analysis	DoD- A combination of sample preparation and instrument determination.
Analysis Code (Acode)	All the set parameters of a test, such as Analytes, Method, Detection Limits and Price.
Analysis Sequence	A compilation of all samples, standards and quality control samples run during a specific amount of time on a particular instrument in the order they are analyzed.
Analyst	TNI- The designated individual who performs the "hands-on" analytical methods and associated techniques and who is the one responsible for applying required laboratory practices and other pertinent quality controls to meet the required level of quality.
Analyte	TNI- A substance, organism, physical parameter, property, or chemical constituent(s) for which an environmental sample is being analyzed. DoD- The specific chemicals or components for which a sample is analyzed; it may be a group of chemicals that belong to the same chemical family and are analyzed together.
Analytical Method	DoD- A formal process that identifies and quantifies the chemical components of interest (target analytes) in a sample.
Analytical Uncertainty	TNI- A subset of Measurement Uncertainty that includes all laboratory activities performed as part of the analysis.
Aliquot	DoD- A discrete, measured, representative portion of a sample taken for analysis.
Annual (or Annually)	Defined by Pace as every 12 months ± 30 days.
Assessment	TNI - The evaluation process used to measure or establish the performance, effectiveness, and conformance of an organization and/or its system to defined criteria (to the standards and requirements of laboratory accreditation). DoD- An all-inclusive term used to denote any of the following: audit, performance evaluation, peer review, inspection, or surveillance conducted on-site.
Atomic Absorption Spectrometer	Instrument used to measure concentration in metals samples.
Atomization	A process in which a sample is converted to free atoms.
Audit	TNI- A systematic and independent examination of facilities, equipment, personnel, training, procedures, record-keeping, data validation, data management, and reporting aspects of a system to determine whether QA/QC and technical activities are being conducted as planned and whether these activities will effectively achieve quality objectives.

Batch	TNI- Environmental samples that are prepared and/or analyzed together with the same process and personnel, using the same lot(s) of reagents. A **preparation batch** is composed of one to 20 environmental samples of the same quality systems matrix, meeting the above-mentioned criteria and with a maximum time between the start of processing of the first and last sample in the batch to be 24 hours. An **analytical batch** is composed of prepared environmental samples (extracts, digestates or concentrates) which are analyzed together as a group. An analytical batch can include prepared samples originating from various quality system matrices and can exceed 20 samples. South Carolina- same definition as TNI except 24 hours should be changed to 8 hours.
Batch, Radiation Measurements (RMB)	TNI- An RMB is composed of 1 to 20 environmental samples that are counted directly without preliminary physical or chemical processing that affects the outcome of the test (e.g., non-destructive gamma spectrometry, alpha/beta counting of air filters, or swipes on gas proportional detectors). The samples in an RMB share similar physical and chemical parameter, and analytical configurations (e.g., analytes, geometry, calibration, and background corrections). The maximum time between the start of processing of the first and last in an RMB is 14 calendar days.
Bias	TNI- The systematic or persistent distortion of a measurement process, which causes errors in one direction (i.e., the expected sample measurement is different from the sample's true value).
Blank	TNI and DoD- A sample that has not been exposed to the analyzed sample stream in order to monitor contamination during sampling, transport, storage or analysis. The blank is subjected to the usual analytical and measurement process to establish a zero baseline or background value and is sometimes used to adjust or correct routine analytical results (See Method Blank). DoD- Blank samples are negative control samples, which typically include field blank samples (e.g., trip blank, equipment (rinsate) blank, and temperature blank) and laboratory blank samples (e.g., method blank, reagent blank, instrument blank, calibration blank, and storage blank).
Blind Sample	A sub-sample for analysis with a composition known to the submitter. The analyst/laboratory may know the identity of the sample but not its composition. It is used to test the analyst's or laboratory's proficiency in the execution of the measurement process.
BNA (Base Neutral Acid compounds)	A list of semi-volatile compounds typically analyzed by mass spectrometry methods. Named for the way they can be extracted out of environmental samples in an acidic, basic or neutral environment.
BOD (Biochemical Oxygen Demand)	Chemical procedure for determining how fast biological organisms use up oxygen in a body of water.

Calibration	TNI- A set of operations that establish, under specified conditions, the relationship between values of quantities indicated by a measuring instrument or measuring system, or values represented by a material measure or a reference material, and the corresponding values realized by standards. 1) In calibration of support equipment, the values realized by standards are established through the use of reference standards that are traceable to the International System of Units (SI); 2) In calibration according to test methods, the values realized by standards are typically established through the use of Reference Materials that are either purchased by the laboratory with a certificate of analysis or purity, or prepared by the laboratory using support equipment that has been calibrated or verified to meet specifications.
Calibration Curve	TNI- The mathematical relationship between the known values, such as concentrations, of a series of calibration standards and their instrument response.
Calibration Method	A defined technical procedure for performing a calibration.
Calibration Range	DoD- The range of values (concentrations) between the lowest and highest calibration standards of a multi-level calibration curve. For metals analysis with a single-point calibration, the low-level calibration check standard and the high standard establish the linear calibration range, which lies within the linear dynamic range.
Calibration Standard	TNI- A substance or reference material used for calibration.
Certified Reference Material (CRM)	TNI- Reference material accompanied by a certificate, having a value, measurement uncertainty, and stated metrological traceability chain to a national metrology institute.
Chain of Custody	An unbroken trail of accountability that verifies the physical security of samples, data, and records.
Chain of Custody Form (COC)	TNI- Record that documents the possession of the samples from the time of collection to receipt in the laboratory. This record generally includes: the number and type of containers; the mode of collection, the collector, time of collection; preservation; and requested analyses.
Chemical Oxygen Demand (COD)	A test commonly used to indirectly measure the amount of organic compounds in water.
Client (referred to by ISO as Customer)	Any individual or organization for whom items or services are furnished or work performed in response to defined requirements and expectations.
Code of Federal Regulations (CFR)	A codification of the general and permanent rules published in the Federal Register by agencies of the federal government.
Comparability	An assessment of the confidence with which one data set can be compared to another. Comparable data are produced through the use of standardized procedures and techniques.
Completeness	The percent of valid data obtained from a measurement system compared to the amount of valid data expected under normal conditions. The equation for completeness is: % Completeness = (Valid Data Points/Expected Data Points)*100

Confirmation	TNI- Verification of the identity of a component through the use of an approach with a different scientific principle from the original method. These may include, but are not limited to: second-column confirmation; alternate wavelength; derivatization; mass spectral interpretation; alternative detectors; or additional cleanup procedures. DoD- Includes verification of the identity and quantity of the analyte being measured by another means (e.g., by another determinative method, technology, or column). Additional cleanup procedures alone are not considered confirmation techniques.
Conformance	An affirmative indication or judgment that a product or service has met the requirements of the relevant specifications, contract, or regulation; also the state of meeting the requirements.
Congener	A member of a class of related chemical compounds (e.g., PCBs, PCDDs).
Consensus Standard	DoD- A standard established by a group representing a cross-section of a particular industry or trade, or a part thereof.
Continuing Calibration Blank (CCB)	A blank sample used to monitor the cleanliness of an analytical system at a frequency determined by the analytical method.
Continuing Calibration Check Compounds (CCC)	Compounds listed in mass spectrometry methods that are used to evaluate an instrument calibration from the standpoint of the integrity of the system. High variability would suggest leaks or active sites on the instrument column.
Continuing Calibration Verification	DoD- The verification of the initial calibration. Required prior to sample analysis and at periodic intervals. Continuing calibration verification applies to both external and internal standard calibration techniques, as well as to linear and non-linear calibration models.
Continuing Calibration Verification (CCV) Standard	Also referred to as a Calibration Verification Standard (CVS) in some methods, it is a standard used to verify the initial calibration of compounds in an analytical method. CCVs are analyzed at a frequency determined by the analytical method.
Continuous Emission Monitor (CEM)	A flue gas analyzer designed for fixed use in checking for environmental pollutants.
Continuous Improvement Plan (CIP)	The delineation of tasks for a given laboratory department or committee to achieve the goals of that department.
Contract Laboratory Program (CLP)	A national network of EPA personnel, commercial labs, and support contractors whose fundamental mission is to provide data of known and documented quality.
Contract Required Detection Limit (CRDL)	Detection limit that is required for EPA Contract Laboratory Program (CLP) contracts.
Contract Required Quantitation Limit (CRQL)	Quantitation limit (reporting limit) that is required for EPA Contract Laboratory Program (CLP) contracts.
Control Chart	A graphic representation of a series of test results, together with limits within which results are expected when the system is in a state of statistical control (see definition for Control Limit)

Control Limit	A range within which specified measurement results must fall to verify that the analytical system is in control. Control limit exceedances may require corrective action or require investigation and flagging of non-conforming data.
Correction	DoD- Action taken to eliminate a detected non-conformity.
Corrective Action	DoD- The action taken to eliminate the causes of an existing non-conformity, defect, or other undesirable situation in order to prevent recurrence. A root cause analysis may not be necessary in all cases.
Corrective and Preventative Action (CAPA)	The primary management tools for bringing improvements to the quality system, to the management of the quality system's collective processes, and to the products or services delivered which are an output of established systems and processes.
Critical Value	TNI- Value to which a measurement result is compared to make a detection decision (also known as critical level or decision level). NOTE: The Critical Value is designed to give a specified low probability α of false detection in an analyte-free sample, which implies that a result that exceeds the Critical Value, gives high confidence (1 – α) that the radionuclide is actually present in the material analyzed. For radiometric methods, α is often set at 0.05.
Customer	DoD- Any individual or organization for which products or services are furnished or work performed in response to defined requirements and expectations.
Data Integrity	TNI- The condition that exists when data are sound, correct, and complete, and accurately reflect activities and requirements.
Data Quality Objective (DQO)	Systematic strategic planning tool based on the scientific method that identifies and defines the type, quality, and quantity of data needed to satisfy a specified use or end user.
Data Reduction	TNI- The process of transforming the number of data items by arithmetic or statistical calculation, standard curves, and concentration factors, and collating them into a more usable form.
Definitive Data	DoD- Analytical data of known quantity and quality. The levels of data quality on precision and bias meet the requirements for the decision to be made. Data that is suitable for final decision-making.
Demonstration of Capability (DOC)	TNI- A procedure to establish the ability of the analyst to generate analytical results of acceptable accuracy and precision. DoD- A procedure to establish the ability of the analyst to generate analytical results by a specific method that meet measurement quality objectives (e.g., for precision and bias).
Department of Defense (DoD)	An executive branch department of the federal government of the United States charged with coordinating and supervising all agencies and functions of the government concerned directly with national security.
Detection Limit (DL)	DoD- The smallest analyte concentration that can be demonstrated to be different than zero or a blank concentration with 99% confidence. At the DL, the false positive rate (Type 1 error) is 1%. A DL may be used as the lowest concentration for reliably reporting a detection of a specific analyte in a specific matrix with a specific method with 99% confidence.

Detection Limit (DL) for Safe Drinking Water Act (SDWA) Compliance	TNI- Laboratories that analyze drinking-water samples for SDWA compliance monitoring must use methods that provide sufficient detection capability to meet the detection limit requirements established in 40 CFR 141. The SDWA DL for radioactivity is defined in 40 CFR Part 141.25.c as the radionuclide concentration, which can be counted with a precision of plus or minus 100% at the 95% confidence level (1.96σ where σ is the standard deviation of the net counting rate of the sample).
Deuterated Monitoring Compounds (DMCs)	DoD- SIM specific surrogates as specified for GC/MS SIM analysis.
Diesel Range Organics (DRO)	A range of compounds that denote all the characteristic compounds that make up diesel fuel (range can be state or program specific).
Digestion	DoD- A process in which a sample is treated (usually in conjunction with heat and acid) to convert the target analytes in the sample to a more easily measured form.
Document Control	The act of ensuring that documents (and revisions thereto) are proposed, reviewed for accuracy, approved for release by authorized personnel, distributed properly and controlled to ensure use of the correct version at the location where the prescribed activity is performed.
Documents	DoD- Written components of the laboratory management system (e.g., policies, procedures, and instructions).
Dry Weight	The weight after drying in an oven at a specified temperature.
Duplicate (also known as Replicate or Laboratory Duplicate)	The analyses or measurements of the variable of interest performed identically on two subsamples of the same sample. The results of duplicate analyses are used to evaluate analytical or measurement precision but not the precision of sampling, preservation or storage internal to the laboratory.
Electron Capture Detector (ECD)	Device used in GC methods to detect compounds that absorb electrons (e.g., PCB compounds).
Electronic Data Deliverable (EDD)	A summary of environmental data (usually in spreadsheet form) which clients request for ease of data review and comparison to historical results.
Eluent	A solvent used to carry the components of a mixture through a stationary phase.
Elute	To extract, specifically, to remove (absorbed material) from an absorbent by means of a solvent.
Elution	A process in which solutes are washed through a stationary phase by movement of a mobile phase.
Environmental Data	DoD- Any measurements or information that describe environmental processes, locations, or conditions; ecological or health effects and consequences; or the performance of environmental technology.
Environmental Monitoring	The process of measuring or collecting environmental data.
Environmental Protection Agency (EPA)	An agency of the federal government of the United States which was created for the purpose of protecting human health and the environment by writing and enforcing regulations based on laws passed by Congress.

Environmental Sample	A representative sample of any material (aqueous, non-aqueous, or multimedia) collected from any source for which determination of composition or contamination is requested or required. Environmental samples can generally be classified as follows: • Non Potable Water (Includes surface water, ground water, effluents, water treatment chemicals, and TCLP leachates or other extracts) • Drinking Water - Delivered (treated or untreated) water designated as potable water • Water/Wastewater - Raw source waters for public drinking water supplies, ground waters, municipal influents/effluents, and industrial influents/effluents • Sludge - Municipal sludges and industrial sludges. • Soil - Predominately inorganic matter ranging in classification from sands to clays. • Waste - Aqueous and non-aqueous liquid wastes, chemical solids, and industrial liquid and solid wastes
Equipment Blank	A sample of analyte-free media used to rinse common sampling equipment to check effectiveness of decontamination procedures.
Extracted Internal Standard Analyte	Isotopically labeled analogs of analytes of interest added to all standards, blanks and samples analyzed. Added to samples and batch QC samples prior to the first step of sample extraction and to standards and instrument blanks prior to analysis. Used for isotope dilution methods.
Facility	A distinct location within the company that has unique certifications, personnel and waste disposal identifications.
False Negative	DoD- A result that fails to identify (detect) an analyte or reporting an analyte to be present at or below a level of interest when the analyte is actually above the level of interest.
False Positive	DoD- A result that erroneously identifies (detects) an analyte or reporting an analyte to be present above a level of interest when the analyte is actually present at or below the level of interest.
Field Blank	A blank sample prepared in the field by filling a clean container with reagent water and appropriate preservative, if any, for the specific sampling activity being undertaken.
Field Measurement	Determination of physical, biological, or radiological properties, or chemical constituents that are measured on-site, close in time and space to the matrices being sampled/measured, following accepted test methods. This testing is performed in the field outside of a fixed-laboratory or outside of an enclosed structure that meets the requirements of a mobile laboratory.
Field of Accreditation	TNI- Those matrix, technology/method, and analyte combinations for which the accreditation body offers accreditation.
Field of Proficiency Testing (FoPT)	TNI- Matrix, technology/method, analyte combinations for which the composition, spike concentration ranges and acceptance criteria have been established by the PTPEC.

Finding	TNI- An assessment conclusion referenced to a laboratory accreditation standard and supported by objective evidence that identifies a deviation from a laboratory accreditation standard requirement. DoD- An assessment conclusion that identifies a condition having a significant effect on an item or activity. An assessment finding may be positive, negative, or neutral and is normally accompanied by specific examples of the observed condition. The finding must be linked to a specific requirement (e.g., this standard, ISO requirements, analytical methods, contract specifications, or laboratory management systems requirements).
Flame Atomic Absorption Spectrometer (FAA)	Instrumentation used to measure the concentration of metals in an environmental sample based on the fact that ground state metals absorb light at different wavelengths. Metals in a solution are converted to the atomic state by use of a flame.
Flame Ionization Detector (FID)	A type of gas detector used in GC analysis where samples are passed through a flame which ionizes the sample so that various ions can be measured.
Gas Chromatography (GC)	Instrumentation which utilizes a mobile carrier gas to deliver an environmental sample across a stationary phase with the intent to separate compounds out and measure their retention times.
Gas Chromatograph/ Mass Spectrometry (GC/MS)	In conjunction with a GC, this instrumentation utilizes a mass spectrometer which measures fragments of compounds and determines their identity by their fragmentation patterns (mass spectra).
Gasoline Range Organics (GRO)	A range of compounds that denote all the characteristic compounds that make up gasoline (range can be state or program specific).
Graphite Furnace Atomic Absorption Spectrometry (GFAA)	Instrumentation used to measure the concentration of metals in an environmental sample based on the absorption of light at different wavelengths that are characteristic of different analytes.
High Pressure Liquid Chromatography (HPLC)	Instrumentation used to separate, identify and quantitate compounds based on retention times which are dependent on interactions between a mobile phase and a stationary phase.
Holding Time	TNI- The maximum time that can elapse between two specified activities. 40 CFR Part 136- The maximum time that samples may be held prior to preparation and/or analysis as defined by the method and still be considered valid or not compromised. For sample prep purposes, hold times are calculated using the time of the start of the preparation procedure. DoD- The maximum time that may elapse from the time of sampling to the time of preparation or analysis, or from preparation to analysis, as appropriate.
Homogeneity	The degree to which a property or substance is uniformly distributed throughout a sample.
Homologue	One in a series of organic compounds in which each successive member has one more chemical group in its molecule than the next preceding member. For instance, methanol, ethanol, propanol, butanol, etc., form a homologous series.
Improper Actions	DoD- Intentional or unintentional deviations from contract-specified or method-specified analytical practices that have not been authorized by the customer (e.g., DoD or DOE).
Incremental Sampling Method (ISM)	Soil preparation for large volume (1 kg or greater) samples.

In-Depth Data Monitoring	TNI- When used in the context of data integrity activities, a review and evaluation of documentation related to all aspects of the data generation process that includes items such as preparation, equipment, software, calculations, and quality controls. Such monitoring shall determine if the laboratory uses appropriate data handling, data use and data reduction activities to support the laboratory's data integrity policies and procedures.
Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES)	Analytical technique used for the detection of trace metals which uses plasma to produce excited atoms that emit radiation of characteristic wavelengths.
Inductively Coupled Plasma- Mass Spectrometry (ICP/MS)	An ICP that is used in conjunction with a mass spectrometer so that the instrument is not only capable of detecting trace amounts of metals and non-metals but is also capable of monitoring isotopic speciation for the ions of choice.
Infrared Spectrometer (IR)	An instrument that uses infrared light to identify compounds of interest.
Initial Calibration (ICAL)	The process of analyzing standards, prepared at specified concentrations, to define the quantitative response relationship of the instrument to the analytes of interest. Initial calibration is performed whenever the results of a calibration verification standard do not conform to the requirements of the method in use or at a frequency specified in the method.
Initial Calibration Blank (ICB)	A blank sample used to monitor the cleanliness of an analytical system at a frequency determined by the analytical method. This blank is specifically run in conjunction with the Initial Calibration Verification (ICV) where applicable.
Initial Calibration Verification (ICV)	DoD- Verifies the initial calibration with a standard obtained or prepared from a source independent of the source of the initial calibration standards to avoid potential bias of the initial calibration.
Injection Internal Standard Analyte	Isotopically labeled analogs of analytes of interest (or similar in physiochemical properties to the target analytes but with a distinct response) to be quantitated. Added to all blanks, standards, samples and batch QC after extraction and prior to analysis.
Instrument Blank	A clean sample (e.g., distilled water) processed through the instrumental steps of the measurement process; used to determine instrument contamination.
Instrument Detection Limits (IDLs)	Limits determined by analyzing a series of reagent blank analyses to obtain a calculated concentration. IDLs are determined by calculating the average of the standard deviations of three runs on three non-consecutive days from the analysis of a reagent blank solution with seven consecutive measurements per day.
Interference, spectral	Occurs when particulate matter from the atomization scatters incident radiation from the source or when the absorption or emission from an interfering species either overlaps or is so close to the analyte wavelength that resolution becomes impossible.
Interference, chemical	Results from the various chemical processes that occur during atomization and later the absorption characteristics of the analyte.
Internal Standard	TNI and DoD- A known amount of standard added to a test portion of a sample as a reference for evaluating and controlling the precision and bias of the applied analytical method.

International Organization for Standardization (ISO)	An international standard-setting body composed of representatives from various national standards organizations.
Intermediate Standard Solution	Reference solutions prepared by dilution of the stock solutions with an appropriate solvent.
International System of Units (SI)	The coherent system of units adopted and recommended by the General Conference on Weights and Measures.
Ion Chromatography (IC)	Instrumentation or process that allows the separation of ions and molecules based on the charge properties of the molecules.
Isomer	One of two or more compounds, radicals, or ions that contain the same number of atoms of the same element but differ in structural arrangement and properties. For example, hexane (C6H14) could be n-hexane, 2-methylpentane, 3-methylpentane, 2,3-dimethylbutane, 2,2-dimethylbutane.
Laboratory	A body that calibrates and/or tests.
Laboratory Control Sample (LCS)	TNI- (also known as laboratory fortified blank (LFB), spiked blank, or QC check sample): A sample matrix, free from the analytes of interest, spiked with verified known amounts of analytes or a material containing known and verified amounts of analytes and taken through all sample preparation and analytical steps of the procedure unless otherwise noted in a reference method. It is generally used to establish intra-laboratory or analyst-specific precision and bias or to evaluate the performance of all or a portion of the measurement system.
Laboratory Duplicate	Aliquots of a sample taken from the same container under laboratory conditions and processed and analyzed independently.
Laboratory Information Management System (LIMS)	DoD- The entirety of an electronic data system (including hardware and software) that collects, analyzes, stores, and archives electronic records and documents.
LabTrack	Database used by Pace to store and track corrective actions and other laboratory issues.
Learning Management System (LMS)	A web-based database used by the laboratories to track and document training activities. The system is administered by the corporate training department and each laboratory's learn centers are maintained by a local administrator.
Legal Chain-of-Custody Protocols	TNI- Procedures employed to record the possession of samples from the time of sampling through the retention time specified by the client or program. These procedures are performed at the special request of the client and include the use of a Chain-of-Custody (COC) Form that documents the collection, transport, and receipt of compliance samples by the laboratory. In addition, these protocols document all handling of the samples within the laboratory.
Limit(s) of Detection (LOD)	TNI- The minimum result, which can be reliably discriminated from a blank with predetermined confidence level. DoD- The smallest concentration of a substance that must be present in a sample in order to be detected at the DL with 99% confidence. At the LOD, the false negative rate (Type II error) is 1%. A LOD may be used as the lowest concentration for reliably reporting a non-detect of a specific analyte in a specific matrix with a specific method at 99% confidence.

Limit(s) of Quantitation (LOQ)	TNI- The minimum levels, concentrations, or quantities of a target variable (e.g., target analyte) that can be reported with a specified degree of confidence. DoD- The smallest concentration that produces a quantitative result with known and recorded precision and bias. For DoD/DOE projects, the LOQ shall be set at or above the concentration of the lowest initial calibration standard and within the calibration range.
Linear Dynamic Range	DoD- Concentration range where the instrument provides a linear response.
Liquid chromatography/ tandem mass spectrometry (LC/MS/MS)	Instrumentation that combines the physical separation techniques of liquid chromatography with the mass analysis capabilities of mass spectrometry.
Lot	TNI- A definite amount of material produced during a single manufacturing cycle, and intended to have uniform character and quality.
Management	Those individuals directly responsible and accountable for planning, implementing, and assessing work.
Management System	System to establish policy and objectives and to achieve those objectives.
Manager (however named)	The individual designated as being responsible for the overall operation, all personnel, and the physical plant of the environmental laboratory. A supervisor may report to the manager. In some cases, the supervisor and the manager may be the same individual.
Matrix	TNI- The substrate of a test sample.
Matrix Duplicate	TNI- A replicate matrix prepared in the laboratory and analyzed to obtain a measure of precision.
Matrix Spike (MS) (spiked sample or fortified sample)	TNI- A sample prepared, taken through all sample preparation and analytical steps of the procedure unless otherwise noted in a referenced method, by adding a known amount of target analyte to a specified amount of sample for which an independent test result of target analyte concentration is available. Matrix spikes are used, for example, to determine the effect of the matrix on a method's recovery efficiency.
Matrix Spike Duplicate (MSD) (spiked sample or fortified sample duplicate)	TNI- A replicate matrix spike prepared in the laboratory and analyzed to obtain a measure of the precision of the recovery for each analyte.
Measurement Performance Criteria (MPC)	DoD- Criteria that may be general (such as completion of all tests) or specific (such as QC method acceptance limits) that are used by a project to judge whether a laboratory can perform a specified activity to the defined criteria.
Measurement Quality Objective (MQO)	TNI- The analytical data requirements of the data quality objectives are project- or program-specific and can be quantitative or qualitative. MQOs are measurement performance criteria or objectives of the analytical process. Examples of quantitative MQOs include statements of required analyte detectability and the uncertainty of the analytical protocol at a specified radionuclide activity, such as the action level. Examples of qualitative MQOs include statements of the required specificity of the analytical protocol, e.g., the ability to analyze for the radionuclide of interest given the presence of interferences.

Measurement System	TNI- A method, as implemented at a particular laboratory, and which includes the equipment used to perform the test and the operator(s). DoD- A test method, as implemented at a particular laboratory, and which includes the equipment used to perform the sample preparation and test and the operator(s).
Measurement Uncertainty	DoD- An estimate of the error in a measurement often stated as a range of values that contain the true value within a certain confidence level. The uncertainty generally includes many components which may be evaluated from experimental standard deviations based on repeated observations or by standard deviations evaluated from assumed probability distributions based on experience or other information. For DoD/DOE, a laboratory's Analytical Uncertainty (such as use of LCS control limits) can be reported as the minimum uncertainty.
Method	TNI- A body of procedures and techniques for performing an activity (e.g., sampling, chemical analysis, quantification), systematically presented in the order in which they are to be executed.
Method Blank	TNI- A sample of a matrix similar to the batch of associated samples (when available) that is free from the analytes of interest and is processed simultaneously with and under the same conditions as samples through all steps of the analytical procedures, and in which no target analytes or interferences are present at concentrations that impact the analytical results for sample analyses.
Method Detection Limit (MDL)	TNI- One way to establish a Detection Limit; defined as the minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix containing the analyte.
Method of Standard Additions	A set of procedures adding one or more increments of a standard solution to sample aliquots of the same size in order to overcome inherent matrix effects. The procedures encompass the extrapolation back to obtain the sample concentration.
Minimum Detectable Activity (MDA)	TNI- Estimate of the smallest true activity that ensures a specified high confidence, $1 - \beta$, of detection above the Critical Value, and a low probability β of false negatives below the Critical Value. For radiometric methods, β is often set at 0.05. NOTE 1: The MDS is a measure of the detection capability of a measurement process and as such, it is an a priori concept. It may be used in the selection of methods to meet specified MQOs. Laboratories may also calculate a "sample specific" MDA, which indicates how well the measurement process is performing under varying real-world measurement conditions, when sample-specific characteristics (e.g., interferences) may affect the detection capability. However, the MDA must never be used instead of the Critical Value as a detection threshold. NOTE 2: For the purpose of this Standard, the terms MDA and minimum detectable concentration (MDC) are equivalent.
MintMiner	Program used by Pace to review large amounts of chromatographic data to monitor for errors or data integrity issues.

Mobile Laboratory	TNI- A portable enclosed structure with necessary and appropriate accommodation and environmental conditions for a laboratory, within which testing is performed by analysts. Examples include but are not limited to trailers, vans, and skid-mounted structures configured to house testing equipment and personnel.
National Environmental Laboratory Accreditation Conference (NELAC)	See definition of The NELAC Institute (TNI).
National Institute of Occupational Safety and Health (NIOSH)	National institute charged with the provision of training, consultation and information in the area of occupational safety and health.
National Institute of Standards and Technology (NIST)	TNI- A federal agency of the US Department of Commerce’s Technology Administration that is designed as the United States national metrology institute (or NMI).
National Pollutant Discharge Elimination System (NPDES)	A permit program that controls water pollution by regulating point sources that discharge pollutants into U.S. waters.
Negative Control	Measures taken to ensure that a test, its components, or the environment do not cause undesired effects, or produce incorrect test results.
Nitrogen Phosphorus Detector (NPD)	A detector used in GC analyses that utilizes thermal energy to ionize an analyte. With this detector, nitrogen and phosphorus can be selectively detected with a higher sensitivity than carbon.
Nonconformance	An indication or judgment that a product or service has not met the requirement of the relevant specifications, contract, or regulation; also the state of failing to meet the requirements.
Not Detected (ND)	The result reported for a compound when the detected amount of that compound is less than the method reporting limit.
Operator Aid	DoD- A technical posting (such as poster, operating manual, or notepad) that assists workers in performing routine tasks. All operator aids must be controlled documents (i.e., a part of the laboratory management system).
Performance Based Measurement System (PBMS)	An analytical system wherein the data quality needs, mandates or limitations of a program or project are specified and serve as criteria for selecting appropriate test methods to meet those needs in a cost-effective manner.
Physical Parameter	TNI- A measurement of a physical characteristic or property of a sample as distinguished from the concentrations of chemical and biological components.
Photo-ionization Detector (PID)	An ion detector which uses high-energy photons, typically in the ultraviolet range, to break molecules into positively charged ions.
Polychlorinated Biphenyls (PCB)	A class of organic compounds that were used as coolants and insulating fluids for transformers and capacitors. The production of these compounds was banned in the 1970’s due to their high toxicity.
Positive Control	Measures taken to ensure that a test and/or its components are working properly and producing correct or expected results from positive test subjects.
Post-Digestion Spike	A sample prepared for metals analyses that has analytes spike added to determine if matrix effects may be a factor in the results.
Power of Hydrogen (pH)	The measure of acidity or alkalinity of a solution.

Practical Quantitation Limit (PQL)	Another term for a method reporting limit. The lowest reportable concentration of a compound based on parameters set up in an analytical method and the laboratory's ability to reproduce those conditions.
Precision	TNI- The degree to which a set of observations or measurements of the same property, obtained under similar conditions, conform to themselves; a data quality indicator. Precision is usually expressed as standard deviation, variance or range, in either absolute or relative terms.
Preservation	TNI and DoD- Any conditions under which a sample must be kept in order to maintain chemical, physical, and/or biological integrity prior to analysis.
Primary Accreditation Body (Primary AB)	TNI- The accreditation body responsible for assessing a laboratory's total quality system, on-site assessment, and PT performance tracking for fields of accreditation.
Procedure	TNI- A specified way to carry out an activity or process. Procedures can be documented or not.
Proficiency Testing (PT)	TNI- A means to evaluate a laboratory's performance under controlled conditions relative to a given set of criteria, through analysis of unknown samples provided by an external source.
Proficiency Testing Program (PT Program)	TNI- The aggregate of providing rigorously controlled and standardized environmental samples to a laboratory for analysis, reporting of results, statistical evaluation of the results and the collective demographics and results summary of all participating laboratories.
Proficiency Testing Provider (PT Provider)	TNI- A person or organization accredited by a TNI-approved Proficiency Testing Provider Accreditor to operate a TNI-compliant PT Program.
Proficiency Testing Provider Accreditor (PTPA)	TNI- An organization that is approved by TNI to accredit and monitor the performance of proficiency testing providers.
Proficiency Testing Reporting Limit (PTRL)	TNI- A statistically derived value that represents the lowest acceptable concentration for an analyte in a PT sample, if the analyte is spiked into the PT sample. The PTRLs are specified in the TNI FoPT tables.
Proficiency Testing Sample (PT)	TNI- A sample, the composition of which is unknown to the laboratory, and is provided to test whether the laboratory can produce analytical results within the specified acceptance criteria.
Proficiency Testing (PT) Study	TNI- a) Scheduled PT Study: A single complete sequence of circulation and scoring of PT samples to all participants in a PT program. The study must have the same pre-defined opening and closing dates for all participants; b) Supplemental PT Study: A PT sample that may be from a lot previously released by a PT Provider that meets the requirements for supplemental PT samples given in Volume 3 of this Standard [TNI] but that does not have a pre-determined opening date and closing date.
Proficiency Testing Study Closing Date	TNI- a) Scheduled PT Study: The calendar date by which all participating laboratories must submit analytical results for a PT sample to a PT Provider; b) Supplemental PT Study: The calendar date a laboratory submits the results for a PT sample to the PT Provider.
Proficiency Testing Study Opening Date	TNI- a) Scheduled PT Study: The calendar date that a PT sample is first made available to all participants of the study by a PT Provider; b) Supplemental PT Study: The calendar date the PT Provider ships the sample to a laboratory.

Protocol	TNI- A detailed written procedure for field and/or laboratory operation (e.g., sampling, analysis) that must be strictly followed.
Qualitative Analysis	DoD- Analysis designed to identify the components of a substance or mixture.
Quality Assurance (QA)	TNI- An integrated system of management activities involving planning, implementation, assessment, reporting and quality improvement to ensure that a process, item, or service is of the type and quality needed and expected by the client.
Quality Assurance Manual (QAM)	A document stating the management policies, objectives, principles, organizational structure and authority, responsibilities, accountability, and implementation of an agency, organization, or laboratory, to ensure the quality of its product and the utility of its product to its users.
Quality Assurance Project Plan (QAPP)	A formal document describing the detailed quality control procedures by which the quality requirements defined for the data and decisions pertaining to a specific project are to be achieved.
Quality Control (QC)	TNI- The overall system of technical activities that measures the attributes and performance of a process, item, or service against defined standards to verify that they meet the stated requirements established by the customer; operational techniques and activities that are used to fulfill requirements for quality; also the system of activities and checks used to ensure that measurement systems are maintained within prescribed limits, providing protection against “out of control” conditions and ensuring that the results are of acceptable quality.
Quality Control Sample (QCS)	TNI- A sample used to assess the performance of all or a portion of the measurement system. One of any number of samples, such as Certified Reference Materials, a quality system matrix fortified by spiking, or actual samples fortified by spiking, intended to demonstrate that a measurement system or activity is in control.
Quality Manual	TNI- A document stating the management policies, objectives, principles, organizational structure and authority, responsibilities, accountability, and implementation of an agency, organization, or laboratory, to ensure the quality of its product and the utility of its product to its users.
Quality System	TNI and DoD- A structured and documented management system describing the policies, objectives, principles, organizational authority, responsibilities, accountability, and implementation plan of an organization for ensuring quality in its work processes, products (items), and services. The quality system provides the framework for planning, implementing, and assessing work performed by the organization and for carrying out required quality assurance and quality control activities.

Quality System Matrix	TNI and DoD- These matrix definitions shall be used for purposes of batch and quality control requirements and may be different from a field of accreditation matrix: • **Air and Emissions**: Whole gas or vapor samples including those contained in flexible or rigid wall containers and the extracted concentrated analytes of interest from a gas or vapor that are collected with a sorbant tube, impinger solution, filter, or other device • **Aqueous**: Any aqueous sample excluded from the definition of Drinking Water or Saline/Estuarine. Includes surface water, groundwater effluents, and TCLP or other extracts. • **Biological Tissue**: Any sample of a biological origin such as fish tissue, shellfish or plant material. Such samples shall be grouped according to origin. • **Chemical Waste**: A product or by-product of an industrial process that results in a matrix not previously defined. • **Drinking Water**: Any aqueous sample that has been designated a potable or potentially potable water source. • **Non-aqueous liquid**: Any organic liquid with <15% settleable solids • **Saline/Estuarine**: Any aqueous sample from an ocean or estuary, or other salt water source such as the Great Salt Lake. • **Solids**: Includes soils, sediments, sludges, and other matrices with >15% settleable solids.
Quantitation Range	DoD- The range of values (concentrations) in a calibration curve between the LOQ and the highest successively analyzed initial calibration standard used to relate instrument response to analyte concentration. The quantitation range (adjusted for initial sample volume/weight, concentration/dilution and final volume) lies within the calibration range.
Quantitative Analysis	DoD- Analysis designed to determine the amounts or proportions of the components of a substance.
Random Error	The EPA has established that there is a 5% probability that the results obtained for any one analyte will exceed the control limits established for the test due to random error. As the number of compounds measured increases in a given sample, the probability for statistical error also increases.
Raw Data	TNI- The documentation generated during sampling and analysis. This documentation includes, but is not limited to, field notes, electronic data, magnetic tapes, untabulated sample results, QC sample results, print outs of chromatograms, instrument outputs, and handwritten records.
Reagent Blank (method reagent blank)	A sample consisting of reagent(s), without the target analyte or sample matrix, introduced into the analytical procedure at the appropriate point and carried through all subsequent steps to determine the contribution of the reagents and of the involved analytical steps.
Reagent Grade	Analytical reagent (AR) grade, ACS reagent grade, and reagent grade are synonymous terms for reagents that conform to the current specifications of the Committee on Analytical Reagents of the American Chemical Society.
Records	DoD- The output of implementing and following management system documents (e.g., test data in electronic or hand-written forms, files, and logbooks).

Reference Material	TNI- Material or substance one or more of whose property values are sufficiently homogenized and well established to be used for the calibration of an apparatus, the assessment of a measurement method, or for assigning values to materials.
Reference Method	TNI- A published method issued by an organization generally recognized as competent to do so. (When the ISO language refers to a “standard method”, that term is equivalent to “reference method”). When a laboratory is required to analyze by a specified method due to a regulatory requirement, the analyte/method combination is recognized as a reference method. If there is no regulatory requirement for the analyte/method combination, the analyte/method combination is recognized as a reference method if it can be analyzed by another reference method of the same matrix and technology.
Reference Standard	TNI- Standard used for the calibration of working measurement standards in a given organization or at a given location.
Relative Percent Difference (RPD)	A measure of precision defined as the difference between two measurements divided by the average concentration of the two measurements.
Reporting Limit (RL)	The level at which method, permit, regulatory and customer-specific objectives are met. The reporting limit may never be lower than the Limit of Detection (i.e., statistically determined MDL). Reporting limits are corrected for sample amounts, including the dry weight of solids, unless otherwise specified. There must be a sufficient buffer between the Reporting Limit and the MDL. DoD- A customer-specified lowest concentration value that meets project requirements for quantitative data with known precision and bias for a specific analyte in a specific matrix.
Reporting Limit Verification Standard (RLVS)	A standard analyzed at the reporting limit for an analysis to verify the laboratory’s ability to report to that level.
Representativeness	A quality element related to the ability to collect a sample reflecting the characteristics of the part of the environment to be assessed. Sample representativeness is dependent on the sampling techniques specified in the project work plan.
Requirement	Denotes a mandatory specification; often designated by the term “shall”.
Retention Time	The time between sample injection and the appearance of a solute peak at the detector.
Revocation	TNI- The total or partial withdrawal of a laboratory’s accreditation by an accreditation body.
Sample	Portion of material collected for analysis, identified by a single, unique alphanumeric code. A sample may consist of portions in multiple containers, if a single sample is submitted for multiple or repetitive analysis.
Sample Condition Upon Receipt Form (SCURF)	Form used by sample receiving personnel to document the condition of sample containers upon receipt to the laboratory (used in conjunction with a COC).
Sample Delivery Group (SDG)	A unit within a single project that is used to identify a group of samples for delivery. An SDG is a group of 20 or fewer field samples within a project, received over a period of up to 14 calendar days. Data from all samples in an SDG are reported concurrently.

Sample Receipt Form (SRF)	Letter sent to the client upon login to show the tests requested and pricing.
Sample Tracking	Procedures employed to record the possession of the samples from the time of sampling until analysis, reporting and archiving. These procedures include the use of a chain-of-custody form that documents the collection, transport, and receipt of compliance samples to the laboratory. In addition, access to the laboratory is limited and controlled to protect the integrity of the samples.
Sampling	TNI- Activity related to obtaining a representative sample of the object of conformity assessment, according to a procedure.
Selected Ion Monitoring (SIM)	A mode of analysis in mass spectrometry where the detector is set to scan over a very small mass range, typically one mass unit. The narrower the range, the more sensitive the detector. DoD- Using GC/MS, characteristic ions specific to target compounds are detected and used to quantify in applications where the normal full scan mass spectrometry results in excessive noise.
Selectivity	TNI- The ability to analyze, distinguish, and determine a specific analyte or parameter from another component that may be a potential interferent or that may behave similarly to the target analyte or parameter within the measurement system.
Sensitivity	TNI- The capability of a method or instrument to discriminate between measurement responses representing different levels (e.g., concentrations) of a variable of interest.
Serial Dilution	The stepwise dilution of a substance in a solution.
Shall	Denotes a requirement that is mandatory whenever the criterion for conformance with the specification requires that there be no deviation. This does not prohibit the use of alternative approaches or methods for implementing the specification as long as the requirement is fulfilled.
Should	Denotes a guideline or recommendation whenever noncompliance with the specification is permissible.
Signal-to-Noise Ratio (S/N)	DoD- A measure of signal strength relative to background noise. The average strength of the noise of most measurements is constant and independent of the magnitude of the signal. Thus, as the quantity being measured (producing the signal) decreases in magnitude, S/N decreases and the effect of the noise on the relative error of a measurement increases.
Source Water	TNI- When sampled for drinking water compliance, untreated water from streams, rivers, lakes, or underground aquifers, which is used to supply private and public drinking water supplies.
Spike	A known mass of target analyte added to a blank sample or sub-sample; used to determine recovery efficiency or for other quality control purposes.
Standard (Document)	TNI- The document describing the elements of a laboratory accreditation that has been developed and established within the consensus principles of standard setting and meets the approval requirements of standard adoption organizations procedures and policies.
Standard (Chemical)	Standard samples are comprised of a known amount of standard reference material in the matrix undergoing analysis. A standard reference material is a certified reference material produced by US NIST and characterized for absolute content, independent of analytical test method.

Standard Blank (or Reagent Blank)	A calibration standard consisting of the same solvent/reagent matrix used to prepare the calibration standards without the analytes. It is used to construct the calibration curve by establishing instrument background.
Standard Method	A test method issued by an organization generally recognized as competent to do so.
Standard Operating Procedure (SOP)	TNI- A written document that details the method for an operation, analysis, or action with thoroughly prescribed techniques and steps. SOPs are officially approved as the methods for performing certain routine or repetitive tasks.
Standard Reference Material (SRM)	A certified reference material produced by the US NIST or other equivalent organization and characterized for absolute content, independent of analytical method.
Statement of Qualifications (SOQ)	A document that lists information about a company, typically the qualifications of that company to compete on a bid for services.
Stock Standard	A concentrated reference solution containing one or more analytes prepared in the laboratory using an assayed reference compound or purchased from a reputable commercial source.
Storage Blank	DoD- A sample of analyte-free media prepared by the laboratory and retained in the sample storage area of the laboratory. A storage blank is used to record contamination attributable to sample storage at the laboratory.
Supervisor	The individual(s) designated as being responsible for a particular area or category of scientific analysis. This responsibility includes direct day-to-day supervision of technical employees, supply and instrument adequacy and upkeep, quality assurance/quality control duties and ascertaining that technical employees have the required balance of education, training and experience to perform the required analyses.
Surrogate	DoD- A substance with properties that mimic the analyte of interest. It is unlikely to be found in environmental samples and is added to them for quality control purposes.
Suspension	TNI- The temporary removal of a laboratory’s accreditation for a defined period of time, which shall not exceed 6 months or the period of accreditation, whichever is longer, in order to allow the laboratory time to correct deficiencies or area of non-conformance with the Standard.
Systems Audit	An on-site inspection or assessment of a laboratory’s quality system.
Target Analytes	DoD- Analytes or chemicals of primary concern identified by the customer on a project-specific basis.
Technical Director	Individual(s) who has overall responsibility for the technical operation of the environmental testing laboratory.
Technology	TNI- A specific arrangement of analytical instruments, detection systems, and/or preparation techniques.
Test	A technical operation that consists of the determination of one or more characteristics or performance of a given product, material, equipment, organism, physical phenomenon, process or service according to a specified procedure. The result of a test is normally recorded in a document sometimes called a test report or a test certificate.
Test Method	DoD- A definitive procedure that determines one or more characteristics of a given substance or product.

Test Methods for Evaluating Solid Waste, Physical/ Chemical (SW-846)	EPA Waste’s official compendium of analytical and sampling methods that have been evaluated and approved for use in complying with RCRA regulations.
Test Source	TNI- A radioactive source that is tested, such as a sample, calibration standard, or performance check source. A Test Source may also be free of radioactivity, such as a Test Source counted to determine the subtraction background, or a short-term background check.
The NELAC Institute (TNI)	A non-profit organization whose mission is to foster the generation of environmental data of known and documented quality through an open, inclusive, and transparent process that is responsive to the needs of the community. Previously known as NELAC (National Environmental Laboratory Accreditation Conference).
Total Petroleum Hydrocarbons (TPH)	A term used to denote a large family of several hundred chemical compounds that originate from crude oil. Compounds may include gasoline components, jet fuel, volatile organics, etc.
Toxicity Characteristic Leaching Procedure (TCLP)	A solid sample extraction method for chemical analysis employed as an analytical method to simulate leaching of compounds through a landfill.
Traceability	TNI- The ability to trace the history, application, or location of an entity by means of recorded identifications. In a calibration sense, traceability relates measuring equipment to national or international standards, primary standards, basic physical conditions or properties, or reference materials. In a data collection sense, it relates calculations and data generated throughout the project back to the requirements for the quality of the project.
Training Document	A training resource that provides detailed instructions to execute a specific method or job function.
Trip Blank	This blank sample is used to detect sample contamination from the container and preservative during transport and storage of the sample. A cleaned sample container is filled with laboratory reagent water and the blank is stored, shipped, and analyzed with its associated samples.
Tuning	A check and/or adjustment of instrument performance for mass spectrometry as required by the method.
Ultraviolet Spectrophotometer (UV)	Instrument routinely used in quantitative determination of solutions of transition metal ions and highly conjugated organic compounds.
Uncertainty, Counting	TNI- The component of Measurement Uncertainty attributable to the random nature of radioactive decay and radiation counting (often estimated as the square root of observed counts (MARLAP). Older references sometimes refer to this parameter as Error, Counting Error or Count Error (c.f., Total Uncertainty).

Uncertainty, Expanded	TNI- The product of the Standard Uncertainty and a coverage factor, k, which is chosen to produce an interval about the result that has a high probability of containing the value of the measurand (c.f., Standard Uncertainty). NOTE: Radiochemical results are generally reported in association with the Total Uncertainty. Either if these estimates of uncertainty can be reported as the Standard Uncertainty (one-sigma) or as an Expanded Uncertainty (k-sigma, where k > 1).
Uncertainty, Measurement	TNI- Parameter associated with the result of a measurement that characterizes the dispersion of the values that could reasonably be attributed to the measurand.
Uncertainty, Standard	TNI- An estimate of the Measurement Uncertainty expressed as a standard deviation (c.f., Expanded Uncertainty).
Uncertainty, Total	TNI- An estimate of the Measurement Uncertainty that accounts for contributions from all significant sources of uncertainty associated with the analytical preparation and measurement of a sample. Such estimates are also commonly referred to as Combined Standard Uncertainty or Total Propagated Uncertainty, and in some older references as the Total Propagated Error, among other similar items (c.f., Counting Uncertainty).
Unethical actions	DoD- Deliberate falsification of analytical or quality control results where failed method or contractual requirements are made to appear acceptable.
United States Department of Agriculture (USDA)	A department of the federal government that provides leadership on food, agriculture, natural resources, rural development, nutrition and related issues based on public policy, the best available science, and effective management.
United States Geological Survey (USGS)	Program of the federal government that develops new methods and tools to supply timely, relevant, and useful information about the Earth and its processes.
Unregulated Contaminant Monitoring Rule (UCMR)	EPA program to monitor unregulated contaminants in drinking water.
Validation	DoD- The confirmation by examination and provision of objective evidence that the particular requirements for a specific intended use are fulfilled.
Verification	TNI- Confirmation by examination and objective evidence that specified requirements have been met. In connection with the management of measuring equipment, verification provides a means for checking that the deviations between values indicated by a measuring instrument and corresponding known values of a measured quantity are consistently smaller than the maximum allowable error defined in a standard, regulation or specification peculiar to the management of the measuring equipment.
Voluntary Action Program (VAP)	A program of the Ohio EPA that gives individuals a way to investigate possible environmental contamination, clean it up if necessary and receive a promise from the State of Ohio that no more cleanup is needed.
Whole Effluent Toxicity (WET)	The aggregate toxic effect to aquatic organisms from all pollutants contained in a facility’s wastewater (effluent).

10.0. REFERENCES

10.1. "Guidelines Establishing Test Procedures for the Analysis of Pollutants Under the Clean Water Act." Federal Register, 40 CFR Part 136, most current version.

10.2. "Test Methods for Evaluating Solid Wastes: Physical/Chemical Methods." SW-846.

10.3. "Methods for Chemical Analysis of Water and Wastes", EPA 600-4-79-020, 1979 Revised 1983, U.S. EPA.

10.4. U.S. EPA Contract Laboratory Program Statement of Work for Organic Analysis.

10.5. U.S. EPA Contract Laboratory Program Statement of Work for Inorganic Analysis.

10.6. "Standard Methods for the Examination of Water and Wastewater." Current Edition APHA-AWWA-WPCF.

10.7. "Annual Book of ASTM Standards", Section 4: Construction, Volume 04.04: Soil and Rock; Building Stones, American Society of Testing and Materials.

10.8. "Annual Book of ASTM Standards", Section 11: Water and Environmental Technology, American Society of Testing and Materials.

10.9. "NIOSH Manual of Analytical Methods", U.S. Department of Health and Human Services, National Institute for Occupational Safety and Health, most current version.

10.10. "Methods for the Determination of Organic Compounds in Finished Drinking Water and Raw Source Water", U.S. EPA, Environmental Monitoring and Support Laboratory – Cincinnati (Sep 1986).

10.11. Quality Assurance of Chemical Measurements, Taylor, John K.; Lewis Publishers, Inc. 1987.

10.12. Methods for Non-conventional Pesticides Chemicals Analysis of Industrial and Municipal Wastewater, Test Methods, EPA-440/1-83/079C.

10.13. Environmental Measurements Laboratory (EML) Procedures Manual, HASL-300, US DOE, February, 1992.

10.14. Requirements for Quality Control of Analytical Data, HAZWRAP, DOE/HWP-65/R1, July, 1990.

10.15. Requirements for Quality Control of Analytical Data for the Environmental Restoration Program, Martin Marietta, ES/ER/TM-16, December, 1992.

10.16. Quality Assurance Manual for Industrial Hygiene Chemistry, AIHA, most current version.

10.17. National Environmental Laboratory Accreditation Conference (NELAC) Standard- most current version.

10.18. ISO/IEC 17025, General requirements for the competence of testing and calibration laboratories- most current version.

10.19. Department of Defense Quality Systems Manual (QSM), most current version.

10.20. TNI (The NELAC Institute) Standard- most current version applicable to each lab.

10.21. UCMR Laboratory Approval Requirements and Information Document, most current version.

10.22. US EPA Drinking Water Manual, most current version.

11.0. REVISIONS

The Pace Corporate Environmental Quality Office files an electronic version of a Microsoft Word document with tracked changes detailing all revisions made to previous versions of the Quality Assurance Manual. This document is available upon request. All current revisions are summarized in the table below.

Document Number	Reason for Change	Date
Quality Assurance Manual 19.0	General: made administrative edits that do not affect the policies or procedures within the document (including revising company name to Pace Analytical Services, LLC). Cover page: removed corporate approval signature lines. Old Section 3: moved to other sections of the QAM as applicable and deleted entire section (All section references below reflect the new section numbers). Section 1.1.2: replaced with section 3.1.1. Sections 1.3, 1.4, 1.11: removed extraneous language. Sections 1.5: added language from old section 1.6. Section 1.6: revised anonymous reporting information. Section 1.7.6: added deputies per position and deleted DoD language from old section 1.7.7. Section 1.8: removed non-key personnel job descriptions. Section 2: rearranged existing sections. Section 2.4: reworded to match existing Sample Acceptance policy document. Section 4: in general, for each QC type, removed language regarding frequency and corrective actions and referenced lab-specific SOPs. Section 5: in general, removed extraneous language and Management of Change section. Section 5.1, 5.2: reorganized into Primary and Secondary Review sections and removed extraneous language. Section 6: removed extraneous language including Quarterly Report section. Section 9 (glossary): revised and added definitions based on 2016 TNI Standard. Section 10: Added EPA DW Manual and revised references as applicable. Attachment III: updated corporate organizational chart. Old Attachment IV: removed floor plan attachment. Old Attachment VII: removed COC (available in SOPs).	06Mar2017

ATTACHMENT I- QUALITY CONTROL CALCULATIONS

PERCENT RECOVERY (%REC)

$$\%REC = \frac{(MSConc - SampleConc)}{TrueValue} * 100$$

NOTE: The SampleConc is zero (0) for the LCS and Surrogate Calculations

PERCENT DIFFERENCE (%D)

$$\%D = \frac{MeasuredValue - TrueValue}{TrueValue} * 100$$

where:
TrueValue = Amount spiked (can also be the $\overline{\text{CF}}$ or $\overline{\text{RF}}$ of the ICAL Standards)
Measured Value = Amount measured (can also be the CF or RF of the CCV)

PERCENT DRIFT

$$\%Drift = \frac{Calculated\,Concentration - TheoreticalConcentration}{TheoreticalConcentrtion} * 100$$

RELATIVE PERCENT DIFFERENCE (RPD)

$$RPD = \frac{|(R1 - R2)|}{(R1 + R2)/2} * 100$$

where:
R1 = Result Sample 1
R2 = Result Sample 2

CORRELATION COEFFICIENT (R)

$$CorrCoeff = \frac{\sum_{i=1}^{N} W_i * (X_i - \overline{X}) * (Y_i - \overline{Y})}{\sqrt{\left(\sum_{i=1}^{N} W_i * (X_i - \overline{X})^2\right) * \left(\sum_{i=1}^{N} W_i * (Y_i - \overline{Y})^2\right)}}$$

With:	N	Number of standard samples involved in the calibration
	i	Index for standard samples
	Wi	Weight factor of the standard sample no. i
	Xi	X-value of the standard sample no. i
	X(bar)	Average value of all x-values
	Yi	Y-value of the standard sample no. i
	Y(bar)	Average value of all y-values

ATTACHMENT I- QUALITY CONTROL CALCULATIONS (CONTINUED)

STANDARD DEVIATION (S)

$$S = \sqrt{\sum_{i=1}^{n} \frac{(X_i - \overline{X})^2}{(n-1)}}$$

where:
n = number of data points
X_i = individual data point
$\overline{X}$ = average of all data points

AVERAGE ($\overline{X}$)

$$\overline{X} = \frac{\sum_{n=1}^{i} X_i}{n}$$

where:
n = number of data points
X_i = individual data point

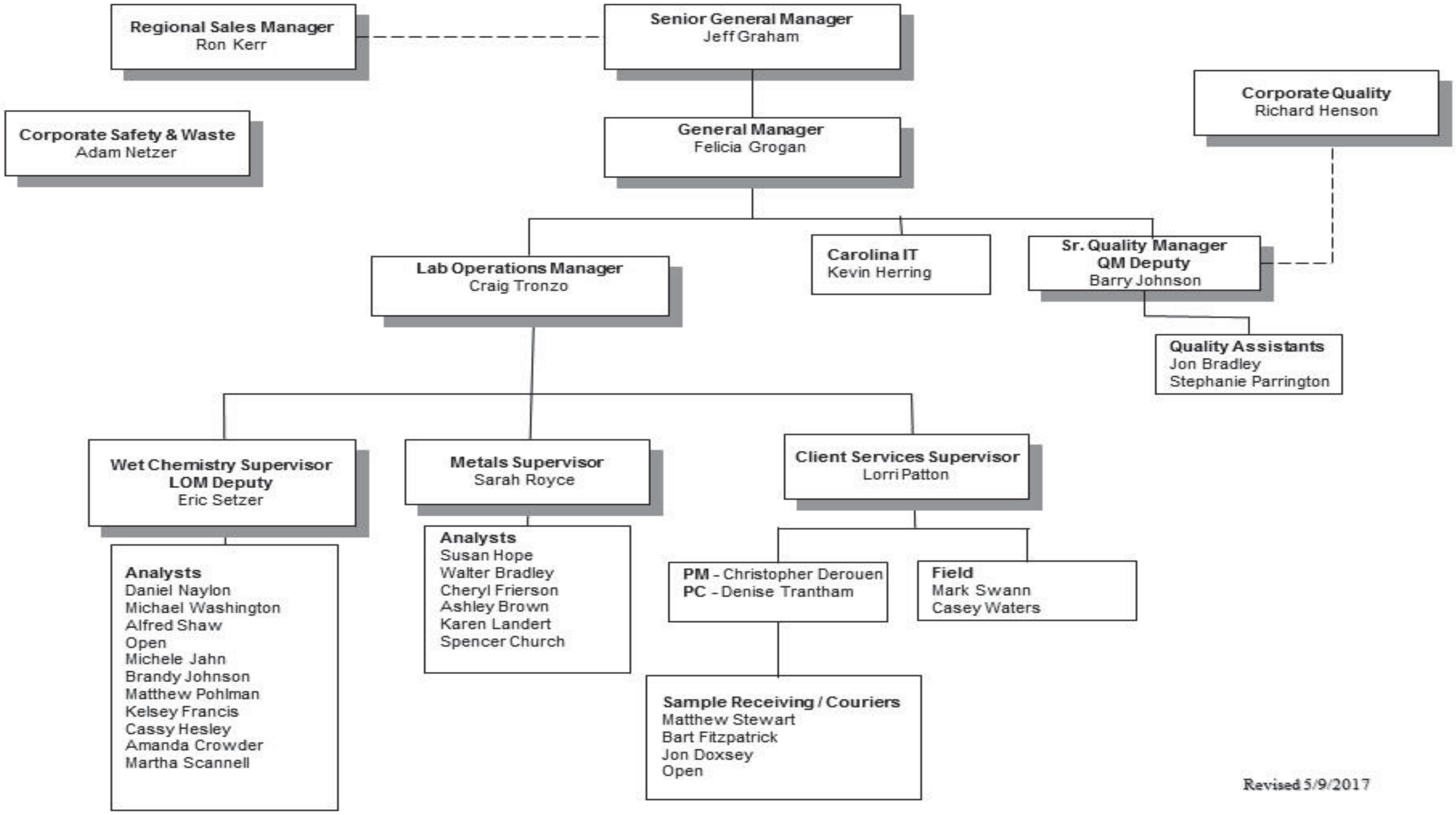
RELATIVE STANDARD DEVIATION (RSD)

$$RSD = \frac{S}{\overline{X}} * 100$$

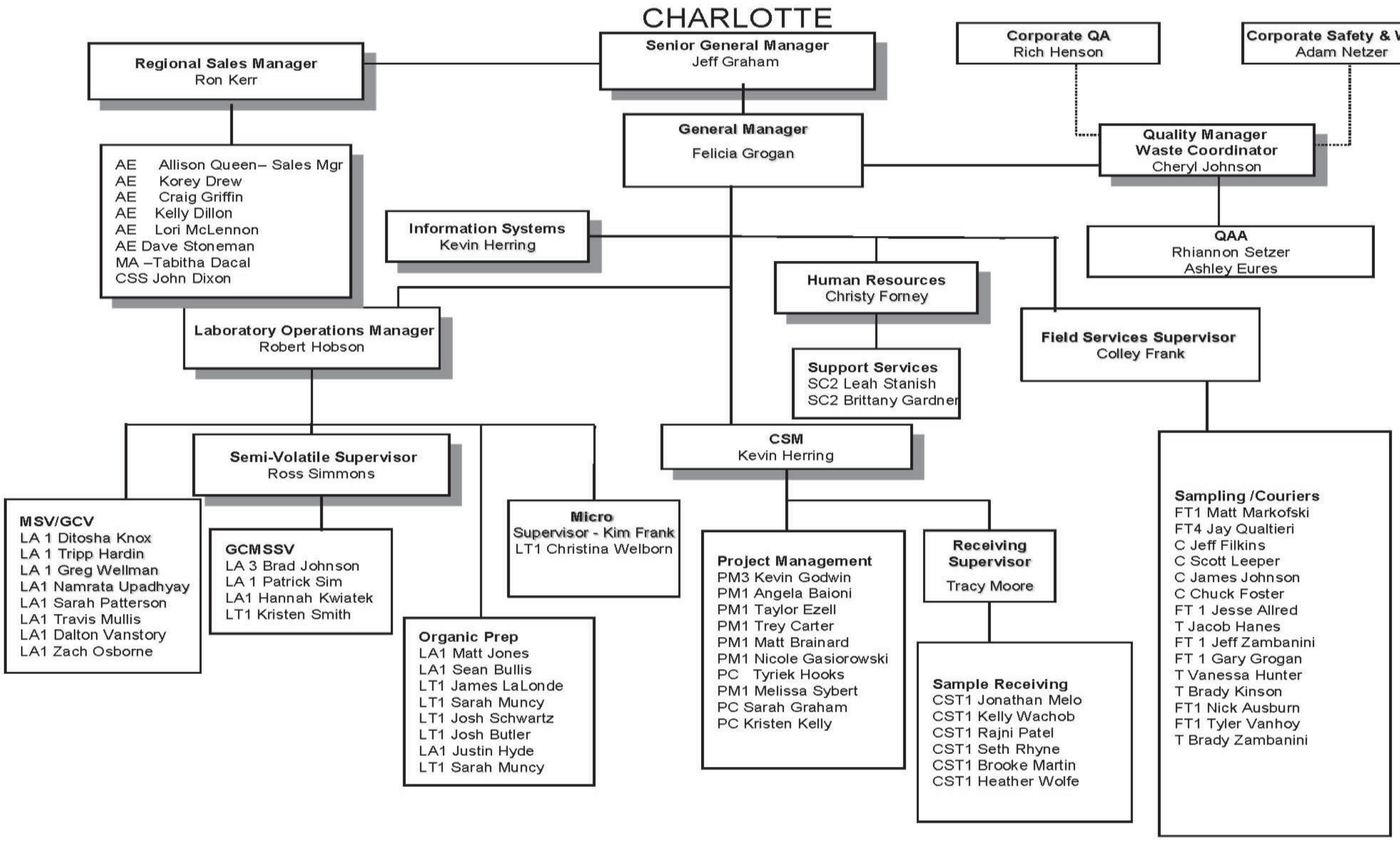
where:
S = Standard Deviation of the data points
$\overline{X}$ = average of all data points

ATTACHMENT II- LABORATORY ORGANIZATIONAL CHARTS (CURRENT AS OF ISSUE DATE)

Pace Carolina's Asheville Laboratory Organization Chart

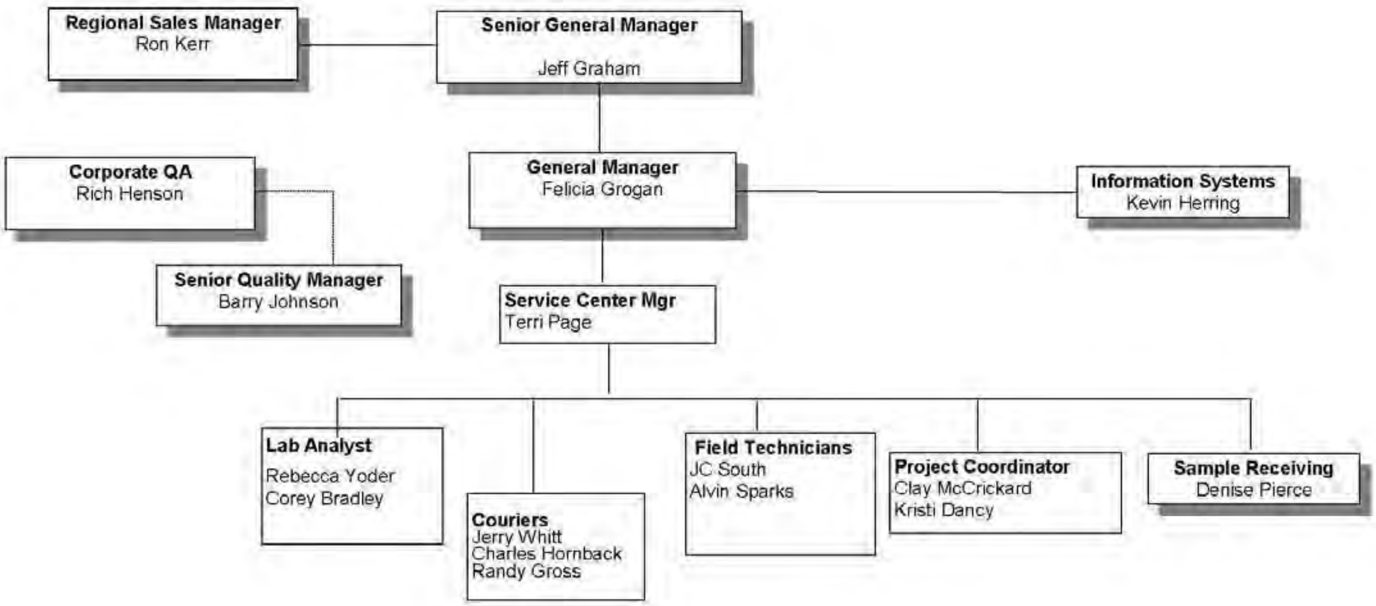


Revised 5/9/2017



Revised 11/11/2016

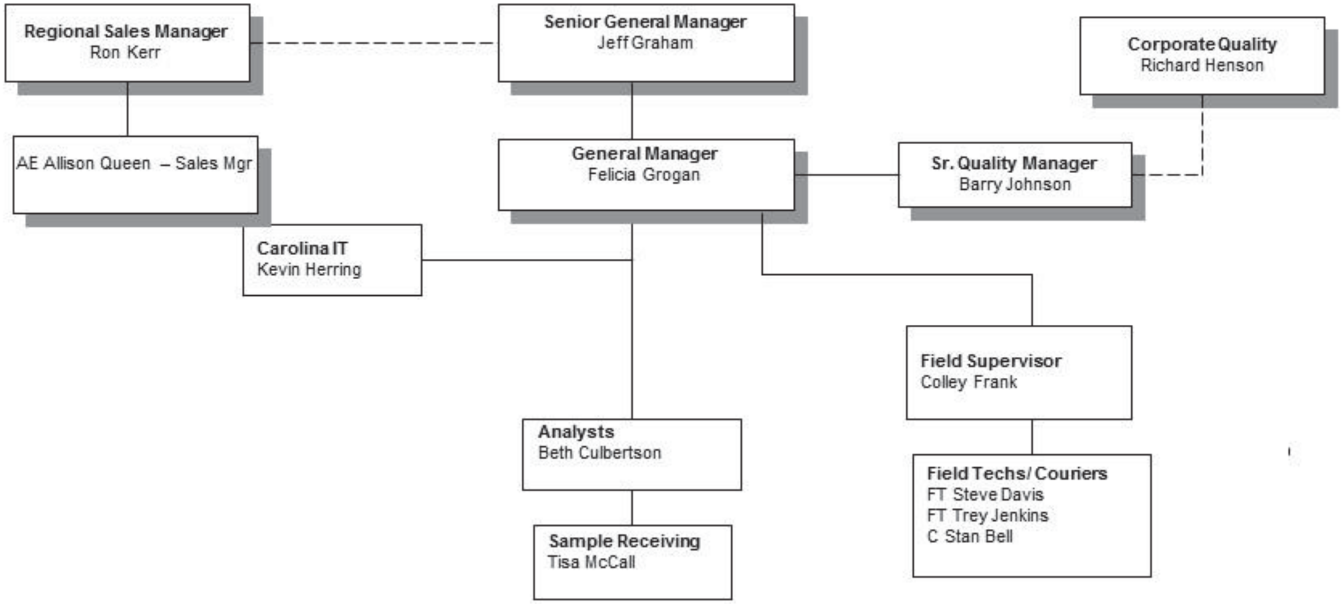
PACE CAROLINA'S EDEN ORGANIZATION CHART



Revised 5/12/2017

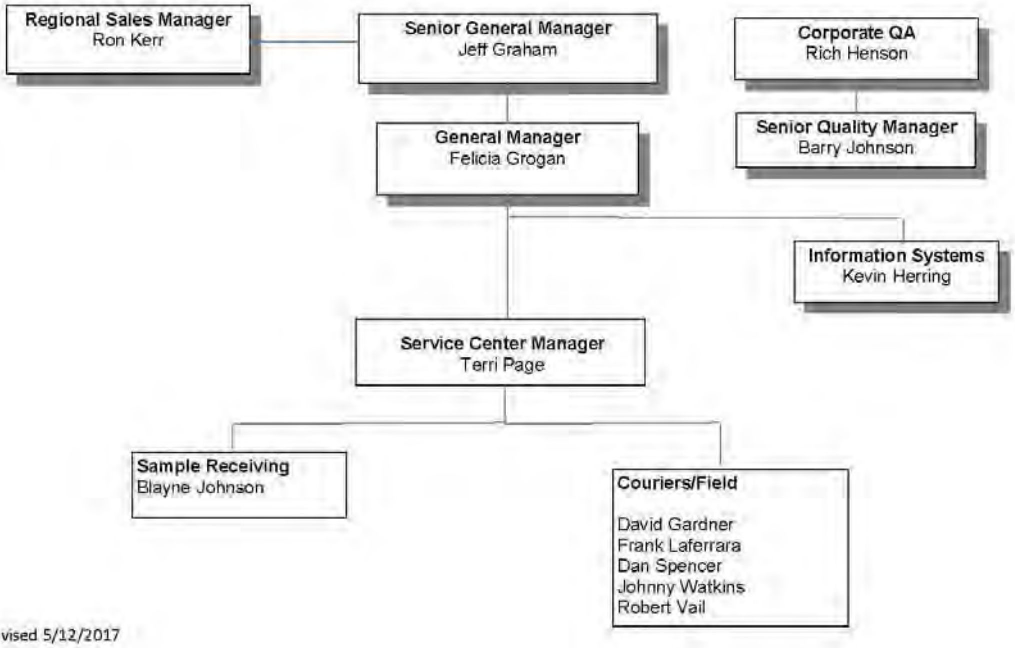
Eden_05122017Org Chart

Pace Carolina's Greenwood Laboratory Organization Chart



Revised 5/12/2017

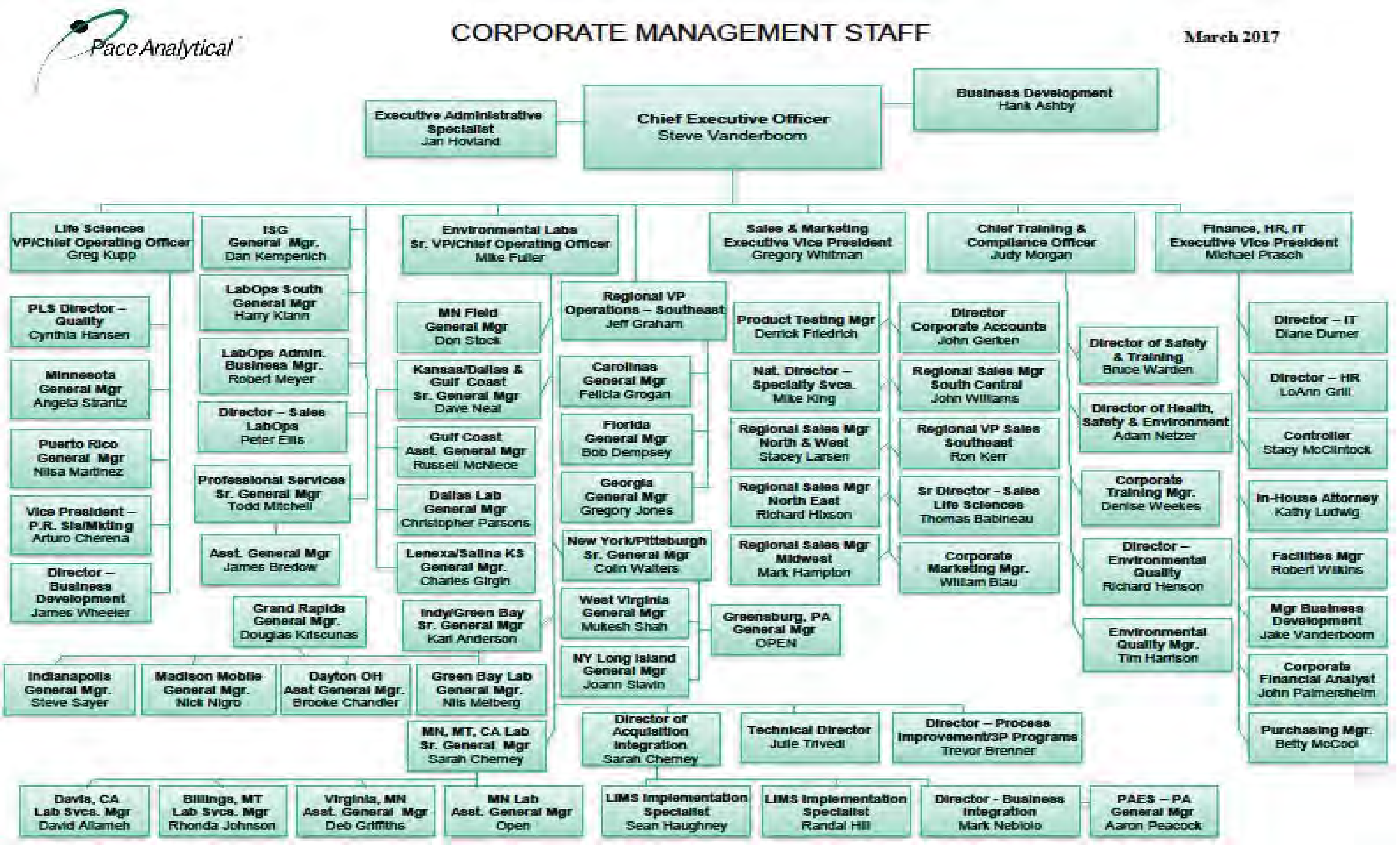
PACE CAROLINA'S RALEIGH ORGANIZATION CHART



Revised 5/12/2017

Revised 5/12/2017

ATTACHMENT III- CORPORATE ORGANIZATIONAL CHART (CURRENT AS OF ISSUE DATE)



ATTACHMENT IV- EQUIPMENT LIST (CURRENT AS OF ISSUE DATE)

Laboratory	Location	Equipment ID	Model / Detector	Equipment	Manufacturer	Serial #	Use
AVL	Quality	Balance #11	CP225D	Balance	Sartorius	22011529	Calibrations
AVL	Micro	Que-2	3325	Colony Counters	Quebec	None	Fecal coliform/HPC
AVL	Metals	92ICP3	ICAP 6500	ICP Analyzer	Thermo Elemental	ICP-2010-4901	ICP
AVL	Metals	Tumbler #2	NA	TCLP Tumbler	Environmental Express	NA	TCLP
AVL	Metals	Tumbler #3	NA	TCLP Tumbler	Environmental Express	NA	TCLP
AVL	Metals	92HG1	M7500	Hg Analyzer	CETAC	100402QTA	Mercury
AVL	Metals	Hotblock 2(36B)	36 Position	Metals Hotblock	Environmental Express	NA	Back Up
AVL	Hg Room	Hotblock 3	36 Position	Metals Hotblock	Environmental Express	NA	Metals
AVL	Metals	Hotblock 5	SC Custom 96 position	Metals Hotblock	Environmental Express	6815CECW3105	Metals
AVL	Metals	92LLHG	M-8000	LL Hg Analyzer	CETAC	071202QM8	LL Hg
AVL	Metals	92ICP4	730-ES	ICP Analyzer	Varian	EL06123880	ICP
AVL	Metals	Centrifuge #1	Rotina 46 S	Centrifuge	Henttich	33180200	Metals Prep
AVL	Metals	Hotblock 7	SC Custom 96 position	Metals Hotblock	Environmental Express	8940CECW3899	Metals
AVL	Wet Chemistry	Balance #5	200DS	Balance	Fisher	BO27039	TSS, TDS, reagents
AVL	Wet Chemistry	Balance #1	PE 400	Balance	Mettler	B29715	Solids/Others

Laboratory	Location	Equipment ID	Model / Detector	Equipment	Manufacturer	Serial #	Use
AVL	Wet Chemistry	Balance #2	xs105DU	Balance	Mettler Toledo AG	1129312116	Solids/Others
AVL	Wet Chemistry	pH meter#2	EA 420A	Expandable Ion Analyzer	Orion	24455	TCLP prep
AVL	Wet Chemistry	COD Reactors (3)	45600	COD Reactor	HACH	900602688	COD
AVL	Wet Chemistry	COD Reactors (1)	45600	COD Reactor	HACH	900601686	COD
AVL	Wet Chemistry	92WTA8	QuickChem 8500	Lachat Analyzer II	Lachat	10080001233	TCN, TKN, Chloride, TP, NH3
AVL	Wet Chemistry	Lachat Micro Dist #2	NA	Lachat Hot block	Lachat Micro Dist.	100700002077	Phenol / TCN
AVL	Wet Chemistry	Lachat Micro Dist #3	NA	Lachat Hot block	VWR	20101008	Phenol / TCN
AVL	Wet Chemistry	Oven #2	655F	Oven	Fisher Isotemp	80600048	TDS<100°C
AVL	Wet Chemistry	DO Meter 1	5100	DO Meter	YSI	98E0889	BOD
AVL	Wet Chemistry	92WTA1	399-W001-01	Smartchem Analyzer	Westco	W0601081	Ammonia, Ferrous Iron
AVL	Wet Chemistry	NA	Aim600	TKN Block or Controller	NA	4826A13455	TKN
AVL	Wet Chemistry	92WTA6	TOC-Vcpn	TOC Analyzer	Shimadzu	H51404535060CS	TOC
AVL	Wet Chemistry	92WTA7	761	IC Analyzer	Metrohm	11145	F and SO4
AVL	Wet Chemistry	Filtration Processor	788	IC Analyzer Sampler	Metrohm	4119	F and SO4
AVL	Wet Chemistry	Ref#1	NA	Refrigerator	Norlake	NA	Shorthold
AVL	Wet Chemistry	Walk-in #2	LSCO5ZAS	Incubator	Heat Craft	D95M 03829	BOD Walk In

Laboratory	Location	Equipment ID	Model / Detector	Equipment	Manufacturer	Serial #	Use
AVL	Wet Chemistry	Freezer #6	NA	Freezer	General Electric	NA	BOD Seed
AVL	Wet Chemistry	Ref #6	NA	Refrigerator	General Electric	NA	Back Up
AVL	Wet Chemistry	Conductivity Meter #2	Orion 3 Star Benchtop Cond Meter	Conductivity Meter	Thermo Scientific / Orion	B29683	Conductivity
AVL	Micro	INC#1	1530	Incubator	VWR	NA	Total Coliform 35°C
AVL	Wet Chemistry	NA	NA	Autoclave	Market Forge	NA	Sterilization
AVL	Wet Chemistry	92WETD	888 Titrando	Analyzer	Metrohm	1789002162	pH, Cond, Alk
AVL	Wet Chemistry	DO Meter 4	5100	DO Meter	YSI	01K0797	BOD
AVL	Wet Chemistry	COD Block 4	DRB 200	COD Block	HACH	1105719	COD
AVL	Wet Chemistry	COD Block 5	45600	COD Block	HACH	890700288	COD
AVL	Wet Chemistry	92WTA9	761	IC Analyzer	Metrohm	12193	F and SO4
AVL	Wet Chemistry	NA	788	IC Analyzer Sampler	Metrohm	N/A	F and SO4
AVL	Wet Chemistry	Oven #3	130	Oven	Precision	9606-003	TDS
AVL	Wet Chemistry	92WET2	Turb 550T	Turbidity Meter	VWR	20100008	Turbidity
AVL	Wet Chemistry	COD Block 7	45600-00	COD Block	HACH	920300006758	COD
AVL	Wet Chemistry	92WTAA	QuickChem 8500	Lachat Analyzer III	Lachat	A83000-2000	Chlorine, TCN, TP
AVL	Field	92WET8	DR 2800	Chlorine Meter	HACH	1198691	low level Chlorine Lab Field
AVL	Micro	water bath #3	182	Water Bath	Precision	10Az-11	QC Testing
AVL	Micro	Water bath #1	66850	Water Bath	Precision	10AY-4	Fecal Coliform (MF) Water Bath
AVL	Micro	INC#2	302	Incubator	Lab Line	0390-0143	Fecal Coliform

Laboratory	Location	Equipment ID	Model / Detector	Equipment	Manufacturer	Serial #	Use
			Imperial III				
AVL	Micro	92BIO5	89-108 94.02	Idexx Quanti Tray Sealer	IDEXX	04412-06-0127	Fecal Coliform Col 18
AVL	Sample Receiving	Walk-in #1	NA	Refrigerator	Arctic	NA	NA
AVL	Wet Chemistry	Ref #8	GDM-72	Refrigerator	TRUE	1-4434482	Std /Reagents
AVL	Waste Chem	92WST5	TOX-100	TOX	Mitsubishi	A7M-30181	Chlorine
AVL	Waste Chem	92WST6	6300 Bomb Calorimeter	BTU	PARR	M9807	BTU
AVL	Metals	Balance # 6	PJ300	Balance	Mettler	I11088	Metals Prep
AVL	Waste Chem	92WST3	S-144DR	Sulfur	LECO	3170	Sulfur
AVL	Waste Chem	92WST7	S-632	Sulfur	LECO	3122	Sulfur
AVL	Quality	Balance #8	CP 124 S	Balance	Sartorius	19550801	QA use
AVL	Waste Chem	92WST4	F47900	Muffle Furnace	Thermo Scientific	NA	Waste Chem/TVS/TVSS
AVL	Waste Chem	Balance #9	BP 121S	Balance	Sartorius	90108632	
AVL	Field	F-1	Pocket Colormeter	Meter	HACH	960600096027	Cl2
AVL	Field	F-2	Pocket Colormeter	Meter	HACH	011100171841	Cl2
AVL	Field	F-3	PC Tester 30	Meter	Oakton	1274116	pH Temp
AVL	Field	F-4	Accumet AP 62	Meter	Accumet	1107794	pH Temp
AVL	Field	F-6	YSI Pro 20	Meter	YSI	JC 01272	DO Temp
AVL	Field	F-7	YSI 30	Meter	YSI	03K1054	Sp.Cond
AVL	Wet Chemistry	Oven #5	1350F	Oven	VWR	0100100	TSS oven

Laboratory	Location	Equipment ID	Model / Detector	Equipment	Manufacturer	Serial #	Use
AVL	Field	F-8	YSI Pro Plus	Meter	YSI	14F101975	pH Temp ORP DO
AVL	Field	F-9	2020we	Meter	LaMotte	1372-3811	Turbidity
AVL	Wet Chemistry	NA	BD-28s/BD50s	TKN Controller	Lachat	4811A13131 - Controller	TKN Block
AVL	Wet Chemistry	NA	Seal	TKN Block	Lachat	4811A13137 - Block	TKN Block
AVL	Wet Chemistry	92WETA	DR 3900	Spectrophotometer	HACH	1582033	TRC, OP, COD, LL COD , S
AVL	Metals	92HG4	M-7600	Hg Analyzer	CETAC	011502Q76	Hg Analyzer
AVL	Wet Chemistry	Oven #6	Heratherm OMH750	Oven	Thermo Fisher	41729011	TSS Oven
AVL	Sample Receiving	Walkin #3	KPS-300	Refrigerator	Kysor	N/A	Sample Storage
AVL	Wet Chemistry	pH meter#1	EA 420A	Expandable Ion Analyzer	Orion	27727	pH
AVL	Wet Chemistry	pHMeter #5	Orion Star A211	pH Meter	Fisher / Orion	X16842	pH
AVL	Metals	Hotblock 10	DigiPrep MS 108 position	Metals Hotblock	SCP Science	MSB1015060047	Metals
AVL	Metals	Hotblock 8	DigiPrep MS 48 position	Metals Hotblock	SCP Science	MSX0510120717	Metals
AVL	Wet Chemistry	NA	BD46	TKN Block	Lachat	1800-282	TKN Block
AVL	Wet Chemistry	N/A	ASIV	TOC Autosampler	HACH	H52104301662	Autosampler
AVL	Wet Chemistry	N/A	SSM-5000A	TOC Solids Unit	HACH	H52504300074	Solids Unit for TOC
AVL	Wet Chemistry	N/A	Series III	Lachat Efluent Pump		A28911-852	N/A
AVL	Wet Chemistry	N/A	ASX-510	Lachat Autosampler	Lachat	100124ASX	N/A
AVL	Wet	N/A	2200-010	Lachat	Lachat	2000-12	N/A

Laboratory	Location	Equipment ID	Model / Detector	Equipment	Manufacturer	Serial #	Use
	Chemistry			Pump			
AVL	Wet Chemistry	N/A	QC 8500 Series 2	Lachat Unit	Lachat	90300001082	N/A
AVL	Waste Chem	92WST8	TOX-300	TOX	Mitsubishi Chemical Analytech	HOAA0034	Chlorine
AVL	Wet Chemistry	Oven #7	3488M	Oven	Barnstead International	1820061118035	TSS Oven
AVL	Metals	92ICM3	7900 ICMPS-3	ICPMS	Aglient	JP16071303	Metals
AVL	Metals	92HG5	Quicktrace M8000	LL Hg Analyzer	Teledyne	VS16050009	LL Mercury
AVL	Metals	Balance #4	AB54-S	Balance	Mettler / Toledo	1126450078	Back Up
AVL	Wet Chemistry	Balance #10	CEM	Balance	Denver	18651	Back up
AVL	Wet Chemistry	92WTAC	930	IC Analyzer	Metrohm	1930100004114	F,Cl,SO4
AVL	Wet Chemistry	Filtration Processor	858	IC Analyzer Sampler	Metrohm	N/A	F,Cl,SO4
AVL	Wet Chemistry	92WETE	PMA5	Flashpoint Analyzer	Anton Parr	60039989	Flashpoint
AVL	Metals	92ICM2	7900 ICMPS	ICPMS	Aglient	JP15260892	Metals
AVL	Wet Chemistry	N/A	Mili-Q	DI Water Purification System	Academie	F4EN78616	DI water purification System
AVL	Wet Chemistry	Oven #8	750G	Oven	Fisher Scientific	N/A	NIU
AVL	Sample Receiving	Ref#2	NA	Refrigerator	Roper	NA	Back UP VOA Samples
AVL	Sample Receiving	Freezer #2	NA	Freezer	Roper	NA	Back UP VOA Samples
AVL	Hg Room	Hotblock 11	SC 151	Metals Hotblock	Environmental	3994CEC1869	Metals

Laboratory	Location	Equipment ID	Model / Detector	Equipment	Manufacturer	Serial #	Use
					Express		
AVL	Field	F-10	Micro TP1 20008	Meter	HF Scientific	201503159	Turbidity
AVL	Field	F-11	DR 1900	Meter	HACH	153310001007	Cl2 Meter
AVL	Wet Chemistry	1	NA	Fume Hood	St. Charles	NA	TKN Blocks / Waste
AVL	Wet Chemistry	2	NA	Fume Hood	St. Charles	NA	Lachat Blocks / muffle Furnace
AVL	Hg Room	3	NA	Fume Hood Enclosure	Cetac	NA	Hg analyer
AVL	Wet Chemistry	5	Canopy	Fume Hood Enclosure	NA	NA	NIU
AVL	Metals Prep	6	Airlite Filter Enclosure	Fume Hood Enclosure	Environmental Express	NA	Hotblocks
AVL	Metals Prep	7	Airlite Filter Enclosure	Fume Hood Enclosure	Environmental Express	NA	Metals Reagents / Prep
AVL	Metals	8	Airlite Filter Enclosure	Fume Hood Enclosure	Environmental Express	NA	Varian Auto Sampler
AVL	Purge Room	9	Canopy	Fume Hood Enclosure	NA	NA	Non hazardous disposal
AVL	Metals Prep	10	Semi Enclosure	Fume Hood Enclosure	CB	NA	Hotblocks
AVL	Metals	10B	Airlite Filter Enclosure	Fume Hood Enclosure	Environmental Express	NA	Auto sampler
AVL	Metals Prep	11	Semi Enclosure	Fume Hood Enclosure	CB	NA	Metals Reagents
AVL	Wastechem	12	Semi Enclosure	Fume Hood Enclosure	CB	NA	Balance
AVL	Wastechem	13	Semi Enclosure	Fume Hood Enclosure	CB	NA	TOX
AVL	LL Hg	14	Filter Hood	Fume Hood Enclosure	Cetac	NA	Reagents
AVL	LL Hg	15	ENC500 Filter Hood	Fume Hood Enclosure	Cetac	NA	Auto sampler

Laboratory	Location	Equipment ID	Model / Detector	Equipment	Manufacturer	Serial #	Use
AVL	LL Hg	16	ENC500 Filter Hood	Fume Hood Enclosure	Cetac	NA	Auto sampler
AVL	Metals	17	ENC500 Filter Hood	Fume Hood Enclosure	Cetac	NA	Auto sampler
AVL	Metals	18	ENC500 Filter Hood	Fume Hood Enclosure	Cetac	NA	Auto sampler
AVL	Metals Prep	19	DigiPrep Filter Enclosure	Fume Hood Enclosure	SCP Science	NA	Hotblock
AVL	Wastechem	20	Canopy	Fume Hood Enclosure	CB	NA	ASH/ BTU
AVL	Hg Room	21	NA	Fume Hood Enclosure	NA	NA	Hg Reagents
AVL	Wetchem	92WTAD	QC8500 Series 2	Lachat Unit	Hach	161000001983	Nitrate + Nitrite, Phenol
AVL				Lachat Pump	Hach		
AVL				Lachat Autosampler	Hach		
AVL	Wetchem	92WETF	SP2005	BOD Robot	Skalar	16275	BOD
AVL	Wetchem	DO Meter 5	Pro Comm II	DO Meter	YSI	160104173	BOD
AVL	Wetchem	DO Probe 5		DO Probe	YSI	16J102373	BOD
AVL	Wetchem	DO Meter 6	Pro Comm II	DO Meter	YSI	16F182651	BOD
AVL	Wetchem	DO Probe 6		DO Probe	YSI	16F103698	BOD
CHLT	Semivolatiles	92GCS11	6890 / Dual FID	GC / FID	Agilent	US00028077	Mass EPH
CHLT	Semivolatiles	92GCS5	6890 / Dual micro ECD	GC / ECD	Agilent	US00043919	8011, 504.1, 552.2, 8081B, 8082A
CHLT	Semivolatiles	92GCS6	6890N / Dual micro ECD	GC / ECD	Agilent	CN10426006	8011, 504.1, 552.2, 8081B, 8082A

Laboratory	Location	Equipment ID	Model / Detector	Equipment	Manufacturer	Serial #	Use
CHLT	Semivolatiles	92GCS8	6890 / Dual FID	GC / FID	Agilent	CN10820003	DRO
CHLT	Semivolatiles	92GCS9	7890A / Dual micro ECD	GC / ECD	Agilent	CN11111076	8011, 504.1, 552.2, 8081B, 8082A
CHLT	Semivolatiles	92MSS3	7890A / MS-5975C	GC / MS	Agilent	CN10816094 / US80819049	8270D, 625, 8270D SIM
CHLT	Semivolatiles	92MSS4	6890N / MS-5975C	GC / MS	Agilent	CN10716061 / US83121512	8270D, 625, 8270D SIM
CHLT	Semivolatiles	92MSS5	6890N / MS-5975C	GC / MS	Agilent	US10628085 / US81819411	8270D, 625, 8270D SIM
CHLT	Semivolatiles	92MSS6	7890N / 5975C	GC / MS	Agilent	CN10251042 / US10263621	8270, 625
CHLT	Volatiles	92GCV1	5890A Series II / PID/FID	GC/PID/FID	Hewlett-Packard	2921A23623	Mass VPH, (GRO)
CHLT	Volatiles	92GCV4	5890E / PID/FID	GC/PID/FID	Hewlett-Packard	3336A56045	GRO, (VPH)
CHLT	Volatiles	92MSV1	6890N / MS-5973	GC / MS	Agilent	CN10805009 / US94240030	8260/524/624
CHLT	Volatiles	92MSV3	6850 / MS-5975C	GC / MS	Agilent	CN10805009 /US92012898	6200B
CHLT	Volatiles	92MSV4	7890A / MS-5975C	GC / MS	Agilent	CN10251038 / US10313603	8260/624/6200
CHLT	Volatiles	92MSV5	6890 / MS-5973	GC / MS	Agilent	US00026359 / US82322063	8260B, 524.2

Laboratory	Location	Equipment ID	Model / Detector	Equipment	Manufacturer	Serial #	Use
CHLT	Volatiles	92MSV6	6850 / MS-5975C	GC / MS	Agilent	CN10802003 / US80118209	8260B
CHLT	Volatiles	92MSV8	7890A / MS-5975C	GC / MS	Agilent	CN11461033 / US71236032	8260B
CHLT	Volatiles	92MSV9	7890A / MS-5973	GC / MS	Agilent	US10247095 / US21864294	8260
CHLT	Volatiles	92GCV8	5890 Series II/FID	GC	Agilent	2843A21058	RSK-175
CHLT	Extractions	MW-1	MARSX	Microwave	CEM	PASI19706	Soil Extraction (3546)
CHLT	Extractions	OG-3	SPE-DEX 3000XL	SPE unit	Horizon	14-1947	Oil&Grease (1664B)
CHLT	Extractions	OG-4	3000XL	SPE unit	Horizon	14-1948	Oil&Grease (1664B)
CHLT	Extractions	SPEEDVAP-3	SpeedVap III	Evaporator	Horizon	14-0881	Concentration (1664B, 9071B)
CHLT	Extractions	SPEEDVAP-4	SpeedVap III	Evaporator	Horizon	14.0883	Concentration (1664B, 9071B)
CHLT	Extractions	SPEEDVAP-2	SpeedVap II	Evaporator	Horizon	00-284	Concentration (1664B, 9071B)
CHLT	Extractions	B-15	SLF302	Balance	Fisher	B621516831	Top-loading Balance
CHLT	Extractions	B-1	R200D	Balance	Sartorius	40040069	Analytical Balance
CHLT	Semivolatiles	B-3	PM2500	Balance	Mettler	K59661	Top-loading balance
CHLT	Volatiles	B-13	PL6001E	Balance	Mettler	B528162097	Top-loading balance
CHLT	Volatiles	B-5	SP202	Balance	Ohaus	7123170886	Top-loading balance
CHLT	Extractions	B-14	PL6001E	Balance	Mettler	B525065656	Top-loading balance
CHLT	Extractions	B-8	SP601	Balance	Ohaus	7131280840	Top-loading balance
CHLT	Extractions	B-10	SP601	Balance	Ohaus	B23628698	Top-loading

Laboratory	Location	Equipment ID	Model / Detector	Equipment	Manufacturer	Serial #	Use
						3	balance
CHLT	Client Services	I-3	Isotemp 503	Incubator	Fisher	361	Total Coliform (SM 9223B)
CHLT	Client Services	I-4	Coliform Incubator Bath	Incubator	Precision	9608-007	Fecal Coliform (SM 9222D)
CHLT	Client Services	O-10		Oven	Thermo Scientific	41976036	percent moisture
CHLT	Client Services	O-2	Isotemp	Oven	Fisher	7859	Oven (SM 2540G)
CHLT	Extractions lab	TCLP-2	42R5BFCI-E3	TCLP Rotator	Bodine Electric Company	0685PXLG 0005	1311/ 1312
CHLT	Main Lab	TCLP-6	34RBFC1-5R	Tumbler	Associated Design & Mfg Co.	0469AQHP 0024	1311 / 1312
CHLT	Extractions	SHAKER-1	3D Shaker	Shaker	Glas-Col	11324048	Sep Funnel Shaker
CHLT	Extractions	SHAKER-2	3D Shaker	Shaker	Glas-Col	11324049	Sep Funnel Shaker
CHLT	Extractions	WB-1	Isotemp 120	Water Bath	Fisher		Concentration
CHLT	Semivolatiles	WB-3	Isotemp GPD 20	Water Bath	Fisher	300092305	HAA
CHLT	Client Services	PH-1	Accumet AP61	pH Meter	Fisher	220713	pH meter
CHLT	Extractions	R-31		Freezer	Whirlpool		Sample Storage
CHLT	Extractions	R-29		Deli Cooler	TRUE		Sample Storage
CHLT	Extractions	Turbovap 1	Turbovap II	Evaporator	Biotage	TV1121N1 6573	Concentration
CHLT	Extractions	Turbovap 2	Turbovap II	Evaporator	Biotage	TV1121N1 6576	Concentration
CHLT	Extractions	Turbovap 3	Turbovap II	Evaporator	Biotage	TV1126N1 6618	Concentration
CHLT	Extractions	Turbovap 4	Turbovap II	Evaporator	Biotage	TV1121N1 6577	Concentration

Laboratory	Location	Equipment ID	Model / Detector	Equipment	Manufacturer	Serial #	Use
CHLT	Extractions	TurboVap 6	Turbovap II / 46368-A	Evaporator	Zymark	TV9445N5821	Concentration
CHLT	Semivolatiles	DI-2	N/A	Deionized Water Tap	N/A		
CHLT	Volatiles - MSV old	DI-3	N/A	Deionized Water Tap	N/A		
CHLT	Volatiles - MSV new	DI-4	N/A	Deionized Water Tap	N/A		
CHLT	Volatiles - GCV	DI-5	N/A	Deionized Water Tap	N/A		
CHLT	Extractions - window	DI-6	N/A	Deionized Water Tap	N/A		
CHLT	Extractions - shake out	DI-7	N/A	Deionized Water Tap	N/A		
CHLT	Extractions - concentration	DI-8	N/A	Deionized Water Tap	N/A		
CHLT	Field	DI-9		Deionized Water Tap	MilliQ DI water system		
CHLT	Volatiles	GEN-1	PEAK Scientific Inst. Ltd	Gas Generator	Zero Air Gas Generator	B-11-08-172	Air for FIDs
CHLT	Prep	O-8	DX-41	Oven	Baxter	2500021	Oven
CHLT	Sample Receiving	I-6	T26B-120085-UB	Incubator	Revco		Total Coliform/HPC
CHLT	Sample Receiving	O-9	STM80	% Moisture Oven	Precision Scientific	Q49216	% Moisture
CHLT	Sample Receiving	92-F-1	WZF34X16DW00	Freezer	Whirlpool	U55102641	VOA FROZEN
CHLT	Volatiles	92MSV10	5890 / 7694	GC / MS	Hewlett-Packard / Agilent	2843A21058 / IT10110720	Screener
CHLT	Extractions lab	TCLP-9	42R6FC1FX3	TCLP Rotator			1311/ 1312

Laboratory	Location	Equipment ID	Model / Detector	Equipment	Manufacturer	Serial #	Use
CHLT	SVOA	92GCS10	6890N	GC	Agilent	US10302103	8011/504.1
CHLT	Sample Receiving	R-37	NA	Deli Cooler	TRUE	NA	asheville storage
CHLT	OEXT	B-11	Scout Pro Balance	Balance	Ohaus	B430850191	Weight out soils for extraction
CHLT	Micro	B-12	Quintix124-1S	Balance	Sartorius	32550238	% Moisutre
CHLT	Volatiles	Concentrator	Evolution	Concentrator	EST	660032515	Concentration
CHLT	OEXT	N-EVAP-1	115	Evaporator	Organomation	8373	concentration
CHLT	main lab	92-WI-1		Walkin Refrigerator			New walk-in
CHLT	volatiles	92GCV6	6890 / Dual FID	GC / FID	Hewlett-Packard	US00021801	RSK-175
CHLT	Volatiles	92MSV7	6890N / 5973	GC / MS	Agilent	CN10430013 / US44621070	
CHLT	Volatiles	Autosampler	LGX-50	Autosampler	EST	LGX113012116	
CHLT	Volatiles	Autosampler	Centurion W/S	Autosampler	EST	CENTS482062514	
CHLT	volatiles	Concentrator	Encon	Concentrator	EST	EV591062514	
CHLT	main lab	92-W-3		Deli Cooler	TRUE		water vial storage
CHLT	main lab	92-W-4	GDM-72	Deli Cooler	TRUE	10211623	water vial storage
CHLT	main lab	92-W-2		Deli Cooler	TRUE		water vial storage
CHLT	main lab	92-WI-2		Walkin Refrigerator			OLD WALK-IN
CHLT	main lab	92-W-1		Deli Cooler	TRUE		water vial storage
CHLT	main lab	92-SL-1		Deli Cooler	TRUE		8260 & VPH
CHLT	sample receiving	92-SUB-1		Deli Cooler	Superior		SUB IN/OUT storage
CHLT	sample receiving	92-D-1		Deli Cooler	TRUE		Asheville storage deli

Laboratory	Location	Equipment ID	Model / Detector	Equipment	Manufacturer	Serial #	Use
CHLT	Semivolatiles	92GCS12	6890N	GC / ECD	Agilent	CN10522046	
CHLT		R-28		Refrigerator	Frigidaire		
CHLT		R-33		Freezer	Frigidaire		
CHLT	Main Lab	R-39	253.7072241	Refrigerator	Kenmore	WA51601991	storage
CHLT	Volatiles	Autosampler	Centurion W/S	Autosampler	EST	CENTS448053013	
CHLT	Volatiles	Autosampler	Centurion W/S	Autosampler	EST	CENTS436020513	
CHLT	Volatiles	Autosampler	Centurion W/S	Autosampler	EST	CENTW303091509	
CHLT	Volatiles	Autosampler	Centurion W/S	Autosampler	EST	CENTS173072810	
CHLT	volatiles	Concentrator	Encon	Concentrator	EST	EV452121212	
CHLT	volatiles	Concentrator	Encon	Concentrator	EST	EV660032515	
CHLT	volatiles	Concentrator	Encon	Concentrator	EST	EV328111510	
CHLT	volatiles	Concentrator	Encon	Concentrator	EST	EV392010312	
CHLT	volatiles	Concentrator	Encon	Concentrator	EST	EV312072810	
CHLT	volatiles	Concentrator	Encon	Concentrator	EST	EV319080210	
CHLT	volatiles	92GCV7	6890 / FID	GC/ FID	Hewlett-Packard	US00000730	VPH
CHLT	OEXT	GPC	AIM3310	Gel Permeation Unit	J2 Scientifice	4738A12420	Gel Permeation Chromatography
EDN	Wet Chemistry	Eden001	CTX17KAB	Refrigerator	Hotpoint	HV776598	Storage
EDN	Wet Chemistry	Eden002	CTX17	Refrigerator	Hotpoint	RT733500	Ice Packs
EDN	Wet Chemistry	Eden004	4	Incubator	Precision	22AJ-11	Total Coliform
EDN	Wet	Eden005	1545	Incubator	VWR	901391	Total Coliform

Laboratory	Location	Equipment ID	Model / Detector	Equipment	Manufacturer	Serial #	Use
	Chemistry						
EDN	Wet Chemistry	Eden006	GP400	Water Bath	Neslab	44.5 C	Fecal Coliform
EDN	Wet Chemistry	Eden008	3510FS	Incubator	Fisher	1879070501400	Solids
EDN	Wet Chemistry	95EDN2	2X	Quanti tray Sealer	Idexx	4518	Ecoli Col 18 Enterococci
EDN	Wet Chemistry	95EDN3	YSI5100	Meter	YSI	00K0582	BOD
EDN	Wet Chemistry	95EDN4	DR2800	Analyzer	HACH	1207494	Color, Hex Chrom, OP
EDN	Wet Chemistry	Eden013	Colorimeter	meter	HACH	1230128764	Chlorine
EDN	Wet Chemistry	95EDN5	SA55NXGTE	Vacuum Pump	Emerson	L87 7	Fecal Coliform
EDN	Wet Chemistry	Eden015			Fisher	803N0752	Fecal Coliform
EDN	Wet Chemistry	95EDN6	720A+	Analyzer	Thermo Orion	92569	Nitrate
EDN	Wet Chemistry	95EDN7	A-160	Balance	Denver Instrument	N0090021	Solids
EDN	Wet Chemistry	Eden018	UVL-56	UV Lamp	Blak-Ray	C22.2	Total Coliform
EDN	Wet Chemistry	Eden019	AP5	meter	Fisher		pH
EDN	Wet Chemistry	Eden020	AP61	meter	Fisher		pH & Temp
EDN	Wet Chemistry	Eden021	Safeaire	Fume Hood	Hamilton	NA	Sample Receiving / Other
EDN	Wet Chemistry	Eden022	R-55-ST	Refrigerator	Migali	1192185	Sample Receiving
EDN	Wet Chemistry	Eden023	Isotemp	Refrigerator	FisherScientifc	NA	BOD
EDN	Wet Chemistry	95EDN8	420A	Meter	Orion	8759	pH
EDN	Wet Chemistry	Eden025	VOLTS	Refrigerator	Precision	9301-02	BOD
EDN	Wet Chemistry	Eden026		?			TSS
EDN	Field	Eden027	Pocket	Meter	HACH	13120E237	Chlorine

Laboratory	Location	Equipment ID	Model / Detector	Equipment	Manufacturer	Serial #	Use
			Colormeter			627	
EDN	Wet Chemistry	Eden028	Moch 1-37L	Incubator	Percival	92J3561.5	BOD
EDN	Wet Chemistry	Eden029	130D	Oven	Precision	9606-003	TSS
EDN	Wet Chemistry	Eden030	1-35 L	Incubator	Percival	91F3518.7	Fecal Colilert 18
EDN	Wet Chemistry	Eden032	1350G	Oven	Shell-Lab	1861350	TSS oven
EDN	Wet Chemistry	Eden033	GR-1310W	?	NA	80402713	Media Plate Supplies
EDN	Wet Chemistry	Eden034	420A	Meter	Orion	8609	pH Meter
EDN	Wet Chemistry	Eden035	2340M	Autoclave	Brinkmann	9701428	Sterilization
EDN	Wet Chemistry	Eden036	516D	Oven	Fisher Scientific	111N0097	Enterococci
EDN	Wet Chemistry	Eden037	1350F	Incubator	VWR	0100100	Ecoli
EDN	Wet Chemistry	95EDNC	Genesys 10 UV	UV Meter	Genesys	2GBC259001	UV ; Free TCN
EDN	Wet Chemistry	Eden039		COD Block	HACH	941200011843	COD
EDN	Wet Chemistry	Eden040	45600-00	COD Block	HACH	920900013148	COD
EDN	Micro	Eden038	Economy	Fecal Incubator	Precision Scientific	601091184	Fecal Incubator
EDN	Wetchem Lab	Eden041	815	BOD Incubator	Precision Scientific	9408-029	BOD Incubator
EDN	Sample Receiving	Eden042	LFHT1817LB4	Refrigerator /Freezer	Frigidaire	BA14821285	Sample Storage
EDN	Wet Chemistry		TOC-VCSH	TOC Unit	HACH	H51104335168CS	TOC Unit
EDN	Micro	Eden043	5317-0120	Desiccator	Nalgene		Micro
EDN	Wet	Eden044	NA	Desiccator	FisherSc	NA	TSS

Laboratory	Location	Equipment ID	Model / Detector	Equipment	Manufacturer	Serial #	Use
	Chemistry				ientifc		
EDN	Wet Chemistry	Eden045	UMM-3135-0	Refrigerator	Hussman	93H05399-764	BOD/TSS
EDN	Wet Chemistry	Eden046	2X	Sealer	IDEXX	1152	E. coli
EDN	Wet Chemistry	Eden047	DRB 200	COD Block	HACH	1200676	COD
EDN	Wet Chemistry	95EDN9	AR20	pH Meter	Fisher Scientific	AR81201543	Alkalinity
EDN	Wet Chemistry	Eden049	A2000-835	Lachat min dist. Block	Lachat	2000-74	Ammonia
EDN	Wet Chemistry	95EDNA	399-Q001-01	Smartchem Analyzer	Westco	W0404051	Chloride/Ammonia
EDN	Wet Chemistry	Eden051	1275PH	Water Bath	VWR	7797	No2/no3
EDN	Wet Chemistry	95EDNB	LTC-3000we	Turbidity Meter	LaMotte	1324 -2016	Turbidity
EDN	Wet Chemistry	95EDN1	Phenoix 8000	TOC/DOC Analyzer	Dohrmann	99342014	TOC / DOC
GWD	Wet Chemistry	92WTAB	881		Metrohm	1881000116126	Anions
GWD	Wet Chemistry	92WTAC	Apollo 9000		Tekmar-Dohrmann	US02179008	TOC
GWD	Wet Chemistry	REF-16	564.954994		Sears	#040830696	WC Reagents
GWD	Wet Chemistry	THE-1	4001		Thermo Spectronic	3SGF344011	Phenols/Tot. PO4
GWD	Wet Chemistry	ASTP-1	2002AL		Aqua Solutions	042252AL	WC/Micro/Asbestos/Field
GWD	Wet Chemistry	HD-3	Unknown		Kewaunee Sc	Unknown	Exhaust Hood
GWD	Wet Chemistry	HD-4	Unknown		Kewaunee Sc	Unknown	Exhaust Hood
GWD	Wet Chem/Microbiology	WB-5	66885		Precision	10AZ-11	Fecal Coliform
GWD	Wet Chem/Micr	BAR-4	ST75935		Barnstead	1118990871243	Sterilization

Laboratory	Location	Equipment ID	Model / Detector	Equipment	Manufacturer	Serial #	Use
	obiology						
GWD	Wet Chem/Microbiology	UVP-1	CC-10		UVP	None	Microbiology
GWD	Wet Chem/Microbiology	UVP-2	UVSL-58		UVP	17077	Microbiology
GWD	Wet Chem/Microbiology	UVP-3	J-225		UVP	44399	UV Intensity Measurement
GWD	Wet Chem/Microbiology	INC-10	IC-43		Yamato	211010	Total Coliform/E. coli
GWD	Wet Chem/Microbiology	INC-6	2		Precision	227I	Spore Check Incubator
GWD	Wet Chem/Microbiology	IDX-2	2X		IDEXX	12-083-07416	E. coli
GWD	Wet Chem/Microbiology	SAR-4	AC120S		Sartorius	30103189	WC/Micro/Asbestos
GWD	Wet Chem/Microbiology	EEX-1	SC100		Environmental Express	145CECD240	Total PO4
GWD	Wet Chem/Microbiology	PH-3	720A		Orion	#011749	Phenols/Micro
GWD	Wet Chem/Microbiology	FUN-1	4238		Gelman	NA	Fecal Coliform
GWD	Wet Chem/Microbiology	FUN-2	4238		Gelman	NA	Fecal Coliform
GWD	Wet Chem/Microbiology	FUN-3	4238		Gelman	NA	Fecal Coliform
GWD	Wet Chem/Microbiology	FUN-4	4238		Gelman	NA	Fecal Coliform
GWD	Wet Chem/Microbiology	FUN-5	4238		Gelman	NA	Fecal Coliform

Laboratory	Location	Equipment ID	Model / Detector	Equipment	Manufacturer	Serial #	Use
GWD	Wet Chem/Microbiology	FUN-7	4238		Gelman	NA	Fecal Coliform
GWD	Wet Chem/Microbiology	FUN-8	4238		Gelman	NA	Fecal Coliform
GWD	Wet Chem/Microbiology	FUN-9	4238		Gelman	NA	Fecal Coliform
GWD	Wet Chem/Microbiology	FUN-10	4238		Gelman	NA	Fecal Coliform
GWD	Wet Chem/Microbiology	FUN-11	4238		Gelman	NA	Fecal Coliform
GWD	Wet Chem/Microbiology	TI-2	TI-36X Pro		Texas Instruments	K0413A	Calculations
GWD	Wet Chem/Microbiology	HD-5	Unknown		Kewaunee Sc	Unknown	Exhaust Hood
GWD	Wet Chem/Microbiology	HD-6	Unknown		Kewaunee Sc	Unknown	Exhaust Hood
GWD	Asbestos	BAL-1	StereoZoom 6		Bausch & Lomb	Unknown	Stereoscopic Exam of Asbestos
GWD	Asbestos	BAL-2	StereoZoom 6		Bausch & Lomb	Unknown	Stereoscopic Exam of Asbestos
GWD	Asbestos	OLY-1	BH-2		Olympus	#031520	PLM Exam of Asbestos
GWD	Asbestos	OLY-2	BH-2		Olympus	#036854	PLM Exam of Asbestos
GWD	Asbestos	OVN-10	AC 299186		Yamato	DX401B5200046	WC/Asbestos
GWD	Asbestos	OVN-11	FB1415M		Barnstead-Therm	746951030721	Asbestos
GWD	Asbestos	OVN-9	48000		Thermolyne	Unknown	Asbestos

Laboratory	Location	Equipment ID	Model / Detector	Equipment	Manufacturer	Serial #	Use
GWD	Asbestos	TI-1	TI-36X Pro		Texas Instruments	K1212A	Calculations
GWD	Asbestos	HD-7	Unknown		Kewaunee Sc	Unknown	Exhaust Hood
GWD	Asbestos	HD-8	Unknown		Kewaunee Sc	Unknown	Exhaust Hood
GWD	Mold	OLY-4	BX40F-3		Olympus	5J02789	Mold Analysis
GWD	Mold	CI-01	Z30 L		Cambridge Instruments	1153TP	Mold Analysis
GWD	Sample Receiving	REF-0	W		Hobart	53 680 960	Sample Storage
GWD	Sample Receiving	REF-13	ESUF15HW		Amana	9404903621	Micro Reagents Storage
GWD	Receiving Office	TRO-8	7036-1		Troemner	1000019942	2 mg ASTM Class 1 Weight
GWD	Receiving Office	TRO-10	NA		Troemner	#07621	Calibrate Balance
GWD	Field	OVN-12	6936		Thermo Fisher	272308-107	TCLP prep
GWD	Field	HFI-2	DRT-15CE		HF Scientific	Unknown	Turbidity
GWD	Field	HFI-3	DRT-15CE		HF Scientific	Unknown	Turbidity
GWD	Field	SAR-2	L2200P		Sartorius	37040166	TCLP prep
GWD	Field	YSI-1	59		YSI	95J38730	Field Dissolved Oxygen
GWD	Field	CLM-6	Pocket Colorimeter II		HACH	06100D059464	Field TRC
GWD	Field	CLM-7	Pocket Colorimeter II		HACH	#040100009468	Field TRC
GWD	Field	HAC-5	S180060		HACH	09070C751896	Field Specific Conductivity

Laboratory	Location	Equipment ID	Model / Detector	Equipment	Manufacturer	Serial #	Use
GWD	Field	HAC-6	SensIONS		HACH	09080C852014	Field Specific Conductivity
GWD	Field	HAC-7	5953004		HACH	13080E228377	Ozone
GWD	Field	INS-1	MDU-420		Indust. Scient.	9803108-006	Methane
GWD	Field	PH-13	SP70P		VWR	#000684	Field pH
GWD	Field	PH-16	SP20		VWR	#002134	Field pH
GWD	Field	PH-19	SP70P		VWR	C01937	Field pH
GWD	Field	PH-20	SP70P		VWR	C02016	Field pH
GWD	Field	PH-22	SP70P		VWR	C02476	Field pH
GWD	Field	YSI-3906	PRO PLUS		YSI	15F103906	Field pH
GWD	Field	YSI-3	58		YSI	92A035993	Field Dissolved Oxygen
GWD	Field	YSI-6	58		YSI	92E038703	Field Dissolved Oxygen
GWD	Field	YSI-7	ProPlus-4		YSI	JC019719	Field Dissolved Oxygen
GWD	Field	BARO-1	Unknown		Eberbach	Unknown	Barometer
GWD	Field	pH-25	250A		Orion	004900	pH
GWD	Greenwood	TRO-10	NA		Troemner	#07621	Calibra. NIST Cert. Wt.
GWD	Wetchem Lab	92WST8	TOX-300	TOX Analyzer	Mitsubishi	H0AA0034	Chlorine
GWD	Wetchem Lab	ABC-001	ABC-210	Automatic Boat Controller	Mitsubishi	D8C20564	Total Chlorine
MEC	Sample Receiving	R-1	FFRT18TPHWO		Frigidaire	BA02405585	Sample Storage
MEC	Sample Receiving	R-2	ET4WSkXST00		Whirlpool	VST460936	Sample Storage
RAL	Bioassay	BA1	818	Balance	Precision	699091193	Bioassay
RAL	Bioassay	BA2	LabLine 844	Balance	Barnstead	NA	Bioassay
RAL	Bioassay	BA3	818	Balance	Precision	305212	Bioassay
RAL	Bioassay	BA4	2020	Balance	VWR	0701999	Bioassay
RAL	Bioassay	Microscope 1	EMZ	Microscope	MEIJI	265999	Bioassay

Laboratory	Location	Equipment ID	Model / Detector	Equipment	Manufacturer	Serial #	Use
RAL	Bioassay	Microscope 2	EMZ	Microscope	MEIJI	20930	Bioassay
RAL	Bioassay	Microscope 3	NA	Microscope	Nikon	50274	Bioassay
RAL	Bioassay	Meter 3	Orion 5 Star	Combo Meter	Thermo	014144	Bioassay/pH/Cond/DO
RAL	Bioassay	Refrigerator 4	FRT17L3FW7	Refrigerator	Frigidaire	BA94912835	Bioassay Reagent Storage
RAL	Bioassay	Refrigerator 5	RT18BKXKQ02	Refrigerator	ROPER	VSR3486634	Chloraphyl A
RAL	Metals	DI 1	Academic A10	DI Water	Milli-Q	NA	DI water for LLHg
RAL	Micro	Autoclave 1	Sterilmatic	Autoclave	Market Forge	189107	Micro
RAL	Micro	NA	3323		Leica	NA	Micro
RAL	Micro	Incubator 1	6LM	Incubator	Precision Scientific	9508-006	Total Coliform/Sludge
RAL	Micro	Water Bath 1	1275PC	Water Bath	VWR	NA	Sludge Fecal/Colilert 18
RAL	Micro	Water Bath 2	253	Water Bath	Precision Scientific	3412-103	
RAL	Micro	Water Bath 3	51221033	Water Bath	Precision Scientific	69910439	Sludge Fecal
RAL	Micro	Incubator 2	Imperial III	Incubator	Lab Line	0598-0329	HPC
RAL	Micro	Incubator	Economy	Incubator	Precision	601091184	Enterococcus
RAL	Micro	Sealer 1	2X	Sealer	IDEXX	5459	E. coli
RAL	Micro	Refrigerator #14	TBX18SIBQLWW	Refrigerator	GE	SV538399	Micro Media Storage
RAL	Micro	Stereomaster 1	Stereomaster	NA	Fisher	J1405-0744-007	Fecal Counting
RAL	Micro	Bal 1	TS400	Balance	OHAUS	5826	Making Media
RAL	Micro	Bal 2	PB303-S	Balance	Mettler	119010966	Wet Chem

Laboratory	Location	Equipment ID	Model / Detector	Equipment	Manufacturer	Serial #	Use
					Toledo		Area
RAL	Sample Receiving	Freezer 1	20163	Freezer	Kenmore	E02941700	Sample Receiving
RAL	Sample Receiving	None		Ice Machine	Manitowac		Ice Maker for Sample Receiving
RAL	Sample Receiving	Refrigerator 7	TMC	Refrigerator	TRUE	NA	Reagent Storage/Refrigerator for Samples not logged in yet
RAL	Sample Receiving	Refrigerator 11	564	Refrigerator	Sears	940300503	Sample Receiving/Samples to be sent to ASH/CHAR/Etc.
RAL	Sample Receiving	Refrigerator 9	GDM-37	Refrigerator	TRUE	957271	Refrigerator for Samples to be Analyzed in Raleigh
RAL	Sample Receiving	Refrigerator 15	RBBCFA27B	Refrigerator	Black & Decker	BS04TE7X0JBKS1V1988	VOA Sample Holding
RAL	Sample Receiving	Refrigerator 16	11EO	Refrigerator	Baxter Scientific	Y20B-128986-YB	Raleigh Short Hold Samples
RAL	Wet Chemistry	91BAL1	AB204-S	Balance	Mettler Toledo	1120142348	All Solids
RAL	Wet Chemistry	BODI 1	FU199A	Incubator	Fisher	1314	BOD Incubator
RAL	Wet Chemistry	BODI 2	LR1201WWW/0	Incubator	Norlake	11020288	BOD Incubator
RAL	Wet Chemistry	BODI 4	11-679-25c	Incubator	Fisher Scientific	2018090423472	BOD Incubator
RAL	Wet Chemistry	Sonicator 1	1210	Sonicator	Branson	1200R-MT	BOD Sonicator
RAL	Wet Chemistry	DO 1	50B	DO Meter	YSI	93L12195	BOD/CBOD
RAL	Wet Chemistry	91WET6	52	DO Meter	YSI	05A2582	BOD/CBOD
RAL	Wet Chemistry	91WET4	QuickChem 8000	Lachat	Lachat	A83000-2257	NOX

Laboratory	Location	Equipment ID	Model / Detector	Equipment	Manufacturer	Serial #	Use
RAL	Not In use	Furnace 1	30400	Furnace	Thermolyne	NA	Volatile Solids
RAL	Wet Chemistry	Furnace 2	62700	Furnace	Thermolyne	6.27951E+11	Volatile Solids
RAL	Wet Chemistry	Oven 1	Empiral V	Oven	Barnstead	NA	103-105 °C
RAL	Wet Chemistry	Meter 4	Star A211	Combo Meter	Orion	X16842	pH & Conductivity/ BOD pH meter
RAL	Wet Chemistry	Meter 2	AR20	Combo Meter	Accumet	AR81201543	pH & Conductivity
RAL	Wet Chemistry	Refrigerator 13	253.6580251	Refrigerator	Kenmore	BA63117872	Wet Chem Reagent Storage
RAL	Wet Chemistry	Spec 1	Pocket Colorimeter II	Spec	HACH	NA	Chlorine
RAL	Wet Chemistry	91WET5	DR/2010	Spec	HACH	990900014809	COD/MBAS/OP
RAL	Wet Chemistry	91WET2	965	Turb. Meter	ORBECO-HELLIGE	5099	Turbidity
RAL	Micro		516D		Fisher Scientific	111N0097	
RAL	BOD Incubator		2020		VWR	303698	received from VA - backup incubator
RAL	Bioassay	BA5	818	Incubator	Precision	10-AV-5	Bioassay incubator
RAL	Bioassay	BA6	818	Incubator	Precision	9206-001	Bioassay incubator
RAL							
RAL	Micro	Incubator 4	307	Incubator	Fisher Scientific	211r0329	NA

ATTACHMENT V- LABORATORY SOP LIST

SOP NUMBER				REV	DOCUMENT NAME	METHOD
S	ALL	Q	020	06	TRAINING AND EMPLOYEE ORIENTATION	
S	ALL	Q	022	04	3P PROGRAM: CONTINUOUS PROCESS IMPROVEMENT	
S	ALL	Q	028	04	USE AND OPERATION OF LAB TRACK SYSTEM	
S	ALL	Q	035	03	DATA RECALL	
S	ALL	T	002	05	LMS SUB-LEARN CENTER SYSTEM AND TRAINING ADMINISTRATOR RESPONSIBILITIES	
S	ALL	Q	029	03	MINTMINER DATA FILE REVIEW FOR DATA INTEGRITY MONITORING	
S	ALL	Q	009	06	LABORATORY DOCUMENTATION	
S	ALL	Q	015	03	REVIEW OF LABORATORY MANAGEMENT SYSTEM	
S	ALL	Q	030	05	OPERATION OF DATA CHECKER	
S	ALL	O	038	2	PROCESSING TENTATIVELY IDENTIFIED COMPOUNDS (TICS) FOR GC/MS	
S	ALL	Q	003	10	DOCUMENT NUMBERING	
S	ALL	S	001	05	HAZARD ASSESSMENTS	
S	ALL	Q	014	06	QUARTERLY QUALITY REPORT	
S	ASV	S	003	002	CONTINGENCY AND EMERGENCY PROCEDURES PLAN	NA

SOP NUMBER				REV	DOCUMENT NAME	METHOD
S	ASV	I	032	008	SULFIDE	SM4500 S2 D REV.2011
S	ASV	I	029	007	SPECIFIC CONDUCTIVITY	EPA 120.1 REV 4
S	ASV	M	043	04	DETERMINATION OF METALS BY ICP 6010C	6010C
S	ASV	I	012	004	FERROUS IRON	SM 3500-FC (MODIFIED)
S	ASV	I	059	004	KJELDAHL NITROGEN IN WATER AND WASTES BY FLOW INJECTION COLORIMETRY	EPA 351.2
S	ASV	M	070	003	LOW LEVEL MERCURY	EPA 1631 E
S	ASV	I	044	004	TOTAL RESIDUAL CHLORINE	SM 4500 CL G
S	ASV	S	002	004	WASTE HANDLING AND MANAGEMENT	NA
S	ASV	I	063	08	DETERMINATION OF TOTAL CYANIDE	SM 4500 CN E, LACHAT QUIK CHEM 10-204-00-1-X, SW 846 9010C/9012 B-2002
S	ASV	I	016	003	HARDNESS, CALCULATION	SM2340B
S	ASV	I	062	05	DETERMINATION OF TOTAL PHOSPHORUS BY INJECTION ANALYSIS - LACHAT METHOD	EPA 365.1
S	ASV	I	060	005	DETERMINATION OF PHENOLIC COMPOUNDS BY FLOW INJECTION ANALYSIS COLORIMETRY	420.4
S	ASV	I	065	003	ASH	ASTM D-482-95
S	ASV	I	067	003	CHLORINE - TOX	SW-846 9076

SOP NUMBER				REV	DOCUMENT NAME	METHOD
S	ASV	I	068	003	SULFUR	SM D4239
S	ASV	I	066	003	DETERMINATION OF CALORIFIC VALUE (BTU) OR WASTE MATERIALS	ASTM D-5468-95
S	ASV	I	069	000	DETERMINATION OF AMMONIA AS NITROGEN	EPA 350.1, 351.2, DEP SOP 10/03/83
S	ASV	M	071	001	6020/200.8 ICP-MS METALS	EPA 6020/EPA 200.8
S	ASV	I	064	05	CHLORIDE BY LACHAT	SM 4500 CL E
S	ASV	M	038	01	DETERMINATION OF METALS BY ICP 200.7	200.7
S	ASV	I	058	007	ION CHROMATOGRAPHY	EPA 300.0
S	ASV	I	035	12	TOTAL ORGANIC CARBON (TOC)	SM 5310B
S	ASV	M	72	000	DETERMINATION OF METALS BY ICP 6010D	EPA 6010D
S	ASV	M	020	009	MERCURY BY COLD VAPOR FOR WATERS AND SOLIDS	245.1 / 7470A / 7471B
S	ASV	I	024	005	PAINT FILTER LIQUIDS TEST	9095A
S	ASV	I	013	009	FLASH POINT - PENSKY MARTENS CLOSED CUP	SW-846 1010
S	CAR	Q	031	02	ESTIMATION OF MEASUREMENT UNCERTAINTY	
S	CAR	Q	021	07	SAMPLE HOMOGENIZATION AND SUB-SAMPLING	
S	CAR	Q	033	03	MCL VIOLATION REPORTING	

SOP NUMBER				REV	DOCUMENT NAME	METHOD
S	CAR	Q	005	04	PURCHASING OF LAB SUPPLIES	
S	CAR	Q	012	05	CORRECTIVE AND PREVENTATIVE ACTIONS	
S	CAR	Q	037	04	DATA REVIEW PROCESS	
S	CAR	Q	001	12	PREPARATION OF STANDARD OPERATING PROCEDURES	
S	CAR	Q	026	04	SPREADSHEET VALIDATION	
S	CAR	Q	036	01	MANAGEMENT OF CHANGE	
S	CAR	Q	025	06	STANDARD AND REAGENT MANAGEMENT AND TRACEABILITY	
S	CAR	Q	032	02	CONTROL CHART GENERATION AND TREND ANALYSIS	
S	CAR	Q	004	08	DETERMINATION OF LIMIT OF DETECTION AND LIMIT OF QUANTITATION	
S	CAR	Q	006	06	RECEIPT AND STORAGE OF LABORATORY SUPPLIES	
S	CAR	Q	027	04	EVALUATION AND QUALIFICATION OF VENDORS	
S	CAR	Q	013	05	SUPPORT EQUIPMENT	
S	CAR	W	003	04	WASTE MANAGEMENT TRAINING REQUIREMENTS	
S	CAR	MB	005	02	E. COLI - QUANTI-TRAY	SM 9223 B QT
S	CAR	WC	001	004	BIOCHEMICAL OXYGEN DEMAND (BOD)	SM 5210 B

SOP Number				Rev	Document Name	Method
S	CAR	WC	002	004	Chemical Oxygen Demand (COD) in Water, Wastwaters and Industrial Wastes	SM 5220D
S	CAR	WC	008	002	Settleable Solids	SM 2540 F
S	CAR	WC	011	002	Turbidity	EPA 180.1 Rev. 2.0
S	CAR	O	002	02	Synthetic Precipitation Leaching Procedure (SPLP)	1312
S	CAR	L	009	01	Monitoring Laboratory Deionized Water	SM 9020B
S	CAR	Q	8	00	Handling and Reporting Results of Drinking Water Samples	
S	CAR	S	002	01	Air Quality Monitoring and Fume Hood Monitoring	
S	CAR	F	008	01	Clean Sampling for Ultra Trace Metals	EPA 1669
S	CAR	MB	002	03	Total Coliforms, Absent/Present	SM 9223 B
S	CAR	MB	004	03	Fecal Coliform - Quantitation by Quanti-Tray/2000 Colilert®-18	Colilert®-18
S	CAR	WC	16	003	Nitrate-N	HACH 10206 (TNT 835)
S	CAR	MB	003	02	Heterotrophic Plate Count	IDEXX SimPlate
S	CAR	C	003	05	Subcontracting Samples	
S	CAR	F	009	02	Turbidity in the field	SM 2130
S	CAR	WC	007	001	pH	SM 4500 / SM 9045B

SOP NUMBER				REV	DOCUMENT NAME	METHOD
S	CAR	WC	003	001	COLOR ADMI	SM 2120 E
S	CAR	WC	004	003	HEXAVALENT CHROMIUMIN IN WATER, WASTEWATER, AND SOIL	SM 3500 CR D
S	CAR	C	006	03	REVIEW OF ANALYTICAL REQUESTS	
S	CAR	C	001	06	SAMPLE MANAGEMENT	
S	CAR	Q	016	07	MANUAL INTEGRATION	
S	CAR	O	001	06	TOXICITY CHARACTERISTIC LEACHING PROCEDURE (TCLP)	1311
S	CAR	Q	011	07	INTERNAL AND EXTERNAL AUDITS	
S	CAR	Q	018	06	MONITORING STORAGE UNITS	
S	CAR	Q	039	01	REPORTING UNACCEPTABLE SAMPLE PRESERVATION TO NORTH CAROLINA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES	
S	CAR	C	004	04	BOTTLE PREPARATION	
S	CAR	MB	001	01	FECAL COLIFORMS	SM 9222 D
S	CAR	F	010	01	FIELD SAMPLING SOP	
S	CAR	L	005	04	MEASUREMENT OF PERCENT MOISTURE IN SOILS AND SOLIDS	
S	CAR	L	010	01	GLASSWARE WASHING	
S	CAR	WC	009	003	THE DETERMINATION OF NITRATE-NITRITE NITROGEN BY AUTOMATED COLORIMETRY	EPA 353.2 (2.0)

SOP NUMBER				REV	DOCUMENT NAME	METHOD
S	CAR	Q	002	06	DOCUMENT CONTROL AND MANAGEMENT	
S	CAR	Q	010	07	PROFICIENCY TESTING PROGRAM	
S	CAR	F	007	03	MEASURING TOTAL RESIDUAL CHLORINE IN THE FIELD	SM4500 CI G
S	CAR	WC	005	004	MEASUREMENT OF SOLIDS IN WATER AND WASTEWATER	SM 2540 B,C,&D
S	CAR	L	006	01	USDA REGULATED SOILS	
S	CAR	F	005	01	MEASURING pH IN THE FIELD	SM4500H
S	CAR	F	002	02	MEASURING DISSOLVED OXYGEN IN THE FIELD	SM 4500 O G
S	CAR	WC	006	06	ORTHO PHOSPHORUS	EPA 365.1 SM 4500 P E-1999
S	CAR	WC	017	00	ALKALINITY, TITRIMETRIC	SM 2320 B
S	CAR	F	006	01	MEASURING TEMPERATURE IN THE FIELD	SM2550B
S	CAR	F	003	03	MEASURING SPECIFIC CONDUCTIVITY IN THE FIELD	EPA 120.2, SM2510B
S	CHR	O	010	05	THE EXTRACTION OF DIESEL RANGE ORGANICS AND OIL RANGE ORGANICS FROM SOLIDS	3546
S	CHR	O	011	06	THE EXTRACTION OF DIESEL RANGE ORGANICS, TENNESSEE EXTRACTABLE PETROLEUM HYDROCARBONS, AND OIL RANGE ORGANICS FROM LIQUIDS	3510C
S	CHR	O	032	05	N-HEXANE EXTRACTABLE MATERIAL (HEM) FOR SEDIMENT AND SOIL SAMPLES	9071B
S	CHR	O	021	04	THE DETERMINATION OF DIESEL RANGE/ORO/TN EPH ORGANICS BY GAS	8015C

SOP NUMBER				REV	DOCUMENT NAME	METHOD
					CHROMATOGRAPHY	
S	CHR	L	001	03	HANDLING AND STORAGE OF RADIOACTIVE MATERIALS	
S	CHR	W	002	04	WASTE HANDLING AND MANAGEMENT	NA
S	CHR	O	040	05	THE DETERMINATION OF GASOLINE RANGE ORGANICS IN WATER AND SOIL	5030B, 8015C
S	CHR	O	031	08	OIL AND GREASE WATER	1664B
S	CHR	O	014	08	THE DETERMINATION OF SEMI-VOLATILE ORGANIC COMPOUNDS IN AQUEOUS, SOLID OR WASTE SAMPLES BY GC/MS ANALYSIS	8270D
S	CHR	O	25	04	THE DETERMINATION OF TRIHALOMETHANES AND REGULATED VOLATILE COMPOUNDS BY GC/MS	524.2
S	CHR	O	054	06	THE DETERMINATION OF VOLATILE PETROLEUM HYDROCARBONS IN WATER AND SOIL	MADEP VPH
S	CHR	O	004	05	THE EXTRACTION OF PCBS FROM OILS	3580
S	CHR	W	002	06	WASTE HANDLING AND MANAGEMENT	
S	CHR	O	044	4	THE EXTRACTION OF PESTICIDES/PCBS FROM NON-AQUEOUS WASTE SAMPLES	3580
S	CHR	O	005	04	THE EXTRACTION OF SEMI-VOLATILE ORGANIC COMPOUNDS FROM NON-AQUEOUS WASTE SAMPLES	3580
S	CHR	O	056	03	THE EXTRACTION OF EXTRACTABLE PETROLEUM RANGE HYDROCARBONS (EPH) FROM SOLIDS	3546
S	CHR	O	057	01	THE EXTRACTION OF EXTRACTABLE PETROLEUM RANGE HYDROCARBONS (EPH) FROM LIQUIDS	3510C, 3535

SOP NUMBER				REV	DOCUMENT NAME	METHOD
S	CHR	O	053	04	THE DETERMINATION OF VOLATILE ORGANICS BY GAS CHROMATOGRAPHY/MASS SPECTROMETRY	6200B 20THED
S	CHR	O	059	01	THE DETERMINATION OF VOLATILE ORGANICS BY SELECTIVE ION MONITORING (SIM) GAS CHROMATOGRAPHY/MASS SPECTROMETRY	8260 SIM
S	CHR	O	007	08	THE EXTRACTION OF SEMI-VOLATILE ORGANICS FROM LIQUID SAMPLES IN PREPARATION FOR GC/MS ANALYSIS BY METHODS 8270D, 8270D SIM, 1,4-DIOXANE AND 625	3510C, 3535, 625
S	CHR	O	043	07	THE EXTRACTION OF PESTICIDES/PCBS FROM LIQUID SAMPLES IN PREPARATION FOR GC ANALYSIS BY METHODS 8081, 8082, AND 608	3510C, 3535, 608
S	CHR	O	033	05	DETERMINATION OF HALOACETIC ACIDS IN DRINKING WATER BY LIQUID-LIQUID EXTRACTION	552.2
S	CHR	L	008	01	STORAGE BLANKS	
S	CHR	O	047	05	THE DETERMINATION OF ORGANOCHLORINE PESTICIDES BY GAS CHROMATOGRAPHY	8081B, 608
F	CHR	S	10	02	CHARLOTTE CONTINGENCY & EMERGENCY PLAN	N/A
S	CHR	O	024	07	THE DETERMINATION OF VOLATILE ORGANICS BY GAS CHROMATOGRAPHY/MASS SPECTROMETRY	624
S	CHR	O	013	06	THE DETERMINATION OF SEMI-VOLATILE ORGANIC COMPOUNDS IN AQUEOUS SAMPLES BY GC/MS	625
S	CHR	L	007	02	USE OF THE pH METER IN SUPPORT OF ANALYTICAL METHODOLOGY	SM 4500HB 18TH
S	CHR	O	052	04	DETERMINATION OF SEMIVOLATILE ORGANICS BY GC/MS-SIM, SELECTIVE ION MONITORING	8270 SIM
S	CHR	O	60	02	DETERMINATION OF DISSOLVED GASES BY GC/FID	RSK-175

SOP NUMBER				REV	DOCUMENT NAME	METHOD
S	CHR	O	048	04	THE DETERMINATION OF 1,4-DIOXANE IN AQUEOUS SAMPLES BY GC/MS SIM ANALYSIS UTILIZING ISOTOPE DILUTION	8270 SIM
S	CHR	O	046	06	THE DETERMINATION OF POLYCHLORINATED BIPHENYLS BY GAS CHROMATOGRAPHY	8082A, 608
S	CHR	O	019	04	THE DETERMINATION OF 1,2-DIBROMOMETHANE (EDB), 1,2-DIBROMO-3-CHLOROPROPANE, AND 1,2,3-TRICHLOROPROPANE (TCP) IN WATER BY MICROEXTRACTION	504.1
S	CHR	O	020	07	THE DETERMINATION OF 1,2-DIBROMOMETHANE (EDB) AND 1,2-DIBROMO-3-CHLOROPROPANE IN WATER BY MICROEXTRACTION	8011
S	CHR	O	023	13	THE DETERMINATION OF VOLATILE ORGANICS BY GAS CHROMATOGRAPHY/MASS SPECTROMETRY	8260B
S	CHR	O	055	01	THE DETERMINATION OF EXTRACTABLE PETROLEUM RANGE HYDROCARBONS BY GAS CHROMATOGRAPHY	MADEP EPH
S	CHR	O	002	06	EXTRACTION OF PESTICIDES AND PCBS FROM SOLIDS	3546
S	CHR	O	041	05	THE EXTRACTION OF SEMI-VOLATILE ORGANICS FROM SOLID SAMPLES IN PREPARATION FOR GC/MS ANALYSIS BY METHOD 8270	3546
S	CHR	O	045	03	THE EXTRACTION OF SEMIVOLATILES FROM WIPES	3580 (MODIFIED)
S	CHR	O	61	00	GEL PERMEATION CHROMATOGRAPHY	3640A
S	EDN	WC	16	002	ENTEROCOCCI	SM 5220D
S	EDN	S	001	001	CONTINGENCY AND EMERGENCY PROCEDURES PLAN	NA
S	EDN	WC	15	002	NITRITE AS NITROGEN	SM 4500-NO2 B

SOP NUMBER				REV	DOCUMENT NAME	METHOD
S	EDN	WC	20	001	TOC/DOC	SM 5310 C - 2000, REV.2011
S	EDN	WC	19	001	UV254	SM 5910 B - 2011
S	EDN	WC	17	01	CHLORIDE BY SMARTCHEM	SM 4500 CL E - 1997
S	EDN	WC	18	001	AMMONIA BY SMARTCHEM	EPA 350.1
S	GWD	I	016	002	TP	SM4500PE-1997-1999
S	GWD	I	002	001	HAMMER MILL	GRINDER FOR TCLP PREP
S	GWD	S	001	000	EMERGENCY AND CONTINGENCY SAFETY PLAN	SAFETY
S	RAL	S	001	002	RALEIGH EMERGENCY CONTINENCY SOP	N/A
				18.0	QUALITY MANUAL	
				10	CHEMICAL HYGIENE PLAN/SAFETY MANUAL	

ATTACHMENT VI- LABORATORY CERTIFICATION LIST (CURRENT AS OF ISSUE DATE) SCOPE AND APPLICATION CERTIFICATES ARE MAINTAINED AND FILED IN THE LOCAL QUALITY DEPARTMENT

Asheville

Analyte	Method	Program	NC DW Lab ID: 37712	NC Lab ID: 40	SC Lab ID: 99030001	VA VELAC ID: 460222	FL TNI Lab ID: E87648
Nitrite as N	EPA 353.2 (as LACHAT 10-107-04-1-A)	Drinking Water	C			C	C
Nitrate as N	EPA 353.2 (as LACHAT 10-107-04-1-A)	Drinking Water	C			C	C
Alkalinity as CaCO3	SM 2320 B	Drinking Water	C				
Alkalinity as CaCO3	SM 2320 B – 2011	Drinking Water				C	C
Coliform	Colisure	Drinking Water	C				
E.coli	Colisure	Drinking Water	C				
Alkalinity	SM 2320 B – 1997	Non- Potable Water		C		C	C
Alkalinity	SM 2320 B-2011	Non- Potable Water			C		
Ammonia as N	EPA 350.1 REV. 2.0 1993 (as LACHAT 10-107-06-1-C)	Non- Potable Water		C	C	C	C
BOD	SM 5210 B - 2001	Non- Potable Water		C		C	C
BOD	SM 5210 B - 2011	Non- Potable Water			C		
Bromide	EPA 300.0 - 1993 Rev 2.1	Non- Potable Water		C		C	C
Bromide	SW-846 9056A	Non- Potable Water		C		C	C
CBOD	SM 5210 B – 2001	Non- Potable Water		C		C	C
CBOD	SM 5210 B - 2011	Non- Potable Water			C		
Chloride	SM4500Cl E – 1997	Non- Potable Water				C	C
Chloride	SM 4500-CL-E-1997, 2011	Non- Potable Water		C	C		
Chloride	EPA 300.0 - 1993 Rev 2.1	Non- Potable Water		C		C	C
Chloride	SW-846 9056 A	Non- Potable Water		C			
Chloride	EPA 9056A (2007)	Non- Potable Water				C	C
Chlorine, Residual	SM 4500 Cl G – 2000, Rev. 2011	Non- Potable Water		C			
COD	SM 5220 D – 1997	Non- Potable Water		C		C	C
COD	SM 5220 D-2011	Non- Potable Water			C		
Conductivity	EPA 120.1 Rev. 1982	Non- Potable Water		C	C	C	C
Conductivity	SW-846 9050 A	Non- Potable Water		C			

Asheville

Analyte	Method	Program	NC DW Lab ID: 37712	NC Lab ID: 40	SC Lab ID: 99030001	VA VELAC ID: 460222	FL TNI Lab ID: E87648
Conductivity	EPA 9050A	Non- Potable Water					
Cyanide	SM 4500CN E – 1999	Non- Potable Water				C	C
Cyanide	SM 4500CN E – 1999, Rev. 2011	Non- Potable Water		C			
Cyanide	SM 4500-CN C-2011	Non- Potable Water			C		
Cyanide	SM 4500-CN E-2011	Non- Potable Water			C		
Cyanide	EPA 9010 C	Non- Potable Water				C	C
Cyanide	EPA 9012B	Non- Potable Water		C		C	C
Cyanide	LACHAT 10-204-00-1-X	Non- Potable Water		C	C	C	C
Dissolved Oxygen	SM 4500 O G – 2001, Rev.2011	Non- Potable Water		C			
Dissolved Oxygen	SM 4500-O G-2011	Non- Potable Water			C		
Fecal Coliform	SM 9222D (MF) – 1997	Non- Potable Water		C			
Fecal Coliform	Colilert®-18	Non- Potable Water		C			
Flash Point	EPA 1010 A	Non- Potable Water		C		C	C
Fluoride	EPA 300.0 - 1993 Rev 2.1	Non- Potable Water		C	C	C	C
Fluoride	SW-846 9056A	Non- Potable Water		C		C	C
Free Liquids	EPA 9095 B (2004)	Non- Potable Water					
Hardness, Total	SM 2340 B – 1997	Non- Potable Water				C	C
Hardness, Total	SM 2340 B--1997, 2011	Non- Potable Water		C	C		
Hexavalent Chromium (Cr 6+)	SM 3500-CR B-2009, Rev. 2011	Non- Potable Water		C		C	C
Hexavalent Chromium (Cr 6+)	SM 3500-CR B-2011	Non- Potable Water			C		
Hexavalent Chromium (Cr 6+)	EPA 7196 A (1994)	Non- Potable Water		C		C	C
Mercury	EPA 7470 A (1994)	Non- Potable Water		C		C	C
Mercury	EPA 7471 B	Non- Potable Water					
Mercury	EPA 245.1 Rev 3 (1994)	Non- Potable Water		C	C	C	C
Mercury	EPA 1631 E	Non- Potable Water		C	C	C	C
Metals	EPA 200.7 - 1994 Rev 4.4	Non- Potable Water		C	C	C	C
Metals	SW-846 6010 C	Non- Potable Water				C	C
Metals	SW-846 6010 D	Non- Potable Water		C		C	C

Asheville

Analyte	Method	Program	NC DW Lab ID: 37712	NC Lab ID: 40	SC Lab ID: 99030001	VA VELAC ID: 460222	FL TNI Lab ID: E87648
Metals	SW-846 6020 B	Non- Potable Water		C		C	C
Metals	EPA 200.8 Rev. 5.4, 1994	Non- Potable Water		C		C	C
Metals, Total	EPA 3005A	Non- Potable Water				C	C
Metals, Total	EPA 3010A	Non- Potable Water				C	C
Nitrate as N	EPA 353.2 REV. 2.0 1993 (as LACHAT 10-107-04-1-A)	Non- Potable Water		C	C	C	C
Nitrate as N	EPA 300.0 Rev.2.1, 1993	Non- Potable Water		C		C	C
Nitrate as N	SW-846 9056A	Non- Potable Water		C		C	C
Nitrate/Nitrite as N	EPA 353.2 REV. 2.0 1993 (as LACHAT 10-107-04-1-A)	Non- Potable Water	C	C	C	C	C
Nitrate/Nitrite as N	EPA 300.0 Rev 2.1, 1993	Non- Potable Water				C	C
Nitrate/Nitrite as N	EPA 9056A (2007)	Non- Potable Water				C	C
Nitrite as N	EPA 353.2 REV. 2.0 1993 (as LACHAT 10-107-04-1-A+C)	Non- Potable Water		c	C	C	C
Nitrite as N	EPA 300.0 Rev.2.1, 1993	Non- Potable Water		C		C	C
Nitrite as N	SW-846 9056A	Non- Potable Water		C		C	C
Orthophosphate as P	EPA 365.1 Rev.2.0, 1993	Non- Potable Water		C			
Orthophosphate as P	SM4500 P E 1999 Rev.2011	Non- Potable Water		C	C	C	C
Orthophosphate as P	EPA 300.0, Rev. 2.1 1993	Non- Potable Water		C		C	C
Orthophosphate as P	SW-846 9056 A	Non- Potable Water		C		C	C
Paint Filter Liquids Test	EPA 9095 B	Non- Potable Water		C		C	C
pH	SW-846 9040 C	Non- Potable Water		C			
pH	EPA 9040 C	Non- Potable Water				C	C
pH	SM 4500-H B --2000, Rev 2011	Non- Potable Water		C	C		
pH	EPA 9045 D	Non- Potable Water					
Phenol	EPA 420.4 (1993) (as LACHAT 10-210-00-1-X)	Non- Potable Water		C		C	C
Phenol	SW-846 9065	Non- Potable Water		C			
Phenol	EPA 9065	Non- Potable Water					
Phosphorus, Total	EPA 365.1 Rev. 2.0, 1993 (as LACHAT 10-115-01-1-E)	Non- Potable Water		C	C	C	C

Asheville

Analyte	Method	Program	NC DW Lab ID: 37712	NC Lab ID: 40	SC Lab ID: 99030001	VA VELAC ID: 460222	FL TNI Lab ID: E87648
Residue, Settleable Soids	SM 2540 F – 1997 , Rev.2011	Non- Potable Water		C		C	C
Residue, Settleable Soids	SM 2540 F - 2011	Non- Potable Water			C		
Residue, Total Dissolved Solids	SM 2540 C – 1997, Rev.2011	Non- Potable Water	C	C		C	C
Residue, Total Dissolved Solids	SM 2540 C - 2011	Non- Potable Water			C		
Residue, Total Solids	SM 2540 B – 1997, Rev.2011	Non- Potable Water		C		C	C
Residue, Total Solids	SM 2540 B – 2011	Non- Potable Water			C		
Residue, Total Suspended Solids	SM 2540 D – 1997, Rev.2011	Non- Potable Water		C		C	C
Residue, Total Suspended Solids	SM 2540 D - 2011	Non- Potable Water			C		
Residue, Volatile Solids	EPA 160.4 (9/86)	Non- Potable Water			C	C	C
Sulfate	EPA 300.0 - 1993 Rev 2.1	Non- Potable Water		C	C	C	C
Sulfate	SW-846 9056A	Non- Potable Water		C			
Sulfate	EPA 9056A	Non- Potable Water				C	C
Sulfide	SM4500 S2 D – 2000, Rev. 2011	Non- Potable Water			C	C	C
Sulfide	SM4500 S2 B – 2011	Non- Potable Water			C		
TKN - Total Kjeldahl Nitrogen	EPA 351.2 Rev.2.0, 1993 (as LACHAT 10-107-06-2-D)	Non- Potable Water		C	C	C	C
TOC	SM 5310 B – 2000, Rev. 2011	Non- Potable Water		C	C	C	C
TOC	SW-846 9060A	Non- Potable Water		C			
TOC	EPA 9060A (2004)	Non- Potable Water				C	C
Turbidity	EPA 180.1 Rev 2 (1993)	Non- Potable Water		C	C	C	C
Turbidity	SM 2130 B	Non- Potable Water					
TCLP	EPA 1311 - 1992	Non- Potable Water		C			
SPLP	EPA 1312 - 1994	Non- Potable Water		C			
Bromide	EPA 9056A (2007)	Solid and Chemical Materials			C		
Chloride	EPA 9056A (2007)	Solid and Chemical Materials			C		
Cyanide	EPA 9012 B (2004)	Solid and Chemical Materials		C	C		
Cyanide Amen, to Chlorination	EPA 9012 B (2004)	Solid and Chemical Materials			C		
Flash Point	EPA 1010 A	Solid and Chemical Materials			C	C	C

Asheville

Analyte	Method	Program	NC DW Lab ID: 37712	NC Lab ID: 40	SC Lab ID: 99030001	VA VELAC ID: 460222	FL TNI Lab ID: E87648
Fluoride	EPA 9056A (2007)	Solid and Chemical Materials			C		
Free Liquids	SW-846 9095 B	Solid and Chemical Materials			C	C	C
Hexavalent Chromium (Cr 6+)	EPA 7196 A (1994)	Solid and Chemical Materials		C	C		
Mercury	EPA 7471 B - (2007)	Solid and Chemical Materials		C	C	C	C
Mercury	7470A (1994)	Solid and Chemical Materials			C		
Metals	EPA 6020 C	Solid and Chemical Materials				C	C
Metals	SW-846 6010 D	Solid and Chemical Materials				C	C
Metals	EPA 6010D (2014)	Solid and Chemical Materials			C		
Metals	EPA 6020 B (2014)	Solid and Chemical Materials		C	C		
Metals Digestion	EPA 3010 A - 1992	Solid and Chemical Materials			C	C	C
Metals Digestion	EPA 3050 B - 1996	Solid and Chemical Materials			C	C	C
Nitrate-Nitrogen	EPA 9056A (2007)	Solid and Chemical Materials			C		
Nitrite-Nitrogen	EPA 9056A (2007)	Solid and Chemical Materials			C		
Orthophosphate as P	EPA 9056A (2007)	Solid and Chemical Materials			C		
pH	EPA 9045 D	Solid and Chemical Materials		C	C	C	C
Phenol	EPA 9056A (2007)	Solid and Chemical Materials			C	C	C
Phenol	SW-846 9065	Solid and Chemical Materials			C		
SPLP	EPA 1312 - 1994	Solid and Chemical Materials		C	C	C	C
Sulfate	EPA 9056A (2007)	Solid and Chemical Materials			C		
TCLP	EPA 1311 - 1992	Solid and Chemical Materials		C	C	C	C
TOC	EPA 9060A (2004)	Solid and Chemical Materials			C		

* Georgia: Approved for all NELAP accredited non-potable water and solid and chemical materials methods.

Charlotte

Analyte	Method	Program	VA VELAC ID: 460221	NC Lab ID: 12	NC DW Lab ID: 37706	NC Field ID: 5342	SC Lab ID: 99006001	FL TNI Lab ID: E87627	GA *	KY $^{\#}$ UST ID: 84
EDB, DBCP, and TCP	EPA 504.1 Rev 1.1 (1995)	Drinking Water	C	C				C		
Trihalomethanes	EPA 524.2 Rev 4.1 (1995)	Drinking Water	C		C		C	C		
Regulated Volatiles	EPA 524.2 Rev 4.1 (1995)	Drinking Water	C		C		C	C		
Haloacetic Acids	EPA 552.2 Rev 1 (1995)	Drinking Water	C		C		C	C		
Heterotrophic Plate Count	SIMPLATE	Drinking Water			C					
Escherichia coli	SM 9223B (Colilert)	Drinking Water			C					
Total Coliform	SM 9223B (Colilert)	Drinking Water			C					
Determinaion of Dissolved Gases	RSK-175	Non-Potable Water	C							
Oil and Grease	EPA 1664B (2010)	Non-Potable Water	C	C			C	C		
Total Petroleum Hydrocarbons	EPA 1664B (2010)	Non-Potable Water	C	C			C	C		
Liquid-Liquid Extraction	EPA 3510C (1996)	Non-Potable Water	C	N/A			C	N/A		
Purge and Trap	EPA 5030B (1996)	Non-Potable Water	C	N/A			C	N/A		
Organochlorine Pesticides and PCBs	EPA 608	Non-Potable Water	C	C			C	C		
Purgeables	EPA 624	Non-Potable Water	C	C			C	C		
Base/Neutrals and Acids	EPA 625 (1982)	Non-Potable Water	C	C			C	C		
EDB and DBCP	EPA 8011 (7/92)	Non-Potable Water	C	C			C	C		
Gasoline Range Organics	EPA 8015C (2000)	Non-Potable Water	C	C				C		
Diesel Range Organics	EPA 8015C (2000)	Non-Potable Water	C	C				C		
Oil Range Organics	EPA 8015C (2000)	Non-Potable Water	C	C						
Organochlorine Pesticides	EPA 8081B (2/07)	Non-Potable Water	C	C			C	C		
Polychlorinated Biphenyls	EPA 8082A (2/07)	Non-Potable Water	C	C			C	C		
Volatile Organic Compounds	EPA 8260B (1996)	Non-Potable Water	C	C			C	C		
Volatile Organic Compounds	EPA 8260B SIM (1996)	Non-Potable Water	C	C			C			
Volatile Organic Compounds	EPA 8260B-OXY	Non-Potable Water	C	C			C	C		
Semivolatile Organic Compounds	EPA 8270D (2/07)	Non-Potable Water	C	C			C	C		
Semivolatile Organic Compounds	EPA 8270D SIM (2/07)	Non-Potable Water	C	C			C	C		
Extractable Petroleum Hydrocarbons	MADEP-EPH	Non-Potable Water		C						

Charlotte			**VA VELAC ID: 460221**	**NC Lab ID: 12**	**NC DW Lab ID: 37706**	**NC Field ID: 5342**	**SC Lab ID: 99006001**	**FL TNI Lab ID: E87627**	**GA ***	**KY $^{\#}$ UST ID: 84**
Analyte	**Method**	**Program**								
Volatile Petroleum Hydrocarbons	MADEP-VPH	Non-Potable Water		C						
Volatile Organic Compounds	SM 6200 B 20th ED (1998)	Non-Potable Water		C						
Total Coliform	SM 9222D (MF)	Non-Potable Water		C						
TCLP	EPA 1311 (1992)	Solid and Chemical Materials	C	C			C	C		
SPLP	EPA 1312 (1994)	Solid and Chemical Materials	C	C						
Liquid-Liquid Extraction	EPA 3510C (1996)	Solid and Chemical Materials	C	N/A			C	N/A		
Microwave Extraction	EPA 3546 (11/00)	Solid and Chemical Materials	C	N/A			C	N/A		
Waste Dilution	EPA 3580A (1992)	Solid and Chemical Materials	C	N/A			C	N/A		
Purge and Trap	EPA 5030B (1996)	Solid and Chemical Materials	C	N/A			C	N/A		
Closed System Purge and Trap	EPA 5035 (1996)	Solid and Chemical Materials	C	N/A			C	N/A		
Gasoline Range Organics	EPA 8015C (2000)	Solid and Chemical Materials	C	C				C		
Diesel Range Organics	EPA 8015C (2000)	Solid and Chemical Materials	C	C				C		
Oil Range Organics	EPA 8015C (2000)	Solid and Chemical Materials	C							
Organochlorine Pesticides	EPA 8081B (2/07)	Solid and Chemical Materials	C	C			C	C		
Polychlorinated Biphenyls	EPA 8082A (2/07)	Solid and Chemical Materials	C	C			C	C		
Volatile Organic Compounds	EPA 8260B (1996)	Solid and Chemical Materials	C	C			C	C		
Volatile Organic Compounds	EPA 8260B SIM (1996)	Solid and Chemical Materials	C							
Semivolatile Organic Compounds	EPA 8270D (2/07)	Solid and Chemical Materials	C	C			C	C		
Semivolatile Organic Compounds	EPA 8270D SIM (2/07)	Solid and Chemical Materials	C				C			
Oil and Grease	EPA 9071B (4/98)	Solid and Chemical Materials	C	C				C		
Non-polar Hexane Extracable Material	EPA 9071B (4/98)	Solid and Chemical Materials	C	C				C		

Charlotte

Charlotte			VA VELAC ID: 460221	NC Lab ID: 12	NC DW Lab ID: 37706	NC Field ID: 5342	SC Lab ID: 99006001	FL TNI Lab ID: E87627	GA *	KY [#] UST ID: 84
Analyte	**Method**	**Program**								
Extractable Petroleum Hydrocarbons	MADEP-EPH	Solid and Chemical Materials		C						
Volatile Petroleum Hydrocarbons	MADEP-VPH	Solid and Chemical Materials		C						
Conductivity	EPA 120.1	Field				C				
Conductivity	SM 2510B (18th)	Field				C	C			
Temperature	SM 2550B (18th)	Field				C	C			
Total Residual Chlorine	SM 4500 Cl G (18th)	Field				C				
pH	SM 4500 H B (18th)	Field				C	C			
Dissolved Oxygen	SM 4500 O G (18th)	Field				C	C			

* Georgia: Approved for all NELAP accredited non-potable water and solid and chemical materials methods.

[#] Kentucky: Certified for analytical testing related to Kentucky's Underground Storage Tank Program.

Eden

Analyte	Method	Program	VA VELAC ID: 460025	NC DW Lab ID: 37738	NC Lab ID: 633
Nitrate as N	HACH 10206	Drinking Water	C	C	
Nitrite as N	SM 4500NO2-B – 2000	Drinking Water	C	C	
Color	SM 2120 B - 2001	Drinking Water	C	C	
Turbidity	SM 2130 B - 2001	Drinking Water	C	C	
Total Coliforms / MPN	SM 9223 Colilert MPN	Drinking Water	C	C	
Total Coliforms	SM 9223 Colisure / COLILERT 18	Drinking Water	C	C	
Escherichia Coliform / MPN	SM 9223 Colilert MPN	Drinking Water	C	C	
Escherichia Coliform	SM 9223 Colisure	Drinking Water	C	C	
Escherichia Coliform	9223B-MW	Drinking Water		C	
Total Organic Carbon	SM 5310 C-2000	Drinking Water	C	C	
Alkalinity as CACO3	SM 2320 B-1997	Drinking Water	C	C	

DOC	SM5310 C-2000	Drinking Water	C	C	
UV254	UV 254	Drinking Water	C	C	
Escherichia Coliform / MPN	Colilert	Non- Potable Water	C		C
Escherichia Coliform / MPN	SM 9223 B – 2004 MPN	Non- Potable Water	C		C
Enterococci	Enterolert	Non- Potable Water	C		C
Ammonia as N	EPA 350.1 Rev2	Non- Potable Water	C		C
BOD	SM 5210 B - 2001	Non- Potable Water	C		C
CBOD	SM 5210 B - 2001	Non- Potable Water	C		C
Chloride	SM 4500-CL- E^{-}1997	Non- Potable Water	C		C
Chemical Oxygen Demand	SM 5220 D-1997	Non- Potable Water	C		C
Color, ADMI	SM 2120 E – on-line	Non- Potable Water			C
Color, PC	SM 2120 B – 2001	Non- Potable Water	C		C
Dissolved Oxygen	SM 4500O G – 2001	Non- Potable Water			C
Hexavalent Chromium (Cr 6+)	SM 3500 Cr- B – 2009	Non- Potable Water	C		C
Hexavalent Chromium (Cr 6+)	EPA 7196 A (1994)	Non- Potable Water	C		C
Fecal Coliform	SM 9222D (MF) – 1997	Non- Potable Water	C		C
Fecal Coliform	Colilert®18	Non- Potable Water			C
Free Cyanide	ASTM D4282-02	Non- Potable Water	C		
Nitrate as N	HACH 10206	Non- Potable Water	C		C
Nitrite as N	SM 4500-NO2 B – 2000	Non- Potable Water			C
pH	SM 4500 H+B – 2000	Non- Potable Water			C
pH	EPA 9040 C	Non- Potable Water	C		C
Orthophosphate as P	SM 4500-P E-1999	Non- Potable Water	C		C
Residue, Settleable Solids	SM 2540 F – 1997	Non- Potable Water	C		C
Residue, Total Suspended Solids	SM 2540 D – 1997	Non- Potable Water	C		C
Turbidity	SM 2130 B – 2001	Non- Potable Water			C

Greenwood

Analyte	Method	Program	VA VELAC ID: 460250	SC Lab ID: 24562	NC Lab ID: 25
Nitrate as N	EPA 300.0	Drinking Water		C	
Nitrite as N	EPA 300.0	Drinking Water		C	

Greenwood

Analyte	Method	Program	VA VELAC ID: 460250	SC Lab ID: 24562	NC Lab ID: 25
Chloride	EPA 300.0	Drinking Water		C	
Fluoride	EPA 300.0	Drinking Water		C	
Sulfate	EPA 300.0	Drinking Water		C	
HPC	Simplate (2000)	Drinking Water		C	
Total Coliforms / P/A	SM 9223 Colilert P/A	Drinking Water		C	
Total Phosphorus	SM 4500 P E (20th)	Drinking Water		C	
Escherichia Coliform / P/A	SM 9223 Colilert P/A	Drinking Water		C	
Residual Chlorine	SM 4500-CL G-2011	Drinking Water		C	
Dissolved Oxygen	SM 4500-0 G-2011	Non- Potable Water		C	
Nitrate as N	EPA 300.0 & EPA 9056A	Non- Potable Water	C	C	C
Nitrite as N	EPA 300.0 & EPA 9056A	Non- Potable Water	C	C	C
Nitrate/Nitrite	EPA 300.0 & EPA 9056A	Non- Potable Water	C	C	C
Chloride	EPA 300.0 & EPA 9056A**	Non- Potable Water	C	C	C
Fluoride	EPA 300.0 & EPA 9056A**	Non- Potable Water	C	C	C
Sulfate	EPA 300.0 & EPA 9056A**	Non- Potable Water	C	C	C
Bromide	EPA 300.0 (1993)	Non- Potable Water		C	
Orthophosphate	SM 4500-P E-2011	Non- Potable Water		C	
Residual Chlorine	SM 4500-CL G-2011	Non- Potable Water		C	
Turbidity	SM2130 B-2011	Non- Potable Water		C	
pH	SM 4500-H B-2011	Non- Potable Water		C	
Specific Conductance	EPA 120.1 / SM 2540 B-2011	Non- Potable Water		C	
Escherichia Coliform / MPN	SM 9223 B – 2022 MPN	Non- Potable Water		C	
pH	EPA 9040C & 9045D	Solid Chemical Waste		C	
Phenol	EPA 9065	Solid Chemical Waste		C	
Fecal Coliform	SM 9222D (MF) – 2011	Non- Potable Water		C	
Bromide	EPA 9050A	Solid Chemical Waste		C	

Greenwood

Analyte	Method	Program	VA VELAC ID: 460250	SC Lab ID: 24562	NC Lab ID: 25
Conductivity	EPA 9050 A	Solid Chemical Waste		C	
Nitrate as N	EPA 9056A	Solid Chemical Waste		C	
Nitrite as N	EPA 9056A	Solid Chemical Waste		C	
Chloride	EPA 9056A	Solid Chemical Waste		C	
Fluoride	EPA 9056A	Solid Chemical Waste		C	
Sulfate	EPA 9056A	Solid Chemical Waste		C	

9056A**not SC Cert.

Raleigh

Analyte	Method	Program	NC Lab ID: 67
Fecal Coliform	SM 9222D (MF) – 1997	Non-Potable Water	C
Fecal Coliform	Idexx Colilert@18 (MPN)	Non-Potable Water	C
Escherichia coli	Colilert (MPN)	Non-Potable Water	C

ATTACHMENT VII- METHOD HOLD TIME, CONTAINER AND PRESERVATION GUIDE (CURRENT AS OF ISSUE DATE)

THE HOLDING TIME INDICATED IN THE CHART BELOW IS THE MAXIMUM ALLOWABLE TIME FROM COLLECTION TO EXTRACTION AND/OR ANALYSIS PER THE ANALYTICAL METHOD. FOR METHODS THAT REQUIRE PROCESSING PRIOR TO ANALYSIS, THE HOLDING TIME IS DESIGNATED AS 'PREPARATION HOLDING TIME/ANALYSIS HOLDING TIME'.

Parameter	Method	Matrix	Container	Preservative	Max Hold Time
Acid Base Accounting	Sobek	Solid	Plastic/Glass	None	N/A
Acidity	SM2310B	Water	Plastic/Glass	$\leq$ 6ºC	14 Days
Acid Volatile Sulfide	Draft EPA 1629	Solid	8oz Glass	$\leq$ 6ºC	14 Days
Actinides	HASL-300	Water	Plastic/Glass	pH<2 HNO_3	180 Days
Actinides	HASL-300	Solid	Plastic/Glass	None	180 Days
Alkalinity	SM2320B/310.2	Water	Plastic/Glass (NY requires separate bottle filled to the exclusion of air)	$\leq$ 6ºC	14 Days
Alkylated PAHs		Water	1L Amber Glass	$\leq$ 6ºC; pH<2 1:1 HCl (optional)	14/40 Days preserved; 7/40 Days unpreserved
Alkylated PAHs		Solid	8oz Glass	$\leq$ 10ºC	1 Year/40 Days
Anions (Br, Cl, F, NO_2, NO_3, o-Phos, SO_4 , bromate, chlorite, chlorate)	300.0/300.1/SM4110B	Water	Plastic/Glass	$\leq$ 6ºC; EDA if bromate or chlorite run	All analytes 28 days except: NO_2, NO_3, o-Phos (48 Hours); chlorite (immediately for 300.0; 14 Days for 300.1). NO_2/NO_3 combo 28 days.
Anions (Br, Cl, F, NO_2, NO_3, o-Phos, SO_4 , bromate, chlorite, chlorate)	300.0	Solid	Plastic/Glass	$\leq$ 6ºC	All analytes 28 days except: NO_2, NO_3, o-Phos (48

Parameter	Method	Matrix	Container	Preservative	Max Hold Time
					hours); chlorite (immediately). NO$_2$/NO$_3$ combo 28 days.
Anions (Br, Cl, F, NO$_2$, NO$_3$, o-Phos, SO$_4$	9056	Water/ Solid	Plastic/Glass	≤ 6°C	48 hours
Aromatic and Halogenated Volatiles (see note 1)	8021	Solid	5035 vial kit	See note 1	14 days
Aromatic and Halogenated Volatiles	602/8021	Water	40mL vials	pH<2 HCl; ≤ 6°C; Na$_2$S$_2$O$_3$ if Cl present	14 Days (7 Days for aromatics if unpreserved)
Asbestos	EPA 600/R-93/116	Solid	Plastic/Glass; bulk- 2" square; popcorn ceiling- 2tbsp; soil- 4oz	None (handling must be done in HEPA filtered fume hood; drying may be required)	N/A
Bacteria, Total Plate Count	SM9221D	Water	Plastic/WK	≤ 6°C; Na$_2$S$_2$O$_3$	24 Hours
Base/Neutrals and Acids	8270	Solid	8oz Glass	≤ 6°C	14/40 Days
Base/Neutrals and Acids	625/8270	Water	1L Amber Glass	≤ 6°C; Na$_2$S$_2$O$_3$ if Cl present	7/40 Days
Base/Neutrals, Acids & Pesticides	525.2	Water	1L Amber Glass	pH<2 HCl; ≤ 6°C; Na sulfite if Cl present	14/30 Days
Biomarkers		Water	≤ 6°C; pH<2 1:1 HCl (optional)	14/40 Days preserved; 7/40 Days unpreserved	≤ 6°C; pH<2 1:1 HCl (optional)
Biomarkers		Solid	≤ 10°C	1 Year/40 Days	≤ 10°C
BOD/cBOD	SM5210B	Water	Plastic/Glass	≤ 6°C	48 hours
Boiling Range Distribution of Petroleum Fractions	ASTM D2887-98	Product	10mL glass vials	≤ 6°C	N/A
BTEX/Total Hydrocarbons	TO-3	Air	Summa Canister	None	28 Days
BTEX/Total Hydrocarbons	TO-3	Air	Tedlar Bag or equivalent	None	72 Hours
Carbamates	531.1	Water	Glass	Na$_2$S$_2$O$_3$,	28 Days

Parameter	Method	Matrix	Container	Preservative	Max Hold Time
				Monochloroacetic acid pH <3; ≤ 6°C	
Carbamates	8318	Water	Glass	Monochloroacetic acid pH 4-5; ≤ 6°C	7/40 Days
Carbamates	8318	Solid	Glass	≤ 6°C	7/40 Days
Carbon Specific Isoptope Analysis (CSIA)	AM24	Water	40mL clear VOA vial with TLS	≤ 6°C, trisodium phosphate or HCl	N/A
Cation/Anion Balance	SM1030E	Water	Plastic/Glass	None	None
Cation Exchange	9081	Solid	8oz Glass	None	unknown
Cations (Ferrous Iron, Ferric Iron, Divalent Manganese)	7199 modified	Water	40mL clear VOA vials with mylar septum	≤ 6°C; HCl	48 Hours
Chloride	SM4500Cl-C,E	Water	Plastic/Glass	None	28 Days
Chlorinated Hydrocarbons in Vapor	AM4.02	Vapor	20cc vapor vial with flat septum	None	N/A
Chlorine, Residual	SM4500Cl-D,E,G/330.5/Hach 8167	Water	Plastic/Glass	None	15 minutes
Chlorophyll	SM10200H	Water	Opaque bottle or aluminum foil	≤ 6°C	48 Hours to filtration
COD	SM5220C, D/410.4/Hach 8000	Water	Plastic/Glass	pH<2 H_2SO_4; ≤ 6°C	28 Days
Coliform, Fecal	SM9222D	Water	100mL Plastic	≤ 10°C; $Na_2S_2O_3$	8 Hours
Coliform, Fecal	SM9222D	Solid	100mL Plastic	≤ 10°C; $Na_2S_2O_3$	24 Hours
Coliform, Fecal	SM9221E	Water	100mL Plastic	≤ 10°C; $Na_2S_2O_3$	8 Hours
Coliform, Fecal	SM9221E	Solid	100mL Plastic	≤ 10°C; $Na_2S_2O_3$	24 Hours
Coliform, Total	SM9222B	Water	100mL Plastic	≤ 10°C; $Na_2S_2O_3$	8 Hours
Coliform, Total	SM9221B	Solid	100mL Plastic	≤ 10°C; $Na_2S_2O_3$	8 Hours
Coliform, Total, Fecal and E. coli	Colilert/ Quanti-tray	Water	100mL Plastic	≤ 10°C; $Na_2S_2O_3$	8 Hours
Coliform, Total and E. coli	SM9223B	Drinking Water	100mL Plastic	≤ 10°C; $Na_2S_2O_3$	30 Hours
Color	SM2120B,E	Water	Covered	≤ 6°C	48 Hours

Parameter	Method	Matrix	Container	Preservative	Max Hold Time
			Plastic/Acid Washed Amber Glass		
Condensable Particulate Emissions	EPA 202	Air	Solutions	None	180 Days
Cyanide, Reactive	SW846 chap.7	Water	Plastic/Glass	None	28 Days
Cyanide, Reactive	SW846 chap.7	Solid	Plastic/Glass	None	28 Days
Cyanide, Total and Amenable	SM4500CN-A,B,C,D,E,G,I,N/9010/ 9012/335.4	Water	Plastic/Glass	pH≥12 NaOH; ≤ 6ºC; ascorbic acid if Cl present	14 Days (24 Hours if sulfide present- applies to SM4500CN only)
Diesel Range Organics- Alaska DRO	AK102	Solid	8oz Glass	≤ 6ºC	14/40 Days
Diesel Range Organics- Alaska DRO	AK102	Water	1L Glass	pH<2 HCl; ≤ 6ºC	14/40 Days
Diesel Range Organics- TPH DRO	8015	Solid	8oz Glass Jar	≤ 6ºC	14/40 Days
Diesel Range Organics- TPH DRO	8015	Water	1L Amber Glass	≤ 6ºC; $Na_2S_2O_3$ if Cl present	7/40 Days
Diesel Range Organics- TPH DRO	8015	Tissue	1L Amber Glass	≤ - 10ºC	1 Year if frozen/40 Days
Diesel Range Organics- TPH DRO	TO-17	Air	Thermal desorption tubes via SKC Pocket Pumps or equivalent	≤ 6ºC but above freezing	28 Days
Diesel Range Organics- NwTPH-Dx	Nw-TPH-Dx	Solid	8oz Glass Jar	≤ 6ºC	14/40 Days
Diesel Range Organics- NwTPH-Dx	Nw-TPH-Dx	Water	1L Amber Glass	pH <2 HCl; ≤ 6ºC	14/40 Days; 7 Days from collection to extraction if unpreserved
Diesel Range Organics- Wisconsin	WI MOD DRO	Solid	Tared 4oz Glass Jar	≤ 6ºC	10/47 Days

Parameter	Method	Matrix	Container	Preservative	Max Hold Time
DRO					
Diesel Range Organics- Wisconsin DRO	WI MOD DRO	Water	1L Amber Glass	≤ 6ºC; pH <2 HCl	14/40 Days
Dioxins and Furans	1613B	Solid	8oz Glass	≤ 6ºC	1 year
Dioxins and Furans	1613B	Water	1L Amber Glass	≤ 6ºC; $Na_2S_2O_3$ if Cl present	1 year
Dioxins and Furans	1613B	Fish/ Tissue	Aluminum foil	≤ 6ºC	1 year
Dioxins and Furans	8290	Water	1L Amber Glass	≤ 6ºC; $Na_2S_2O_3$ if Cl present	30/45 Days
Dioxins and Furans	8290	Solid	8oz Glass	≤ 6ºC	30/45 Days
Dioxins and Furans	8290	Fish/ Tissue	Not specified	< -10ºC	30/45 Days
Dioxins and Furans	TO-9	Air	PUF	None	7/40 Days
Diquat/Paraquat	549.2	Water	Amber Plastic	≤ 6ºC; $Na_2S_2O_3$	7/21 Days
EDB/DBCP (8011) EDB/DBCP/1,2,3-TCP (504.1)	504.1/8011	Water	40mL vials	≤ 6ºC; $Na_2S_2O_3$ if Cl present	14 Days
Endothall	548.1	Water	Amber Glass	≤ 6ºC; $Na_2S_2O_3$	7/14 Days
Enterococci	EPA 1600	Water	100mL Plastic	≤ 10ºC	8 Hours
Enterococci	Enterolert	Water	100mL Plastic	≤ 10ºC; $Na_2S_2O_3$	8 Hours
Explosives	8330/8332	Water	1L Amber Glass	≤ 6ºC	7/40 Days
Explosives	8330/8332	Solid	8oz Glass Jar	≤ 6ºC	14/40 Days
Extractable Petroleum Hydrocarbons (aliphatic and aromatic)	NJ EPH	Water	1L Amber Glass	pH < 2 HCl; ≤ 6ºC	14/40 Days
Extractable Petroleum Hydrocarbons (aliphatic and aromatic)	NJ EPH	Solid	4oz Glass Jar	≤ 6ºC	14/40 Days
Extractable Petroleum Hydrocarbons (aliphatic and aromatic)	MA-EPH	Water	1L Amber Glass	pH<2 HCl; ≤ 6ºC	14/40 Days
Extractable Petroleum	MA-EPH	Solid	4oz Glass Jar	≤ 6ºC	7/40 Days

Parameter	Method	Matrix	Container	Preservative	Max Hold Time
Hydrocarbons (aliphatic and aromatic)					
Fecal Streptococci	SM9230B	Water	100mL Plastic	≤ 10°C; $Na_2S_2O_3$	8 Hours
Ferrous Iron	SN3500Fe-D; Hach 8146	Water	Glass	None	Immediate
Flashpoint/ Ignitability	1010	Liquid	Plastic/Glass	None	28 Days
Florida PRO	FL PRO DEP (11/1/95)	Liquid	Glass, PTFE lined cap	≤ 6°C; pH <2 H_2SO_4 or HCl	7/40 Days
Fluoride	SM4500Fl-C,D	Water	Plastic	None	28 Days
Gamma Emitting Radionuclides	901.1	Water	Plastic/Glass	pH<2 HNO_3	180 days
Gasoline Range Organics	8015	Water	40mL vials	pH<2 HCl	14 Days
Gasoline Range Organics	8015	Solid	5035 vial kit	See note 1	14 days
Gasoline Range Organics (C3-C10)	8260B modified	Water	40mL vials	≤ 6°C; HCl	14 Days
Gasoline Range Organics (C3-C10)	8260B modified	Solid	4oz Glass Jar	≤ 6°C	14 Days
Gasoline Range Organics- Alaska GRO	AK101	Solid	5035 vial kit	See 5035 note*	28 Days if GRO only (14 Days with BTEX)
Gasoline Range Organics- Alaska GRO	AK101	Water	40mL vials	pH<2 HCl; ≤ 6°C	14 Days
Gasoline Range Organics- NwTPH-Gx	Nw-TPH-Gx	Water	40mL vials	pH<2 HCl; ≤ 6°C	7 Days unpreserved; 14 Days preserved
Gasoline Range Organics- NwTPH-Gx	Nw-TPH-Gx	Solid	40mL vials	≤ 6°C; packed jars with no headspace	14 Days
Gasoline Range Organics- Wisconsin GRO	WI MOD GRO	Water	40mL vials	pH<2 HCl; ≤ 6°C	14 Days
Gasoline Range Organics- Wisconsin GRO	WI MOD GRO	Solid	40mL MeOH vials	≤ 6°C in MeOH	21 Days
Glyphosate	547	Water	Glass	≤ 6°C; $Na_2S_2O_3$	14 Days (18 Months frozen)
Grain Size	ASTM D422	Solid	Not specified	Ambient	N/A

Parameter	Method	Matrix	Container	Preservative	Max Hold Time
Gross Alpha (NJ 48Hr Method)	NJAC 7:18-6	Water	Plastic/Glass	pH<2 HNO_3	48 Hrs
Gross Alpha and Gross Beta	9310/900.0	Water	Plastic/Glass	pH<2 HNO_3	180 Days
Gross Alpha and Gross Beta	9310	Solid	Glass	None	180 Days
Haloacetic Acids	552.1/552.2	Water	40mL Amber vials	NH_4Cl; $\leq 6^oC$	14/7 Days if extracts stored $\leq 6^oC$ or 14/14 Days if extracts stored at $\leq -10^oC$
Hardness, Total ($CaCO_3$)	SM2340B,C/130.1	Water	Plastic/Glass	pH<2 HNO_3	180 Days
Heterotrophic Plate Count (SPC/HPC)	SM9215B	Water	100mL Plastic	$\leq 10^oC$; $Na_2S_2O_3$	8 Hours
Heterotrophic Plate Count (SPC/HPC)	SimPlate	Water	100mL Plastic	$\leq 10^oC$; $Na_2S_2O_3$	8 Hours
Herbicides, Chlorinated	8151	Solid	8oz Glass Jar	$\leq 6^oC$	14/40 Days
Herbicides, Chlorinated	8151	Water	1L Amber Glass	$\leq 6^oC$; $Na_2S_2O_3$ if Cl present	7/40 Days
Herbicides, Chlorinated	515.1/515.3	Water	1L Amber Glass	$\leq 6^oC$; $Na_2S_2O_3$ if Cl present	14/28 Days
Hexavalent Chromium	7196/218.6/ SM3500Cr-B, C, D	Water	Plastic/Glass	$\leq 6^oC$	24 Hours (see note 4)
Hexavalent Chromium	218.6/SM3500Cr-B, C, D	Water	Plastic/Glass	Ammonium Buffer pH 9.3-9.7	28 Days (see note 4)
Hexavalent Chromium	218.6/218.7	Drinking Water	Plastic/Glass	Ammonium Buffer pH >8	14 Days (see note 4)
Hexavalent Chromium	7196 (with 3060A)	Solid		$\leq 6^oC$	30 Days from collection to extraction and 7 days from extraction to analysis
Hydrocarbons in Vapor	AM4.02	Vapor	20cc vapor vial with flat septum	None	N/A
Hydrogen by Bubble Strip	SM9/AM20GAx	Water	20cc vapor vial with stopper septum	None	14 Days
Hydrogen Halide and Halogen	EPA 26	Air	Solutions	None	6 Months

Parameter	Method	Matrix	Container	Preservative	Max Hold Time
Emissions					
Ignitability of Solids	1030	Non-liquid Waste	Plastic/Glass	None	28 Days
Lead Emissions	EPA 12	Air	Filter/Solutions	None	6 Months
Light Hydrocarbons by Bubble Strip	SM9/AM20GAx	Water	20cc vapor vial with stopper septum	None	14 Days
Light Hydrocarbons in Vapor	AM20GAx	Vapor	20cc vapor vial with flat septum	None	14 Days
Lipids	Pace Lipids	Tissue	Plastic/Glass	$\leq$ -10ºC	1 Year if frozen
Mercury, Low-Level	1631E	Solid	Glass	None	28 Days
Mercury, Low-Level	1631E	Water	Fluoropolymer bottles (Glass if Hg is only analyte being tested)	12N HCl or BrCl	48 Hours for preservation or analysis; 28 Days to preservation if sample oxidized in bottle; 90 Days for analysis if preserved
Mercury, Low-Level	1631E	Tissue	Plastic/Glass	$\leq$ - 10ºC	28 Days if frozen
Mercury	7471	Solid	8oz Glass Jar	$\leq$ 6ºC	28 Days
Mercury	7470/245.1/245.2	Water	Plastic/Glass	pH<2 HNO_3	28 Days
Mercury	7471/245.6	Tissue	Plastic/Glass	$\leq$ - 10ºC	28 Days if frozen
Metals (GFAA)	7000/200.9	Water	Plastic/Glass	pH<2 HNO_3	180 Days
Metals (ICP)	NIOSH 7300A/7303	Air	Filters	None	180 Days
Metals (ICP/ICPMS)	6010/6020	Solid	8oz Glass Jar	None	180 Days
Metals (ICP/ICPMS)	6010/6020/200.7/200.8	Water	Plastic/Glass	pH<2 HNO_3	180 Days
Metals (ICP/ICPMS)	6020	Tissue	Plastic/Glass	$\leq$ -10ºC	180 Days if frozen
Methane, Ethane, Ethene	8015 modified	Water	40mL vials	HCl	14 Days
Methane, Ethane, Ethene	RSK-175; PM01/AM20GAx	Water	20mL vials	HCl; or trisodium phosphate or	14 Days; 7 Days

Parameter	Method	Matrix	Container	Preservative	Max Hold Time
				benzalkonium chloride and ≤ 6°C	unpreserved
Methane, Ethane, Ethene	EPA 3C	Air	Summa Canister	None	28 Days
Methane, Ethane, Ethene	EPA 3C	Air	Tedlar Bag or equivalent	None	5 Days
Methanol, Ethanol	8015 modified	Water	40mL vials	≤ 6°C	14 Days
Methanol, Ethanol	8015 modified	Solid	2oz Glass	≤ 6°C	14 Days
Methyl Mercury	1630	Water	Teflon/ fluoropolymer	Fresh water-4mL/L HCl; Saline water-2mL/L H_2SO_4 (must be preserved within 48 hours of collection)	6 months
Methyl Mercury	1630	Tissue	2-4oz glass jar	≤ 0°C	28 Days; ethylated distillate 48 hours
Nitrogen, Ammonia	SM4500NH3/350.1	Water	Plastic/Glass	pH<2 H_2SO_4; ≤ 6°C	28 Days
Nitrogen, Total Kjeldahl (TKN)	351.2	Solid	Plastic/Glass	≤ 6°C	28 Days
Nitrogen, Total Kjeldahl (TKN)	SM4500-Norg/351.2	Water	Plastic/Glass	pH<2 H_2SO_4; ≤ 6°C	28 Days
Nitrogen, Nitrate	SM4500-NO3/352.1	Water	Plastic/Glass	≤ 6°C	24 Hours preferred
Nitrogen, Nitrate & Nitrite combination	353.2	Solid	Plastic/Glass	≤ 6°C	28 Days
Nitrogen, Nitrate & Nitrite combination	SM4500-NO3/353.2	Water	Plastic/Glass	pH<2 H_2SO_4; ≤ 6°C	28 Days
Nitrogen, Nitrite or Nitrate separately	SM4500-NO2/353.2	Water	Plastic/Glass	≤ 6°C	48 Hours
Nitrogen, Organic	SM4500-Norg/351.2	Water	Plastic/Glass	pH<2 H_2SO_4; ≤ 6°C	28 Days
Non-Methane Organics	EPA 25C	Air	Summa Canister	None	28 Days
Non-Methane Organics	EPA 25C	Air	Tedlar Bag or equivalent	None	72 Hours
Odor	SM2150B	Water	Glass	≤ 6°C	24 Hours
Oil and Grease/HEM	1664A/SM5520B/9070	Water	Glass	pH<2 H_2SO_4 or HCl; ≤ 6°C	28 Days
Oil and Grease/HEM	9071	Solid	Glass	≤ 6°C	28 Days
Oil Range Organics	8015	Solid	Glass	≤ 6°C	14/40 Days

Parameter	Method	Matrix	Container	Preservative	Max Hold Time
Oil Range Organics	8015	Water	Glass	≤ 6°C	7/40 Days
Organic Matter	ASA 29-3.5.2	Solid	Plastic/Glass	None; samples air-dried and processed prior to analysis	N/A
Oxygen, Dissolved (Probe)	SM4500-O	Water	Glass	None	15 minutes
Oxygenates on Product (GCMS SIM)	1625 modified	Product	10mL glass vial	≤ 6°C	14 Days (7 Days from extraction)
PBDEs	1614	Water	1L Amber Glass	≤ 6°C	1 Year/1 Year
PBDEs	1614	Solid	Wide Mouth Jar	≤ 6°C	1 Year/1 Year
PBDEs	1614	Tissue	Aluminum Foil	≤ -10°C	1 Year/1 Year
PCBs and Pesticides, Organochlorine (OC)	TO-4/TO-10	Air	PUF	None	7/40 Days
PCBs and Pesticides, Organochlorine (OC)	608	Water	1L Amber Glass	≤ 6°C; $Na_2S_2O_3$ if Cl present	Pest: 7/40 Days; PCB: 1 Year/1 Year
PCBs, Pesticides (OC), Herbicides	508.1	Water	Glass	Na2SO3; pH<2 HCl; ≤ 6°C	14/30 Days
PCBs, total as Decachlorobiphenyl	508A	Water	1L Glass, TFE lined cap	≤ 6°C	14/30 Days
Perchlorate	331	Water	Plastic/Glass	≥0-6°C, field filtered with headspace	28 Days
Permanent Gases (O2, N2, CO2)	RSK-175; PM01/AM20GAx	Water	40mL vials	benzalkonium chloride and ≤ 6°C	14 Days
Permanent Gases by Bubble Strip	SM9/AM20GAx	Water	20cc vapor vial with stopper septum	None	14 Days
Permanent Gases in Vapor	AM20GAx	Vapor	20cc vapor vial with flat septum	None	14 Days
Pesticides, Organochlorine (OC)	8081	Water	1L Amber Glass	≤ 6°C; $Na_2S_2O_3$ if Cl present	7/40 Days
Pesticides,	8081	Solid	8oz Glass Jar	≤ 6°C	14/40 Days

Parameter	Method	Matrix	Container	Preservative	Max Hold Time
Organochlorine (OC)					
Pesticides, Organochlorine (OC)	8081	Tissue	8oz Glass Jar	≤ -10ºC	1 Year if frozen/40 Days
Pesticides, Organophosphorous (OP)	8141	Solid	8oz Glass Jar	≤ 6ºC	14/40 Days
Pesticides, Organophosphorous (OP)	8141	Water	1L Amber Glass	pH 5-8 with NaOH or H_2SO_4; ≤ 6ºC; $Na_2S_2O_3$ if Cl present	7/40 Days
PCBs (Aroclors)	8082	Water	1L Amber Glass	≤ 6ºC; $Na_2S_2O_3$ if Cl present	1 Year/1 Year
PCBs (Aroclors)	8082	Solid	8oz Glass Jar	≤ 6ºC	1 Year/1 Year
PCBs (Aroclors)	8082	Tissue	Plastic/Glass	≤ -10ºC	1 Year if frozen/1 Year
PCB Congeners	1668A	Water	1L Amber Glass	≤ 6ºC but above freezing	1 Year/1 Year
PCB Congeners	1668A	Solid	4-8oz Glass Jar	≤ 6ºC but above freezing	1 Year/1 Year
PCB Congeners	1668A	Tissue	4-8oz Glass Jar	≤ -10ºC	1 Year/1 Year
Paint Filter Liquid Test	9095	Water	Plastic/Glass	None	N/A
Particle Size	ASA 15-5 modified	Solid	Plastic/Glass (100g sample)	None	N/A
Particulates	PM-10	Air	Filters	None	180 Days
Permanent Gases	EPA 3C	Air	Summa Canister	None	28 Days
Permanent Gases	EPA 3C	Air	Tedlar Bag or equivalent	None	5 Days
pH	SM4500H+B/9040	Water	Plastic/Glass	None	15 minutes
pH	9045	Solid	Plastic/Glass	None	7 Days
Phenol, Total	420.1/420.4/9065/9066	Water	Glass	pH<2 H_2SO_4; ≤ 6ºC	28 Days
Phosphorus, Orthophosphate	SM4500P/365.1/365.3	Water	Plastic	≤ 6ºC	Filter within 15 minutes, Analyze within 48 Hours
Phosphorus, Total	SM4500P/ 365.1/365.3/365.4	Water	Plastic/Glass	pH<2 H_2SO_4; ≤ 6ºC	28 Days
Phosphorus, Total	365.4	Solid	Plastic/Glass	≤ 6ºC	28 Days
Polynuclear	TO-13	Air	PUF	None	7/40 Days

Parameter	Method	Matrix	Container	Preservative	Max Hold Time
Aromatic Hydrocarbons (PAH)					
Polynuclear Aromatic Hydrocarbons (PAH)	TO-17	Air	Thermal desorption tubes via SKC Pocket Pumps or equivalent	≤ 6°C but above freezing	28 Days
Polynuclear Aromatic Hydrocarbons (PAH)	8270 SIM	Solid	8oz Glass Jar	≤ 6°C	14/40 Days
Polynuclear Aromatic Hydrocarbons (PAH)	8270 SIM	Water	1L Amber Glass	≤ 6°C; $Na_2S_2O_3$ if Cl present	7/40 Days
Polynuclear Aromatic Hydrocarbons (PAH)	8270 SIM	Tissue	Plastic/Glass	≤ -10°C	1 Year if frozen/40 Days
Purgeable Organic Halides (POX)	9021	Water	Glass; no headspace	≤ 6°C	14 Days
Radioactive Strontium	905.0	Water	Plastic/Glass	pH<2 HNO_3	180 days
Radium-226	903.0/903.1	Water	Plastic/Glass	pH<2 HNO_3	180 days
Radium-228 (see note 3)	9320/904.0	Water	Plastic/Glass	pH<2 HNO_3	180 days
Radium-228 (see note 3)	9320	Solid	Plastic/Glass		
Residual Range Organics- Alaska RRO	AK103	Solid	8oz Glass	≤ 6°C	14/40 Days
Saturated Hydrocarbons		Water	≤ 6°C; pH<2 1:1 HCl (optional)	14/40 Days preserved; 7/40 Days unpreserved	≤ 6°C; pH<2 1:1 HCl (optional)
Saturated Hydrocarbons		Solid	≤ 10°C	1 Year/40 Days	≤ 10°C
Silica, Dissolved	SM4500Si-D	Water	Plastic	≤ 6°C	28 Days
Solids, Settleable	SM2540F	Water	Glass	≤ 6°C	48 Hours
Solids, Total	SM2540B	Water	Plastic/Glass	≤ 6°C	7 Days
Solids, Total	SM2540G	Solid	Plastic/Glass	≤ 6°C	7 Days
Solids, Total (FOC, OM, Ash)	ASTM D2974	Solid	Plastic/Glass	≤ 6°C	7 Days
Solids, Total	SM2540C	Water	Plastic/Glass	≤ 6°C	7 Days

Parameter	Method	Matrix	Container	Preservative	Max Hold Time
Dissolved					
Solids, Total Suspended	SM2540D/USGS I-3765-85	Water	Plastic/Glass	≤ 6ºC	7 Days
Solids, Total Volatile	160.4/SM2540E	Water	Plastic/Glass	≤ 6ºC	7 Days
Solids, Total Volatile	160.4	Solid	Plastic/Glass	≤ 6ºC	7 Days
Specific Conductance	SM2510B/9050/120.1	Water	Plastic/Glass	≤ 6ºC	28 Days
Stationary Source Dioxins and Furans	EPA 23	Air	XAD Trap	None	30/45 Days
Stationary Source Mercury	EPA 101	Air	Filters	None	180 Days, 28 Days for Hg
Stationary Source Metals	EPA 29	Air	Filters	None	180 Days, 28 Days for Hg
Stationary Source PM10	EPA 201A	Air	Filters	None	180 Days
Stationary Source Particulates	EPA 5	Air	Filter/Solutions	None	180 Days
Sulfate	SM4500SO4/9036/9038/375.2/ASTM D516	Water	Plastic/Glass	≤ 6ºC	28 Days
Sulfide, Reactive	SW-846 Chap.7	Water	Plastic/Glass	None	28 Days
Sulfide, Reactive	SW-846 Chap.7	Solid	Plastic/Glass	None	28 Days
Sulfide, Total	SM4500S/9030	Water	Plastic/Glass	pH>9 NaOH; ZnOAc; ≤ 6ºC	7 Days
Sulfite	SM4500SO3	Water	Plastic/Glass	None	15 minutes
Surfactants (MBAS)	SM5540C	Water	Plastic/Glass	≤ 6ºC	48 Hours
Total Alpha Radium (see note 3)	9315/903.0	Water	Plastic/Glass	pH<2 HNO_3	180 days
Total Alpha Radium (see note 3)	9315	Solid	Plastic/Glass	None	180 days
Total Inorganic Carbon (TIC)	PM01/AM20GAx	Water	40mL VOA vial with mylar septum	≤ 6ºC	14 Days
Total Organic Carbon (TOC)	SM5310B,C,D/9060	Water	Glass	pH<2 H_2SO_4 or HCl; ≤ 6ºC	28 Days
Total Organic Carbon (TOC)	9060/Walkley Black/Lloyd Kahn	Solid	Glass	≤ 6ºC	14 Days
Total Organic Halogen (TOX)	SM5320/9020	Water	Glass; no headspace	≤ 6ºC	14 Days
Total Petroleum Hydrocarbons (aliphatic and aromatic)	TPHCWG	Water	40mL vials	pH<2 HCl, no headspace, ≤ 6ºC	7 Days

Parameter	**Method**	**Matrix**	**Container**	**Preservative**	**Max Hold Time**
Total Petroleum Hydrocarbons (aliphatic and aromatic)	TPHCWG	Solid	Glass	≤ 6ºC	14 days
Tritium	906.0	Water	Glass	None	180 days
Turbidity	SM2130B/180.1	Water	Plastic/Glass	≤ 6ºC	48 Hours
Total Uranium	908.0/ASTM D5174-97	Water	Plastic/Glass	pH<2 HNO_3	180 days
UCMR Metals	200.8	Water	Plastic or glass	pH<2 HNO_3	28 Days
UCMR Hexavalent Chromium	218.7	Water	HDPE or propylene	$Na_2CO_3/NaHCO_3/(NH_4)_2SO_4$; pH>8	14 Days
UCMR Chlorate	300.1	Water	Plastic or glass	EDA	28 Days
UCMR Perfluorinated Compounds	537	Water	Polypropylene	Trizma	14 Days
UCMR 1, 4 Dioxane	522	Water	Glass	Na_2SO_3, $NaHSO_4$; pH<4	28 Days
UV254	SM5910B	Water	Glass	≤ 6ºC	48 Hours
Vermiculite	EPA 600/R-93/116	Solid	Plastic/Glass	None (handling must be done in HEPA filtered fume hood; drying may be required)	N/A
Volatile Fatty Acids	AM21G	Water	40mL clear VOA vials	≤ 6ºC	21 Days
Volatile Fatty Acids (low level)	AM23G	Water	40mL clear VOA vials	≤ 6ºC with benzalkonium chloride	14 Days
Volatile Petroleum Hydrocarbons (aliphatic and aromatic)	MA-VPH	Water	40mL vials	pH<2 HCl; ≤ 6ºC	14 Days preserved
Volatile Petroleum Hydrocarbons (aliphatic and aromatic)	MA-VPH	Solid	4-8oz Glass Jar	≤ 6ºC; packed jars with no headspace	7/28 Days
Volatiles	TO-14	Air	Summa Canister	None	28 Days
Volatiles	TO-14	Air	Tedlar Bag or equivalent	None	72 Hours
Volatiles	TO-15	Air	Summa Canister or Tedlar Bag	None	28 Days

Parameter	Method	Matrix	Container	Preservative	Max Hold Time
Volatiles	TO-17	Air	Thermal desorption tubes via SKC Pocket Pumps or equivalent	≤ 6ºC but above freezing	28 Days
Volatiles	TO-18/8260	Air	Tedlar Bag or equivalent	None	72 Hours
Volatiles	8260	Solid	5035 vial kit	See note 1 (analyze for acrolein and acrylonitrile per local requirements)	14 days
Volatiles	8260	Water	40mL vials	pH<2 HCl; ≤ 6ºC; Na$_2$S$_2$O$_3$ if Cl present (preserve and analyze for acrolein and acrylonitrile per local requirements)	14 Days
Volatiles	8260	Conc. Waste	5035 vial kit or 40mL vials	≤ 6ºC	14 Days
Volatiles	624	Water	40mL vials	pH<2 HCl; ≤ 6ºC; Na$_2$S$_2$O$_3$ if Cl present (or unpreserved if run within 7 days of collection) (preserve and analyze for acrolein and acrylonitrile per local requirements)	14 Days (7 Days for aromatics if unpreserved)
Volatiles (see note 2)	524.2	Water	40mL vials (in duplicate)	pH<2 HCl; ≤ 6ºC; Ascorbic acid or Na$_2$S$_2$O$_3$ if Cl present[2]	14 Days
Whole Oil	ASTM D3328 (prep); ASTM D5739	Product	10mL glass vials	≤ 6ºC	N/A

[1] **5035/5035A Note**: 5035 vial kit typically contains 2 vials water, preserved by freezing **or**, 2 vials aqueous sodium bisulfate preserved at 4ºC, **and** one vial methanol preserved at ≤6ºC **and** one container of unpreserved sample stored at ≤6ºC.

[2] Method 524.2 lists ascorbic acid as the preservative when residual chlorine is suspected, unless gases or Table 7 compounds are NOT compounds of interest and then sodium thiosulfate is the preservative recommended.

[3] Methods 9315 and 9320 both state that if samples are unpreserved, the samples should be brought to the lab within 5 days of collection, preserved in the lab, and then allowed to sit for a minimum of 16 hours before sample preparation/analysis.

[4] The holding time for hexavalent chromium may be extended by the addition of the ammonium buffer listed in EPA 218.6 per the 2012 EPA Method Update Rule. Although Method 218.6 stipulates a different pH range (9.0 to 9.5) for buffering, this method requirement was modified in the Method Update Rule to a pH range of 9.3 to 9.7.For non-potable waters, adjust the pH of the sample to 9.3 to 9.7 during collection with the method required ammonium sulfate buffer to extend the holding time to 28 days. For potable waters, addition of the buffer during collection will extend the holding time for 14 days per EPA 218.7 and the EPA UCMR program.

Pace Analytical®
www.pacelabs.com

CHAIN-OF-CUSTODY / Analytical Request Document

The Chain-of-Custody is a LEGAL DOCUMENT. All relevant fields must be completed accurately.

Page: of

Section A **Required** Client Information:		**Section B** **Required** Project Information:	**Section C** Invoice Information:
Company:		Report To:	Attention:
Address:		Copy To:	Company Name:
			Address:
Email To:		Purchase Order No.:	Pace Quote Reference:
Phone:	Fax:	Project Name:	Pace Project Manager:
Requested Due Date/TAT:		Project Number:	Pace Profile #:

REGULATORY AGENCY

☐ NPDES ☐ GROUND WATER ☐ DRINKING WATER
☐ UST ☐ RCRA ☐ OTHER ____________

Site Location
STATE: ____________

Section D
Required Client Information

SAMPLE ID
(A-Z, 0-9 / ,-)
Sample IDs MUST BE UNIQUE

Matrix Codes

MATRIX	CODE
Drinking Water	DW
Water	WT
Waste Water	WW
Product	P
Soil/Solid	SL
Oil	OL
Wipe	WP
Air	AR
Tissue	TS
Other	OT

Requested Analysis Filtered (Y/N)

ITEM #	SAMPLE ID	MATRIX CODE (see valid codes to left)	SAMPLE TYPE (G=GRAB C=COMP)	COLLECTED COMPOSITE START DATE	TIME	COMPOSITE END/GRAB DATE	TIME	SAMPLE TEMP AT COLLECTION	# OF CONTAINERS	Preservatives Unpreserved	H_2SO_4	HNO_3	HCl	NaOH	$Na_2S_2O_3$	Methanol	Other	Y/N → → Analysis Test →												Residual Chlorine (Y/N)	Pace Project No./ Lab I.D.
1																															
2																															
3																															
4																															
5																															
6																															
7																															
8																															
9																															
10																															
11																															
12																															

ADDITIONAL COMMENTS	RELINQUISHED BY / AFFILIATION	DATE	TIME	ACCEPTED BY / AFFILIATION	DATE	TIME	SAMPLE CONDITIONS			
							Temp in °C	Received on Ice (Y/N)	Custody Sealed Cooler (Y/N)	Samples Intact (Y/N)

SAMPLER NAME AND SIGNATURE

PRINT Name of SAMPLER:

SIGNATURE of SAMPLER: **DATE Signed (MM/DD/YY):**

*Important Note: By signing this form you are accepting Pace's NET 30 day payment terms and agreeing to late charges of 1.5% per month for any invoices not paid within 30 days.

F-ALL-Q-020rev.07, 15-May-2007

Instructions for completing Chain of Custody (COC)

1. **Section A and B:** Complete all Client information at top of sheet: company name, address, phone, fax, contact (the person to contact if there are questions, and who will receive the final report.), e-mail address (if available), PO#, Project Name and/or Project Number as you would like to see it appear on the report.
2. **Section C:** Invoice Information: Billing information is included in this section. This information should include the name and address of the person receiving the invoice.
3. Quote Reference should be completed if a quotation was provided by Pace Analytical. The Project Manager, and Profile No. will be completed by Pace Analytical Services.
4. **Site Location:** A separate COC must be filled out for each day of sample collection. Record the two letter postal code for the US state in which the samples were collected.
5. **Regulatory Agency:** List the program that is guiding the work to ensure proper regulations are followed.
6. **Section D:** Complete a Sample Description in the "SAMPLE ID' section as you would like it to appear on the laboratory report. The following information should also be included: the sample matrix, sample type (G (grab) or C (composite). When collecting a composite, the start time and end time should be documented in the respective boxes. The collection time for a grab (G) sample should be entered in the boxes marked 'Composite End/Grab'), Sample temp at collection (if required by state), the total number of containers, and preservative used.
7. Mark if the sample was filtered in the field by marking Y or N in 'Filtered' row by the Analysis requested.
8. Requested Analysis: List the required analysis and methods on the lines provided and place a check in the column for the samples requiring the analysis. Additional comments should be referenced in the bottom left hand corner or include attachments for extended lists of parameters.
9. The sampler should print their name in the space provided and sign their name followed by the date of the sampling event at the bottom of the COC in the spaces designated for 'SAMPLER NAME AND SIGNATURE'.
10. When relinquishing custody of the samples to a representative of the laboratory or other organization, indicate the Item Numbers of those samples being transferred; sign relinquished by, date and time, and include your affiliation.

***Important Note:**

Standard Turnaround Time is 2 Weeks/10 business days. Results will be delivered by end of business on the date due unless other arrangements have been made with your project manager.

Special Project Requirements such as Low Level Detection Limits or level of QC reported must be included on the chain of custody in the Additional Comments section.

APPENDIX C

ALS ENVIRONMENTAL QUALITY ASSURANCE MANUAL

QUALITY ASSURANCE MANUAL

ALS Environmental – Simi Valley Facility
2655 Park Center Drive, Suite A
Simi Valley, CA, 93065
(805)526-7161 (T)
(805)526-7270 (F)
www.alsglobal.com

QUALITY ASSURANCE MANUAL

Doc ID: ALSMV-QAM **Rev. Number:** 32.0 **Effective Date:** 10/01/2017

Approved By: ______________________ **Date:** 08/11/17
Laboratory Director - Kelly Horiuchi

Approved By: ______________________ **Date:** 8/11/17
QA Manager - Chaney Humphrey

Approved By: ______________________ **Date:** 8/14/17
Technical Manager (Volatiles GC/MS & Semi-Volatiles) - Chris Parnell

Approved By: ______________________ **Date:** 8/14/17
Technical Manager (Volatiles GC) - Wade Henton

Approved By: ______________________ **Date:** 8/14/17
Technical Manager (Wet/Gen) - Sue Anderson

Archival Date: ________ **Doc Control ID#:** Uncontrolled **Editor:** ________

TABLE OF CONTENTS

QA MANUAL CROSS REFERENCE TABLE

ALS QAM	ISO/IEC 17025:2005 Section	TNI Vol 1 2009 Module/Section
2	4.1	2/4.1
3	4.2	2/4.2
4	4.3	2/4.3
5	4.4	2/4.4
6	4.5	2/4.5
7	4.6	2/4.6
8	4.7	2/4.7
9	4.8	2/4.8
15	4.9	2/4.9
16	4.10	2/4.10
16	4.11	2/4.11
16	4.12	2/4.12
17	4.13	2/4.13
18	4.14	2/4.14
19	4.15	2/4.15
2, 12, 13, 14	5.1	2/5.1
20	5.2	2/5.2
10	5.3	2/5.3
12, 13, 14	5.4	2/5.4
10	5.5	2/5.5
13	5.6	2/5.6
11	5.7	2/5.7
11, 12, 13	5.8	2/5.8
14	5.9	2/5.9
21	5.10	2/5.10

1) Introduction and Scope

The purpose of this Quality Assurance Manual is to outline the quality system for the Simi Valley location of ALS Environmental (ALS Group USA Corp. dba ALS Environmental). ALS Environmental is a professional analytical services laboratory which performs chemical and microbiological analyses on a wide variety of sample matrices, including drinking water, groundwater, surface water, wastewater, soil, sludge, sediment, tissue, industrial and hazardous waste, air, and other material. Refer to Appendix J for a list of analytical capabilities specific to the Simi Valley location and corresponding accreditation status.

Quality Control (QC) procedures are used to continually assess performance of the laboratory and quality systems. ALS Environmental maintains control of analytical results by adhering to written standard operating procedures (SOPs), using analytical control parameters with all analyses, and by observing sample custody requirements. All analytical results are calculated and reported in units consistent with project specifications to allow comparability of data. Appendix H includes a list of data qualifiers and acronyms.

This QAM is applicable to the facility listed on the title page. The information in this QAM has been organized according to requirements found in the National Environmental Laboratory Accreditation Program (NELAP) Quality Systems Standards (2003 and 2009), DoD Quality Systems Manual, Naval Sea Systems Command Laboratory Accreditation Program (NAVSEA-LAP), the EPA Requirements for Quality Assurance Project Plans, EPA QA/R-5, USEPA, 2001; and *General Requirements for the Competence of Testing and Calibration Laboratories*, ISO/IEC 17025:2005.

2) Organization

2.1 Laboratory Organizational Structure

ALS Environmental – Simi Valley is legally identifiable as ALS Group USA, Corp., dba ALS Environmental. ALS Group USA Corp. is a component of ALS Limited, a publicly held Australian company. The ALS global website may be referred to for corporate ownership information (www.alsglobal.com). Organizational charts detailing the operational structure and reporting relationships in the laboratory are provided in Appendix B.

2.2 Avoiding Conflict of Interest through Organizational Structure

2.2.1 Through application of the policies and procedure outlined in this QA Manual and use of a defined organizational structure, the laboratory assures that it is impartial and that personnel are free from undue commercial, financial, or other undue pressures that might influence their technical judgment.

2.2.2 Policies are in place to prevent outside pressures or involvement in activities that may affect competence, impartiality, judgment, operational integrity, or the quality of the work performed at the laboratory.

2.2.3 Management and technical personnel have the authority and resources to carry out their duties and have procedures to identify and correct departures from the laboratory's management system.

2.2.4 Personnel understand the relevance and importance of their duties as related to the maintenance of the laboratory's management system. Ethics and data integrity procedure ensure that personnel do not engage in activities that diminish confidence in the laboratory's capabilities. Procedures and policies are also established to ensure confidentiality is maintained.

3) Management

The purpose of the QA program at ALS Environmental is to ensure that our clients are provided with analytical data that is scientifically sound, legally defensible, and of known and documented quality.

3.1 Quality Policy Statement

The policy at ALS is to use good professional practices, to maintain quality, to uphold the highest standard of service, and to operate in accordance with these requirements and those of regulatory agencies, accrediting authorities, and certifying organizations. We recognize that quality assurance requires a commitment to quality by everyone in the organization - individually, within each operating unit, and throughout the entire laboratory. Laboratory management is committed to ensuring the effectiveness of its quality systems and to ensure that all tests are carried out in accordance to customer requirements. Key elements of this commitment are set forth in the *SOP for Laboratory Ethics and Data Integrity* (CE-GEN001) and in this Quality Assurance Manual (QAM). ALS Environmental is committed to operate in accordance with these requirements and those of regulatory agencies, accrediting authorities, and certifying organizations. The laboratory also strives for improvement through varying continuous improvement initiatives and projects.

Quality Management Systems are established, implemented and maintained by management. Policies and procedures are established in order to meet requirements of accreditation bodies and applicable programs as well as client's quality objectives. The laboratory's management is committed to complying with the National Environmental Laboratory Accreditation Program (NELAP) Quality Systems Standards (2003 and 2009 NELAP/TNI standards), ISO/IEC 17025:2005, Naval Sea System Command Laboratory Accreditation Program (NAVSEA-LAP), and the Department of Defense (DoD) Quality Systems Manual for Environmental Laboratories. Systems are designed so that there will be sufficient Quality Assurance (QA) activities conducted in the laboratory to ensure that all analytical data generated and processed will be scientifically sound, legally defensible, of known and documented quality, and will accurately reflect the material being tested. Quality Systems are applicable to all fields of testing in which the laboratory is involved. All personnel involved with environmental testing and calibration activities must familiarize themselves with the quality documentation and implement the policies and procedures in their work.

3.2 Quality Management Systems

The laboratory has developed a Quality Management System to ensure all products and services meet our client's needs. The system is implemented and maintained by the Quality Assurance Manager (QA Manager) with corporate oversight by the Corporate Quality Assurance Manager (CQAM). These systems are based upon ISO/IEC 17025:2005 standards, upon which fundamental programs (TNI/NELAP, NAVSEA-LAP, and DoD QSM) are based. Implementation and documentation against these standards are communicated in corporate policy statements, this QAM, and SOPs. Actual procedures, actions and documentation are defined in both administrative and technical SOPs. Figure 3-1 shows the relationships of the quality systems and associated documentation. Quality systems include:

- Standard Operating Procedures
- Sample Management and Chain of Custody procedures
- Statistical Control Charting
- Standards Traceability

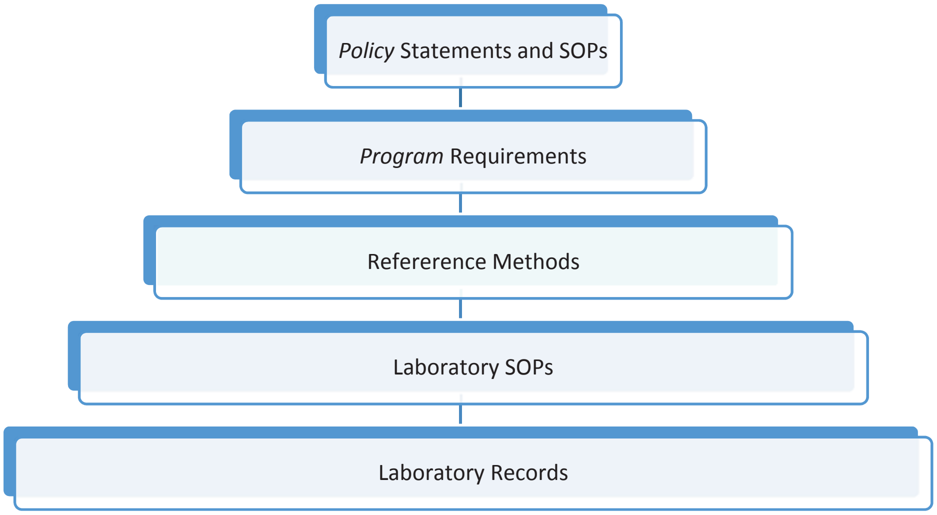
- Ethics Training
- Document Control
- Corrective Action Program
- Management Reviews
- Demonstration of Capability

The effectiveness of the quality system is assessed in several ways, including:

- Internal and External Audits covering all aspects of the organization
- Annual Management Reviews
- Analysis of Customer Feedback
- Internal and External Proficiency Testing

Figure 3-1

Relationships of Quality Management Systems and Documentation



3.3 Technical Elements of the Quality Assurance Program

The laboratory's technical procedures are based upon procedures published by various agencies or organizations (See Section 23). The Quality Assurance Program provides laboratory organization, procedures, and policies by which the laboratory operates. The necessary certifications and approvals administered by external agencies are maintained by the QA department. This includes method approvals and audit administration. In addition, internal audits are performed to assess compliance with policies and procedures. SOPs are maintained for technical and administrative functions. A document control system is used for SOPs, as well as laboratory notebooks, and this QA Manual. A list of QA Program documents is provided in Appendix I and SOPs in Appendix G.

Acceptable calibration procedures are defined in the SOP for each test procedure. Calibration procedures for other laboratory equipment (balances, thermometers, etc.) are also defined. Quality Control (QC) procedures are used to monitor the testing performed. Each analytical procedure has associated QC requirements to be achieved in order to demonstrate data quality. The use of method detection limit studies, control charting, technical training and preventive maintenance procedures further ensure the quality of data produced. Proficiency Testing (PT) samples are used as an external means of monitoring the quality and proficiency of the laboratory. PT samples are obtained from qualified vendors and are performed on a regular basis. In addition to method proficiency, documentation of analyst training is performed to ensure proficiency and competency of laboratory analysts and technicians. Sample handling and custody procedures are defined in SOPs. Procedures are also in place to monitor the sample storage areas. The technical elements of the QA program are discussed in further detail in later sections of this QA manual.

3.4 Professional Conduct

One of the most important aspects of the success of ALS Environmental is the emphasis placed on the integrity of the data provided and the services rendered. This success is reliant on both the professional conduct of all employees within ALS Environmental as well as established laboratory practices.

To promote quality, ALS Environmental requires certain standards of conduct and ethical performance among employees. The following examples of documented ALS Environmental policy are representative of these standards, and are not intended to be limiting or all-inclusive:

- Under no circumstances is the willful act of fraudulent manipulation of analytical data condoned. Such acts are to be reported immediately to senior management for appropriate corrective action.
- Unless specifically required in writing by a client, alteration, deviation or omission of written contractual requirements is not permitted. Such changes must be in writing and approved by senior management.
- Falsification of data in any form will not be tolerated. While much analytical data is subject to professional judgment and interpretation, outright falsification, whenever observed or discovered, will be documented, and appropriate remedies and punitive measures will be taken toward those individuals responsible.
- It is the responsibility of all ALS Environmental employees to safeguard sensitive company information, client data, records, and information; and matters of national security concern should they arise. The nature of our business and the well-being of our company and of our clients is dependent upon protecting and maintaining proprietary company/client information. All information, data, and reports (except that in the public domain) collected or assembled on behalf of a client is treated as confidential. Information may not be given to third parties without the consent of the client. Unauthorized release of confidential information about the company or its clients is taken seriously and is subject to formal disciplinary action. All employees sign a confidentiality agreement upon hire to protect the company and client’s confidentiality and proprietary rights.

3.5 Prevention and Detection of Improper, Unethical or Illegal Actions

It is the intention of ALS Environmental to proactively prevent and/or detect any improper, unethical or illegal action conducted within the laboratory.

This is performed by the implementation of a program designed for not only the detection but also prevention. Prevention consists of educating all laboratory personnel of their roles and duties as employees, company policies, inappropriate practices, and their corresponding implications as described here.

In addition to education, appropriate and inappropriate practices are included in SOPs such as manual integration, data review and specific method procedures. Electronic and hardcopy data audits are performed regularly, including periodic audits of chromatographic electronic data. Requirements are described in the *SOP for Internal Audits* (CE-QA001) and details are listed in laboratory administrative SOPs. All aspects of this program are documented and retained on file according to the company policy on record retention.

The *SOP for Laboratory Ethics and Data Integrity* (CE-GEN001) also contains information on the ALS Environmental ethics and data integrity program, including mechanisms for reporting and seeking advice on ethical decisions.

3.6 Laboratory Data Integrity and Ethics Training

New employees complete a QA and Ethics orientation as part of the induction process. On an ongoing basis, all employees receive annual ethics refresher training. Topics covered are documented in writing and all training is documented. It is the responsibility of the QA Manager to ensure that the training is conducted as described.

Key topics covered are the organizational mission and its relationship to the critical need for honesty and full disclosure in all analytical reporting, how and when to report data integrity issues and record keeping. Training includes discussion regarding all data integrity procedures, data integrity training documentation, in-depth data monitoring and data integrity procedure documentation.

Data integrity training provides assurance that a highly ethical approach to testing is a key component of all laboratory planning, method implementation, and training. There are four elements to the laboratory's procedures for data integrity. These include:

1) Data integrity training (conducted initially and at least annually);
2) Signed data integrity documentation for all employees;
3) In-depth periodic monitoring of data integrity;
4) Data integrity procedure documentation (*SOP for Laboratory Ethics and Data Integrity* (CE-GEN001)).

There is specific emphasis on the importance of proper written narration on the part of the analyst with respect to those cases where analytical data may be useful, but are in one sense or another partially deficient. A signature attestation sheet of data integrity training including their understanding of their obligations related to data integrity and as specified in the training is generated for attendees and maintained on file for review. Trainees are required to understand that any infractions of the laboratory data integrity procedures will result in a detailed investigation that could lead to very serious consequences including immediate termination, or civil/criminal prosecution.

The training session includes many concepts and topics, numerous examples of improper actions (defined by DoD as deviations from contract-specified or method-specified analytical practices and may be intentional or unintentional), legal and liability implications (company and personal), causes, prevention, awareness, and reporting mechanisms.

3.7 Management and Employee Commitment

ALS Environmental makes every attempt to ensure that employees are free from any commercial, financial, or other undue pressures that might affect their quality of work. Related policies are described in the *SOP for Laboratory Ethics and Data Integrity* (CE-GEN001). This includes:

- ALS Environmental Open Door Policy – Employees are encouraged to bring any work related problems or concerns to the attention of local management or their Human Resources representative. However, depending on the extent or sensitivity of the concern, employees are encouraged to directly contact any member of upper management.
- An anonymous and confidential reporting system available to all employees that is used to communicate misconduct and other concerns. The program shall help minimize negative morale, promote a positive work place, and encourage reporting suspected misconduct without retribution. Associated upper management is notified and the investigations are documented.
- Use of flexible work hours. Within reason and as approved by supervisors, employees are allowed flexible work hours in order to help ease schedule pressures which could impact decision-making and work quality.
- Operational and project scheduling assessments are continually made to ensure that project planning is performed and that adequate resources are available during anticipated periods of increased workloads. Procedures for subcontracting work are established, and within the ALS Environmental laboratory network additional capacity is typically available for subcontracting, if necessary.
- Gifts and Favors (Code of Conduct Agreement) – To avoid possible conflict of interest implications, employees do not receive unusual gifts or favors to, nor accept such gifts or favors from, persons outside the Company who are, or may be, in any way concerned with the projects on which the Company is professionally engaged.

All employees are required to sign and adhere to the requirements set forth in the *Code of Conduct Agreement, Confidentiality Agreement,* and *Ethics and Data Integrity Agreement.* The *Ethics and Data Integrity Agreement* is signed by all employees on an annual basis (see Appendix C).

3.8 The ALS Environmental-Simi Valley staff, consisting of approximately 30 employees, includes chemists, technicians and support personnel. They represent diverse educational backgrounds, experience, and provide the comprehensive skills that the laboratory requires. As seasonal workload increases, temporary employees may be hired to perform specific tasks.

ALS Environmental is committed to providing an environment that encourages excellence. All employees share the responsibility for maintaining and improving the quality of our analytical services. The responsibilities of key personnel within the laboratory are described below. Table 3-1 lists the ALS Environmental-Simi Valley personnel assigned to these key positions. Managerial staff members are provided the authority and resources needed to perform their duties. An organizational chart of the laboratory, as well as the resumes of key personnel, can be found in Appendix B.

- The role of the **Laboratory Director** is to provide technical, operational, and administrative leadership through planning, allocation and management of personnel and equipment resources. The Laboratory Director provides leadership and support for the QA program including ensuring compliance with ISO/IEC 17025:2005 and is responsible for overall laboratory efficiency and the financial performance of the Simi Valley facility.

  The Laboratory Director has the authority to stop work in response to quality problems. The Laboratory Director also provides resources for implementation of the QA program, reviews and approves this QA Manual, reviews and approves standard operating procedures (SOPs), and provides support for business development by identifying and developing new markets through continuing support of the management of existing client activities.

- The Director of Operations, USA is responsible for all aspects of the USA Environmental business including all operational regions and support groups. These include, but are not limited to, Eastern USA, Western USA, Finance, Human Resources, LIMS, IT, Sales, and Marketing.
- The **Quality Assurance Manager** (QA Manager) has the authority and responsibility for implementing, maintaining, and improving the quality system. This includes coordination of QA activities within the laboratory, ensuring that all personnel understand their contributions to the quality system, ensuring communication takes place at all levels within the laboratory regarding the effectiveness of the quality system, evaluating the effectiveness of training; and monitor trends and continually improve the quality system. Audit and surveillance results, control charts, proficiency testing results, data analysis, corrective and preventive actions, customer feedback, and management reviews can all be used to support quality system implementation. The QA Manager is responsible for ensuring compliance with all applicable regulatory compliance quality standards (i.e. NELAP/TNI, ISO/IEC 17025:2005, NAVSEA-LAP, DoD QSM, etc.). The QA Manager works with laboratory staff to establish effective quality control and assessment plans and has the authority to stop work in response to quality problems. The QA Manager is responsible for maintaining the QA Manual and performing an annual review of it; reviewing and approving SOPs and ensuring the annual review of technical SOPs; maintaining QA records such as metrological records, archived logbooks, PT results, etc.; document control; conducting PT sample studies; approving nonconformity and corrective action reports; maintaining the laboratory's certifications and approvals; and performing internal QA audits.

  The QA Manager reports directly to the Laboratory Director and also reports indirectly to the Manager of Quality Assurance, USA. It is important to note that when evaluating data, the QA Manager does so in an objective manner and free of outside, or managerial, influence.
- The Manager of Quality Assurance, USA is responsible for the overall QA program at all the ALS Environmental Group laboratories. The Manager of Quality Assurance, USA is responsible for oversight of QA Managers regulatory compliance efforts (NELAP/TNI, ISO/IEC 17025:2005, NAVSEA-LAP, DoD QSM, etc) and may perform internal audits to evaluate compliance. The Manager of Quality Assurance, USA approves company-wide SOPs and provides assistance to the laboratory QA staff and laboratory managers as necessary.

➢ In the case of absence of the Laboratory Director or QA Manager, deputies are assigned to act in that role. Default deputies for these positions are a Project Manager or Volatiles (GC/MS)/Semi-Volatiles Technical Manager (for the Laboratory Director) and the Laboratory Director (for the QA Manager).

The following deputies are assigned in the case of absence of a Technical Manager. The Volatiles (GC/MS)/Semi-Volatiles Technical Manager will serve as the deputy for the Volatiles (GC) Technical Manager and General (WET) Chemistry Technical Manager. The Volatile (GC) Technical Manger will serve as the deputy for the Volatile (GC/MS)/Semi-Volatiles Technical Manager.

- ➢ In the event that work is stopped in response to quality problems, only the Laboratory Director or QA Manager have the authority to resume work. Projects falling under the Naval Sea Systems Command Laboratory Accreditation Program (NAVSEA-LAP) require that the resumption of work after a work stoppage be approved in writing by the QA Manager.

- The **Environmental Health and Safety Coordinator** (EH&S) is responsible for the administration of the laboratory health and safety policies.

  This includes the formulation and implementation of safety policies, the supervision of new-employee safety training, the review of accidents, incidents and prevention plans, the monitoring of hazardous waste disposal and the conducting of departmental safety inspections. The EH&S Coordinator is also designated as the Chemical Hygiene Officer. The EH&S Coordinator has a dotted-line reporting responsibility to ALS North America EH&S Manager.

- The **Data Validation Coordinator/Reporting Supervisor** is responsible for data review, data package preparation, review and coordination, and preparation of case narratives (based on the information provided by the laboratory).

- The **Client Services Manager** is responsible for the Client Services Department defined for the laboratory (i.e. Project Managers, data reporting, etc.) and the sample management office/bottle preparation sections. The Client Services Department provides a complete interface with clients from initial project specifications to final deliverables. Sample management handles all activities associated with receiving, storage, and disposal of samples. The Client Services Manager has the authority to stop subcontractor work in response to quality problems.

- The **Project Manager** is a scientist assigned to each client to act as a technical liaison between the client and the laboratory. The Project Manager is responsible for ensuring that the analyses performed by the laboratory meet all project, contract, and regulatory-specific requirements. This entails coordinating with the ALS Environmental laboratory and administrative staff to ensure that client-specific needs are understood and that the services ALS Environmental provides are properly executed and satisfy the requirements of the client.

- The Analytical Laboratory is divided into operational units based upon specific disciplines. Each department is responsible for establishing, maintaining and documenting a QC program meeting department needs. Each **Department Manager and Supervisor** has the responsibility to ensure compliance with ISO/IEC 17025:2005, ensure that QC functions are carried out as planned, and to guarantee the production of high quality data. Department managers and bench-level supervisors have the responsibility to monitor the day-to-day operations to ensure that productivity and data quality objectives are met. Each department manager has the authority to stop work in response to quality problems in their area. Analysts have the responsibility to carry out testing according to prescribed methods, SOPs, and quality control guidelines particular to the laboratory in which he/she is working.

- The **Sample Management Office** plays a key role in the laboratory QA program by performing and/or assisting in the proper preparation and shipment of sampling media. In addition, personnel are responsible for the verification of sample receipt information, performing sample acceptance and log-in and distribution of documentation per laboratory defined procedures and the initial storage of samples in the proper environment and location and performing proper sample disposal. Responsibilities also include monitoring and recording of critical thermal preservation equipment temperatures and calibration of associated thermometers against NIST traceable thermometers.

- **Information Technology** (IT) staff is responsible for the administration of the Laboratory Information Management System (LIMS) and other necessary support services. Other functions of the IT staff include laboratory network maintenance, IT systems development and implementation, education of analytical staff in the use of scientific software, Electronic Data Deliverable (EDD) generation, and data back-up, archival and integrity operations.
- The **LIMS Manager** is responsible for LIMS development including all areas of software development such as design, coding, testing and distribution.
- The **Procurement Manager** is responsible for directing and coordinating activities of personnel engaged in buying materials and supplies.

Table 3-1
Summary of Technical Experience and Qualifications

Simi Valley Personnel	Years of Experience	Project Role
Kelly Horiuchi, B.A.	17	Laboratory Director / Project Manager
Chaney Humphrey, B.S.	13	Quality Assurance Manager
Ku-Jih Chen, B.S.	42	Principle Chemist
Robin Gill	37	Data Validation Coordinator / Reporting Supervisor
Robert De La O	27	Systems Analyst / Information Technology
Sue Anderson, B.S.	27	General (WET) Chemistry Technical Manager / Project Manager
Samantha Henningsen, B.S.	8	Project Manager
Kathleen Kaneko, B.A.	28	Client Services Manager / Project Manager
Wade Henton, B.S.	31	Volatiles (GC) Technical Manager
Chris Parnell, B.S.	31	Volatiles (GC/MS)/Semi-Volatiles Technical Manager
Wida Ang, B.S., M.S.	32	Volatiles (GC/MS) Team Leader

Evelyn Alvarez, B.S.	7	Semi-Volatiles Team Leader / Environmental Health and Safety Coordinator
Mike Conejo, B.A.	6	Volatiles (GC) Team Leader / Environmental Health and Safety Coordinator

Corporate Level Personnel	Project Role
James Klippel, B.S., M.B.A	Director of Operations, ALS Environmental Divisions USA
Lee Wolf, B.S.	Corporate Quality Assurance Manager, USA
Hirenkumar Prajapati, B.S.	IT Manager USA
Albert Valle, A.A.S.	LIMS Manager USA
Steven Manak, B.S.	Procurement Group Leader

4) Document Control

4.1 Procedures for control and maintenance of documents are described in the *SOP for Document Control* (CE-GEN005). The requirements of the SOP apply to all laboratory logbooks (standards, maintenance, run logbooks, etc), certificates of analysis, SOPs, QAMs, quality assurance project plans (QAPPs), Environmental Health & Safety (EHS) manuals, and other controlled ALS Environmental documents. Management system documents generated by the laboratory shall include page numbering and include the total number of pages or a mark to signify the end of the document.

4.2 The contents of this manual are reviewed, revised (as needed) and approved for use at least annually by authorized personnel (QA Manager, Laboratory Director, and Technical Managers) where the scope of the review ensures that it continuously reflects current policies and practices and incorporates all applicable requirements. Additionally, the date the review was completed is indicated by the date of the last approval signature on the title page.

4.3 Each controlled copy of a controlled document will be released only after a document control number is assigned and the recipient is recorded on a document distribution list. Filing and distribution is performed by the QA Manager, or designee, and ensures that only the most current version of the document is distributed and in use. A document control number is assigned to logbooks. Completed logbooks that are no longer in use are archived in a master logbook file. Logbook entries are standardized following the *SOP for Making Entries onto Analytical Records* (CE-QA007). The entries made into laboratory logbooks are reviewed and approved at a regular interval (quarterly).

4.4 A records system is used which ensures all laboratory records (including raw data, reports, and supporting records) are retained and available. The archiving system is described in the *SOP for Data and Record Archiving* (ADM-ARC).

4.5 External documents relative to the management system are managed by the QA Manager. To prevent the use of invalid and/or outdated external documents, the laboratory maintains a master list of current documents and their availability. The list is reviewed before making the documents available. External documents are not issued to personnel.

4.6 Electronic Signatures It is a policy of ALS Environmental to allow the use of electronic signatures. For data reporting an electronic signature may be applied to the report by an approved report signatory and is binding to the same extent as a handwritten wet signature.

To authenticate the electronic signature the identity of the signatory is verified before their electronic signature can be created. Each electronic signature shall be unique to a single individual and shall not be used by any other individual. These signatures are established using only defined procedures within the software and are verified using the two distinct components of *username* and *password*. The report may not be changed once the signature has been applied.

Additionally, as a form of 'signature' used for LIMS, email, and certain internal documentation processes (e.g. acknowledgements, attestations, audit trails, etc.), and other electronic tools the user's system login credentials are used to verify and authenticate the identity of the user. Following login, these credentials are used to identify and document the user.

5) Review of Requests, Tenders and Contracts

5.1 Procedure for the Review of Work Requests

5.1.1 Requests for new work are reviewed prior to signing any contracts or otherwise agreeing to perform the work. The specific methods to be used are agreed upon between the laboratory and the client. A capability review is performed to determine if the laboratory has or needs to obtain certification to perform the work, to determine if the laboratory has the resources (personnel, equipment, materials, capacity, skills, expertise) to perform the work, and if the laboratory is able to meet the client's required reporting and QC limits. The results of this review are communicated to the client and any potential conflict, deficiency, lack of appropriate accreditation status, or concerns of the ability to complete the client's work are resolved.

5.1.2 Any differences between the request or tender and the contract shall be resolved before any work commences. The client should be notified at this time if work is expected to be subcontracted. Each contract shall be acceptable both to the laboratory and the client. Records are maintained of pertinent discussions with a client relating to the client's requirements or the results of the work.

5.1.3 If a contract needs to be amended after work has commenced, the contract review process is repeated and any amendments are communicated to all affected personnel. Changes in accreditation status affecting ongoing projects must be reported to the client.

5.2 Allowed Deviations from Standard Operating Procedures

5.2.1 When a client requests a modification to an SOP the Project Manager must discuss the proposed deviation with the laboratory supervisor and obtain approval to accept the project. The Laboratory Director and QA Manager may also be involved. The Project Manager is responsible for documenting the approved or allowed deviation from the SOP.

5.2.2 When a client request necessitates a deviation or departure from company policies or procedure involving any non-technical function, the allowed deviation must be approved by the laboratory or the Laboratory Director. Frequent departure from policy is not encouraged. However, if frequent departure from any policy is noted, the Laboratory Director will address the possible need for a change in policy.

6) Subcontracting of Tests

Analytical services are subcontracted when the laboratory needs to balance workload or when the requested analyses are not performed by the laboratory. Subcontracting, to capable qualified laboratories is only done with the knowledge and approval of the client. Subcontracting to another ALS Environmental laboratory is preferred over external-laboratory subcontracting. Established procedures are used to qualify external subcontract laboratories. These procedures are described in the *SOP for Qualification of Subcontract Laboratories* (CE-QA004). The QA Manager is responsible for maintaining a list of qualified subcontract laboratories.

7) Purchasing Services and Supplies

The quality level of reagents and materials (grade, traceability, etc.) required is specified in the analytical SOPs. Department supervisors ensure that the proper materials are purchased. Inspection and verification of material ordered is performed at the time of receipt by receiving personnel. The receiving staff labels the material with the date received. Expiration dates are assigned as appropriate for the material. Storage conditions and expiration dates are specified in the analytical SOP. The *SOP for Handling Consumable Materials* (ADM-CONSUM) provides default expiration requirements. Supplies and services that are critical in maintaining the quality of laboratory testing are procured from pre-approved vendors. The policy and procedure for purchasing and procurement are described in the *SOP for Procurement and Control of Laboratory Services and Supplies* (CE-GEN007). Also, refer to section 13.5 for a discussion of reference materials.

Receipt procedures include technical review of the purchase order/request to verify that what was received is identical to the item ordered. The laboratory checks new lots of reagents for unacceptable levels of contamination prior to use in sample preservation, sample preparation, and sample analysis by following the *SOP for Quality of Reagents and Standards* (CE-QA012).

8) Service to the Client

The laboratory uses a number of systems to assess its daily operations. In addition to the routine quality control (QC) measurements, the senior laboratory management examines a number of other indicators to assess the overall ability of the laboratory to successfully perform analyses for its clients including; on-time performance, customer complaints, training reports and non-conformity reports. A frequent, routine assessment must also be made of the laboratory's facilities and resources in anticipation of accepting an additional or increased workload.

ALS Environmental utilizes a number of different methods to ensure that adequate resources are available for service demands. Senior staff meetings, tracking of outstanding proposals and an accurate, current synopsis of incoming work all assist the senior staff in properly allocating sufficient resources. All Requests for Proposal (RFP) documents are reviewed by Project Managers, Business Development and appropriate managerial staff to identify any project specific requirements that differ from the standard practices of the laboratory. Any requirements that cannot be met are noted and communicated to the client, as well as requesting the client to provide any project specific Quality Assurance Project Plans (QAPPs) if available. Status/production meetings are also conducted regularly with the laboratory and project managers to inform the staff of the status of incoming work, future projects, or project requirements.

When a customer requests a modification to an SOP, policy, or standard specification the Project Manager will discuss the proposed deviation with the Laboratory Director and department manager to obtain approval for the deviation. The QA Manager may also be involved. All project-specific requirements must be on-file and with the service request upon logging in the samples. The modification or deviation must be documented. A Project-Specific Communication Form, LIMS comments, or similar, may be used to document such deviations.

The laboratory shall afford clients cooperation to clarify the client's request and to monitor the laboratory's performance in relation to the work performed, provided that the laboratory ensures confidentiality to other clients. The laboratory maintains and documents timely communication with the client for the purposes of seeking feedback and clarifying customer requests. Feedback is used and analyzed to improve the quality of services. The *SOP for Handling Customer Feedback* (CE-GEN010) is in place for these events.

9) Complaints

The laboratory maintains a system for dealing with customer complaints. The person who initially receives the feedback (typically the Project Manager) is responsible for documenting the complaint. If the Project Manager is unable to satisfy the customer, the complaint is brought to the attention of the Client Services Manager, Laboratory Director, or QA Manager for final resolution. The complaint and resolution are documented. The procedure is described in the *SOP for Handling Customer Feedback* (CE-GEN010).

10) Facilities and Equipment

ALS Environmental-Simi Valley maintains approximately 20,000 square feet of laboratory and administrative workspace. The laboratory has been designed and constructed to provide safeguards against cross-contamination of samples and is arranged according to work function, which enhances the efficiency of analytical operations. The ventilation system is designed to meet any needs of analyses performed in the separate work areas. ALS Environmental-Simi Valley minimizes laboratory contamination sources by employing janitorial staff to ensure good housekeeping. In addition, the segregated laboratory areas are designed for safe and efficient handling of a variety of sample types. These specialized areas (and access restrictions) include:

- Sample Management Office; Shipping and Receiving
- Records Archival
- Volatile Organics Laboratory (GC and GC/MS)
- Semi-Volatiles Laboratory (GC, GC/MS and HPLC)
- Ultra-Low Level Volatile Organics GC/MS
- General/Wet Chemistry Laboratory
- R&D Laboratory
- Canister Conditioning and Maintenance

- Flow Controller and Critical Orifice Calibration Station
- Sample Storage Walk-in Refrigerator
- Sample, Standards, and Media Storage
- Waste Disposal
- Laboratory Deionized Water System
- Laboratory Management, Client Service, Report Generation and Administration
- Information Technology (IT)

The designated areas for sample receiving, refrigerated sample storage, dedicated sample container preparation and shipping provide for the efficient and safe handling of a variety of sample types. Refer to Appendix D for facility floor plan. The laboratory is equipped with state-of-the-art analytical and administrative support equipment. The equipment and instrumentation are appropriate for the procedures in use. Appendix E lists the major equipment, illustrating the laboratory's overall capabilities and depth.

10.1 Preventive Maintenance

Preventive maintenance is a crucial element of the Quality Assurance program. Instruments at ALS Environmental (e.g., GC/MS systems, gas and liquid chromatographs, analytical balances, gas and liquid chromatographs, etc.) are maintained under commercial service contracts or by qualified, in-house personnel. All instruments are operated and maintained according to the instrument operating manuals. All routine and special maintenance activities pertaining to the instruments are recorded in instrument maintenance logbooks. The maintenance logbooks used at ALS Environmental contain extensive information about the instruments used at the laboratory.

An initial demonstration of analytical control is required on every instrument used at ALS Environmental before it may be used for sample analysis. Each instrument must be recalibrated following any instrument maintenance which may change or effect the sensitivity or linearity of the instrument or if the continuing calibration verification acceptance criteria have not been met as specified in the standard operating procedure. If an instrument is modified or repaired, a return to analytical control is required before subsequent sample analyses can occur. When an instrument is acquired at the laboratory, the following information is noted in a bound maintenance notebook specifically associated with the new equipment:

- The equipment’s serial number;
- Date the equipment was received;
- Date the equipment was placed into service;
- Condition of equipment when received (new, used, reconditioned, etc.); and
- Prior history of damage, malfunction, modification or repair (if known).

Preventive maintenance procedures, frequencies, etc. are available for each instrument used at ALS Environmental. They may be found in the various SOPs for routine methods performed on an instrument and may also be found in the operating or maintenance manuals provided with the equipment at the time of purchase.

Responsibility for ensuring that routine maintenance is performed lies with the department supervisor or laboratory director. The supervisor may perform the maintenance or assign the maintenance task to a qualified bench level analyst who routinely operates the equipment. In the case of non-routine repair of capital equipment, the department supervisor is responsible for providing the repair, either by performing the repair themselves with manufacturer guidance or by acquiring on-site manufacturer repair. The laboratory maintains an adequate supply of expendable maintenance items (expected lifetime of part of less than 1 year.) These parts include items needed to perform the preventive maintenance procedures listed in Table 16-1.

When performing maintenance on an instrument (whether preventive or corrective), additional information about the problem, attempted repairs, etc. is also recorded in the notebook. Typical logbook entries include the following information:

- Details and symptoms of the problem;
- Repairs and/or maintenance performed;
- Description and/or part number of replaced parts;
- Source(s) of the replaced parts;
- Analyst's signature and date; and
- Demonstration of return to analytical control.

See the Table 16-1 for a list of preventive maintenance activities and frequency for each instrument.

For further information regarding Instrumentation see the *SOP for Analytical Instrument Acquisition, Reassignment, Maintenance and Documentation* (ADM-INSTRUM).

10.2 Temperature Control

Temperatures are monitored and recorded for all critical measurement temperature-regulating devices including freezers, refrigerators and ovens. Each piece of equipment is labeled with a unique identifier, the required temperature or range of use according to the needs of the analysis or application. Temperature record logs are kept which contain equipment identifier, daily-recorded temperatures (if in use, business days), acceptance criteria and the initials of the laboratory staff member who performed the checks for all temperature-regulating devices in daily use.

10.3 Water Purification Systems

Purified water is utilized for a number of laboratory functions including instrument and method blanks, trip blanks, washes and sample dilutions. The water purification system utilizes three mixed-ion beds, four filters, and resistively lights with constant water recirculation. It is designed to produce deionized water of ASTM Type II quality, with 16-18 megohm-cm resistance at 25˚C and is checked and recorded daily (prior to and if in use). Maintenance and repair on the system is conducted by an approved service supplier and all records including purification checks/verifications are maintained on file for review. For procedures on additional purification (i.e., boiling and/or purging) and purification checks/verifications, refer to the applicable method standard operating procedures.

11) Sample Management

Standard operating procedures have been established for all aspects of sample management within the laboratory including sample receiving, handling, acceptance, log-in, protection, storage, retention, transportation, and disposal. The procedures include provisions necessary to protect the integrity of the sample (as received) and to protect the interests of the laboratory as well as the client. These procedures ensure that samples are handled properly and that all associated documentation is complete and consistent. The sample handling factors that must be taken into account to ensure accurate, defensible analytical results include but are not limited to:

- Amount of sample taken (sampling)
- Type of container used

- Existence and type of sample preservation
- Holding Time
- Proper custodial documentation
- Sample storage, tracking and/or transfer
- Retention
- Disposal

A record of all procedures to which a sample is subjected while in the possession of the laboratory including acceptance, rejection, login, identification, preservation checks, storage, tracking, and disposal are documented and maintained. In addition, all indirect procedures which support each record of a sample and protects the integrity of a sample is documented and maintained (i.e., refrigerator and freezer temperature checks, thermometer calibrations, etc.).

11.1 Sampling

The quality of analytical results is highly dependent upon the quality of the procedures used to collect, preserve and store samples.

ALS Environmental-Simi Valley does not provide sampling services. The laboratory only provides materials needed for sample collection; therefore, ALS Environmental-Simi Valley recommends that clients follow sampling guidelines described in the specific reference methods including 40 CFR 136 and/or USEPA SW-846, NIOSH, OSHA, ASTM, CARB and SCAQMD as appropriate.

When transporting samples to the laboratory, the most expedient but lawful route of transport should be utilized. Also, the hazardous potential of the samples needs to be considered when shipping samples via air freight or passenger airlines.

11.2 Preservation

ALS Environmental-Simi Valley uses sample preservation, container, and holding time recommendations published in a number of referenced documents including, but not limited to USEPA SW 846, USEPA 600/4-79-020, USEPA 600/R-93-100 (inorganic substances), EPA/625/R-96/010b (air samples), and EPA 40CFR part 136 and associated Method Update Rules. The complete citation for each of these and other references can be found in Section 23 of this document. The appropriate container, preservation and holding time information are summarized in Appendix F. Additional information on this is addressed in each corresponding method SOP.

11.3 Shipping of Containers and Samples

ALS Environmental-Simi Valley provides sample containers to clients via media requests for all matrices (soil, water, air) with the appropriate preservatives (as applicable). These containers include Tedlar bags, Summa canisters, silica-gel tubes, etc. ALS Environmental-Simi Valley keeps client-specific shipping requirements on file and utilizes all major transportation carriers to guarantee that sample shipping requirements (same-day, overnight, etc.) are met. ALS Environmental-Simi Valley also provides its own courier service that makes scheduled courier runs in the greater Los Angeles metropolitan area. The procedures for all requirements directed toward media requests follow the requirements detailed in the *SOP for Media Request Fulfillment* (ADM-Media_Req).

11.4 Sample Receiving and Acceptance

It is the policy of ALS Environmental-Simi Valley to check and record the condition of each sample (i.e. pressure, temperature, etc.) delivered to the Sample Management Office (SMO) and received by the Sample Management Custodian or alternates against certain acceptance criteria as documented in the *SOP for Sample Receiving, Acceptance, and Log-In* (SMO-SMPL_REC). This policy is available to all sample management personnel for reference. Any samples, which deviate from these outlined areas, will be clearly flagged with the nature and substance of the deviation. Assessment and condition checks utilized by ALS Environmental-Simi Valley for the acceptance or rejection of samples are based on the criteria found in Appendix F, applicable Quality Assurance Project Plan (QAPP), permit, program or rule where appropriate. This verification of sample integrity is conducted by the Sample Custodian and may be dependent on the matrix (i.e., temperature, preservation, and headspace) being submitted.

Any abnormalities or departures from specified condition requirements (as described herein) as observed during the initial assessment are recorded. When there is any doubt as to the suitability of a sample for testing, including signs of damage, when a sample does not conform to the description provided, or when the test method required is not specified in sufficient detail the appropriate Project Manager (PM) is notified.

The Project Manager is to consult with the client, whenever possible, regarding specific integrity issues documented during sample receipt for further instructions before proceeding and retain a written record of discussion. There may be instances where the client is unavailable, in which case the PM shall document all attempts at contacting the client.

There may be a need to inform the client that a sample(s) is rejected and cannot be accepted for analysis into the laboratory. This situation includes, but is not limited to loss of sample or insufficient amount (subsampling may be performed if it would not cause loss of sample integrity, but the procedure must be indicated with the test results). Subsampling as in the case of air samples is not appropriate.

The procedures for sample documentation, handling acceptance requirements and deviations from the sample acceptance policy are discussed in detail in the *SOP for Sample Receiving, Acceptance and Log-In* (SMO-SMPL_REC). This procedure is also in place to ensure samples are received and properly logged into the laboratory, and that all associated sample documentation, including Chain-of-Custody (COC) records are complete and consistent with the samples received. All associated documentation, including chain of custody forms, memos, transmittal forms, and phone logs, are kept with each project file.

11.5 Sample Log-in

Each sample is logged into the laboratory in such a way as to ensure traceability and cross-reference with regards to the unique laboratory job number, sample identifications and client sample identifications. The laboratory identification is retained throughout the life of the sample in the laboratory. The identification system is designed and operated to ensure that samples cannot be confused physically or in laboratory documentation. Additional information is provided in the *SOP for Sample Receiving, Acceptance, and Log-In* (SMO_SMPL_REC).

11.6 Sample Custody

A sample is in someone's "custody" if:

1. It is in one's actual physical possession;
2. It is in one's view, after being in one's physical possession;
3. It is in one's physical possession and then locked up so that no one can tamper with it;
4. It is kept in a secured area, restricted to authorized personnel only.

Chain-of-Custody (COC) records are used to establish the legal custody of samples, showing the continuous possession of samples from sample collection and transportation to final destination at the laboratory. Custody of each sample is maintained from receipt through disposal (internally utilizing LIMS). When environmental samples are shipped to other laboratories for analysis, the sample management office follows formalized procedures for maintaining the chain of custody, which is written in SOPs for *Sample Receiving, Acceptance and Login* and *Laboratory Storage, Analysis, and Tracking*.

Laboratory security and access is important in maintaining the integrity of samples received at ALS Environmental-Simi Valley. Access to the building is limited to the reception area and sample receiving doors, which are manned during business hours and locked at all other times. In addition, the sample storage area within the laboratory is a controlled access area. The laboratory is equipped with an alarm system which is monitored by a private security firm who provides nighttime and weekend security.

11.7 Sample Storage, Analysis and Tracking

The procedures and requirements for documenting the storage, analysis and tracking as well as maintaining integrity of samples are detailed in the *SOP for Laboratory Storage, Analysis, and Tracking* (ADM-LabSAT).

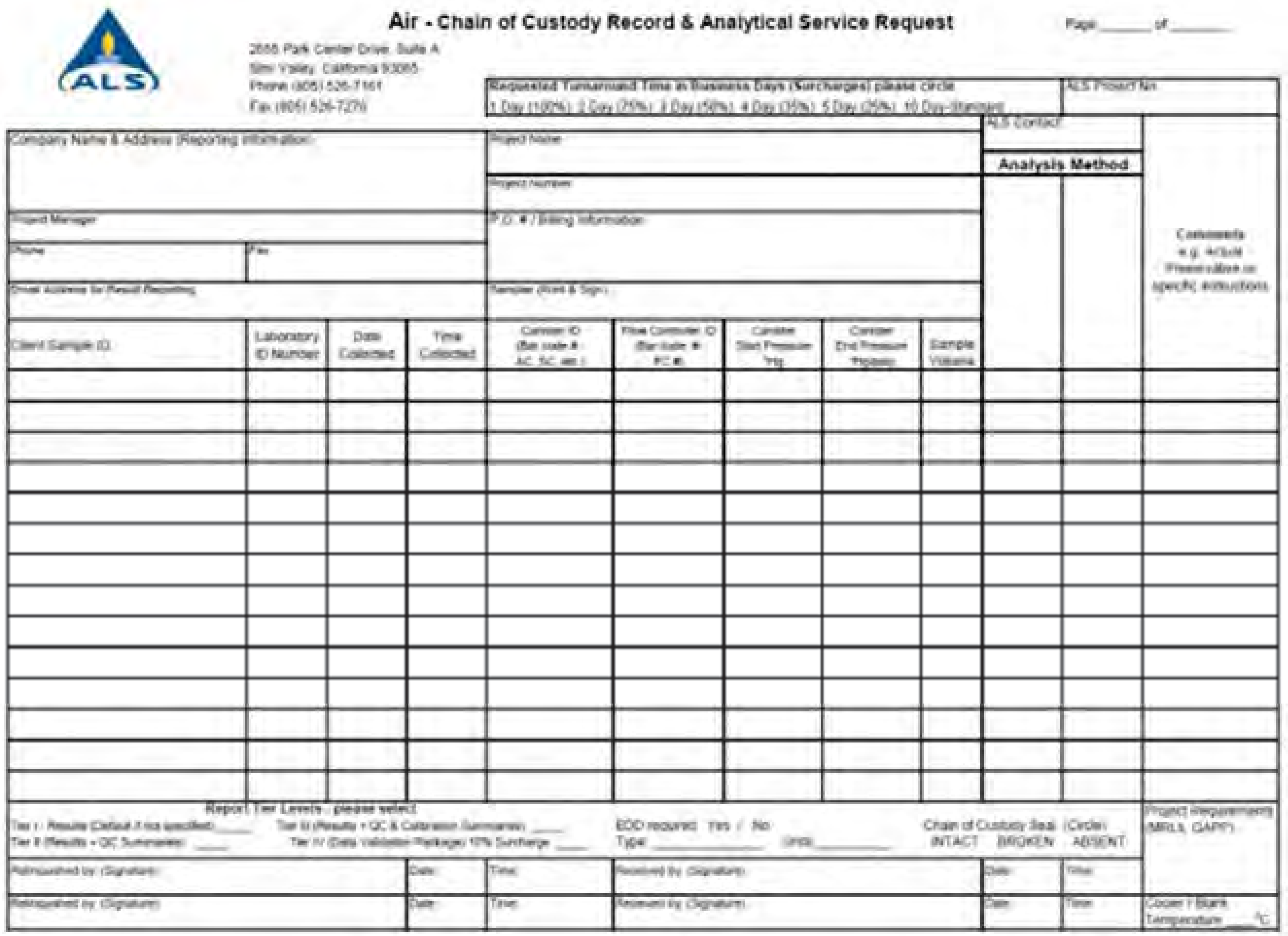
11.8 Sample Retention and Waste Disposal

Upon completion of all analyses, the laboratory samples are retained in accordance with the requirements specified in the method SOPs and the *SOP for Waste Disposal* (ADM-Waste). The samples are disposed according to approved disposal practices or returned to the client (if applicable). All samples are characterized according to hazardous/non-hazardous waste criteria and are segregated accordingly. This evaluation is generally based on results from analyses performed on the sample by ALS Environmental-Simi Valley or an approved subcontract laboratory. It should be noted that all wastes produced at the laboratory, including the laboratory's own various hazardous waste streams, are treated in accordance with all applicable local, State and Federal laws. Complete documentation is maintained for samples from initial receipt through final disposal. This ensures an accurate record of the samples from "cradle to grave."

11.9 Intra-laboratory / Inter-laboratory Transfer of Samples

When environmental samples are shipped to another laboratory for analysis, samples are properly packed for shipment and preserved if necessary. Sample bottles are wrapped in protective material and placed in a plastic bag (preferably Ziploc®) to avoid any possible cross-contamination of samples during the transportation process. Blue or wet ice is used for temperature preservation, where necessary.

Figure 11-1
Air Chain of Custody Form



Air - Chain of Custody Record & Analytical Service Request

Page_____ of_____

2655 Park Center Drive, Suite A
Simi Valley, California 93065
Phone (805) 526-7161
Fax (805) 526-7270

Requested Turnaround Time in Business Days (Surcharges) please circle
1 Day (100%) 2 Day (75%) 3 Day (50%) 4 Day (35%) 5 Day (25%) 10 Day-Standard

ALS Project No.

ALS Contact

Company Name & Address (Reporting Information)

Project Name

Project Number

Project Manager

P.O. # / Billing Information

Phone

Fax

Email Address for Result Reporting

Sampler (Print & Sign)

Client Sample ID	Laboratory ID Number	Date Collected	Time Collected	Canister ID (Bar code # - AC, SC, etc.)	Flow Controller ID (Bar code # - FC #)	Canister Start Pressure "Hg	Canister End Pressure "Hg/psig	Sample Volume	Analysis Method		Comments e.g. Actual Preservative or specific instructions

Report Tier Levels - please select
Tier I - Results (Default if not specified) _____
Tier II (Results + QC Summaries) _____
Tier III (Results + QC & Calibration Summaries) _____
Tier IV (Data Validation Package) 10% Surcharge _____

EDD required Yes / No
Type: ______________ Units: __________

Chain of Custody Seal: (Circle)
INTACT BROKEN ABSENT

Project Requirements (MRLs, QAPP)

Relinquished by: (Signature)	Date:	Time:	Received by: (Signature)	Date:	Time:
Relinquished by: (Signature)	Date:	Time:	Received by: (Signature)	Date:	Time:

Cooler / Blank Temperature _____°C

Figure 11-2
Soil / Water Chain of Custody Form

Soil / Water - Chain of Custody Record & Analytical Service Request Page ______ of ______

2655 Park Center Drive, Suite A
Simi Valley, California 93065
Phone (805) 526-7161
Fax (805) 526-7270

Requested Turnaround Time in Business Days (Surcharges) please circle
1 Day (100%) 2 Day (75%) 3 Day (50%) 4 Day (35%) 5 Day (25%) 10 Day-Standard

ALS Project No.

ALS Contact:

Company Name & Address (Reporting Information)

Project Name

Project Number

Project Manager

P.O. # / Credit Card / Billing Information

Phone

Fax

Email Address for Result Reporting

Client Sample ID	Laboratory ID Number	Date Collected	Time Collected	Water	Soil	Solid	Other	Analysis			Comments

Report Tier Levels - please select
Tier I - Results (Default if not specified) ____
Tier II (Results + QC Summaries) ____
Tier III (Results + QC & Calibration Summaries) ____
Tier IV (Data Validation Package) 10% Surcharge ____

EDD required Yes / No
Type: ______________ Units: __________

Chain of Custody Seal: (Circle)
INTACT BROKEN ABSENT

Project Requirements (MRLs, QAPP)

Relinquished by: (Signature)	Date:	Time:	Received by: (Signature)	Date:	Time:
Relinquished by: (Signature)	Date:	Time:	Received by: (Signature)	Date:	Time:
Relinquished by: (Signature)	Date:	Time:	Received by: (Signature)	Date:	Time:

Cooler / Blank / Ice / No Ice
Temperature ______°C

Figure 11-3

ALS Environmental
Sample Acceptance Check Form

Client: ____________________ Work order: ____________
Project: ____________________
Sample(s) received on: ____________ Date opened: ____________ by: ____________

Note: This form is used for _all_ samples received by ALS. The use of this form for custody seals is strictly meant to indicate presence/absence and not as an indication of compliance or nonconformity. Thermal preservation and pH will only be evaluated either at the request of the client and/or as required by the method/SOP.

		Yes	No	N/A
1	Were **sample containers** properly marked with client sample ID?	☐	☐	☐
2	Did **sample containers** arrive in good condition?	☐	☐	☐
3	Were **chain-of-custody** papers used and filled out?	☐	☐	☐
4	Did **sample container labels** and/or tags agree with custody papers?	☐	☐	☐
5	Was **sample volume** received adequate for analysis?	☐	☐	☐
6	Are samples within specified holding times?	☐	☐	☐
7	Was proper **temperature** (thermal preservation) of cooler at receipt adhered to?	☐	☐	☐
8	Were **custody seals** on outside of cooler/Box/Container?	☐	☐	☐
	Location of seal(s)? ____________ Sealing Lid?	☐	☐	☐
	Were signature and date included?	☐	☐	☐
	Were seals intact?	☐	☐	☐
9	Do containers have appropriate **preservation**, according to method/SOP or Client specified information?	☐	☐	☐
	Is there a client indication that the submitted samples are **pH** preserved?	☐	☐	☐
	Were **VOA vials** checked for presence/absence of air bubbles?	☐	☐	☐
	Does the client/method/SOP require that the analyst check the sample pH and _if necessary_ alter it?	☐	☐	☐
10	**Tubes:** Are the tubes capped and intact?	☐	☐	☐
11	**Badges:** Are the badges properly capped and intact?	☐	☐	☐
	Are dual bed badges separated and individually capped and intact?	☐	☐	☐

Lab Sample ID	Container Description	Required pH *	Received pH	Adjusted pH	VOA Headspace (Presence/Absence)	Receipt / Preservation Comments

Explain any discrepancies: (include lab sample ID numbers): ____________

RSK - MEEPP, HCL (pH<2); RSK - CO2 (pH 5-8); Sulfur (pH>4)

12) Analytical Procedures

ALS Environmental employs methods and analytical procedures from a variety of external sources. Reference documents include but are not limited to: ASTM, CARB, NCASI, NIOSH, OSHA, SCAQMD, USEPA SW-846, USEPA 600/4-79-020, 600/R-93/100 (inorganic substances), 600/625/R-96/010b (air samples), EPA 40 CFR part 136 and associated Method Update Rules and Supplements, and *Standard Methods for the Examination of Water and Wastewater* for water and wastewater samples. Complete citations for these references can be found in Section 23. Other published procedures, such as state-specific methods, program-specific methods, or in-house methods may be used. Several factors are involved with the selection of analytical methods to be used in the laboratory. These include the method detection limit, the concentration of the analyte being measured, method selectivity, accuracy and precision of the method, the type of sample being analyzed, and the regulatory compliance objectives. The implementation of methods by ALS Environmental is described in SOPs specific to each method. A list of accredited methods is given in Appendix J. Further details are described below.

12.1 Standard Operating Procedures (SOPs) and Laboratory Notebooks

ALS Environmental maintains SOPs for use in both technical and administrative functions (Refer to Appendix G). SOPs are written following standardized format and content requirements as described in the *SOP for Establishing Standard Operating Procedures* (CE-GEN009). Each SOP is reviewed and approved by a minimum of two managers (the Laboratory Director and/or Department Manager and the QA Manager). All SOPs undergo a documented review according to the schedule outlined in the *SOP for Establishing Standard Operating Procedures* to make sure current practices are described. The QA Manager maintains a comprehensive list of current SOPs. The document control process ensures that only the most currently prepared version of an SOP is being used. The QA Manual, QAPPs, SOPs, standards preparation logbooks, maintenance logbooks, et al., are controlled documents, unless otherwise noted. The procedures for document control are described in the *SOP for Document Control* (CE-GEN005). In addition to SOPs, each laboratory department maintains a current file, accessible to all laboratory staff, of the current methodology used to perform analyses. Laboratory notebook entries are standardized following the guidelines in the *SOP for Making Entries onto Analytical Records* (CE-QA007). Entries made into laboratory notebooks are reviewed and approved by the appropriate supervisor at a regular interval.

12.2 Modified Procedures

ALS Environmental strives to perform published methods as described in the referenced documents. If there is a material deviation from the published method, the method is cited as a “Modified” method in the analytical report. Modifications to the published methods are listed in the standard operating procedure. Standard operating procedures are available to analysts and are also available to our clients for review, especially those for “Modified” methods. Client approval is obtained for the use of “Modified” methods prior to the performance of the analysis.

12.3 Analytical Batch

The basic unit for analytical quality control is the analytical batch. The definition that ALS Environmental-Simi Valley has adopted for the analytical batch is listed below. The overriding principle for describing an analytical batch is that all the samples in a batch, both field samples and quality control samples are to be handled exactly the same way, and all of the data from each analysis is to be manipulated in exactly the same manner. The minimum requirements of an analytical batch are:

1) The number of (field) samples in a batch is not to exceed 20.
2) All (field) samples in a batch are of the same matrix.
3) The QC samples to be processed with the (field) samples include:
    a) Method Blank (a.k.a. Laboratory Reagent Blank)

        Function: Determination of laboratory contamination

    b) Laboratory Control Sample

        Function: Assessment of method performance

    c) Matrix Spiked (field) Sample (a.k.a. Laboratory Fortified Sample Matrix)*

        Function: Assessment of matrix bias

    d) Duplicate Matrix Spiked (field) Sample or Duplicate (field) Sample (a.k.a. Laboratory Duplicate)*

        Function: Assessment of batch precision

    * A sample identified as a field blank, an equipment blank, or a trip blank is not to be matrix spiked or duplicated.

4) A single lot of reagents is used to process the batch of samples.
5) Each operation within the analysis is performed by a single analyst, technician, chemist, or by a team of analysts/technicians/chemists.
6) Samples are analyzed in a continuous manner over a timeframe not to exceed 24-hours between the start of processing of the first and last sample of the batch.
7) (Field) samples are assigned to batches commencing at the time that sample processing begins. For example: for analysis of metals, sample processing begins when the samples are digested. For analysis of organic constituents, it begins when the samples are extracted.
8) The QC samples are to be analyzed in conjunction with the associated field samples prepared with them. However, for tests which have a separate sample preparation step that defines a batch (digestion, extraction, etc.), the QC samples in the batch do not require analysis each time a field sample within the preparation batch is analyzed (multiple instrument sequences to analyze all field samples in the batch need not include re-analyses of the QC samples).
9) The batch is to be assigned a unique identification number that can be used to correlate the QC samples with the field samples.
10) Batch QC refers to the QC samples that are analyzed in a batch of (field) samples.
11) Project-specific requirements may be exceptions. If project, program, or method requirements are more stringent than these laboratory minimum requirements, then the project, program, or method requirements will take precedence. However, if the project, program, or method requirements are less stringent than these laboratory minimum requirements, these laboratory minimum requirements will take precedence.

Note: Matrix spiked samples are often not feasible for air matrices. Therefore, the MS shall be used as required by the test method and as specified by the corresponding method SOP.

12.4 Specialized Procedures

ALS Environmental not only strives to provide results that are scientifically sound, legally defensible, and of known and documented quality; but also strives to provide the best solution to analytical challenges. Procedures using specialized instrumentation and methodology have been developed to improve sensitivity (provide lower detection limits), selectivity (minimize interferences while maintaining sensitivity), and overall data quality for low concentration applications. Examples are specialized GC/MS analyses and low level organics analyses.

12.5 Demonstration of Capability

A demonstration of capability (DOC) is made prior to using any new test method or when a technician is new to the method. This demonstration is made following regulatory, accreditation, or method specified procedures. In general, this demonstration does not test the performance of the method in real world samples, but in the applicable clean matrix free of target analytes and interferences.

A quality control sample material may be obtained from an outside source or may be prepared in the laboratory. The analyte(s) is (are) diluted in a volume of clean matrix (for analytes which do not lend themselves to spiking the demonstration of capability may be performed using quality control samples). Where specified, the method-required concentration levels are used. Four aliquots are prepared and analyzed according to the test procedure. The mean recovery and standard deviations are calculated and compared to the corresponding acceptance criteria for precision and accuracy in the test method or laboratory-generated acceptance criteria (if there are not established mandatory criteria). All parameters must meet the acceptance criteria. Where spike levels are not specified, actual Laboratory Control Sample results may be used to meet this requirement, provided acceptance criteria are met.

12.6 Method Detection Limits and Method Reporting Limits & Limits of Detection/ Quantitation

Method Detection Limits (MDL) for methods performed at ALS Environmental-Simi Valley are determined during initial method set up and if any significant changes are made. If an MDL study is not performed annually, the established MDL is verified by performing a limit of detection (LOD) verification on every instrument used in the analysis. The MDLs are determined by following the *SOP for Performing Method Detection Limits Studies and Establishing Limits of Detection and Quantitation* (CE-QA011), which is based on the procedure in 40 CFR Part 136, Appendix B. As required by NELAP and DoD protocols, the validity of MDLs is verified using LOD verification samples.

The Method Reporting Limit (MRL) is the lowest amount of an analyte in a sample that can be quantitatively determined with stated, acceptable precision and accuracy under stated analytical conditions (i.e. limit of quantitation - LOQ). LOQ are analyzed on an annual basis and cannot be lower than the lowest calibration standard. Current MDLs and MRLs are available from the laboratory.

13) Measurement Traceability and Calibration

All equipment and instruments used at ALS Environmental are operated, maintained and calibrated according to the manufacturer's guidelines and recommendations, as well as to criteria set forth in the applicable analytical methodology. Operation and calibration are performed by personnel who have been properly trained in these procedures. Documentation of calibration information is maintained in appropriate reference files. Brief descriptions of the calibration procedures for major laboratory equipment and instruments are described below. Calibration verification is performed according to the applicable analytical methodology. Calibration verification procedures and criteria are listed in laboratory Standard Operating Procedures. Documentation of calibration verification is maintained in appropriate reference files. Records are maintained to provide traceability of reference materials.

Traceability is defined as the property of a measurement result or value of a standard which can be related to stated references through an unbroken chain, each with stated uncertainties and is documented for all material used to perform calibrations. The documentation, a certificate of analysis containing, at a minimum, the manufacturer, address, accreditation number (where applicable), how traceability was achieved, the traceable values, their associated uncertainty, and the unique serial or laboratory identification number of the equipment or standard reference material (SRM) shall serve as initial point in the chain of traceability. The unique serial number or laboratory identification number is used throughout the laboratory to trace equipment and materials back to the original certificate of analysis.

Laboratory support equipment (thermometers, balances, and weights) are verified on an annual basis by a vendor accredited to ISO/IEC 17025:2005 International Standards. All analytical measurements generated at ALS Environmental are performed using materials and/or processes that are traceable to a reference material. Metrology equipment (analytical balances, thermometers, etc.) is calibrated using reference materials traceable to the National Institute of Standards and Technology (NIST). These primary reference materials are themselves recertified on an annual basis. Vendors used for metrology support are required to verify compliance to International Standards by supplying the laboratory with a copy of their scope of accreditation.

Equipment subjected to overloading or mishandling, or has been shown by verification to be defective, is taken out of service and labeled until repaired. That piece of equipment is placed back in service only after verifying, by calibration, that it performs satisfactorily.

13.1 Temperature Measuring Devices

All thermometers are identified by a unique identifying number (i.e., serial number), and the calibration of these thermometers is checked annually against a National Institute of Standards and Technology (NIST) certified thermometer. All corresponding correction factors are noted on the device as well as in the thermometer calibration logbook. The NIST calibrated thermometer is recertified by an approved vendor accredited ISO/IEC 17025:2005 International Standard on an annual basis and certificates are retained on file for review. All temperature monitoring is conducted in accordance with the *SOP for Sample Receipt, Acceptance and Log-In* (SMO-SMPL_REC) and thermometer calibration requirements are performed in accordance with the *SOP for Calibration and Use of the Laboratory Support Equipment* (ADM-SupEQ).

Specific thermometers include a temperature range per certain project requirements (complies with Department of Defense Quality Systems Manual for Environmental Laboratories); this range is recorded to document consistent compliance with required temperatures for refrigerators and freezers, where applicable.

13.2 Volumetric Dispensing Devices

The accuracy of pipettes used to make critical-volume measurements is verified on a quarterly basis. The indicated volume or range (where applicable) of the pipette is checked and an accuracy and precision verification performed. The calibrations are evaluated against the intended use (volume or range) of the pipette and if the calibration is not approved for the specified volume(s) it is tagged accordingly (i.e. "Do Not Use Below 5uL"). The results for all calibration verifications are recorded and maintained.

Note: Glass microliter syringes including gas-tight syringes are considered in the same manner as Class A glassware and are not held to the calibration/verification requirements as are other volumetric dispensing devices.

13.3 Analytical Balances and Weights

Analytical balances and weights are calibrated/recertified and certificates issued annually by an approved vendor accredited to ISO/IEC 17025:2005 International Standard. The calibration of each balance is checked once each day (prior to use) in the expected range, utilizing the calibrated weights. Bound record books are kept which contain the identification of balance (serial number), recorded measurements and the initials of the analyst who performed the check. All certificates for the balances and weights are available for review.

13.4 Pressure/Vacuum Gauges

ALS Environmental-Simi Valley digital pressure/vacuum gauges are used in a number of critical measurements within the laboratory. The following is a list of the uses for this gauge type.

- Canister cleaning and conditioning.
- Measure the vacuum on canisters before they are sent to the client for sampling.
- Measure the initial/final vacuum/pressure of canisters prior to analysis.
- Measure pressure during the preparation of selected standards.

Digital pressure/vacuum gauges are calibrated and certificates issued once per year by an approved metrology organization. All calibrations are performed against standards traceable to the National Institute of Standards and Technology (NIST) or other recognized national metrology institutes. In addition, ALS Environmental-Simi Valley performs a calibration check for each gauge six months following the calibration date. The laboratory retains all corresponding calibration and verification documentation for review.

13.5 Source and Preparation of Standards and Reference Materials

Consumable reference materials routinely purchased by the laboratories (e.g., analytical standards) are purchased from nationally recognized, reputable vendors. All vendors where possible have fulfilled the requirements for ISO 9001 certification and/or are ISO/IEC 17025:2005 accredited. ALS Environmental-Simi Valley relies on a primary vendor for the majority of its analytical supplies. Consumable primary stock standards are obtained from certified commercial sources or from sources referenced in a specific method. Supelco, Ultra Scientific, AccuStandard, Chem Services, Inc., Aldrich Chemical Co., etc. are examples of the vendors used. Reference material information is recorded in the appropriate logbook(s) and materials are stored under conditions that provide maximum protection against deterioration and contamination.

The logbook entry includes such information as an assigned logbook identification code, the source of the material (i.e. vendor identification), solvent (if applicable) and concentration of analyte(s), reference to the certificate of analysis and an assigned expiration date. The date that the standard is received in the laboratory is marked on the container. When the reference material is used for the first time, the date of usage and the initials of the analyst are also recorded on the container.

Stock solutions and calibration standard solutions are prepared fresh as often as necessary according to their stability. All standard solutions are properly labeled as to analyte concentration, solvent, date, preparer, and expiration date; these entries are also recorded in the appropriate notebook(s) following the *SOP for Making Entries onto Analytical Records* (CE-QA007). Prior to sample analysis, all calibration reference materials are verified with a second, independent source of the material.

13.6 Instrument Calibration

The laboratory specifies the procedures and documentation for initial instrument calibration and continuing calibration verification in the applicable method standard operating procedures to ensure that data is of known quality and is appropriate for a specific regulation and/or client requirement. The procedural steps for calibration including, frequency, number of points, integration, calculations, acceptance criteria (appropriate to the calibration technique employed), corrective action, associated statistics, and data qualifications are included in applicable methods, method standard operating procedures and/or client project plans. The essential elements that define the procedures and required documentation for initial instrument calibrations are specified below.

- Sufficient raw data records are retained to permit reconstruction of all calibrations.
- If a reference or mandated method does not specify the number of calibration standards, the initial calibration range shall consist of a minimum of 5 contiguous calibration points for organics and a minimum of 3 contiguous calibration points for inorganics. The actual numbers of points utilized is specified in the corresponding method SOP.
- The concentrations should bracket the expected concentration range of samples.
- Initial instrument calibration procedures referenced in test methods (either directly or indirectly) are readily available to the analysts.
- All sample results are quantitated from the initial instrument calibration and are not quantitated from any continuing instrument calibration verification unless otherwise specified by regulation, method or program.
- The initial instrument calibration is verified with a standard obtained from a second manufacturer or lot and traceability to a national standard is maintained, where available.
- The acceptance criteria utilized is appropriate for the calibration technique employed.
- The lowest calibration standard in the initial calibration is at or below the lowest concentration for which quantitative data are to be reported and is referred to at this laboratory as the method reporting limit (MRL). Some programs and/or agencies refer to this limit as the practical quantitation limit (PQL) or Limit of Quantitation (LOQ).
- Any data reported below the MRL or above the highest calibration standard is considered to have an increased quantitative uncertainty and is appropriately qualified in the report.
- The lowest calibration standard is above the limit of detection or method detection limit (MDL).

13.7 Internal and External Calibrations

Internal standard calibration involves the comparison of instrument responses from the target compounds in the sample to the responses of specific standards added to the sample or sample extract prior to injection. The ratio of the peak area of the target compound in the sample or sample extract to the peak area of the internal standard in the sample or sample extract is compared to a similar ratio derived for each calibration standard. The ratio is termed the response factor (RF) or relative response factor (RRF) in some methods.

External standard calibration involves comparison of instrument responses from the sample to the responses from the target compounds in the calibration standards. Sample peak areas are compared to peak areas of the standards. The ratio of the detector responses to the amount (mass) of analyte in the calibration standard is defined as the calibration factor or in some cases it may be referred to as response factor.

13.8 Continuing Calibration Verification

The essential elements that define the procedures and required documentation for continuing instrument calibration verification are specified below.

- When an initial calibration is not performed on the day of analysis, continuing instrument calibration verification is analyzed with each batch.
- Calibration is verified for each reported compound, element or parameter; however, for analyses such as total petroleum hydrocarbons a representative chemical related substance or mixture may be used. The allowance for this exception is dependent on applicable regulatory, method, or client project plans.
- Generally, the instrument calibration verification is performed at the beginning, end, and every ten samples of each analytical batch (except, if an internal standard is used, only one verification needs to be performed at the beginning of the analytical batch); whenever it is suspected that the analytical system may be out of calibration; if the time period for calibration or most previous calibration verification has expired; or for analytical systems that contain a specific calibration verification requirement. Specific requirements for the frequency of continuing calibration verification, for a particular method, is specified in the corresponding method standard operating procedure.

14) Assuring the Quality of Results

A primary focus of ALS Environmental's QA Program is to ensure the accuracy, precision and comparability of all analytical results. Prior to using a procedure for the analysis on field samples, acceptable method performance is established by performing demonstration of capability analyses. Performance characteristics are established by performing method detection limit studies and assessing accuracy and precision according to the reference method. ALS Environmental has established Quality Control (QC) objectives for precision and accuracy that are used to determine the acceptability of the data that is generated. These QC limits are either specified in the test methodology or are statistically derived based on the laboratory's historical data. Quality Control objectives are defined below.

14.1 Quality Control Objectives

14.1.1 Accuracy - Accuracy is a measure of the closeness of an individual measurement (or an average of multiple measurements) to the true or expected value. Accuracy is determined by calculating the mean value of results from ongoing analyses of laboratory-fortified blanks, standard reference materials, and standard solutions.

In addition, laboratory-fortified (i.e. matrix-spiked) samples are also measured; this indicates the accuracy or bias in the actual sample matrix. Accuracy is expressed as percent recovery (% REC.) of the measured value, relative to the true or expected value. If a measurement process produces results whose mean is not the true or expected value, the process is said to be biased. Bias is the systematic error either inherent in a method of analysis (e.g., extraction efficiencies) or caused by an artifact of the measurement system (e.g., contamination).

ALS Environmental utilizes several quality control measures to eliminate analytical bias, including systematic analysis of method blanks, laboratory control samples and independent calibration verification standards. Because bias can be positive or negative, and because several types of bias can occur simultaneously, only the net, or total, bias can be evaluated in a measurement.

14.1.2 Precision - Precision is the ability of an analytical method or instrument to reproduce its own measurement. It is a measure of the variability, or random error, in sampling, sample handling and in laboratory analysis. The American Society of Testing and Materials (ASTM) recognizes two levels of precision: repeatability - the random error associated with measurements made by a single test operator on identical aliquots of test material in a given laboratory, with the same apparatus, under constant operating conditions, and reproducibility - the random error associated with measurements made by different test operators, in different laboratories, using the same method but different equipment to analyze identical samples of test material.

"Within-batch" precision is measured using replicate sample or QC analyses and is expressed as the relative percent difference (RPD) between the measurements. The "batch-to-batch" precision is determined from the variance observed in the analysis of standard solutions or laboratory control samples from multiple analytical batches.

14.1.3 Control Limits - The control limits for accuracy and precision originate from two different sources. For analyses having enough QC data, control limits are calculated at the 99% confidence limits. For analyses not having enough QC data, or where the method is prescriptive, control limits are taken from the method on which the procedure is based. If the method does not have stated control limits, then control limits are assigned method-default or reasonable values. Control limits are updated periodically when new statistical limits are generated for the appropriate surrogate, laboratory control sample, and matrix spike compounds (typically once a year) or when method prescribed limits change. The updated limits are reviewed by the QA Manager. The new control limits replace the previous limits and data is assessed using the new values. Current acceptance limits for accuracy and precision are available from the laboratory. For inorganics, the precision limit values listed are for laboratory duplicates. For organics, the precision limit values listed are for duplicate laboratory control samples or duplicate matrix spike analyses.

14.1.4 Representativeness - Representativeness is the degree to which the field sample, being properly preserved, free of contamination, and analyzed within holding time, represents the overall sample site or material. This can be extended to the sample itself, in that representativeness is the degree to which the subsample that is analyzed represents the entire field sample submitted for analysis. ALS Environmental has sample handling procedures to ensure that the sample used for analysis is representative of the entire sample. Further, analytical SOPs specify appropriate sample handling and sample sizes to further ensure the sample aliquot that is analyzed is representative of entire sample. Air samples received by the laboratory in canisters and bags are considered to be homogenous and therefore, no special sample preparation procedures are necessary.

14.1.5 Comparability – Comparability expresses the confidence with which one data set can be compared to another and is directly affected by data quality (accuracy and precision) and sample handling (sampling, preservation, etc). Only data of known quality can be compared. The objective is to generate data of known quality with the highest level of comparability, completeness, and usability. This is achieved by employing the quality controls listed below and standard operating procedures for the handling and analysis of all samples. Data is reported in units specified by the client and using ALS Environmental or project-specified data qualifiers.

14.2 Quality Control Procedures

The specific types, frequencies, and processes for quality control sample analysis are described in detail in method-specific standard operating procedures and listed below. These sample types and frequencies have been adopted for each method and a definition of each type of QC sample is provided below.

14.2.1 Method Blank (a.k.a. Laboratory Reagent Blank)

The method blank is an analyte-free matrix (air, water, soil, etc.) subjected to the entire analytical process. When analyte-free soil is not available, anhydrous sodium sulfate, organic-free sand, or an acceptable substitute is used. The method blank is analyzed to demonstrate that the analytical system itself does not introduce contamination. The method blank results should be below the Method Reporting Limit (MRL) or, if required for DoD projects, < ½ MRL for the analyte(s) being tested. Otherwise, corrective action must be taken. A method blank is included with the analysis of every sample preparation batch, every 20 samples, or as stated in the method, whichever is more frequent.

14.2.2 Calibration Blanks

For some methods, calibration blanks are prepared along with calibration standards in order to create a calibration curve. Calibration blanks are free of the analyte of interest and, where applicable, provide the zero point of the calibration curve. Additional project-specific requirements may also apply to calibration blanks.

14.2.3 Continuing Calibration Blanks

Continuing calibration blanks (CCBs) are solutions of analyte-free water, reagent, or solvent that are analyzed in order to verify the system is contamination-free when CCV standards are analyzed.

The frequency of CCB analysis is once every ten samples or as indicated in the method, whichever is greater. Additional project-specific requirements may also apply to continuing calibration blanks.

14.2.4 Calibration Standards

Calibration standards are vapors, liquids or solutions of known concentration prepared from primary standard or stock standard materials. Calibration standards are used to calibrate the instrument response with respect to analyte concentration.

Standards are analyzed in accordance with the requirements stated in the particular method being used.

14.2.5 Initial (or Independent) Calibration Verification Standards

Initial (or independent) calibration verification standards (ICVs) are standards that are analyzed *after* calibration but *prior to* sample analysis, in order to verify the validity and accuracy of the standards used for calibration. Once it is determined that there is no defect or error in the calibration standard(s), standards are considered valid and may be used for subsequent calibrations and quantitative determinations (as expiration dates and methods allow). The ICV standards are prepared from materials obtained from a source independent of that used for preparing the calibration standards ("second-source"). ICVs are also analyzed in accordance with method-specific requirements.

14.2.6 Continuing Calibration Verification Standards

Continuing calibration verification standards (CCVs) are midrange standards that are analyzed in order to verify that the calibration of the analytical system is still acceptable. The frequency of CCV analysis is either once every ten samples, or as indicated in the method.

14.2.7 Internal Standards

Internal standards are known amounts of specific compounds that are added to each sample prior to instrument analysis. Internal standards are generally used for GC/MS procedures to correct sample results that have been affected by changes in instrument conditions or changes caused by matrix effects. The requirements for evaluation of internal standards are specified in each method and SOP.

14.2.8 Surrogates

Surrogates are organic compounds which are similar in chemical composition and chromatographic behavior to the analytes of interest, but which are not normally found in environmental samples. Depending on the analytical method, one or more of these compounds is added to method blanks, calibration and check standards, and samples (including duplicates, matrix spike samples, duplicate matrix spike samples and laboratory control samples) prior to extraction and analysis in order to monitor the method performance on each sample. The percent recovery is calculated for each surrogate, and the recovery is a measurement of the overall method performance.

Recovery (%) = (M/T) x 100

Where: M = The measured concentration of analyte,
T = The theoretical concentration of analyte added.

14.2.9 Laboratory Control Samples

The laboratory control sample (LCS) is an aliquot of analyte-free liquid, solid or air matrix to which known amounts of the method analyte(s) is (are) added. A reference material of known matrix type, containing certified amounts of target analytes, may also be used as an LCS. An LCS is prepared and analyzed at a minimum frequency of one LCS per 20 samples, with every analytical batch or as stated in the method, whichever is more frequent. The LCS sample is prepared and analyzed in exactly the same manner as the field samples.

The percent recovery of the target analytes in the LCS is compared to established control limits and assists in determining whether the methodology is in control and whether the laboratory is capable of making accurate and precise measurements at the required reporting limit. Comparison of batch-to-batch LCS analyses enables the laboratory to evaluate batch-to-batch precision and accuracy.

Recovery (%) = (M/T) x 100

Where: M = The measured concentration of analyte,
T = The theoretical concentration of analyte added.

14.2.10 Laboratory Fortified Blanks - LFB

A laboratory blank fortified at the MRL used to verify the minimum reporting limit. The LFB is carried through the entire extraction and analytical procedure.

14.2.11 Matrix Spikes (a.k.a. Laboratory Fortified Sample Matrix)

Matrix spiked samples are aliquots of samples to which a known amount of the target analyte (or analytes) is (are) added. The samples are then prepared and analyzed in the same analytical batch, and in exactly the same manner as are routine samples. For the appropriate methods, matrix spiked samples are prepared and analyzed and at a minimum frequency of one spiked sample (and one duplicate spiked sample, if appropriate) per twenty samples. The spike recovery measures the effects of interferences caused by the sample matrix and reflects the accuracy of the method for the particular matrix in question. Spike recoveries are calculated as follows:

Recovery (%) = (S - A) x 100 ÷ T

Where: S = The observed concentration of analyte in the spiked sample,
A = The analyte concentration in the original sample, and
T = The theoretical concentration of analyte added to the spiked sample.

Note: Matrix spiked samples are often not feasible for air matrices. Therefore, the MS shall be used as required by the test method and as specified by the corresponding method SOP.

14.2.12 Laboratory Duplicates and Duplicate Matrix Spikes

Duplicates are additional replicates of samples that are subjected to the same preparation and analytical scheme as the original sample.

Depending on the method of analysis, either a duplicate analysis (and/or a matrix spiked sample) or a matrix spiked sample and duplicate matrix spiked sample (MS/DMS) are analyzed. The relative percent difference between duplicate analyses or between an MS and DMS is a measure of the precision for a given method and analytical batch. The relative percent difference (RPD) for these analyses is calculated as follows:

$$\text{Relative Percent Difference (RPD)} = (S1 - S2) \times 100 \div S_{ave}$$

Where S1 and S2 = The observed concentrations of analyte in the sample and its duplicate, or in the matrix spike and its duplicate matrix spike, and

S_{ave} = The average of observed analyte concentrations in the sample and its duplicate, or in the matrix spike and its duplicate matrix spike.

Depending on the method of analysis, either duplicates (and/or matrix spikes) or MS/DMS analyses are performed at a minimum frequency of one set per 20 samples. If an insufficient quantity of sample is available to perform a laboratory duplicate or duplicate matrix spikes, duplicate LCSs will be prepared and analyzed.

14.2.13 Control Charting

The generation of control charts is routinely performed at ALS Environmental. Surrogate, Matrix Spike and LCS recoveries are all monitored and charted. In addition, the laboratory also monitors the Relative Percent Difference (RPD) measurement of precision. Control charts are available to each department to monitor the data generated and identify trends in the analytical results. If trends in the data are perceived, various means of corrective action may then be employed in order to prevent future problems with the analytical system(s). Finally, data quality reports using control charts are generated for specific clients and projects pursuant to contract requirements. The control charting procedure is described in the SOP for *Control Limits* (CE-QA009).

14.2.14 Glassware Washing

Glassware washing and maintenance play a crucial role in the daily operation of a laboratory. The glassware used at ALS Environmental undergoes a rigorous cleansing procedure prior to every usage. The *SOP for Glassware Cleaning* (ADM-GLASS) outlines the various procedures used at ALS Environmental-Simi Valley; each procedure is specific to the end-use of the equipment as well as to the overall analytical requirements of the project. In addition, other equipment that may be routinely used at the laboratory is also cleaned following instructions in the appropriate SOP.

14.2.15 Collection Efficiency

In the case of sampling trains (consisting of one or more multi-section sorbent tubes), which are received intact by the laboratory, the “front” and “back” sections shall be separated if required by the client. Each section shall be processed and analyzed separately and the analytical results reported accordingly.

14.2.16 Desorption Efficiency and Method Reporting Limits (Industrial Hygiene)

Desorption efficiency (DE) is the ability of an analytical method to recover the analyte from the collection media. Desorption efficiencies are determined initially and for each analyte to be reported. In addition, a DE study is performed each time there is a change in the test method, or with each new lot of media. Desorption efficiency shall be determined using sorbent media from the same lot number used for the field samples, if possible, and of the identical size and type. The DE values are used to correct the sample results (for all samples except passive samplers) before reporting.

Minimum reporting limits for each reportable analyte are determined initially by the analysis of spiked media, prepared at the desired reporting limit and carried through the entire analytical process. The reporting limit is verified or re-established annually (or if there is a change in methodology or instrumentation) and instrument performance is checked with each analytical batch through the analysis of an analytical standard prepared at the reporting limit.

14.2.17 Field and Trip Blanks

Field and trip blanks are analyzed when they are submitted to the laboratory for analysis. The actual field samples are flagged (when analytes are found in the blank) if and only if the laboratory is able to analyze the samples in the same analytical sequence as the corresponding field or trip blank. If this is not possible due to client submission restrictions then the results for the samples and blanks shall be reported independently with no flag. However, an explanation of this is included in the final report. This laboratory does not feel that Summa canisters are suitable for use as trip blanks. It is for this reason that the results for these types of containers are reported as separate samples and flagging is not considered appropriate.

14.3 Uncertainty

When requested by the client or relevant to the validity of reported results, the estimation of measurement uncertainty will be provided to a client or regulatory agency. How the uncertainty will be reported may be dictated by the client's reporting specifications. Procedures for determining and reporting uncertainty are given in the *SOP for Estimation of Uncertainty of Analytical Measurements* (CE-QA010).

15) Control of Non-Conforming Environmental Testing Work

If a quality control measure is found to be out of control, and the data is to be reported, all samples associated with the failed quality control measure shall be reported with the appropriate data qualifier(s) (See Appendix H). Failure to meet established analytical controls, such as the quality control objectives, prompts corrective action. Corrective action may take several forms and may involve a review of the calculations, a check of the instrument maintenance and operation, a review of analytical technique and methodology, and reanalysis of quality control and field samples. If a potential problem develops that cannot be solved directly by the responsible analyst, the supervisor, team leader, department manager, and/or the QA Manager may examine and pursue alternative solutions. In addition, the appropriate Project Manager is notified in order to ascertain if the client needs to be notified.

16) Corrective Action, Preventive Action, and Improvement

When work does not conform to established quality control procedures, responsible management will evaluate the significance of the nonconforming work and when required take corrective action to address the nonconformance. The laboratory takes all appropriate steps necessary to ensure all sample results are reported with acceptable quality control results.

Nonconforming events such as errors, deficiencies, deviations from SOP, proficiency (PT) failure or results that fall outside of established QC limits are documented using a *Nonconformity and Corrective Action Report* form. The procedure and responsibilities for addressing nonconforming work is defined in the *SOP for Nonconformance and Corrective Action* (CE-QA008). Nonconformances are reported to the client using various means (voice, email, narrative, etc). When a nonconformance occurs that casts doubt on the validity of the test results or additional client instructions are needed, the Project Manager notifies the client the same business day that the nonconformance is confirmed and reported. The QA Manager reviews each problem, ensuring that appropriate corrective action has been taken by the appropriate personnel. The Nonconformity and Corrective Action Report (NCAR) is filed in the associated service request file and a copy is kept by the QA Manager. The QA Manager periodically reviews all NCARs looking for chronic, systematic problems that need more in-depth investigation and alternative corrective action consideration. In addition, the appropriate Project Manager is promptly notified of any problems in order to inform the client and proceed with any action the client may want to initiate.

Part of the corrective action process involves determining the root cause. Identifying the root cause of a nonconformance can be difficult, but important for implementing effective corrective action. Root cause principles are used to determine assignable causes, which leads to corrective action taken to prevent recurrence.

16.1 Preventive Action and Improvement

Various preventive action and improvement processes are used for eliminating potential problems or averting problems before they occur. This is explained in the *SOP for Preventive Action* (CE-GEN004).

Table 16-1

Equipment Maintenance Procedures

Instrument	Applicable Activity	Frequency	Performed
Gas Chromatographs	Replace septum	As required	In-House and Outside Vendor
	Check system for gas leaks, loose/fray wires and insulation	With cylinder change/Open system	
	Replace injection port liner	As required	
	ECD wipe test	Every 6 months	
	Thermally Clean ECD	As needed	
	Clean FID	As required	
	Change TCD assembly	As required	
	SCD – Change reaction tube	As required	
	Catalyst check	As required	
Gas Chromatography / Mass Spectrometers	Tune MSD	As needed	In-House and Outside Vendor
	Change Semi-VOA capillary column	As needed	
	Change Semi-VOA injection port septum	As required	
	Change Semi-VOA injection port liner	As required	
	Replace trap (VOA)	As required	
	Clean ion source	As required	
	Change filament	As required	
	Change electron multiplier	As required	
	Vacuum System: • Mechanical pumps: change oil, change trap pellets (HP only) • Diffusion pump: check oil, check cooling fan, change oil • Turbo pump	• Check every 6 months, check level monthly, change at least annually or sooner is necessary • As required • Replace as required	In-House
	Air Preconcentrators / Autosampler: • Change traps • Inspect Rotors • Calibrate Mass Flow Controllers	• As required • As required • Every 6 months	In-House

Instrument	Applicable Activity	Frequency	Performed
HPLC	Replace/clean check valve filter	As required	In-House
	Replace lamp UV/vis detector	As required	
	Replace flow cell	As required	
	Check flow	Quarterly	
Analytical Balances	Clean pan and compartment	Prior to and after use	In-House and Outside Vendor
	Check with NIST traceable weights	Prior to use	
	Field service	Annually	
Refrigerators and Freezers	Monitor Temperature	Daily	In-House
	Adjust Temperature	As required	
	Clean, Defrost	As required	
Ovens	Clean	As needed or if temperature is outside limit	In-House
pH probes	Condition probe	When fluctuations occur	In-House
	Change Filling Solution	Weekly	
Ammonia ISE	Store in storage solution	Between uses	In-House
UV-visible Spectrophotometer	Wavelength check	Annually	In-House
Restek Thermal Gas Purifier	Check getter tube	Monthly, change as required	In-House

17) Control of Records

17.1 Documentation

ALS Environmental maintains a records system which ensures that all laboratory records of analysis data are retained and available. Analysis data is retained for 5 years from the report date unless contractual terms or regulations specify a longer retention time. Archival procedures are described in the *SOP for Data and Record Archiving* (ADM-ARC).

17.1.1 Documentation and Archiving of Sample Analysis Data

The archiving system includes, but is not limited to, the following items (where applicable) for each set of analyses performed:

- Benchsheets describing sample preparation (if appropriate) and analysis;
- Instrument parameters (or reference to the data acquisition method);
- Sample analysis sequence;
- Instrument printouts, including chromatograms and peak integration reports for all samples, standards, blanks, spikes, duplicates and reruns;
- Applicable standard identification numbers;
- Chain of custody, service request and sample acceptance check forms;
- Initial calibration and data review checklist(s);
- Copies of report sheets submitted to the work request file; and
- Copies of Nonconformity and Corrective Action Reports, if necessary.

Individual sets of analyses are identified by analysis date and service request number. Since many analyses are performed with computer-based data systems, the final sample concentrations can be automatically calculated. If additional calculations are needed, they are written on the integration report or securely stapled to the chromatogram, if done on a separate sheet.

For organics analysis, data applicable to all analyses within the batch, such as GCMS tunes, CCVs, batch QC, and analysis sequences; are kept using a separate documentation system. This system is used to archive data on a batch-specific basis and is segregated according to the date of analysis. This system also includes results for the most recent calibration curves, as well as method validation results.

17.2 Information Technology

The generation, compilation, reporting, and archiving of electronic data is a critical component of laboratory operations. In order to generate data of known and acceptable quality, the quality assurance systems and quality control practices for electronic data systems must be complete and comprehensive and in keeping with the overall quality assurance objectives of the organization. ALS Environmental management provides the tools and resources to implement electronic data systems and establishes information technology standards and policies.

17.2.1 Software Quality Assurance

Practices are defined for assuring the quality of the computer software used throughout all laboratory operations to generate, compile, report, and store electronic data. These practices are described in the *SOP for Software and Data Quality Assurance* (ADM-SftwreQA).

The purpose of the SOP is to describe the policies and practices for the procurement, configuration management, development, validation and verification, data security, maintenance, and use of computer software. The policies and practices described in the plan apply to purchased computer software as well as to internally developed computer software. Key components of this plan are policies for software validation and control.

17.2.2 IT Support

The local ALS Environmental Information Technology (IT) department is established to provide technical support for all computing systems. The IT department staff continually monitors the performance and output of operating systems. The IT department oversees routine system maintenance and data backups to ensure the integrity of all electronic data described in the *SOP for Electronic Data Backup, Archiving, and Restoration* (ADM-DATA_BU). A software inventory is maintained. Additional IT responsibilities are described in the *SOP for Software and Data Quality Assurance* (ADM-SftwreQA).

In addition to the local IT department, ALS Environmental corporate IT provides support for network-wide systems. ALS Environmental also has personnel assigned to information management duties such as development and implementation of reporting systems; data acquisition, and Electronic Data Deliverable (EDD) generation.

17.2.3 Information Management Systems

ALS Environmental has various systems in place to address specific data management needs. The Laboratory Information Management System (LIMS) is used to manage sample information and invoicing. Access is controlled by password. This system defines sample identification, analysis specifications, and provides a means of sample tracking. This system is used during sample login to generate the internal service request.

Included on the service request is a summary of client information, sample identification, required analyses, work instructions, and deliverable requirements. The LIMS is used to track the status of a sample and is important in maintaining internal chain of custody.

Where possible, instrument data acquired locally is immediately moved to a server (Microsoft Windows Server 2008 R2). This provides a reliable, easily maintained, high-volume acquisition and storage system for electronic data files. With password entry, users may access the system from many available computer stations, improving efficiency and flexibility. The server is also used for data reporting, EDD generation, and administrative functions. Access to these systems is controlled by password. A standardized EDI (electronic data interchange) format is used as a reporting platform, providing functionality and flexibility for end users. With a common standardized communication platform, the EDI provides data reporting in a variety of hardcopy and electronic deliverable formats.

17.2.4 Backup and Security

Laboratory data is either acquired directly to the centralized acquisition server or acquired locally and then transferred to the server. All data is eventually moved to the centralized data acquisition server for reporting and archiving.

Full backups onto a hard drive are performed on all file server information once per day. In addition, the laboratory’s data warehouse located in Canada performs an offsite full backup nightly.

Access to sample information and data is on a need-to-know basis. Access is restricted to the person’s areas of responsibility. Passwords are required on all systems. No direct external, non-ALS Environmental access is allowed to any of our network systems.

The external e-mail system and Internet access is established via a single gateway to discourage unauthorized entry. ALS Environmental uses a closed system for company e-mail. Files, such as electronic deliverables, are sent through the external e-mail system only via a trusted agent or comparable service. The external messaging system operates through a single secure gateway. E-mail attachments sent in and out of the gateway are subject to a virus scan. Because the Internet is not regulated, we use a limited access approach to provide a firewall for added security. Virus screening is performed continuously on all network systems with Internet access.

18) Audits

Quality audits are an essential part of ALS Environmental-Simi Valley's quality assurance program. There are two types of audits used at the facility: System Audits are conducted to qualitatively evaluate the operational details of the QA program, while Performance Audits are conducted by analyzing proficiency testing samples in order to quantitatively evaluate the outputs of the various measurement systems.

18.1 System Audits

The system audit examines the presence and appropriateness of laboratory systems. External system audits of ALS Environmental-Simi Valley are conducted regularly by various regulatory agencies and clients. Appendix J lists the certification and accreditation programs in which ALS Environmental-Simi Valley participates. Programs and certifications are added as required. Additionally, internal system audits of ALS Environmental-Simi Valley are conducted regularly under the direction of the QA Manager. The internal audit procedures are described in the *SOP for Internal Audits* (CE-QA001). The internal audits are performed as follows:

- Comprehensive lab-wide system audit – performed annually. This audit is conducted such that all elements of the ALS Quality System are assessed.
- Technical/method audits
- Hardcopy report audits

All audit findings, and corrective actions are documented. The results of each audit are reported to the Laboratory Director and Department Managers for review. Any deficiencies identified are summarized in the audit report. Managers must respond with corrective actions correcting the deficiency within a defined timeframe. Should problems impacting data quality be found during an internal audit, any client whose data is adversely impacted will be given written notification within the corrective action period (if not already provided).

Electronic data audits may be performed in conjunction with hardcopy data audits. The electronic audits focus on organic chromatographic data and include an examination of audit trails, peak integrations, calibration practices, GCMS tuning data, peak response data, use of appropriate files, and other components of the analysis. The audit also verifies that the electronic data supports the hardcopy reported data.

Additional internal audits or data evaluations may be performed as needed to address any potential data integrity issues that may arise.

18.2 Performance Audits

ALS Environmental-Simi Valley also participates in the analysis of interlaboratory proficiency testing (PT) samples. Participation in PT studies is performed on a regular basis and is designed to evaluate all analytical areas of the laboratory. General procedures for these analyses are described in the *SOP for Proficiency Sample Testing Analysis* (CE-QA006). ALS Environmental-Simi Valley routinely participates in the following studies:

- Air and Emissions PT studies, 2 per year
- Other studies as required for specific certifications, accreditations, or validations.

PT samples are processed by entering them into the LIMS system as samples (assigned Service Request, due date, testing requirements, etc.) and are processed the same as field samples. The laboratory sections handle samples the same as field samples, performing the analyses following method requirements and performing data review. The laboratory sections submit results to the QA Manager for subsequent reporting to the appropriate agencies or study provider. Results of the performance evaluation samples and audits are reviewed by the QA Manager, Laboratory Director, the laboratory staff, and the Manager of Quality Assurance, USA. For any results outside acceptance criteria, the analysis data is reviewed to identify a root cause for the deficiency, and corrective action is taken and documented through nonconformance (NCAR) procedures.

19) Management Review

Quality assurance requires an active, ongoing commitment by ALS Environmental personnel at all levels of the organization. Communication and feedback mechanisms are designed so that analysts, supervisors and managers are aware of QA issues in the laboratory. Analysts performing routine testing are responsible for generating a data quality narrative or data review document with every analytical batch processed. This report also allows the analyst to provide appropriate notes and/or a narrative if problems were encountered with the analyses. A Non-Conformity and Corrective Action Report (NCAR) may also be initiated. Supervisors or qualified analysts review all of the completed analytical batches to ensure that all QC criteria have been examined and any deficiencies noted and addressed.

It is the responsibility of each laboratory unit to provide the reporting department with reviewed data accompanied by signature approval. The data validation coordinators provide the Project Manager with a final report of the data. Footnotes and/or narrative notes must accompany any data package if problems were encountered that require further explanation to the client. Each data package is submitted to the appropriate Project Manager, who in turn reviews the entire collection of analytical data for completeness and to ensure that any and all client-specified objectives were successfully achieved. A case narrative is written (or approved) by the Project Manager to explain any unusual problems with a specific analysis or sample, etc.

The QA Manager provides overview support to the Project Managers as required (e.g., contractually specified, etc.). The QA Manager is also responsible for the oversight of all internal and external audits, for all proficiency testing sample and analysis programs, and for all laboratory certification/accreditation responsibilities. The QA Manager regularly communicates with the Laboratory Director to review the various QA/QC activities, priorities, and status of program implementation; including such topics as the following:

- Status, schedule, and results of internal and external audits;
- Status, schedule, and results of internal and external proficiency testing studies;
- Status of certifications, accreditations, and approvals;
- Status of QA Manual and SOP review and revision;
- Status of MDLs studies;
- Discussion of QC problems in the laboratory;
- Discussion of corrective action program issues;
- Status of staff training and qualification; and
- Other topics as appropriate.

An annual management review of the quality and testing systems is performed as described in the *SOP for Laboratory Management Review* (CE-QA005). This is done to identify any necessary changes or improvements to the quality system or quality assurance policies. This review is documented in a Managerial Review of the Laboratory's Quality Systems and Testing Activities and sent to senior management.

20) Personnel

Technical position descriptions are available for all employees, regardless of position or level of seniority. These documents are maintained by the Human Resources personnel and are available for review. In order to assess the technical capabilities and qualifications of a potential employee, all candidates for employment at ALS Environmental are evaluated, in part, against the appropriate technical description.

Training begins the first day of employment at ALS Environmental when the company policies are presented and discussed. Safety and QA/QC requirements are integral parts of all technical SOPs and, consequently, are integral parts of all training processes at ALS Environmental. Safety training begins with reading the *Environmental Health and Safety Manual.* Employees are also required to participate in periodic safety training performed by the Environmental, Health and Safety Coordinator.

Employees are responsible for complying with the requirements of the QA Manual and QA/QC requirements associated with their function(s). Quality Systems training begins with Quality Assurance orientation for new employees and reading the Quality Assurance Manual. New employees receive Ethics training and learn about ALS Environmental quality systems as part of the induction process. Each employee participates in annual Ethics Refresher training.

ALS Environmental also encourages its personnel to continue to learn and develop new skills that will enhance their performance and value to the Company. Ongoing training occurs for all employees through a variety of mechanisms. The corporate, company-wide training and development program, external and internal technical seminars and training courses, and laboratory-specific training exercises are all used to provide employees with professional growth opportunities.

All technical training is documented and records are maintained by the QA department. Training requirements and its documentation are described in the *SOP for Training Policy* (CE-QA003). A training plan is developed whenever an employee starts a new procedure or new position. The training plan includes a description of the step-by-step process for training an employee and for initial demonstration of capability. Where the analyst performs the entire procedure, a generic training plan may be used.

20.1 Initial Demonstration of Capability (IDOC)

Training in analytical procedures typically begins with the reading of the Standard Operating Procedure (SOP) for the method. Hands-on training begins with the observation of an experienced analyst performing the method, followed by the trainee performing the method under close supervision, and culminating with independent performance of the method on quality control samples. Successful completion of the applicable Demonstration of Capability analysis qualifies the analyst to perform the method independently. Demonstration of Capability is performed by one of the following:

- Successful completion of an Initial Precision and Recovery (IPR) study (required where mandated by the method).
- Analysis of 4 consecutive Laboratory Control Samples, with acceptable accuracy and precision.
- Where spiking is not possible but QC standards are used (“non-spiked” Laboratory Control Samples), analysis of 4 consecutive Laboratory Control Samples with acceptable accuracy and precision.
- Where one of the three above is not possible training is performed and supervisor approval is documented.

A flowchart identifying the Demonstration of Proficiency requirements is given in Figure 20-1. The flowchart identifies allowed approaches to assessing Demonstration of Capability when a 4-replicate study is not mandated by the method, when spiking is not an option, or when QC samples are not readily available.

20.2 Continuing Demonstration of Proficiency

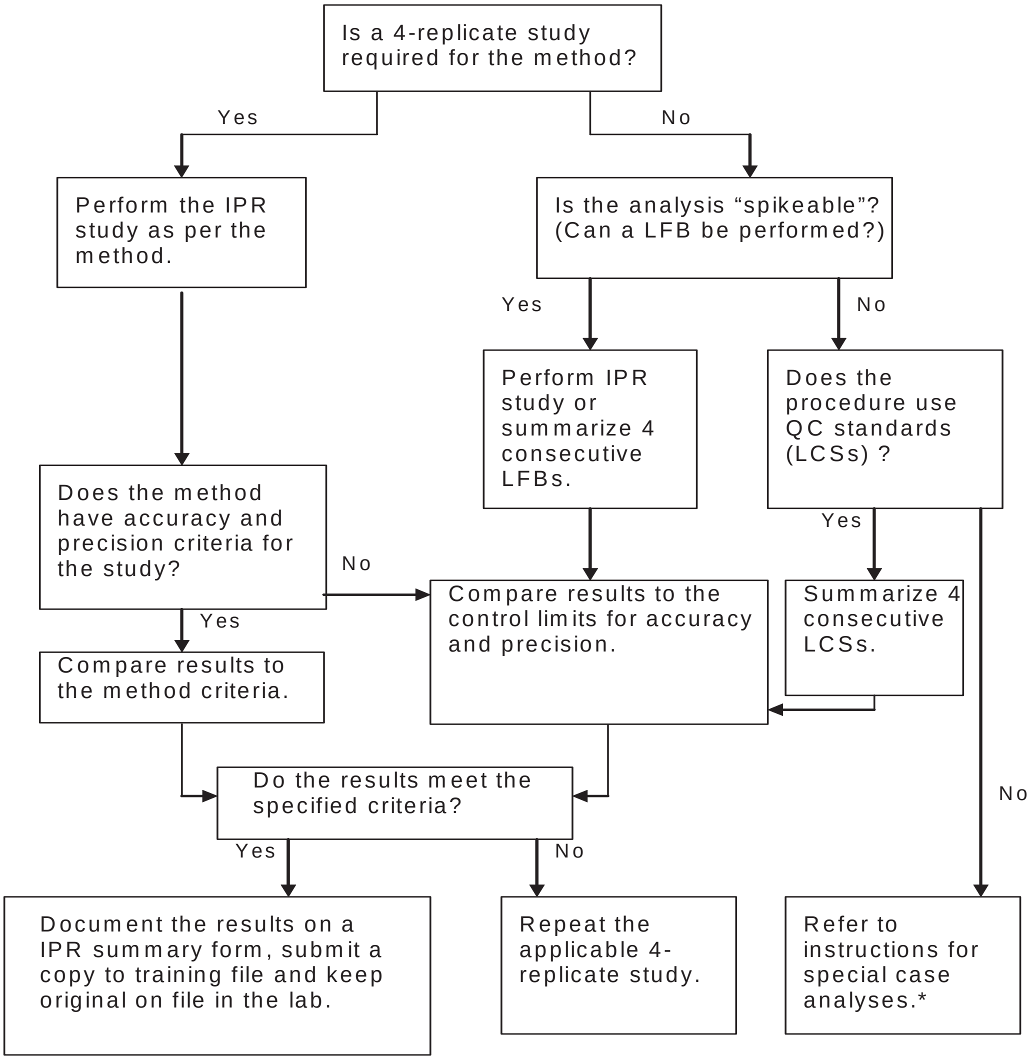
A periodic demonstration of proficiency is required to maintain continuing qualification. Continuing Demonstration of Proficiency is required each year, and may be performed one of the following ways:

- Successful performance on external (independent) single-blind sample analyses using the test method, or a similar test method using the same technology. I.e. PT sample or QC sample blind to the analyst.
- Performing Initial Demonstration of Capability as described above, with acceptable levels of precision and accuracy.
- Analysis of at least 4 consecutive LCSs with acceptable levels of accuracy and precision from in-control analytical batches.
- If the above cannot be performed, analysis of authentic samples with results statistically indistinguishable from those obtained by another trained analyst.
- For methods for which PT samples are not available and a spiked analysis (LFB, MDL, etc.) is not possible, analysis of field samples that have been analyzed by another analyst with statistically indistinguishable results.

20.3 Documentation of Training

Records are maintained to indicate the employee has the necessary training, education, and experience to perform their functions. Information of previously acquired skills and abilities for a new employee is maintained in Human Resources personnel files and ALS Environmental resumes. QA maintains a database to record the various technical skills and training acquired while employed by ALS Environmental. Information includes the employee’s name, a description of the skill including the appropriate method and SOP reference, the mechanism used to document proficiency, and the date the training was completed. General procedures for documenting technical training are described in the *SOP for Training Policy* (CE-QA003).

Figure 20-1
Initial Demonstration of Capability Requirements[a]



[a] For IDOC IPR or LFB studies, "second-source" reference materials are used, as per TNI/NELAP requirements

* Refer to the SOP for Training Policy for details. References for Quality Systems, External Documents, Manuals, Standards, and Analytical Procedures

21) Reporting of Results

ALS Environmental reports the analytical data produced in its laboratories to the client via the certified analytical report. This report includes a transmittal letter, a case narrative, client project information, specific test results, quality control data, chain of custody information, and any other project-specific support documentation. The following procedures describe our data reduction, validation and reporting procedures.

21.1 Data Reduction and Review

Results are generated by the analyst who performs the analysis and works up the data. All data is initially reviewed and processed by analysts using appropriate methods (e.g., chromatographic software, instrument printouts, hand calculation, etc.). Equations used for calculation of results are found in the applicable analytical SOPs. The resulting data set is either manually entered into an electronic report form or is electronically transferred into the report from the software used to process the original data set (e.g., chromatographic software). The data is then reviewed by the analyst for accuracy. Once the primary analyst has checked the data for accuracy and acceptability, the supervisor or second qualified analyst reviews the data for errors. Where calculations are not performed using a validated software system, the reviewer rechecks a minimum of 10% of the calculations. When the entire data set has been found to be acceptable it is turned into the reporting department where final reports are generated and then validated by a Data Validation Coordinator. The hardcopy or electronic final report is physically or electronically signed by the project manager and the final report may be stored electronically or in hardcopy format. Test analysis data shall be kept in the appropriate service request folder. Data review and reporting procedures are described in the *SOP for Data Review and Reporting* (ADM-DATA_REV).

Policies and procedures for manual editing of data are established. The analyst making the change must initial and date the edited data entry, without obliteration of the original entry. The policies and procedures are described in the *SOP for Making Entries onto Analytical Records* (CE-QA007).

Policies and procedures for electronic manual integration of chromatographic data are established. The analyst performing the integration must document the integration change by printing both the “before” and “after” integrations and including them in the raw data records. The policies and procedures are described in the *SOP for Manual Integration Policy* (CE-QA002).

21.2 Confirmation Analysis

21.2.1 Gas Chromatographic and Liquid Chromatographic Analyses

For gas chromatographic (GC) and liquid chromatographic (LC) analyses, all positive results are confirmed as required by the method, typically by a second column, a second detector, a second wavelength (HPLC/UV), or by GC/MS analysis, unless exempted by one of the following situations:

- The analyte of interest produces a chromatogram containing multiple peaks exhibiting a characteristic pattern, which matches appropriate standards. This is limited to petroleum hydrocarbon analyses (e.g., gasoline and diesel).
- The sample meets all of the following requirements:
  1. All samples (liquid or solid) come from the same source (e.g., groundwater samples from the same well) for continuous monitoring.

Samples of the same matrix from the same site, but from different sources (e.g., different sampling locations) are not exempt.

2. All analytes have been previously analyzed in sample(s) from the same source, identified and confirmed by a second column or by GC/MS. The chromatogram is largely unchanged from the one for which confirmation was carried out. The documents indicating previous confirmation must be available for review.

21.2.2 Confirmation Data

Confirmation data will be provided as specified in the method. Identification criteria for GC, LC or GC/MS methods are summarized below:

- GC and LC Methods
  1. The analyte must fall within plus or minus three times the standard deviation (established for the analyte/column) of the retention time of the daily midpoint standard in order to be qualitatively identified. The retention-time windows will be established and documented, as specified in the appropriate Standard Operating Procedure (SOP).
  2. When sample results are confirmed by two dissimilar columns or detectors, the agreement between quantitative results must be evaluated. The relative percent difference between the two results is calculated and evaluated against SOP and/or method criteria.
- GC/MS Methods - Two criteria are used to verify identification:
  1. Elution of the analyte in the sample will occur at the same relative retention time (RRT) as that of the analyte in the standard.
  2. The mass spectrum of the analyte in the sample must, in the opinion of a qualified analyst or the department manager, correspond to the spectrum of the analyte in the standard or the current GC/MS reference library.

21.3 Data Review and Validation of Results

The integrity of the data generated is assessed through the evaluation of the sample results, calibrations, and QC samples (method blanks, laboratory control samples, sample duplicates, matrix spikes, trip blanks, etc.). A brief description of the evaluation of these analyses is described below, with details listed in applicable SOPs. The criteria for evaluation of QC samples are listed within each method-specific SOP. Other data evaluation measures may include (as necessary) a check of the accuracy check of the QC standards and a check of the system sensitivity. Data transcriptions and calculations are also reviewed.

Note: Within the scope of this document, all possible data assessment requirements for various project protocols cannot be included in the listing below. This listing gives a general description of data evaluation practices used in the laboratory in compliance with NELAP Quality Systems requirements. Additional requirements exist for certain programs, such as projects under the DoD QSM protocols, and project-specific QAPPs.

- Method Calibration – Following the analysis of calibration blanks and standards according to the applicable SOP the calibration correlation coefficient, average response factor, etc. is calculated and compared to specified criteria. If the calibration meets criteria analysis may continue. If the calibration fails, any problems are isolated and corrected and the calibration standards reanalyzed. Following calibration and analysis of the independent calibration verification standard(s) the percent difference for the ICV is calculated. If the percent difference is within the specified limits the calibration is complete. If not, the problem associated with the calibration and/or ICV are isolated and corrected and verification and/or calibration is repeated.

- Continuing Calibration Verification (CCV) – Following the analysis of the CCV standard the percent difference is calculated and compared to specified criteria. If the CCV meets the criteria analysis may continue. If the CCV fails, routine corrective action is performed and documented and a 2nd CCV is analyzed. If this CCV meets criteria, analysis may continue, including any reanalysis of samples that were associated with a failing CCV. If the routine corrective action failed to produce an immediate CCV within criteria, then either acceptable performance is demonstrated (after additional corrective action) with two consecutive calibration verifications or a new initial calibration is performed.
- Method Blank – Results for the method blank are calculated as performed for samples. If results are less than the MRL (<½ MRL for DoD projects), the blank may be reported. If not, associated sample results are evaluated to determine the impact of the blank result. If possible, the source of the contamination is determined. If the contamination has affected sample results the blank and samples are reanalyzed. If positive blank results are reported, the blank (and sample) results are flagged with an appropriate flag, qualifier, or footnote.
- Sample Results (Inorganic) – Following sample analysis and calculations (including any dilutions made due to the sample matrix) the result is verified to fall within the calibration range. If not, the sample is diluted and analyzed to bring the result into calibration range. When sample and sample duplicates are analyzed for precision, the calculated RPD is compared to the specified limits.

  The sample and duplicate are reanalyzed if the criteria are exceeded. The samples may require re-preparation and reanalysis. Results are reported when within the calibration range, or as estimates when outside the calibration range. When dilutions are performed the MRL is elevated accordingly.
- Sample Results (Organic) – For GC/MS analyses, it is verified that the analysis was within the prescribed tune window. If not, the sample is reanalyzed. Following sample analysis and calculations (including any dilutions made due to the sample matrix) peak integrations, retention times, and spectra are evaluated to confirm qualitative identification. Internal standard responses and surrogate recoveries are evaluated against specified criteria. If internal standard response does not meet criteria, the sample is diluted and reanalyzed. Results outside of the calibration range are diluted to within the calibration range. When dilutions are performed the MRL is elevated accordingly.
- Surrogate Results (Organic) – The percent recovery of each surrogate is compared to specified control limits. If recoveries are acceptable, the results are reported. If recoveries do not fall within control limits, the sample matrix is evaluated. When matrix interferences are present or documented, the results are reported with a qualifier that matrix interferences are present.

  If no matrix interferences are present and there is no cause for the outlier, the sample is reanalyzed. However, if the recovery is above the upper control limit with non-detected target analytes, the sample may be reported. All surrogate recovery outliers are appropriately qualified on the report.

- Duplicate Sample and/or Duplicate Matrix Spike Results – The RPD is calculated and compared to the specified control limits. If the RPD is within the control limits the result is reported. If not, an evaluation of the sample is made to verify that a homogenous sample was used and the results are compared to the MRL. The samples and duplicates are reanalyzed and if re-analysis also produces out-of-control results, the results are reported with an appropriate qualifier.
- Laboratory Control Sample Results – Following analysis of the LCS the percent recovery is calculated and compared to specified control limits. If the recovery is within control limits, the analysis is in control and results may be reported. If not, this indicates that the analysis is not in control. Samples associated with the 'out of control' LCS, shall be considered suspect and the samples reanalyzed or the data reported with the appropriate qualifiers.
- Matrix Spike Results – Following analysis of the MS the percent recovery is calculated and compared to specified control limits. If the recovery is within control limits the results may be reported. If not, and the LCS is within control limits, this indicates that the matrix potentially biases analyte recovery. It is verified that the spike level is at least five times the background level. If not, the results are reported with a qualifier that the background level is too high for accurate recovery determination. If matrix interferences are present or results indicate a potential problem with sample preparation, steps may be taken to improve results; such as dilution and reanalysis, or re-preparation and reanalysis. Results that do not meet acceptance limits are reported with an appropriate qualifier.

21.4 Data Reporting

When an analyst determines that a data package has met the data quality objectives (and/or any client-specific data quality objectives) of the method and has qualified any anomalies in a clear, acceptable fashion, the data package will undergo a peer review by a trained chemist. Prior to release of the report to the client, the Project Manager reviews and approves the entire report for completeness and to ensure that any and all client-specified objectives were successfully achieved. The original raw test data, along with a copy of the final report, is retained by service request number for archival purposes. ALS Environmental maintains control of analytical results by adhering to standard operating procedures and by observing sample custody requirements. All data is calculated and reported in units consistent with project specifications, to enable easy comparison of data from report to report.

To the extent possible, samples shall be reported only if all QC measures are acceptable. If a QC measure is found to be out of control, and the data is to be reported, all samples associated with the failed quality control measure shall be reported with the appropriate data qualifier(s). The *SOP for Data Review and Reporting* (ADM-DATA_REV) addresses the flagging and qualification of data. The ALS Environmental-defined data qualifiers, state-specific data qualifiers, or project-defined data qualifiers are used depending on project requirements. A case narrative may be written by the analyst or project manager to explain problems with a specific analysis or sample, etc.

For subcontracted analyses, the Project Manager verifies that the report received from the subcontractor is complete. This includes checking that the correct analyses were performed, the analyses were performed for each sample as requested, a report is provided for each analysis, and the report is signed. The Project Manager accepts the report if all verification items are complete. Acceptance is demonstrated by forwarding the report to the ALS Environmental client.

21.5 Deliverables

In order to meet individual project needs, ALS Environmental provides several levels of analytical reports. Standard specifications for each level of deliverable are described in Table 21-1. Variations may be provided based on client or project specifications.

When requested, ALS Environmental provides Electronic Data Deliverables (EDDs) in the format specified by client need or project specification. ALS Environmental is capable of generating EDDs with many different formats and specifications. The EDD is prepared by report production staff using the electronic version of the laboratory report to minimize transcription errors. User guides and EDD specification outlines are used in preparing the EDD. The EDD is reviewed and compared to the final report for accuracy.

Table 21-1
Descriptions of ALS Environmental Standard Data Deliverables

Tier I. Routine Certified Analytical Report includes the following:

1. Transmittal letter
2. Chain of custody documents and sample/cooler receipt documentation
3. Sample analytical results
4. Method blank results
5. Surrogate recovery results and acceptance criteria for applicable organic methods
6. Dates of sample preparation and analysis for all tests
7. Case narrative - optional

Tier II. In addition to the Tier I Deliverables, this includes the following:

1. Matrix spike result(s) with calculated recovery and including associated acceptance criteria
2. Duplicate or duplicate matrix spike result(s) (as appropriate to method), with calculated relative percent difference
3. Laboratory Control Sample result(s) with calculated recovery and including associated acceptance criteria
4. Case narrative - optional

Tier III. Data Validation Package. In addition to the Tier II Deliverables, this includes the following:

1. Case narrative - required
2. Summary forms for all associated QC and Calibration parameters, with associated control criteria/acceptance limits

<u>Note</u>: Other summary forms specified in QAPPs or project/program protocols, or those related to specialized analyses will be included.

Tier IV. Full Data Validation Package:

1. All raw data associated with the sample analysis, including but not limited to:
    a. Preparation and analysis bench sheets and instrument printouts,
    b. For organics analyses, all applicable chromatograms, spectral, confirmation, and manual integration raw data. For GC/MS this includes tuning results, mass spectra of all positive hits, and the results and spectra of TIC compounds when requested.
    c. QC data,
    d. Calibration data (initial, verification, continuing, etc),
    e. Calibration blanks or instrument blanks (as appropriate to method).
2. If a project QAPP or program protocol applies, the report will be presented as required by the QAPP.

22) Summary of Changes and Document History

Revision Number	Effective Date	Document Editor	Description of Changes
32	10/01/17	C. Humphrey	Section 1 – removed off-site extraction facility and combined 3rd and 4th paragraphs
			Section 2.1 – updated website address
			Table 3-1 – updated
			Section 3.8 – changed ALS North America EH&S Director to ALS North America EH&S Manager
			Section 4.6 – removed second from last sentence from 2nd paragraph
			Section 10 – removed last paragraph (extraction facility)
			Section 11.2 – minor revision and removed USEPA 600/4-91-010 (not applicable to Simi Valley Laboratory)
			Section 11.6 – removed off-site extraction facility information
			Section 12 – removed reference document USEPA 600/4-91-010 (not applicable to Simi Valley Laboratory)
			Section 12.4 – removed reference to PAHs, pesticides, and PCBs
			Section 12.5 – removed example (not applicable to Simi Valley Laboratory)
			Section 13.1 – minor revision to 2nd paragraph
			Section 13.2 – minor wording revision
			Section 13.3 – added "(prior to use)"
			Section 13.8 – revised 2nd bullet to remove aroclors
			Section 14.2.10 – removed last sentence with drinking water requirement (not applicable to Simi Valley Laboratory)
			Section 14.2.13 – minor revision
			Section 14.2.14 – minor wording revision
			Table 16-1 – updated
			Section 21.2.1 – removed polychlorinated biphenyls
			Table 21-1 – removed HRGC/MS example under Tier III (not applicable to Simi Valley Laboratory)
			Section 23 – combined DoD QSM versions under one bullet and added version 5.1
			Appendix B – updated organization charts; updated resumes
			Appendix D – removed Extraction Laboratory floor plan and updated Main Laboratory floor plan
			Appendix E – updated equipment list
			Appendix F – updated
			Appendix G – updated SOP lists
			Appendix I – Updated locations of QA Program Files
			Appendix J – Updated laboratory accreditations

23) References for Quality System Standards, External Documents, Manuals, and Test Procedures

The analytical methods used at ALS Environmental generally depend upon the end-use of the data. Since most of our work involves the analysis of environmental samples for regulatory purposes, specified federal and/or state testing methodologies are used and followed closely. Typical methods used at ALS Environmental are taken from the references listed below. Additional QA program documents are listed in Appendix I.

- National Environmental Laboratory Accreditation Program (NELAP), 2003 Quality Standards.
- 2009 TNI Standards.
- American National Standard *General requirements for the competence of testing and calibration laboratories,* ANSI/ISO/IEC 17025:2005(E).
- *DoD Quality Systems Manual for Environmental Laboratories,* Version 4.2, 2010; Version 5.0, 2013; and Version 5.1, 2017.
- Naval Sea Systems Command Laboratory Accreditation Program (LAP): S0005-AC-TED-010, Revision 3, July 31, 2013.
- 3M Organic Vapor Monitor Sampling and Analysis Guide, *Organic Vapor Monitors 3500/3510 and Organic Vapor Monitors 3520/3530*, Technical Bulletin 1028, January 1, 2004.
- 40 CFR Part 60, Test Methods for Standards of Performance for New Stationary Sources, Appendix A.
- 40 CFR Part 63, Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater, Appendix A.
- 40 CFR Part 63, National Emission Standards for Hazardous Air Pollutants for Source Categories, Subchapter C.
- 40 CFR Part 136, Definition and Procedure for the Determination of the Method Detection Limit, Appendix B
- American Society for Testing and Materials (ASTM), Gaseous Fuel, Coal and Coke, Volume 05.06, September 2006.
- American Society for Testing and Materials (ASTM), Annual Book of ASTM Standards, Philadelphia, PA.
- Arizona Administrative Code, *Department of Health Services – Laboratories*, Title 9, Ch. 14, Article 6. *Licensing of Environmental Laboratories*, R9-14-601 through R9-14-621, October 1, 2016.
- California Environmental Protection Agency Air Resources Board, *Methods for Determining Emissions of Toxic Air Contaminants from Stationary Sources*, Volume 3, July 28, 1997.
- California Code of Regulations (CCR), Title 22, Chapter 11 *Identification and Listing of Hazardous Waste*, 7/20/05.
- Minnesota Administrative Rules, *Department of Health*, Chapter 4740, Laboratories; Accreditation Requirements.
- *Good Automated Laboratory Practices, Principles and Guidance to Regulations For Ensuring Data Integrity In Automated Laboratory Operations*, EPA 2185 (August 1995).

- Environmental Protection Agency, Methods Update Rule (MUR), Guidelines for Establishing Test Procedures for the Analysis of Pollutants Under the Clean Water Act; Analysis and Sampling Procedures; 40 CFR Parts 122, 136, 143, 430, 455 & 465; Final Rule 3/12/07, Effective April 11, 2007.
- Environmental Protection Agency, *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods,* SW-846, Third Edition, 1986 and Updates I (7/92), II (9/94), III (12/96), IIIA (4/98), IIIB (11/04), IVA & IVB. See Chapters 1, 2, 3, 4, 5, 6, and 8.
- Environmental Protection Agency, *Methods for Chemical Analysis of Water and Wastes*, EPA-600/4-79-020, 1983.
- Environmental Protection Agency, *Methods for the Determination of Inorganic Substances in Environmental Samples,* EPA 600/R-93-100, August 1993.
- Environmental Protection Agency, *EPA Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air*, Second Edition, EPA/625/R-96-010b, January 1999.
- Environmental Protection Agency, *EPA Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air*, Second Edition Addendum, October 4, 2000.
- National Institute for Occupational Safety and Health (NIOSH) *Manual of Analytical Methods*, Third Edition (August 1987); Fourth Edition (August 1994); 1st Supplement Publication 96-135, 2nd Supplement Publication 98-119, 3rd Supplement 2003-154
- National Council for Air and Stream Improvement, Inc. (NCASI). 2007*. Appendix E - Technical Bulletin Cross Reference Guide for NCASI Methods.* Methods Manual (05).
- *SKC 575 Series Passive Sampler Rate/Selection Guide,* Form #37021, Rev 0012.
- *Standard Methods for the Examination of Water and Wastewater*, 20th Edition (1998).
- South Coast Air Quality Management District, *Laboratory Methods of Analysis for Enforcement Samples.*
- U.S. Department of Labor, Occupational Safety and Health Administration *OSHA Analytical Methods Manual.*

APPENDIX A – Glossary

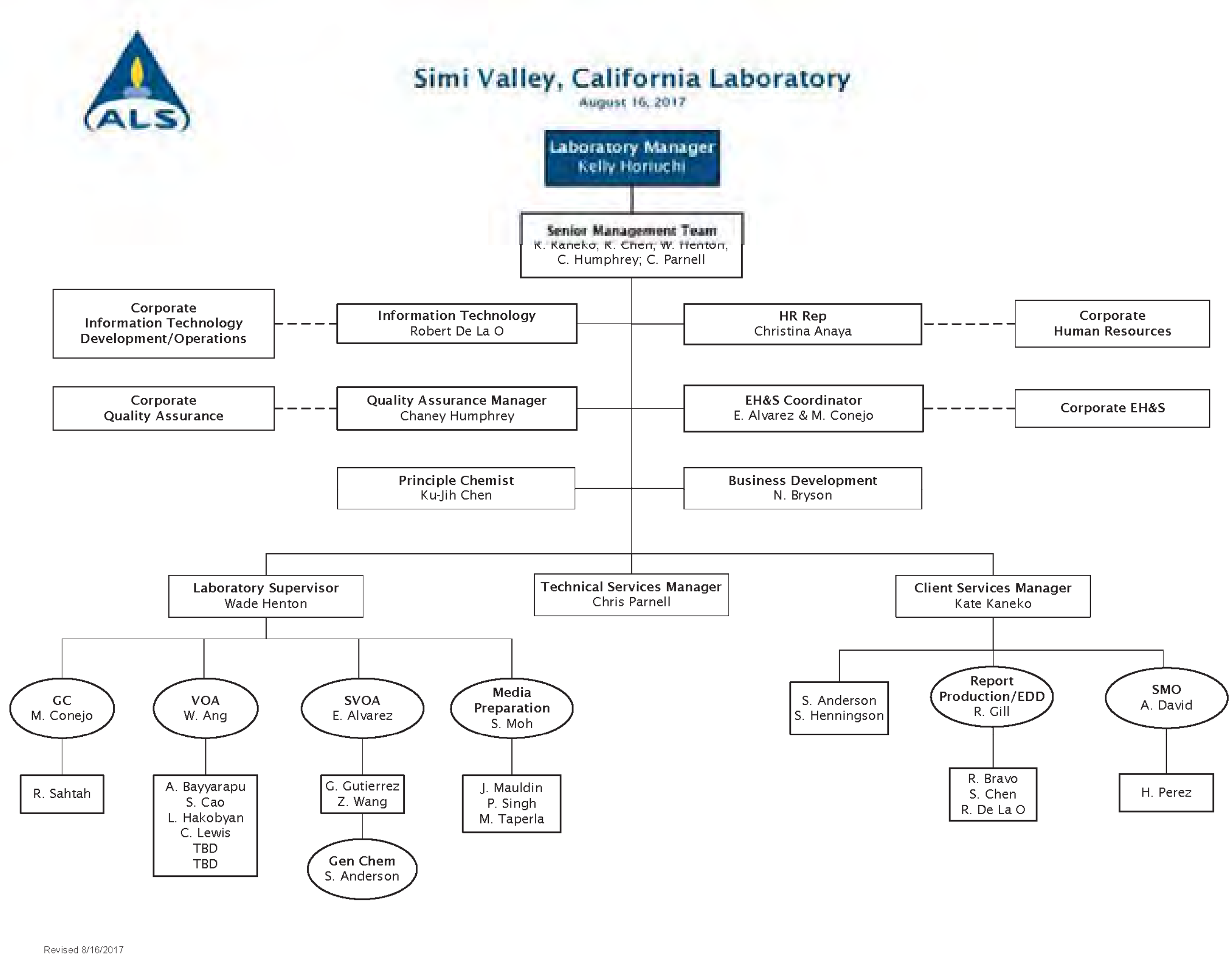
Acronym	Definition
AB	Accrediting Body
ACS	American Chemical Society
ANSI	American National Standards Institute
ASTM	American Society for Testing and Materials
A2LA	American Association for Laboratory Accreditation
BFB	4-Bromofluorobenzene
BTEX	Benzene, Toluene, Ethylbenzene, Xylenes
CARB	California Air Resources Board
CAS Number	Chemical Abstract Service Registry Number
CCB	Continuing Calibration Blank sample
CCC	Continuing Calibration Check sample
CCV	Continuing Calibration Verification sample
CDC	Ongoing Demonstration of Capability
CLP	Contract Laboratory Program (through USEPA)
COC	Chain-of-Custody
DCM	Dichloromethane (aka Methylene Chloride)
DEC	Department of Environmental Conservation
DEQ	Department of Environmental Quality
DHS	Department of Health Services
DOC	Demonstration of Capability
DOE	Department of Ecology (state or federal)
DOH	Department of Health
EPA	U.S. Environmental Protection Agency (aka USEPA)
EPCRA	Emergency Planning & Community Right-to-Know Act
ERA	Environmental Resource Associates
ELAP	Environmental Laboratory Accreditation Program
FID	Flame Ionization Detector
FIFRA	Federal Insecticide, Fungicide & Rodenticide Act
FR	Federal Register
GC	Gas Chromatography
GC/MS	Gas Chromatography/Mass Spectrometry
HP	Hewlett-Packard (mfg. GC instruments)

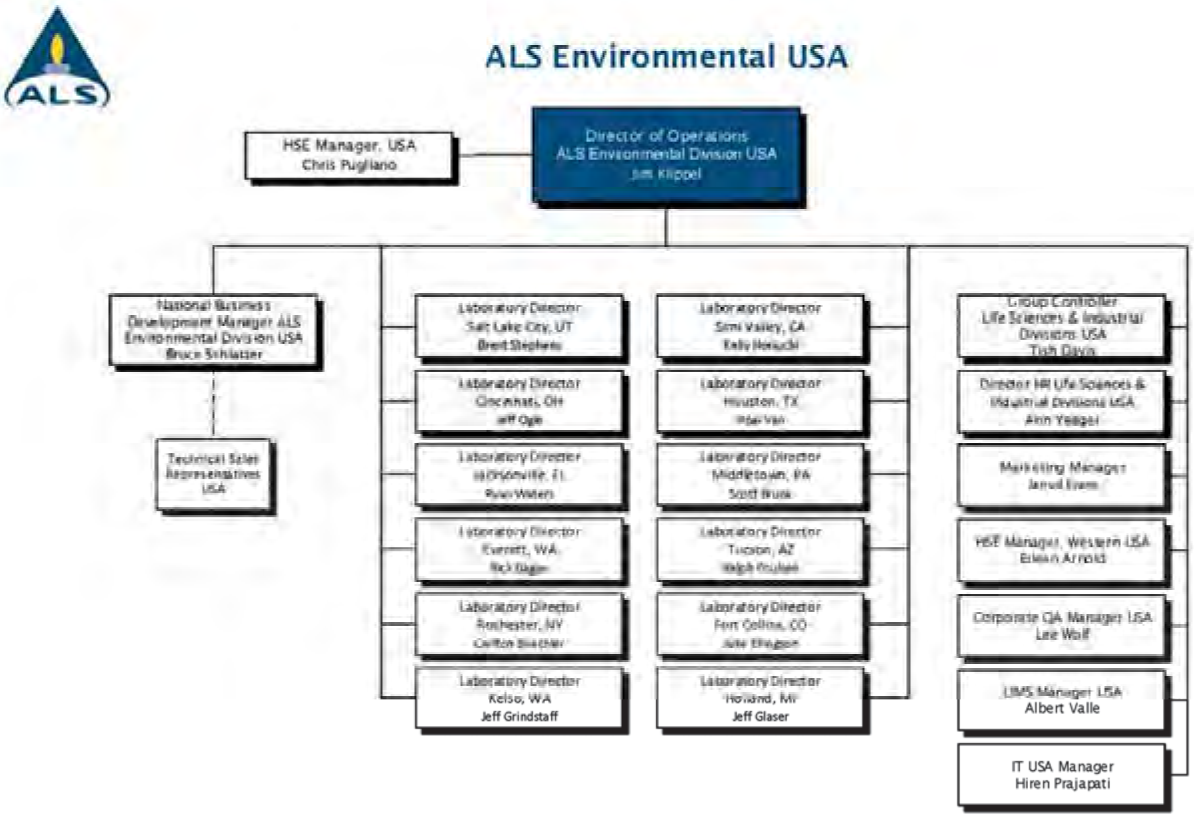
HPLC	High Performance Liquid Chromatography
IC	Ion Chromatography
ICAL	Initial Calibration
ICB	Initial Calibration Blank sample
IDC	Initial Demonstration of Capability
ICV	Initial Calibration Verification sample
IFB	Invitation for Bid
ISO/IEC	International Organization for Standardization/International Electrochemical Commission
LCS	Laboratory Control Sample
LIMS	Laboratory Information Management System
LUFT	Leaking Underground Fuel Tank
MB	Method Blank
MDL	Method Detection Limit
MRL	Method Reporting Limit
MS	Matrix Spike
MSD	Matrix Spike Duplicate
NA	Not Applicable
NAS	National Academy of Sciences
NELAP	National Environmental Laboratory Accreditation Program
NCASI	National Council for Air and Stream Improvement (for the Paper Industry)
NCI	National Cancer Institute
ND	Not Detected
NIH	National Institute of Health
NIOSH	National Institute for Occupational Safety and Health
NIST	National Institute of Standards and Technology
NPD	Nitrogen Phosphorus Detector
NPDES	National Pollutant Discharge Elimination System
NSF	National Science Foundation
NTIS	National Technical Information System
NTP	National Toxicology Program
OSHA	Occupational Safety and Health Administration
PCBs	Polychlorinated Biphenyls
PE	Performance Evaluation sample
PID	Photoionization Detector

PQL	Practical Quantitation Limit
PT	Proficiency Test
QA	Quality Assurance
QAM	Quality Assurance Manual
QC	Quality Control
RAS	Routine Analytical Services (Contracts through USEPA)
RCRA	Resource Conservation and Recovery Act
RFP	Requests for Proposal
RPD	Relative Percent Difference
RSD	Relative Standard Deviation
SAS	Special Analytical Services (contracts through USEPA)
SIE	Selective Ion Electrode
SIM	Selected Ion Monitoring
SMO	Sample Management Office (aka Sample Receiving)
SOC	Semi-Volatile Organic Compounds
SOP	Standard Operating Procedure
SOQ	Statement of Qualifications
SOW	Statement of Work
SVOAs	Semi-Volatile Organic Analytes
SVOCs	Semi-Volatile Organic Compounds
SW-846	Test Methods for Evaluating Solid Waste, Physical/Chemical Methods
TNI	The NELAC Institute
TPH	Total Petroleum Hydrocarbons
TSCA	Toxic Substances Control Act
UST	Underground Storage Tank
UV	Ultraviolet Spectrophotometer
VOA	Volatile Organic Analyte
VOC	Volatile Organic Compounds
WP	Water Pollution
WS	Water Supply

Units	Definition
mg/kg	Milligrams per Kilogram
mg/L	Milligrams per Liter
mg/m3	Milligrams per Cubic Meter
ng/L	Nanograms per Liter
ppb	Parts Per Billion
ppbV	Parts Per Billion Volume
ppm	Parts Per Million
ppmV	Parts Per Million Volume
ug/L	Micrograms per Liter
ug/m3	Micrograms per Cubic Meter

APPENDIX B – Organization Charts and Key Personnel Qualifications





Revised 12/30/2016

ALS Group USA, Corp.
2655 Park Center Drive, Suite A
Simi Valley, CA 93065
T +1 805 526 7161 F +1 805 526 7270

EVELYN ALVAREZ

Semi-Volatiles Team Leader/Environmental Health and Safety Coordinator
2016 – Present, Simi Valley Laboratory

As Environmental Health and Safety Coordinator, is responsible for the implementation of the Environmental Health and Safety program of ALS North America to this facility. Duties include accident investigation and incident review, maintenance of all safety-related equipment and documents, and performing safety audits and reporting results to management. Semi-Volatiles Team Leader responsibilities include training of junior analysts, data reduction, peer review of analytical data, writing and reviewing standard operating procedures, development and implementation of new methods, and performance evaluations of direct reports. Additional responsibilities are analyzing ambient air and source emissions samples using GC, GC/MS and HPLC utilizing NIOSH and EPA mandated methodologies. Routine and necessary instrument maintenance.

PREVIOUS EXPERIENCE

GC/MS Chemist, 2014 - 2016
ALS Group USA, Corp.
Simi Valley, CA

Responsibilities include analyzing indoor air, ambient air, and source emission samples by GC/MS methods, standard preparation, perform maintenance on instruments when required, real time data reduction, participation in peer review process, and good practice of all QA/QC requirements.

Semi-Volatiles Chemist, 2011 - 2014
ALS Group USA, Corp.
Simi Valley, CA

Responsibilities include analyzing ambient air, source emissions, and industrial hygiene samples using GC, GC/MS and HPLC. Preparation and analysis of air samples taken on various sorbent tubes for semi-volatile organic compounds. Determination of Carbonyls, Phenols, and Cresols in ambient air and source emission samples using HPLC. Other responsibilities include standard preparation, performing maintenance on instruments when required, real time data reduction, participation in peer review process, and good practice of all QA/QC requirements.

Undergraduate Researcher, 2010
CLU Swenson Science Internship Program
Thousand Oaks, CA

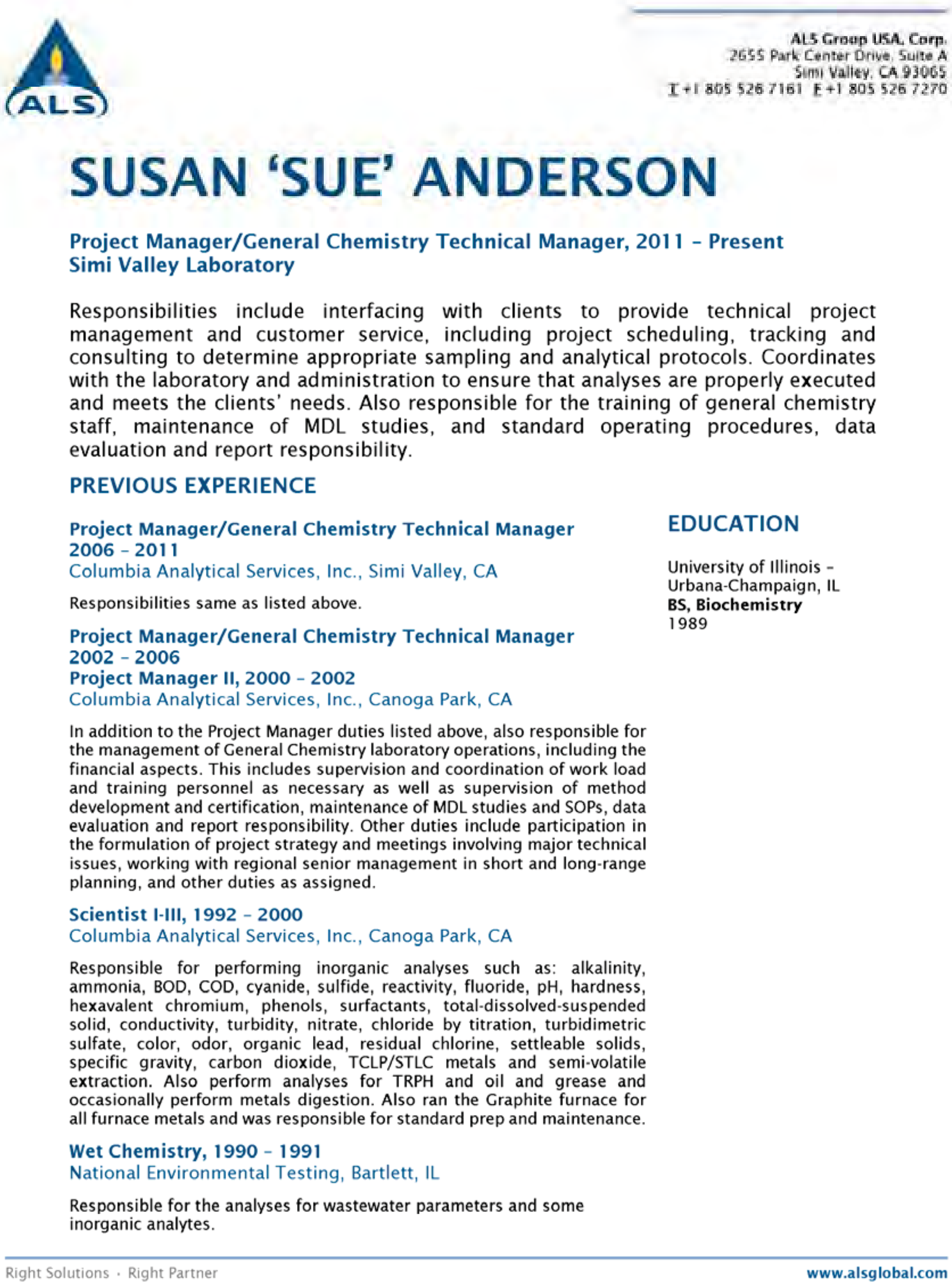
Worked on developing a soil-extraction method for organochlorine and organophosphorus pesticides. Modeled the photodegradation of organochlorine pesticides over time.

EDUCATION

California Lutheran University - Thousand Oaks, CA
BS, Environmental Science
2011

Right Solutions · Right Partner

www.alsglobal.com



ALS Group USA, Corp.
2655 Park Center Drive, Suite A
Simi Valley, CA 93065
T +1 805 526 7161 F +1 805 526 7270

SUSAN 'SUE' ANDERSON

Project Manager/General Chemistry Technical Manager, 2011 – Present
Simi Valley Laboratory

Responsibilities include interfacing with clients to provide technical project management and customer service, including project scheduling, tracking and consulting to determine appropriate sampling and analytical protocols. Coordinates with the laboratory and administration to ensure that analyses are properly executed and meets the clients' needs. Also responsible for the training of general chemistry staff, maintenance of MDL studies, and standard operating procedures, data evaluation and report responsibility.

PREVIOUS EXPERIENCE

Project Manager/General Chemistry Technical Manager
2006 – 2011
Columbia Analytical Services, Inc., Simi Valley, CA

Responsibilities same as listed above.

Project Manager/General Chemistry Technical Manager
2002 – 2006
Project Manager II, 2000 – 2002
Columbia Analytical Services, Inc., Canoga Park, CA

In addition to the Project Manager duties listed above, also responsible for the management of General Chemistry laboratory operations, including the financial aspects. This includes supervision and coordination of work load and training personnel as necessary as well as supervision of method development and certification, maintenance of MDL studies and SOPs, data evaluation and report responsibility. Other duties include participation in the formulation of project strategy and meetings involving major technical issues, working with regional senior management in short and long-range planning, and other duties as assigned.

Scientist I-III, 1992 – 2000
Columbia Analytical Services, Inc., Canoga Park, CA

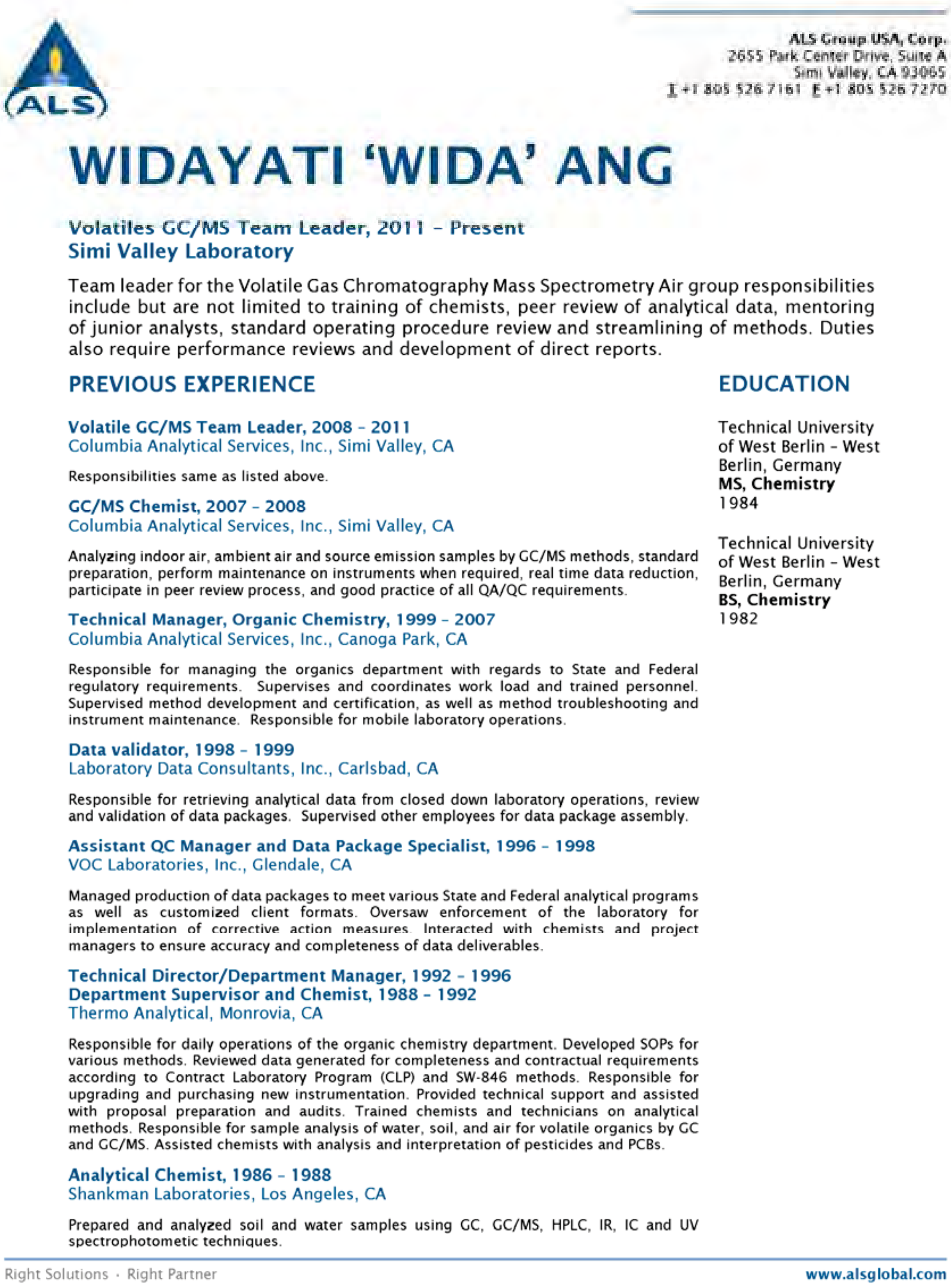
Responsible for performing inorganic analyses such as: alkalinity, ammonia, BOD, COD, cyanide, sulfide, reactivity, fluoride, pH, hardness, hexavalent chromium, phenols, surfactants, total-dissolved-suspended solid, conductivity, turbidity, nitrate, chloride by titration, turbidimetric sulfate, color, odor, organic lead, residual chlorine, settleable solids, specific gravity, carbon dioxide, TCLP/STLC metals and semi-volatile extraction. Also perform analyses for TRPH and oil and grease and occasionally perform metals digestion. Also ran the Graphite furnace for all furnace metals and was responsible for standard prep and maintenance.

Wet Chemistry, 1990 – 1991
National Environmental Testing, Bartlett, IL

Responsible for the analyses for wastewater parameters and some inorganic analytes.

EDUCATION

University of Illinois –
Urbana-Champaign, IL
BS, Biochemistry
1989



ALS Group USA, Corp.
2655 Park Center Drive, Suite A
Simi Valley, CA 93065
T +1 805 526 7161 F +1 805 526 7270

WIDAYATI 'WIDA' ANG

Volatiles GC/MS Team Leader, 2011 – Present
Simi Valley Laboratory

Team leader for the Volatile Gas Chromatography Mass Spectrometry Air group responsibilities include but are not limited to training of chemists, peer review of analytical data, mentoring of junior analysts, standard operating procedure review and streamlining of methods. Duties also require performance reviews and development of direct reports.

PREVIOUS EXPERIENCE

Volatile GC/MS Team Leader, 2008 – 2011
Columbia Analytical Services, Inc., Simi Valley, CA

Responsibilities same as listed above.

GC/MS Chemist, 2007 – 2008
Columbia Analytical Services, Inc., Simi Valley, CA

Analyzing indoor air, ambient air and source emission samples by GC/MS methods, standard preparation, perform maintenance on instruments when required, real time data reduction, participate in peer review process, and good practice of all QA/QC requirements.

Technical Manager, Organic Chemistry, 1999 – 2007
Columbia Analytical Services, Inc., Canoga Park, CA

Responsible for managing the organics department with regards to State and Federal regulatory requirements. Supervises and coordinates work load and trained personnel. Supervised method development and certification, as well as method troubleshooting and instrument maintenance. Responsible for mobile laboratory operations.

Data validator, 1998 – 1999
Laboratory Data Consultants, Inc., Carlsbad, CA

Responsible for retrieving analytical data from closed down laboratory operations, review and validation of data packages. Supervised other employees for data package assembly.

Assistant QC Manager and Data Package Specialist, 1996 – 1998
VOC Laboratories, Inc., Glendale, CA

Managed production of data packages to meet various State and Federal analytical programs as well as customized client formats. Oversaw enforcement of the laboratory for implementation of corrective action measures. Interacted with chemists and project managers to ensure accuracy and completeness of data deliverables.

Technical Director/Department Manager, 1992 – 1996
Department Supervisor and Chemist, 1988 – 1992
Thermo Analytical, Monrovia, CA

Responsible for daily operations of the organic chemistry department. Developed SOPs for various methods. Reviewed data generated for completeness and contractual requirements according to Contract Laboratory Program (CLP) and SW-846 methods. Responsible for upgrading and purchasing new instrumentation. Provided technical support and assisted with proposal preparation and audits. Trained chemists and technicians on analytical methods. Responsible for sample analysis of water, soil, and air for volatile organics by GC and GC/MS. Assisted chemists with analysis and interpretation of pesticides and PCBs.

Analytical Chemist, 1986 – 1988
Shankman Laboratories, Los Angeles, CA

Prepared and analyzed soil and water samples using GC, GC/MS, HPLC, IR, IC and UV spectrophotometic techniques.

EDUCATION

Technical University of West Berlin – West Berlin, Germany
MS, Chemistry
1984

Technical University of West Berlin – West Berlin, Germany
BS, Chemistry
1982

Right Solutions · Right Partner
www.alsglobal.com

ALS Group USA, Corp.
2655 Park Center Drive, Suite A
Simi Valley, CA 93065
T +1 805 526 7161 F +1 805 526 7270

KU-JIH CHEN

Principle Chemist, 2011 – Present
Simi Valley Laboratory

Responsible for the development and validation of sampling and analysis methods, new technology, and laboratory automation.

PREVIOUS EXPERIENCE

Principle Chemist, 2000 – 2011
Columbia Analytical Services, Inc.
Simi Valley, CA

Responsibilities same as listed above.

Scientist VII, 1994 – 2000
Columbia Analytical Services, Inc, (dba Performance Analytical, Inc.)
Los Angeles, CA

Responsibilities included operating the gas chromatography and sample preparation laboratories, developing methods (previously developed the Total Combustion Analyzer for the measurement of reactive organic gases in stationary source samples, and the Determination of Reduced Sulfur Compounds and fixed atmospheric gases in POTW emissions, refinery and landfill gases), and serving as the laboratory's primary Industrial Hygiene Chemist.

Principle Chemist, 1989 – 1994
Performance Analytical, Inc.
Canoga Park, CA

Responsibilities same as listed above.

Extraction Laboratory Supervisor, 1984 – 1989
C-E Environmental, Inc.
Camarillo, CA

Responsibilities included supervising chemists, associate chemists, and technicians, preparing SOPs, analytical standards, and spiking solutions, serving as Primary Extraction Chemist for the Love Canal Habitability Study, and previously responsible for instrumental analysis using GC, LC, GC/MS, and AA.

Research and Development Chemist, 1980 – 1984
Paolyta Company
Taipei, Taiwan

Research Chemist, 1975 – 1980
Panlabs Taiwan Ltd.
Taipei, Taiwan

EDUCATION

National Chung-Hsing University – Taipei, Taiwan
BS, Botany
1975

Right Solutions · Right Partner www.alsglobal.com

ALS Group USA, Corp.
2655 Park Center Drive, Suite A
Simi Valley, CA 93065
T +1 805 526 7161 F +1 805 526 7270

MICHAEL ‘MIKE’ CONEJO

Volatiles (GC) Team Leader and Environmental Health and Safety Coordinator
2016 - Present
Simi Valley Laboratory

As Environmental Health and Safety Coordinator, is responsible for the implementation of the Environmental Health and Safety program of ALS North America to this facility. Duties include accident investigation and incident review, maintenance of all safety-related equipment and documents, and performing safety audits and reporting results to management. Volatiles (GC) Team Leader responsibilities include but are not limited to training and mentoring of junior analysts, standard operating procedure review, and streamlining of methods. Additional responsibilities include analysis of vapor phase and liquid samples for various volatile compounds, performing maintenance on instruments when required, real time data reduction, peer review of analytical data, maintaining working knowledge of all GC methods performed in laboratory, and good practice of all QA/QC requirements.

PREVIOUS EXPERIENCE

GC Chemist, 2011 - 2016
ALS Group USA, Corp.
Simi Valley, CA

Analysis of vapor phase and liquid samples for various volatile compounds, performed maintenance on instruments when required, real time data reduction, participation in peer review process, maintained working knowledge of all GC methods performed in department, and good practice of all QA/QC requirements.

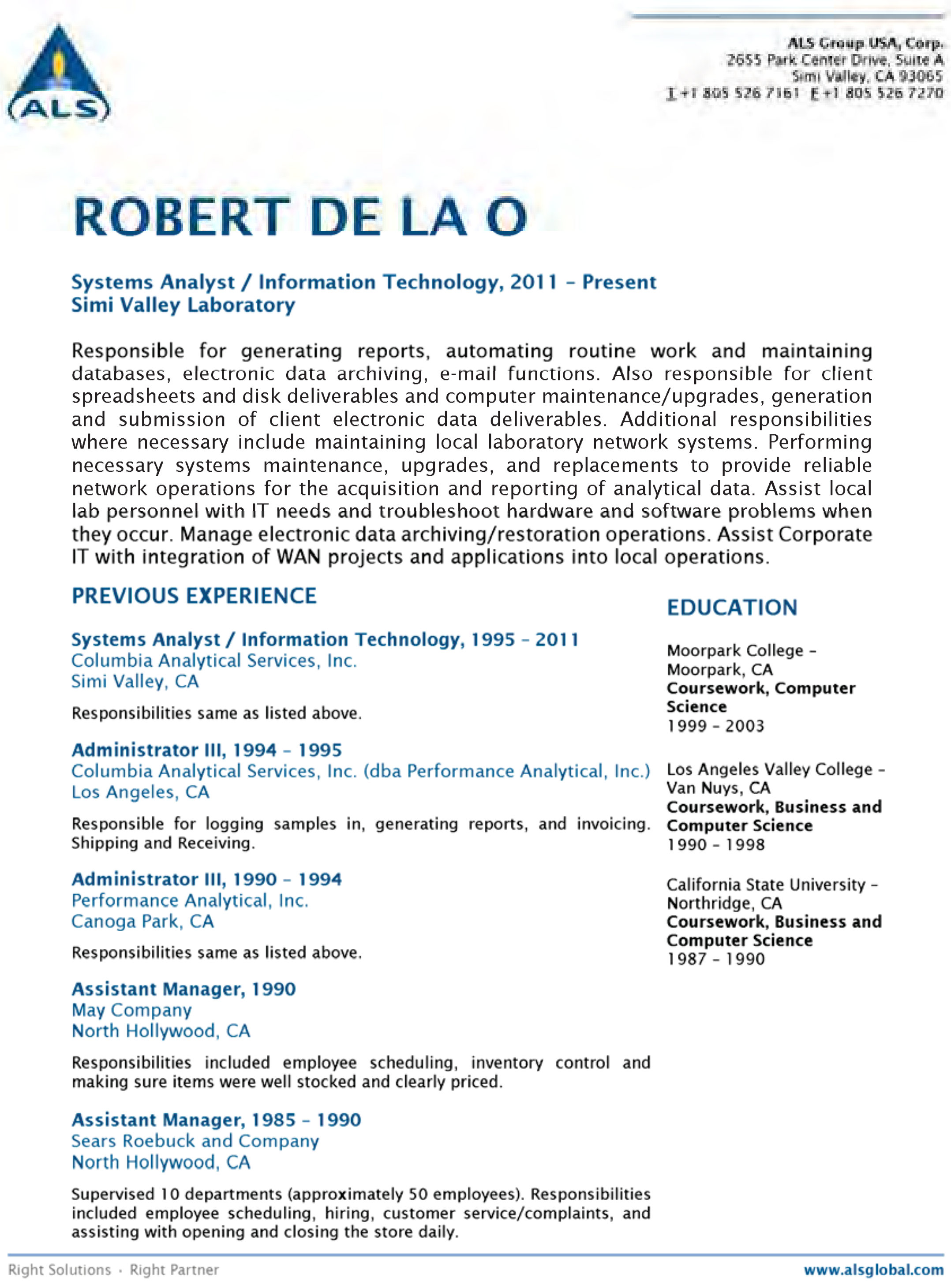
Technician, 2011
Columbia Analytical Services, Inc.
Simi Valley, CA

Responsibilities included canister conditioning and preparation, fulfillment of media requests and shipping samples. Additional responsibilities included training within the department of flow controller and critical orifice calibration and checks.

EDUCATION

University of California -
Santa Barbara, CA
BA, Sociology
2010

College of the Canyons -
Santa Clarita, CA
Coursework, Chemistry
2012



ALS Group USA, Corp.
2655 Park Center Drive, Suite A
Simi Valley, CA 93065
T +1 805 526 7161 F +1 805 526 7270

ROBERT DE LA O

Systems Analyst / Information Technology, 2011 – Present
Simi Valley Laboratory

Responsible for generating reports, automating routine work and maintaining databases, electronic data archiving, e-mail functions. Also responsible for client spreadsheets and disk deliverables and computer maintenance/upgrades, generation and submission of client electronic data deliverables. Additional responsibilities where necessary include maintaining local laboratory network systems. Performing necessary systems maintenance, upgrades, and replacements to provide reliable network operations for the acquisition and reporting of analytical data. Assist local lab personnel with IT needs and troubleshoot hardware and software problems when they occur. Manage electronic data archiving/restoration operations. Assist Corporate IT with integration of WAN projects and applications into local operations.

PREVIOUS EXPERIENCE

Systems Analyst / Information Technology, 1995 – 2011
Columbia Analytical Services, Inc.
Simi Valley, CA

Responsibilities same as listed above.

Administrator III, 1994 – 1995
Columbia Analytical Services, Inc. (dba Performance Analytical, Inc.)
Los Angeles, CA

Responsible for logging samples in, generating reports, and invoicing. Shipping and Receiving.

Administrator III, 1990 – 1994
Performance Analytical, Inc.
Canoga Park, CA

Responsibilities same as listed above.

Assistant Manager, 1990
May Company
North Hollywood, CA

Responsibilities included employee scheduling, inventory control and making sure items were well stocked and clearly priced.

Assistant Manager, 1985 – 1990
Sears Roebuck and Company
North Hollywood, CA

Supervised 10 departments (approximately 50 employees). Responsibilities included employee scheduling, hiring, customer service/complaints, and assisting with opening and closing the store daily.

EDUCATION

Moorpark College –
Moorpark, CA
Coursework, Computer Science
1999 – 2003

Los Angeles Valley College –
Van Nuys, CA
Coursework, Business and Computer Science
1990 – 1998

California State University –
Northridge, CA
Coursework, Business and Computer Science
1987 – 1990

ALS Group USA, Corp.
2655 Park Center Drive, Suite A
Simi Valley, CA 93065
T +1 805 526 7161 F +1 805 526 7270

ROBIN GILL

Data Validation Coordinator and Team Leader, 2011 – Present
Simi Valley Laboratory

Team leader responsibilities are evaluation and approval of work shifts, vacation requests, training and mentoring new data validation team members, in addition to yearly performance reviews to evaluate job achievements. Data validation responsibilities are for data review and validation as well as data package compilation, job tracking, archiving and the production of laboratory reports. Interacts with project managers and Quality Assurance Manager to ensure that all reports fulfill client requirements as well as QA/QC needs. Also serves as a backup for case narrative generation and manages the turnaround times so that reports are distributed to the clients in a timely manner.

PREVIOUS EXPERIENCE

Data Validation Coordinator and Team Leader, 2002 – 2011
Columbia Analytical Services, Inc.
Simi Valley, CA

Responsibilities same as listed above.

Project Manager III, Quality Control Coordinator, 1994 – 2002
Columbia Analytical Services, Inc. (dba Performance Analytical, Inc.)
Los Angeles, CA

Responsibilities same as listed above.

Project Manager III, 1991 – 1994
Performance Analytical Services, Inc.
Canoga Park, CA

Primarily responsible for data review and validation as well as data package compilation. Also responsible for job tracking, archiving, and the production of laboratory reports.

Data Group Supervisor, 1980 – 1991
ABB Environmental
Camarillo, CA

Supervised five employees in the Data Group Department. Responsible for data review and validation, document control, data package compilation, job tracking and archiving, and the organization and prioritization of workload.

Right Solutions · Right Partner
www.alsglobal.com

ALS Group USA, Corp.
2655 Park Center Drive, Suite A
Simi Valley, CA 93065
T +1 805 526 7161 F +1 805 526 7270

SAMANTHA HENNINGSEN

Project Manager, 2011 – Present
Simi Valley Laboratory

Responsibilities include interfacing with clients to provide technical project management and customer service, including project scheduling, tracking and consulting to determine appropriate sampling and analytical protocols. Coordinates with the laboratory and administration to ensure that analyses are properly executed and meets the clients' needs. Responsibilities also include overseeing all "non-routine" projects, as well as coordinating and directing internal laboratory research and method development.

PREVIOUS EXPERIENCE

Project Manager, 2010 – 2011
Columbia Analytical Services, Inc.
Simi Valley, CA

Responsibilities include interfacing with clients to provide technical project management and customer service, including project scheduling, tracking and consulting to determine appropriate sampling and analytical protocols. Coordinates with the laboratory and administration to ensure that analyses are properly executed and meets the clients' needs. Responsibilities also include overseeing all "non-routine" projects, as well as coordinating and directing internal laboratory research and method development.

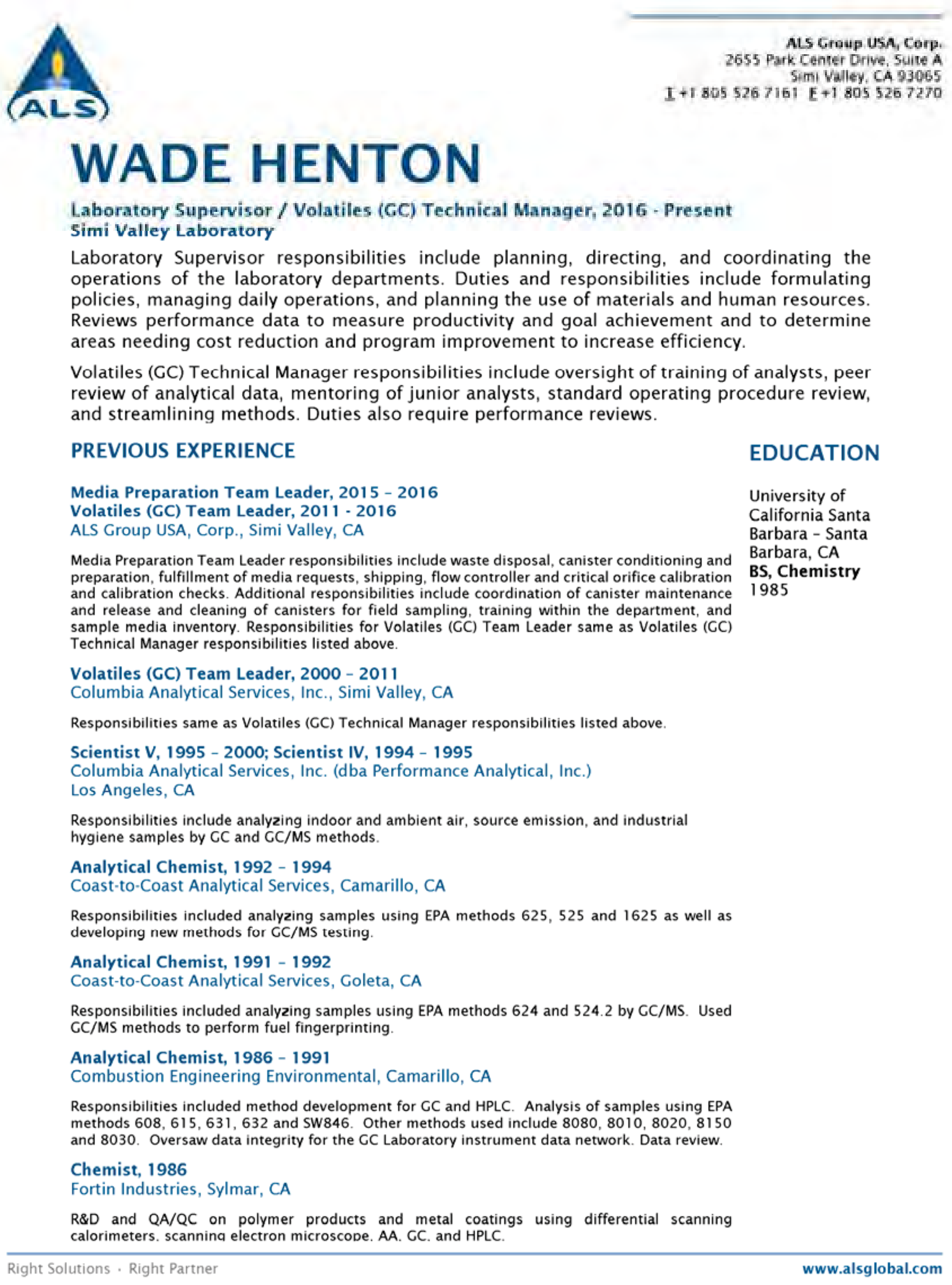
Biofuels Research Assistant, 2009 – 2010
University of Nevada
Reno, NV

Studied a wide variety of feasibility parameters of the microalgae Duneliella salina such as overall energy content and density, novel extraction methods, separation systems, mass transfer limitations, and recycling systems of excess carbon dioxide and residual biomass.

EDUCATION

University of Nevada – Reno, NV
BS, Chemical Engineering
2010

Right Solutions · Right Partner
www.alsglobal.com



ALS Group USA, Corp.
2655 Park Center Drive, Suite A
Simi Valley, CA 93065
T +1 805 526 7161 F +1 805 526 7270

WADE HENTON

Laboratory Supervisor / Volatiles (GC) Technical Manager, 2016 - Present
Simi Valley Laboratory

Laboratory Supervisor responsibilities include planning, directing, and coordinating the operations of the laboratory departments. Duties and responsibilities include formulating policies, managing daily operations, and planning the use of materials and human resources. Reviews performance data to measure productivity and goal achievement and to determine areas needing cost reduction and program improvement to increase efficiency.

Volatiles (GC) Technical Manager responsibilities include oversight of training of analysts, peer review of analytical data, mentoring of junior analysts, standard operating procedure review, and streamlining methods. Duties also require performance reviews.

PREVIOUS EXPERIENCE

Media Preparation Team Leader, 2015 – 2016
Volatiles (GC) Team Leader, 2011 - 2016
ALS Group USA, Corp., Simi Valley, CA

Media Preparation Team Leader responsibilities include waste disposal, canister conditioning and preparation, fulfillment of media requests, shipping, flow controller and critical orifice calibration and calibration checks. Additional responsibilities include coordination of canister maintenance and release and cleaning of canisters for field sampling, training within the department, and sample media inventory. Responsibilities for Volatiles (GC) Team Leader same as Volatiles (GC) Technical Manager responsibilities listed above.

Volatiles (GC) Team Leader, 2000 – 2011
Columbia Analytical Services, Inc., Simi Valley, CA

Responsibilities same as Volatiles (GC) Technical Manager responsibilities listed above.

Scientist V, 1995 – 2000; Scientist IV, 1994 – 1995
Columbia Analytical Services, Inc. (dba Performance Analytical, Inc.)
Los Angeles, CA

Responsibilities include analyzing indoor and ambient air, source emission, and industrial hygiene samples by GC and GC/MS methods.

Analytical Chemist, 1992 – 1994
Coast-to-Coast Analytical Services, Camarillo, CA

Responsibilities included analyzing samples using EPA methods 625, 525 and 1625 as well as developing new methods for GC/MS testing.

Analytical Chemist, 1991 – 1992
Coast-to-Coast Analytical Services, Goleta, CA

Responsibilities included analyzing samples using EPA methods 624 and 524.2 by GC/MS. Used GC/MS methods to perform fuel fingerprinting.

Analytical Chemist, 1986 – 1991
Combustion Engineering Environmental, Camarillo, CA

Responsibilities included method development for GC and HPLC. Analysis of samples using EPA methods 608, 615, 631, 632 and SW846. Other methods used include 8080, 8010, 8020, 8150 and 8030. Oversaw data integrity for the GC Laboratory instrument data network. Data review.

Chemist, 1986
Fortin Industries, Sylmar, CA

R&D and QA/QC on polymer products and metal coatings using differential scanning calorimeters, scanning electron microscope, AA, GC, and HPLC.

EDUCATION

University of California Santa Barbara – Santa Barbara, CA
BS, Chemistry
1985

Right Solutions · Right Partner

www.alsglobal.com

ALS Group USA, Corp.
2655 Park Center Drive, Suite A
Simi Valley, CA 93065
T +1 805 526 7161 F +1 805 526 7270

KELLY M. HORIUCHI

Laboratory Director, 2011 – Present
Simi Valley Laboratory

Primary responsibilities include management of all laboratory departments, scheduling, productivity, reporting and evaluation of analytical methodologies, project planning, budgeting, and Quality Assurance/Quality Control protocol oversight. Other responsibilities include conducting facility compliance reviews; providing departmental support for equipment purchases; resolving personnel issues; determining resource allocation; and providing supervision, training, and leadership to key laboratory staff.

PREVIOUS EXPERIENCE

Laboratory Director, 2009 – 2011
Columbia Analytical Services, Inc.
Simi Valley, CA

Responsibilities same as listed above.

Project Manager, 2005 – 2009
Columbia Analytical Services, Inc.
Simi Valley, CA

Interfacing with clients to provide technical project management and customer service, including project scheduling, tracking and consulting to determine appropriate sampling and analytical protocols. Coordinated with the laboratory and administration to ensure that analyses were properly executed and meets the client's needs.

Data Validation Coordinator, 2003 – 2005
Columbia Analytical Services, Inc.
Simi Valley, CA

Performed analysis of test date through data audits and queries, maintained extensive database, and coordinated data audits between Northern and Southern California locations. Additional duties included assisting in the creation of new databases, as needed, creation of SOP for phenotypic and genotypic data collecting, and process improvements for subject flow through the research project.

Database Analyst, 2002 – 2003
Cure Autism Now
Los Angeles, CA

Performed analysis of test date through data audits and queries, maintained extensive database, and coordinated data audits between Northern and Southern California locations. Additional duties included assisting in the creation of new databases, as needed, creation of SOP for phenotypic and genotypic data collecting, and process improvements for subject flow through the research project.

Scientist II, Data Validation Coordinator, 2000 – 2002
Columbia Analytical Services, Inc. (dba Performance Analytical, Inc.)
Simi Valley, CA

Same as Data Validation Coordinator responsibilities listed above.

EDUCATION

California State University – Northridge, CA
BA, Biology
1998

Right Solutions · Right Partner

www.alsglobal.com

ALS Group USA, Corp.
2655 Park Center Drive, Suite A
Simi Valley, CA 93065
T +1 805 526 7161 F +1 805 526 7270

CHANEY K. HUMPHREY

Quality Assurance Manager, 2011 – Present
Simi Valley Laboratory

Responsibilities include facilitate ethics and QA training, maintain all training documentation, perform QA orientation for new employees, review data (both hardcopy and electronic), perform internal QA audits and prepare written reports, review, approve, and control Standard Operating Procedures, maintain QA Manual, maintain QA records (including archived logbooks, archived certificates of analysis, nonconformity and corrective action reports, MDL studies results, SOP revision and distribution, statistical control limits, PE sample results), serve as document control officer and PC for all PE sample analyses, prepare corrective action report for any unacceptable PE sample results, maintain laboratory's certifications and approvals, facilitator for external QA audits and prepare written response to deficiencies, prepare activity report to management.

PREVIOUS EXPERIENCE

Quality Assurance Manager, 2009 – 2011
Columbia Analytical Services, Inc.
Simi Valley, CA

Responsibilities same as listed above.

Data Validation Coordinator, 2007 – 2009
Columbia Analytical Services, Inc.
Simi Valley, CA

Responsibilities included validation of analytical results produced by the laboratory. Verification of client analytical requests, sample information, and reporting formats. Interacted with project managers and Quality Assurance Manager to ensure that all reports fulfilled client requirements as well as QA/QC needs. Compiled quality control summary and calibration data upon client request for data packages.

GC/MS Chemist, 2005 -2007
Columbia Analytical Services, Inc.
Simi Valley, CA

Analyzed indoor air, ambient air and source emission samples by GC/MS methods, standard preparation, performed maintenance on instruments when required, real time data reduction, participated in peer review process, and good practice of all QA/QC requirements.

Analyst, 2004 -2005
Columbia Analytical Services, Inc.
Kelso, WA

Performed a variety of analytical tests within the General Chemistry laboratory according to EPA Methodologies including Ion Chromatography, total sulfur, and solids. Saturday crew member responsible for performance of all short hold time methods including microbiology methodologies.

EDUCATION

Oregon State University – Corvallis, OR
BS, Biology
2004

Right Solutions · Right Partner
www.alsglobal.com

ALS Group USA, Corp.
2655 Park Center Drive, Suite A
Simi Valley, CA 93065
T +1 805 526 7161 F +1 805 526 7270

KATHLEEN 'KATE' KANEKO

Client Services Manager/Project Manager, 2011 – Present
Simi Valley Laboratory

Responsibilities include interfacing with clients to provide technical project management and customer service, including project scheduling, tracking and consulting to determine appropriate sampling and analytical protocols. Coordinates with the laboratory and administration to ensure that analyses are properly executed and meets the clients' needs.

PREVIOUS EXPERIENCE

Project Manager, 1997 – 2011
Columbia Analytical Services, Inc.
Simi Valley, CA

Responsibilities include interfacing with clients to provide technical project management and customer service, including project scheduling, tracking and consulting to determine appropriate sampling and analytical protocols. Coordinates with the laboratory and administration to ensure that analyses are properly executed and meets the client's needs.

GC/MS Analytical Chemist, 1994 – 1997
Columbia Analytical Services, Inc. (dba Performance Analytical, Inc.)
Los Angeles, CA

Analysis of air samples using EPA compendium methods TO-1, TO-2 and TO-14 using cryogenic concentration and thermal desorption techniques on whole air samples collected in summa canisters, Tedlar bags, and solid sorbent air samples. Proficient in the interpretation of mass spectra. Responsible for the preparation and quality control verification of solid sorbent sampling media for EPA Compendium methods TO-1 and TO-2.

GC/MS Analytical Chemist, 1992 – 1994
Performance Analytical, Inc.
Canoga Park, CA

Responsibilities same as listed above.

GC Analytical Chemist, 1989 – 1992
Performance Analytical, Inc.
Canoga Park, CA

Performed analyses of air samples for reduced sulfur compounds, hydrocarbon distribution and speciation, fixed atmospheric gases and total gaseous non-Methane organics. Performed analyses of soil and water samples for TPHg (mod. 8015) and BTEX. Performed extractions and analyses of CARB, NIOSH, OSHA and EPA 8000 series methods. Also performed metals analysis using flame and graphite furnace atomic absorption spectrophotometry (AA, GFAA).

EDUCATION

California State University – Northridge, CA
BA, Chemistry
1989

AFFILIATIONS

American Chemical Society

Right Solutions · Right Partner
www.alsglobal.com

ALS Group USA, Corp.
2655 Park Center Drive, Suite A
Simi Valley, CA 93065
T +1 805 526 7161 F +1 805 526 7270

CHRISTOPHER PARNELL

Volatiles (GC/MS) and Semi-Volatiles Technical Manager, 2016 – Present
Simi Valley Laboratory

Technical Manager for the Volatiles Gas Chromatography Mass Spectrometry and Semi-Volatiles departments. Has the responsibility of oversight of training of chemists, peer review of analytical data, mentoring of junior analysts, standard operating procedure review and streamlining of methods. Duties also require performance reviews and development of direct reports.

PREVIOUS EXPERIENCE

Operations Manager, 2012 – 2016 / Technical Advisor (VOA/GCMS) 2011 – 2016
ALS Group USA, Corp., Simi Valley, CA

Responsibilities: Technical Advisor for the Volatile Gas Chromatography Mass Spectrometry department. Has the responsibility of oversight of training of chemists, peer review of analytical data, mentoring of junior analysts, standard operating procedure review and streamlining of methods. Duties also require performance reviews and development of direct reports.

Operations Managers responsibilities include planning, directing, and coordinating the operations of the laboratory departments. Duties and responsibilities include formulating policies, managing daily operations, and planning the use of materials and human resources. Reviews performance data to measure productivity and goal achievement and to determine areas needing cost reduction and program improvement to increase efficiency.

Technical Advisor (VOA GC/MS), 2008 – 2011
Columbia Analytical Services, Inc., Simi Valley, CA

Technical Advisor responsibilities listed above.

GC/MS Team Leader, 2000 – 2008
Columbia Analytical Services, Inc., Simi Valley, CA

Team leader for the Volatile Gas Chromatography Mass Spectrometry group. Responsibilities include training of chemists, peer review of analytical data, mentoring of junior analysts, standard operating procedure review, and streamlining of methods. Duties also require performance reviews and development of direct reports.

Scientist VI, 1994 – 2000
Columbia Analytical Services, Inc. (dba Performance Analytical, Inc.), Los Angeles, CA

Responsibilities include analyzing indoor air, ambient air and source emission samples by GC/MS methods, standards preparation, perform maintenance on instruments when required, real time data reduction, participation in peer review process, and good practice of all QA/QC requirements.

Scientist VI, 1991 – 1994
Performance Analytical, Inc., Canoga Park, CA

Responsibilities listed above.

Air Toxics Laboratory Supervisor, 1990 – 1991
ABB Environmental, Camarillo, CA

Responsibilities included scheduling client analyses and developing methods for non-routine analyses, and operating the Air Toxics laboratory.

Analytical Chemist, 1987 – 1990
C-E Environmental Inc., EMSI, Camarillo, CA

Responsibilities included overseeing the Pesticide/PCB analysis of samples under the EPA CLP, and interfacing with the EPA and regional offices, and performing GC analyses and extractions.

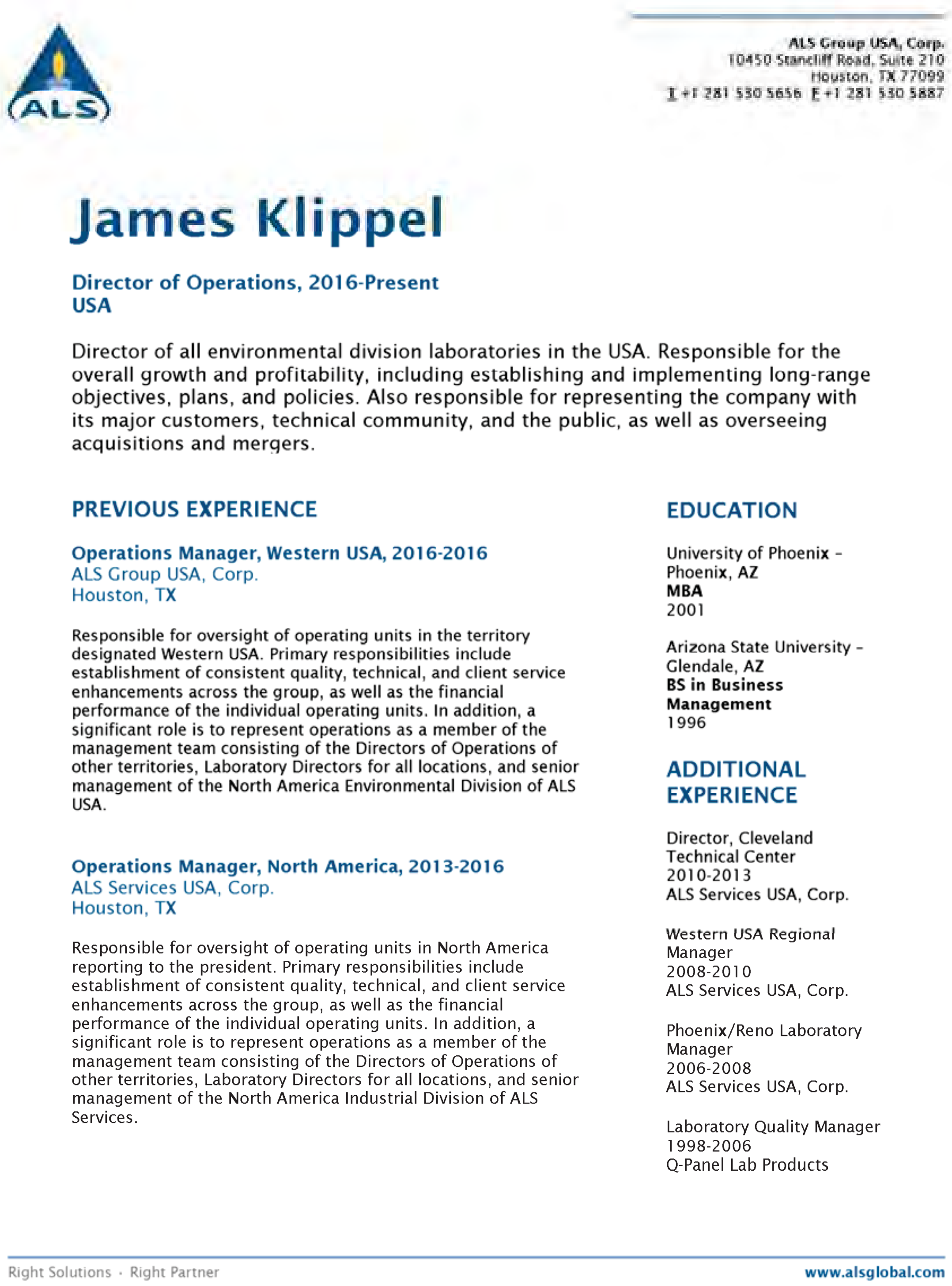
Chemist, 1986 – 1987
Damon Reference Laboratory, Newbury Park, CA

Responsibilities included performing Enzyme-linked immunosorbent assays, Western-Blot assays, and Protein Electrophoresis.

EDUCATION

University of California Santa Barbara – Santa Barbara, CA
BS, Chemistry
1986

Right Solutions · Right Partner
www.alsglobal.com



ALS Group USA, Corp.
10450 Stancliff Road, Suite 210
Houston, TX 77099
T +1 281 530 5656 F +1 281 530 5887

James Klippel

Director of Operations, 2016-Present
USA

Director of all environmental division laboratories in the USA. Responsible for the overall growth and profitability, including establishing and implementing long-range objectives, plans, and policies. Also responsible for representing the company with its major customers, technical community, and the public, as well as overseeing acquisitions and mergers.

PREVIOUS EXPERIENCE

Operations Manager, Western USA, 2016-2016
ALS Group USA, Corp.
Houston, TX

Responsible for oversight of operating units in the territory designated Western USA. Primary responsibilities include establishment of consistent quality, technical, and client service enhancements across the group, as well as the financial performance of the individual operating units. In addition, a significant role is to represent operations as a member of the management team consisting of the Directors of Operations of other territories, Laboratory Directors for all locations, and senior management of the North America Environmental Division of ALS USA.

Operations Manager, North America, 2013-2016
ALS Services USA, Corp.
Houston, TX

Responsible for oversight of operating units in North America reporting to the president. Primary responsibilities include establishment of consistent quality, technical, and client service enhancements across the group, as well as the financial performance of the individual operating units. In addition, a significant role is to represent operations as a member of the management team consisting of the Directors of Operations of other territories, Laboratory Directors for all locations, and senior management of the North America Industrial Division of ALS Services.

EDUCATION

University of Phoenix - Phoenix, AZ
MBA
2001

Arizona State University - Glendale, AZ
BS in Business Management
1996

ADDITIONAL EXPERIENCE

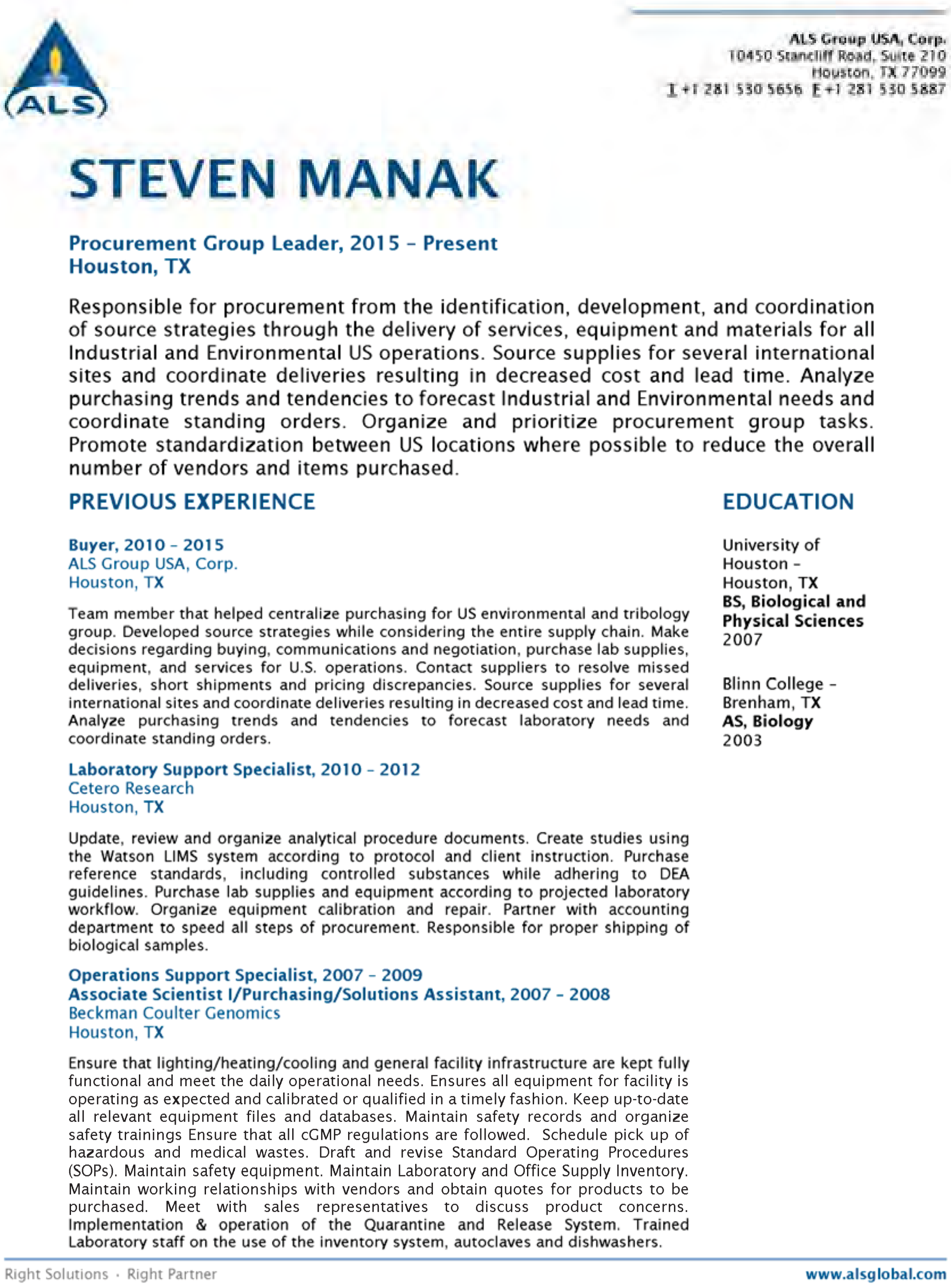
Director, Cleveland Technical Center
2010-2013
ALS Services USA, Corp.

Western USA Regional Manager
2008-2010
ALS Services USA, Corp.

Phoenix/Reno Laboratory Manager
2006-2008
ALS Services USA, Corp.

Laboratory Quality Manager
1998-2006
Q-Panel Lab Products

Right Solutions · Right Partner   **www.alsglobal.com**



ALS Group USA, Corp.
10450 Stancliff Road, Suite 210
Houston, TX 77099
T +1 281 530 5656 F +1 281 530 5887

STEVEN MANAK

Procurement Group Leader, 2015 – Present
Houston, TX

Responsible for procurement from the identification, development, and coordination of source strategies through the delivery of services, equipment and materials for all Industrial and Environmental US operations. Source supplies for several international sites and coordinate deliveries resulting in decreased cost and lead time. Analyze purchasing trends and tendencies to forecast Industrial and Environmental needs and coordinate standing orders. Organize and prioritize procurement group tasks. Promote standardization between US locations where possible to reduce the overall number of vendors and items purchased.

PREVIOUS EXPERIENCE

Buyer, 2010 – 2015
ALS Group USA, Corp.
Houston, TX

Team member that helped centralize purchasing for US environmental and tribology group. Developed source strategies while considering the entire supply chain. Make decisions regarding buying, communications and negotiation, purchase lab supplies, equipment, and services for U.S. operations. Contact suppliers to resolve missed deliveries, short shipments and pricing discrepancies. Source supplies for several international sites and coordinate deliveries resulting in decreased cost and lead time. Analyze purchasing trends and tendencies to forecast laboratory needs and coordinate standing orders.

Laboratory Support Specialist, 2010 – 2012
Cetero Research
Houston, TX

Update, review and organize analytical procedure documents. Create studies using the Watson LIMS system according to protocol and client instruction. Purchase reference standards, including controlled substances while adhering to DEA guidelines. Purchase lab supplies and equipment according to projected laboratory workflow. Organize equipment calibration and repair. Partner with accounting department to speed all steps of procurement. Responsible for proper shipping of biological samples.

Operations Support Specialist, 2007 – 2009
Associate Scientist I/Purchasing/Solutions Assistant, 2007 – 2008
Beckman Coulter Genomics
Houston, TX

Ensure that lighting/heating/cooling and general facility infrastructure are kept fully functional and meet the daily operational needs. Ensures all equipment for facility is operating as expected and calibrated or qualified in a timely fashion. Keep up-to-date all relevant equipment files and databases. Maintain safety records and organize safety trainings Ensure that all cGMP regulations are followed. Schedule pick up of hazardous and medical wastes. Draft and revise Standard Operating Procedures (SOPs). Maintain safety equipment. Maintain Laboratory and Office Supply Inventory. Maintain working relationships with vendors and obtain quotes for products to be purchased. Meet with sales representatives to discuss product concerns. Implementation & operation of the Quarantine and Release System. Trained Laboratory staff on the use of the inventory system, autoclaves and dishwashers.

EDUCATION

University of Houston –
Houston, TX
BS, Biological and Physical Sciences
2007

Blinn College –
Brenham, TX
AS, Biology
2003

Right Solutions · Right Partner
www.alsglobal.com

ALS Group USA, Corp.
10450 Stancliff Road, Suite 210
Houston, TX 77099
T +1 281 530 5656 F +1 281 530 5887

HIRENKUMAR PRAJAPATI

IT Manager – Life Sciences and Industrial, 2011 – Present
Houston, TX

Responsible for providing direction, guidance and definition of an infrastructure architecture to support the business and IT strategy. Develop staff and strategies for systems and solutions. Design and document infrastructure for network, server, storage, backup and security systems. Evaluate and recommend new products and maintain knowledge of emerging technologies.

PREVIOUS EXPERIENCE

IT Manager, 2007 – 2011
ALS Group USA, Corp.
Houston, TX

Establish and maintain a strong business relationship with senior and operating-level business leaders. Be a Thought Partner with business owners and business process development. Engage and ensure effective delivery of business deliverables and tasks with partners for technology solutions.

Lan Administrator, 2008 – 2009
ALS Group USA, Corp.
Houston, TX

Assist with administrative functions on network, active directory, IP Office and other. Manager support staff. Manage all technology inventories to included server room, telecommunication rooms and off-site locations.

IT Assistant, 2007 – 2008
ALS Group USA, Corp.
Houston, TX

Provide helpdesk support and resolve problems to the end user's satisfaction. Document internal procedures. Maintain inventory of all equipment, software and software licenses. Configure and manage routers and internet systems.

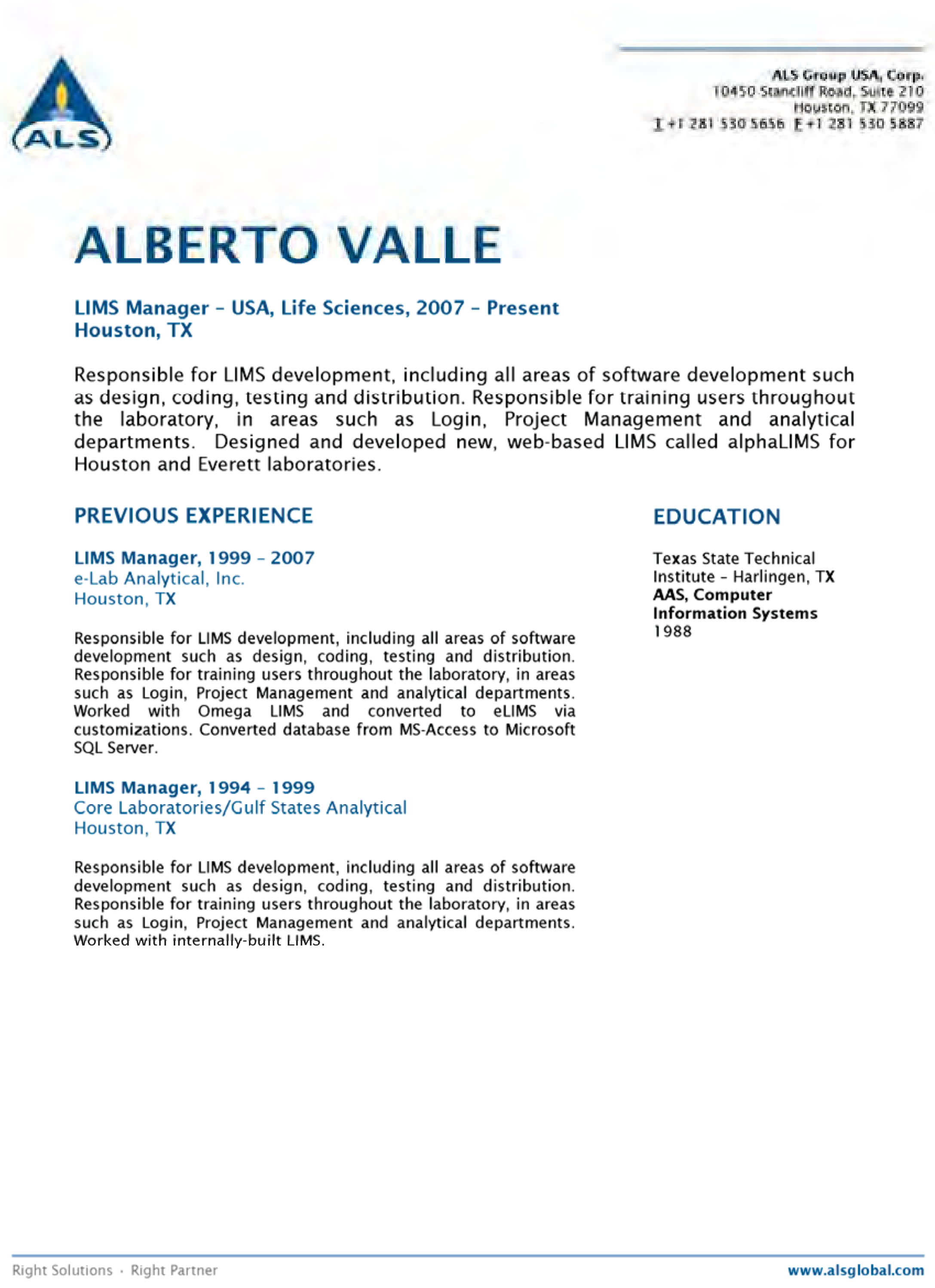
Head Consultant, 2004 – 2010
Compusys
Houston, TX

Manage multiple mandatory, essential, high-, moderate- and low-priority business projects. Responsible for adherence to the IDS Project Governance guidelines and Enterprise Project Methodology, including the approvals processes, as well as project and reporting structures. Analyze project standards, methodologies, and impacts. Coordinate activities and information dissemination with committees, management, and other necessary participants.

EDUCATION

University of Houston – Houston, TX
BS, Computer Information Systems
2009

Right Solutions · Right Partner
www.alsglobal.com



ALS Group USA, Corp.
10450 Stancliff Road, Suite 210
Houston, TX 77099
T +1 281 530 5656 F +1 281 530 5887

ALBERTO VALLE

LIMS Manager – USA, Life Sciences, 2007 – Present
Houston, TX

Responsible for LIMS development, including all areas of software development such as design, coding, testing and distribution. Responsible for training users throughout the laboratory, in areas such as Login, Project Management and analytical departments. Designed and developed new, web-based LIMS called alphaLIMS for Houston and Everett laboratories.

PREVIOUS EXPERIENCE

LIMS Manager, 1999 – 2007
e-Lab Analytical, Inc.
Houston, TX

Responsible for LIMS development, including all areas of software development such as design, coding, testing and distribution. Responsible for training users throughout the laboratory, in areas such as Login, Project Management and analytical departments. Worked with Omega LIMS and converted to eLIMS via customizations. Converted database from MS-Access to Microsoft SQL Server.

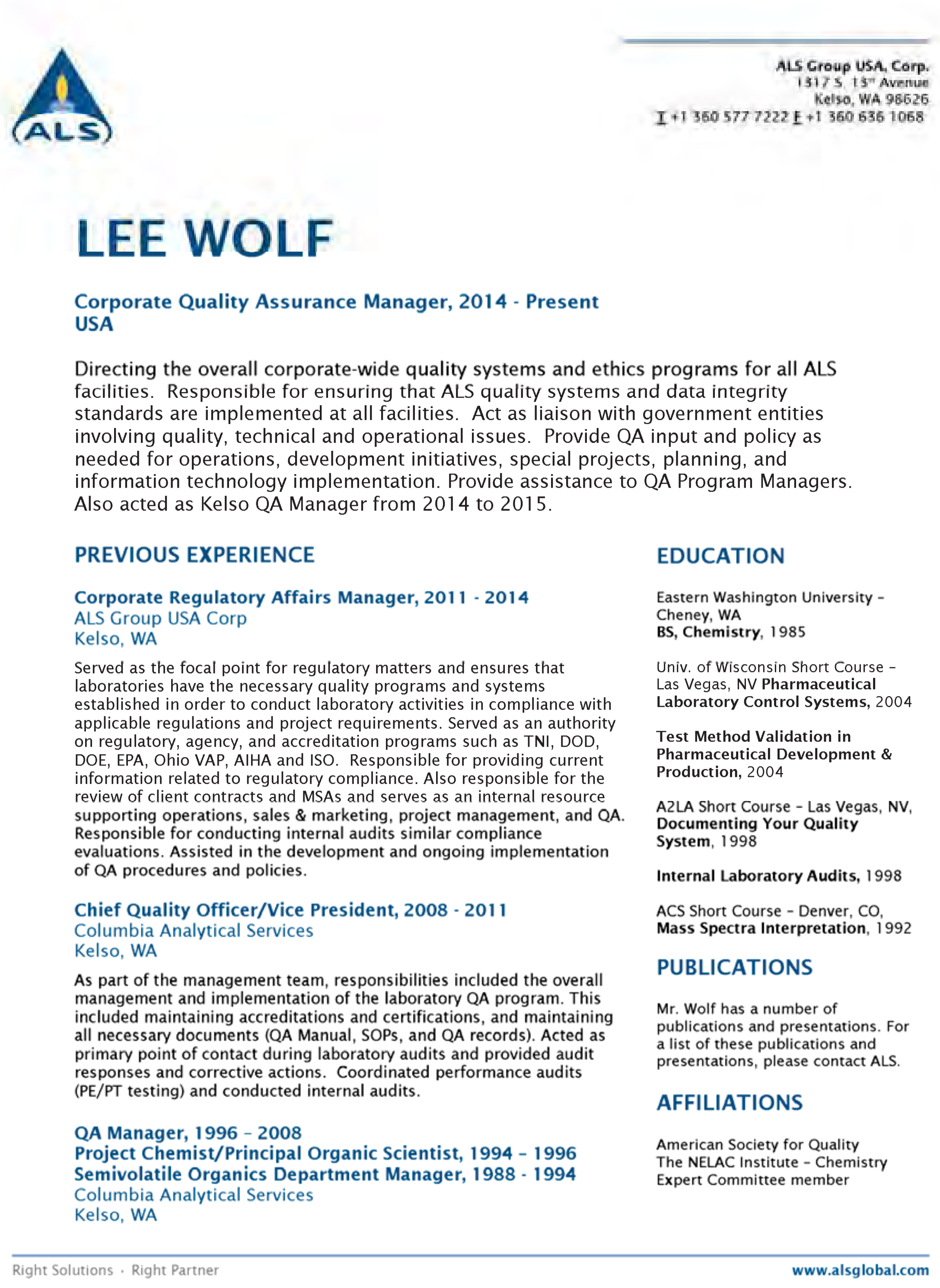
LIMS Manager, 1994 – 1999
Core Laboratories/Gulf States Analytical
Houston, TX

Responsible for LIMS development, including all areas of software development such as design, coding, testing and distribution. Responsible for training users throughout the laboratory, in areas such as Login, Project Management and analytical departments. Worked with internally-built LIMS.

EDUCATION

Texas State Technical Institute – Harlingen, TX
AAS, Computer Information Systems
1988

Right Solutions · Right Partner www.alsglobal.com



ALS Group USA, Corp.
1317 S. 13th Avenue
Kelso, WA 98626
T +1 360 577 7222 F +1 360 636 1068

LEE WOLF

Corporate Quality Assurance Manager, 2014 - Present
USA

Directing the overall corporate-wide quality systems and ethics programs for all ALS facilities. Responsible for ensuring that ALS quality systems and data integrity standards are implemented at all facilities. Act as liaison with government entities involving quality, technical and operational issues. Provide QA input and policy as needed for operations, development initiatives, special projects, planning, and information technology implementation. Provide assistance to QA Program Managers. Also acted as Kelso QA Manager from 2014 to 2015.

PREVIOUS EXPERIENCE

Corporate Regulatory Affairs Manager, 2011 - 2014
ALS Group USA Corp
Kelso, WA

Served as the focal point for regulatory matters and ensures that laboratories have the necessary quality programs and systems established in order to conduct laboratory activities in compliance with applicable regulations and project requirements. Served as an authority on regulatory, agency, and accreditation programs such as TNI, DOD, DOE, EPA, Ohio VAP, AIHA and ISO. Responsible for providing current information related to regulatory compliance. Also responsible for the review of client contracts and MSAs and serves as an internal resource supporting operations, sales & marketing, project management, and QA. Responsible for conducting internal audits similar compliance evaluations. Assisted in the development and ongoing implementation of QA procedures and policies.

Chief Quality Officer/Vice President, 2008 - 2011
Columbia Analytical Services
Kelso, WA

As part of the management team, responsibilities included the overall management and implementation of the laboratory QA program. This included maintaining accreditations and certifications, and maintaining all necessary documents (QA Manual, SOPs, and QA records). Acted as primary point of contact during laboratory audits and provided audit responses and corrective actions. Coordinated performance audits (PE/PT testing) and conducted internal audits.

QA Manager, 1996 – 2008
Project Chemist/Principal Organic Scientist, 1994 – 1996
Semivolatile Organics Department Manager, 1988 - 1994
Columbia Analytical Services
Kelso, WA

EDUCATION

Eastern Washington University – Cheney, WA
BS, Chemistry, 1985

Univ. of Wisconsin Short Course – Las Vegas, NV **Pharmaceutical Laboratory Control Systems,** 2004

Test Method Validation in Pharmaceutical Development & Production, 2004

A2LA Short Course – Las Vegas, NV, **Documenting Your Quality System**, 1998

Internal Laboratory Audits, 1998

ACS Short Course – Denver, CO, **Mass Spectra Interpretation**, 1992

PUBLICATIONS

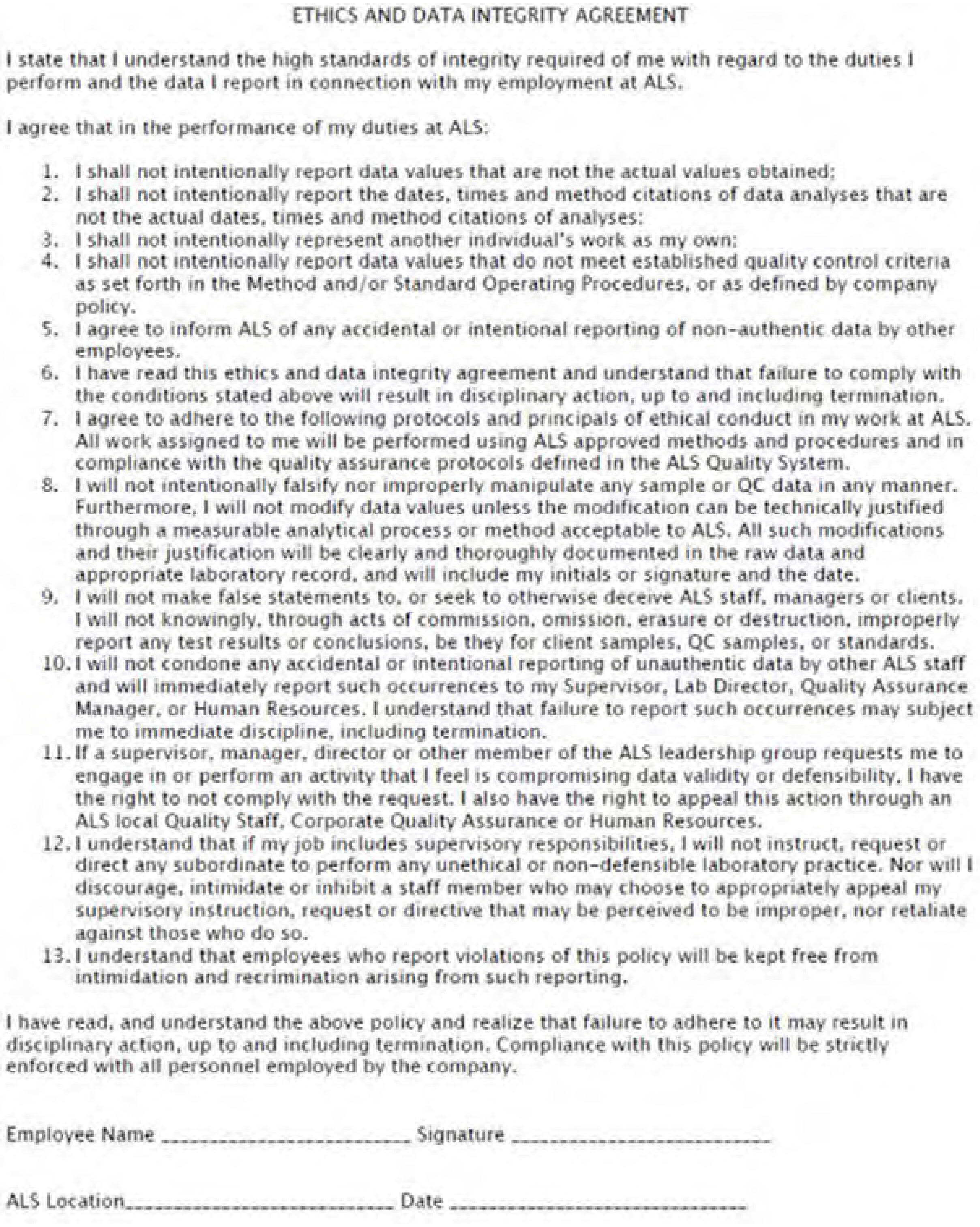
Mr. Wolf has a number of publications and presentations. For a list of these publications and presentations, please contact ALS.

AFFILIATIONS

American Society for Quality
The NELAC Institute – Chemistry Expert Committee member

Right Solutions · Right Partner
www.alsglobal.com

APPENDIX C – Ethics and Data Integrity Policy



ETHICS AND DATA INTEGRITY AGREEMENT

I state that I understand the high standards of integrity required of me with regard to the duties I perform and the data I report in connection with my employment at ALS.

I agree that in the performance of my duties at ALS:

1. I shall not intentionally report data values that are not the actual values obtained;
2. I shall not intentionally report the dates, times and method citations of data analyses that are not the actual dates, times and method citations of analyses;
3. I shall not intentionally represent another individual's work as my own;
4. I shall not intentionally report data values that do not meet established quality control criteria as set forth in the Method and/or Standard Operating Procedures, or as defined by company policy.
5. I agree to inform ALS of any accidental or intentional reporting of non-authentic data by other employees.
6. I have read this ethics and data integrity agreement and understand that failure to comply with the conditions stated above will result in disciplinary action, up to and including termination.
7. I agree to adhere to the following protocols and principals of ethical conduct in my work at ALS. All work assigned to me will be performed using ALS approved methods and procedures and in compliance with the quality assurance protocols defined in the ALS Quality System.
8. I will not intentionally falsify nor improperly manipulate any sample or QC data in any manner. Furthermore, I will not modify data values unless the modification can be technically justified through a measurable analytical process or method acceptable to ALS. All such modifications and their justification will be clearly and thoroughly documented in the raw data and appropriate laboratory record, and will include my initials or signature and the date.
9. I will not make false statements to, or seek to otherwise deceive ALS staff, managers or clients. I will not knowingly, through acts of commission, omission, erasure or destruction, improperly report any test results or conclusions, be they for client samples, QC samples, or standards.
10. I will not condone any accidental or intentional reporting of unauthentic data by other ALS staff and will immediately report such occurrences to my Supervisor, Lab Director, Quality Assurance Manager, or Human Resources. I understand that failure to report such occurrences may subject me to immediate discipline, including termination.
11. If a supervisor, manager, director or other member of the ALS leadership group requests me to engage in or perform an activity that I feel is compromising data validity or defensibility, I have the right to not comply with the request. I also have the right to appeal this action through an ALS local Quality Staff, Corporate Quality Assurance or Human Resources.
12. I understand that if my job includes supervisory responsibilities, I will not instruct, request or direct any subordinate to perform any unethical or non-defensible laboratory practice. Nor will I discourage, intimidate or inhibit a staff member who may choose to appropriately appeal my supervisory instruction, request or directive that may be perceived to be improper, nor retaliate against those who do so.
13. I understand that employees who report violations of this policy will be kept free from intimidation and recrimination arising from such reporting.

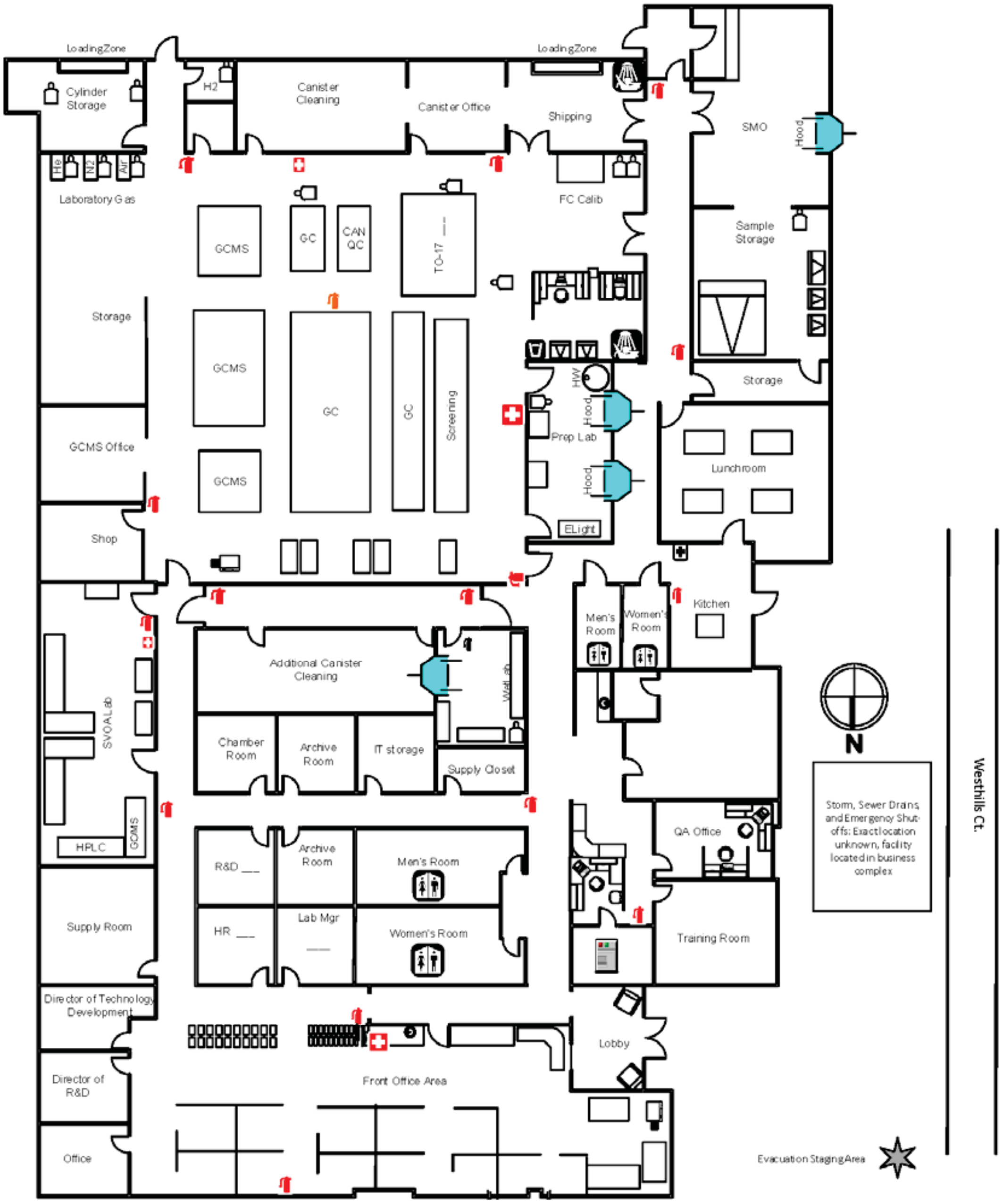
I have read, and understand the above policy and realize that failure to adhere to it may result in disciplinary action, up to and including termination. Compliance with this policy will be strictly enforced with all personnel employed by the company.

Employee Name ____________________________ Signature ____________________________

ALS Location______________________________ Date ________________________________

APPENDIX D – Laboratory Floor Plan

ALS Environmental-Simi Valley Laboratory Floor Plan



CAS SIMI VALLEY FLOOR PLAN

2655 Park Center Drive, Suite A, Simi Valley, California 93065

✚ -First Aid	HW -Hazardous Waste Cabinet	
▦ -Network Server Room	-Emergency Shower	FW -Flammable Waste Cabinet
-Fire Extinguisher	-Gas Cylinder(s)	
▽ -Refrigerator/Freezer	-Deionized Water	

APPENDIX E – Analytical Equipment

Equipment Description - Gas Chromatography	Purchased / Acquired	Location
Screen 02: Hewlett-Packard 5890 with FID Detector	-	VOA GC/MS Screen
Screen 03: Hewlett-Packard 5890 with FID Detector	-	VOA GC/MS Screen
GC01: Hewlett-Packard 5890 with FID/TCD Detectors *Fixed Gas Analyzer/Total Combustion Analyzer (TCA)*	1995	VOA GC
GC06: Hewlett-Packard 6890 with ECD/ECD Detectors *Hewlett-Packard 6890 Injector*	1995	SVOA
GC08: Hewlett-Packard 5890 Series II with TCD/FID Detectors	1998	VOA GC
GC09: Hewlett-Packard 5890 Series II with FID Detector	1999	VOA GC/MS Screen
GC10: Hewlett-Packard 5890A with FID/TCD Detectors	1999	VOA GC
GC12: Hewlett-Packard 5890 Series II+ with FID Detector *Hewlett-Packard 6890 Injector* (combined with MS02)	2004	SVOA
GC13: Agilent 6890A combined with Sievers 355 (SCD 1)	2001	VOA GC
GC14: Agilent 6890N with NPD/FID Detectors *Agilent 7683 Injector*	2005	SVOA
GC15: Agilent 6890N with NPD/FID Detectors *Agilent 7683 Injector*	2005	SVOA
GC16: Agilent 6890N with PFPD Detector and *OI Detector Controller* *Agilent 7683 Injector*	2005	SVOA
GC20: Agilent 7890A with FID/TCD Detectors	2008	VOA GC
GC21: Hewlett-Packard 5890 Series II with FID Detector	2009	VOA GC
GC22: Agilent 7890A combined with Agilent 355 (SCD 3)	2009	VOA GC
GC23: Hewlett-Packard 6890+ with ECD Detector (combined with MS14)	2007	SVOA
GC30: Agilent 7890B combined with Agilent 355 (SCD 2)	2016	VOA GC
GC31: Hewlett-Packard 6890A with ECD Detector	1999	SVOA

Equipment Description - GC/MS Systems	Purchased / Acquired	Location
MS02: HP 5890 Series II+ with FID Detector (GC12) & HP 5972 MSD *Hewlett-Packard 6890 Injector*	1994	SVOA
MS05: Agilent 6890/5973N MSD *Hewlett-Packard 7673 Injector*	1999	SVOA
MS07: HP 6890A/ Agilent 5973N MSD *Agilent 6890 Injector*	2001	SVOA
MS08: Agilent 6890N/5973inert MSD Tekmar AUTOCAN Autosampler	2004	VOA GC/MS
MS09: Agilent 6890N/5973inert MSD Tekmar AUTOCAN Autosampler	2005	VOA GC/MS
MS10: HP 6890A/5973 MSD	2006	SVOA
MS13: Agilent 6890N/5975B inert MSD Tekmar AUTOCAN Autosampler	2006	VOA GC/MS
MS14: HP 6890+ with ECD Detector (GC23) & HP 5973 MSD HP 7673 Injector	2007	SVOA
MS16: Agilent 6890N/5975C inert MSD Tekmar AUTOCAN Autosampler	2007	VOA GC/MS
MS18: Agilent 7890A /5975C inert XL MSD Markes Series 2 Unity Thermal Desorber Markes Series 2 Ultra TD Autosampler	2010	VOA GC/MS
MS19: Agilent 7890A (GC26)/5975C inert XL MSD Tekmar AUTOCAN Autosampler	2011	VOA GC/MS
MS20: Agilent 7890A (GC27)/5975C inert XL MSD Markes Series 2 Unity Thermal Desorber Markes Series 2 Ultra TD Autosampler	2011	VOA GC/MS
MS21: Agilent 7890A (GC28)/5975C inert XL MSD Tekmar AUTOCAN Autosampler	2012	VOA GC/MS
MS22: Agilent 7890B (GC29)/5977A MSD Markes CIA Advantage Autosampler	2015	VOA GC/MS
MS23: Agilent 7890B (GC32)/5977B MSD	2017	VOA GC/MS

Liquid Chromatography	**Purchased / Acquired**	**Location**
LC03: Agilent Infinity LC 1220	2011	SVOA
Spectrophotometer	**Purchased / Acquired**	**Location**
SPM01: Spectronic Instrument 20+ from SC	2001	GENCHEM
pH and Specific Ion Meters	**Purchased / Acquired**	**Location**
pH01: Thermo Orion 920 Selective Ion Meter	2001	GENCHEM
Miscellaneous Equipment	**Purchased / Acquired**	**Location**
US Filter Water Purification System	2006	Main Lab

Note: Purchase/Acquired year may represent when instrument was first maintained by ALS Environmental-Simi Valley or other in-network ALS Laboratory and does not reflect age of instrument.

Air sampling containers / Flow Controllers / Critical Orifices

Six-liter Summa passivated stainless steel canisters

- 1231 Ambient
- 1292 Source
- 194 Standard

Six-liter Silonite passivated stainless steel canisters

- 1141 Ambient
- 466 Source

Three-liter Silco passivated stainless steel canisters (67)

One-liter Summa passivated stainless steel canisters (1149)

One-liter Silonite passivated stainless steel canisters (765)

Low volume flow controllers for time integrated sampling

- 957 Ambient
- 148 Source

Low-flow flow controllers for multi-day sampling (277)

Critical orifices (2369)

Critical orifices – Sulfur (145)

Automated Summa Canister Conditioning Units

- Twenty-four position, microprocessor controlled conditioners with heater controller, vacuum gauge, humidified nitrogen fill capability and large-capacity vacuum pump (2)
- Fourteen position, microprocessor controlled conditioners with heater controller, vacuum gauge, humidified nitrogen fill capability and large-capacity vacuum pump (1)
- Sixteen position, microprocessor controlled conditioner with heater controller, vacuum gauge, humidified nitrogen fill capability and large-capacity vacuum pump (1)
- Six position, microprocessor controlled conditioner with heater controller, vacuum gauge, humidified nitrogen fill capability and large-capacity vacuum pump (1)
- Twelve position, microprocessor controlled conditioner with heater controller, vacuum gauge, humidified nitrogen fill capability and large-capacity vacuum pump (2)
- Twenty-four position (Bottle Vac Cleaning Manifold), microprocessor controlled conditioners with heater controller, vacuum gauge, humidified nitrogen fill capability and large-capacity vacuum pump (2)

APPENDIX F – Containers, Preservation and Holding Times

Sample Preservation and Holding Times for Performed Methods

Determination (Method)	Matrix	Container	Preservation	Maximum Holding Time	Sample Vol.[c]
Amines (In-House Method)	Air	Treated Alumina Tubes	Sample Receipt-NA; Storage 4°C±2°C	30 days	100L
Ammonia (OSHA ID-188/ID-164)	Air	H_2SO_4 Treated Carbon Bead Tubes	Sample Receipt-NA; Storage 4°C±2°C	28 days	TWA: 24L STEL: 7.5L
BTU by ASTM D 3588 (SULFUR, ASTM D 5504; C1-C6+, EPA TO-3M; FIXED GASES, 3C)	Gaseous Fuels	Tedlar Bag Mylar Bag Summa Canister Bottle Vac	N/A	Sulfur Bag – 24 hours Canister – 7 days[b] Bottle Vac[a] – 7 days[b] C1-C6+ Bag – 72 hours Canister[a] – 30 days[b] Bottle Vac[a] – 30 days[b] 3C Bag – 72 hours Canister[a] – 30 days[b] Bottle Vac[a] – 30 days[b]	Bags 500mL Canisters and Bottle Vacs ≥1.0L
Carboxylic Acids (In-House Method)	Air	Treated Silica Gel Tubes	Sample Receipt-NA Storage 4°C±2°C	30 days until extraction; 14 days for analysis	100L
Total Gaseous Non-methane Organics (TGNMO) (EPA 25C)	Air	Tedlar Bag Mylar Bag Summa Canister Bottle Vac	N/A	Bag – 72 hours Canister[a] – 30 days[b] Bottle Vac[a] – 30 days[b]	Bags 500mL Canisters and Bottle Vacs ≥1.0L
Fixed Gases (EPA 3C & ASTM D 1946)	Air	Tedlar Bag Mylar Bag Summa Canister Bottle Vac	N/A	Bag – 72 hours Canister[a] – 30 days[b] Bottle Vac[a] – 30 days[b]	Bags 500mL Canisters and Bottle Vacs ≥1.0L
Helium & Hydrogen (EPA 3C Modified)	Air	Summa Canister Bottle Vac	N/A	Canister[a] – 30 days[b] Bottle Vac[a] – 30 days[b]	Bags 500mL Canisters and Bottle Vacs ≥1.0L
Methane, Ethane, Ethene, Propane, Propene (RSK 175)	Aqueous	Glass w/Teflon-Lined Lid	No Headspace HCl to pH<2 4°C±2°C	14 days when preserved	(3) 40mL Vials

Sample Preservation and Holding Times for Performed Methods

Determination (Method)	Matrix	Container	Preservation	Maximum Holding Time	Sample Vol.[c]
Carbon Dioxide (RSK 175)	Aqueous	Glass w/Teflon Lined Lid	No Headspace neutral pH (5-8) 4°C±2°C	N/A[d]	(3) 40mL Vials
Sulfur Compounds (In-House Method)	Aqueous	Glass w/Teflon Lined Lid	No Headspace; pH>4; 4°C±2°C	Following pH adjustment – 24 hours	(2) 40mL Vials
Sulfur Compounds (ASTM D 5504; SCAQMD 307-91; Modified SCAQMD 307-91)	Air	Tedlar Bag Fused Silica Lined Stainless Steel Canister Bottle Vac	No direct sunlight	Bag – 24 hours Canister – 7 days[b] Bottle Vac[a] – 7 days[b]	Bags 500mL Canisters and Bottle Vacs ≥1.0L
C_1-C_6+ (EPA TO-3 Modified)	Air	Tedlar Bag Mylar Bag Summa Canister Bottle Vac	N/A	Bag – 72 hours Canister[a] – 30 days[b] Bottle Vac[a] – 30 days[b]	Bags 500mL Canisters and Bottle Vacs ≥1.0L
Methanol, Ethanol, Isopropyl alcohol, Freon, and Methylene Chloride (EPA TO-3 Modified)	Air	Tedlar Bag Mylar Bag Summa Canister Bottle Vac	N/A	Bag – 72 hours Canister[a] – 30 days[b] Bottle Vac[a] – 30 days[b]	Bags 500mL Canisters and Bottle Vacs ≥1.0L
Total Petroleum Hydrocarbons (TPHG) (EPA TO-3 Modified)	Air	Tedlar Bag Mylar Bag Summa Canister Bottle Vac	N/A	Bag – 72 hours Canister[a] – 30 days[b] Bottle Vac[a] – 30 days[b]	Bags 500mL Canisters and Bottle Vacs ≥1.0L
Formaldehyde & Other Carbonyl Compounds (EPA TO-11A)	Air	DNPH-Coated Silica Gel Cartridge w/ Polypropylene Cap; SKC UME[x] and Bacharach GMD 570 Passive Monitors (formaldehyde only)	Sample Receipt, 4°C±2°C; Laboratory Preservation, 4°C±2	14 days until extraction; 30 days for analysis	100 – 150L
Volatile Organic Compounds (EPA TO-14A & TO-15)	Air	Tedlar Bag, Summa Canister (1L, 6L) Bottle Vac	N/A	Bag – 72 hours Canister – 30 days Bottle Vac[a] – 30 days[b]	Bags 500mL Canisters 1.0L/6.0 Bottle Vacs 1.0L

Sample Preservation and Holding Times for Performed Methods

Determination (Method)	Matrix	Container	Preservation	Maximum Holding Time	Sample Vol.[c]
Volatile Organic Compounds (EPA TO-17)	Air	Sorbent Tubes w/Swagelock Caps & PTFE Ferrules	<4°C; organic solvent free environment; Laboratory Storage, 4°C±2°C	30 days	1-4L
Volatile Organic Compounds (EPA 325B)	Air	Sorbent Tubes w/Swagelock Caps & PTFE Ferrules	Laboratory Storage <23°C	30 days	1-4L
Air-Phase Petroleum Hydrocarbons (MADEP APH)	Air	Summa Canister Bottle Vac	N/A	28 days Bottle Vac[a] – 30days[b]	Canisters 1.0L/6.0L Bottle Vacs 1.0L
Halogenated Volatile Organic Compounds (CARB 422)	Air	Tedlar Bag Summa Canister (1L, 6L) Bottle Vac	N/A	Bag – 72 hours Canister[a] – 30 days[b] Bottle Vac[a] – 30 days[b]	Bags 500mL Canisters 1.0L/6.0L Bottle Vacs 1.0L
Butyl Cellosolve (2-butoxyethanol) (NIOSH 1403)	Air	Charcoal Tube	Sample Receipt-NA; Store sample and extract ≤4°C	14 days until desorption; 30 days for analysis	Project Specific
Orthorhombic Cyclooctasulfur (ASTM C471M-14)	Solid Wallboard	Ziploc Bag	Sample Receipt-NA; Storage 4°C±2°C; Extract -10°C to -20°C	Extracts – 40 days for analysis	2"x2"
Siloxanes (In-House Method)	Air	SPE Cartidges Tedlar Bags	N/A	14 days until extraction; Tedlar Bags – transfer onto sorbent tube within 72 hours. 30 days for analysis	30L Cartridges Bags 500ml
Reduced Sulfur Compounds (NCASI Method RSC-02.02)	Aqueous	40ml amber, borosilicate glass vials with Teflon faced silicone backed caps.	MeSH, DMS, and DMTS (RSCs non-H2S) addition of ascorbic acid and pH adjustment to <2.5 with 1:2 phosphoric acid solution upon collection. Laboratory Preservation, 4°C±2	14 days	(2) 40ml VOA Vials

Determination (Method)	Matrix	Container	Preservation	Holding Time	Sample Vol.[c]
Total Sulfide (NCASI Method RSC-02.02)	Aqueous	40ml amber, borosilicate glass vials with Teflon faced silicone backed caps.	Addition of Zinc acetate solution and pH adjustment to >10 with 1 N NaOH solution upon collection. Laboratory Preservation, 4˚C±2	14 days	(2) 40ml VOA Vials
Hydrogen Sulfide (In-House Method)	Air	Radiello Samplers	N/A	6 months	1 hour to 15 days exposure (dependent on sampling environment)

Footnotes:

a.	Some methods do not specify the utilization of canisters; therefore, there is no required hold time and this will be noted in the case narrative.
b.	Laboratory recommended hold time; therefore, samples analyzed outside this hold time will be noted in the case narrative accordingly.
c.	Sample volumes are the minimum, which should be received by the laboratory; however, canister volumes should match the canister size utilized.
d.	There is no holding time requirement available and laboratory studies are not available indicating the validity of data prior to or following a specified length of time. Therefore, no holding time notation or qualifier will be adhered to results.

APPENDIX G – Standard Operating Procedures

Corporate SOP Titles	SOP ID
Laboratory Ethics and Data Integrity	CE-GEN001
(Proprietary – Client Specific)	CE-GEN002
Records Management Policy	CE-GEN003
Preventive Action	CE-GEN004
Document Control	CE-GEN005
Data Recall	CE-GEN006
Procurement and Control of Laboratory Services and Supplies	CE-GEN007
Method Development	CE-GEN008
Establishing Standard Operating Procedures	CE-GEN009
Handling Customer Feedback	CE-GEN010
Assigning a TSR to a Project	CE-GEN011
Policy for the use of Accreditation Organization Names, Symbols, and Logos	CE-GEN012
(Proprietary – Client Specific)	CE-GEN013
Management of Change Procedure	CE-GEN015
Policy for Continuous Quality Improvement	CE-GEN016
Internal Audits	CE-QA001
Manual Integration Policy	CE-QA002
Training Policy	CE-QA003
Qualification of Subcontract Laboratories and Inter-Company Subcontracting Protocol	CE-QA004
Laboratory Management Review	CE-QA005
Proficiency Testing	CE-QA006
Making Entries onto Analytical Records	CE-QA007
Nonconformance and Corrective Action	CE-QA008
Control Limits	CE-QA009
Estimation of Uncertainty of Analytical Measurements	CE-QA010
Performing Method Detection Limit Studies and Establishing Limits of Detection and Quantitation	CE-QA011
Quality of Reagents and Standards	CE-QA012

Local Administrative SOP Titles	SOP Code
Data and Record Archiving	ADM-ARC
Batches and Sequences	ADM-BATCH_SEQ
Handling Consumable Materials	ADM-CONSUM
Electronic Data Backup, Archiving, and Restoration	ADM-DATA_BU
Data Review and Reporting	ADM-DATA_REV
Glassware Cleaning	ADM-GLASS
Analytical Instrument Acquisition, Reassignment, Maintenance and Documentation	ADM-INSTRUM
Laboratory Storage, Analysis, and Tracking	ADM-LabSAT
Media Request Fulfillment	ADM-Media_Req
Project Management	ADM-PMgmt
Software and Data Quality Assurance	ADM-SftwreQA
Significant Figures	ADM-SIG_FIG
Calibration and Use of Laboratory Support Equipment	ADM-SupEQ
Waste Disposal	ADM-WASTE
Cleaning and Certification of Summa Canisters and Other Specially Prepared Canisters	SMO-Can_Cert
Evaluation and Pressurization of Specially Prepared Stainless Steel Canisters	SMO-Can_Press
Flow Controllers and Critical Orifices	SMO-Flow_Cntrl
Sample Receiving, Acceptance and Log-In	SMO-SMPL_REC

Volatile SOP Titles	SOP Code
Calculating Heat Value, Compressibility Factor, and Relative Density of Gaseous Fuels in Accordance with ASTM D 3588	VOA-BTU
Samples Preparation in Glass Chambers	VOA-CHAMBER
Dissolved Gas Analysis in Aqueous Samples Using a GC Headspace Equilibration Technique	VOA-DISGAS
Sample Preparation of Drywall for Sulfur Analysis and the Determination of Copper Corrosion	VOA-DRYWALL
Determination of Total Gaseous Nonmethane Organic (TGNMO) Emissions as Carbon in Landfill Gases in Accordance with EPA Method 25C	VOA-EPA25C
Determination of Methane, Carbon Monoxide, Carbon Dioxide, and Total Gaseous Nonmethane Organic (TGNMO) Emissions as Carbon in Landfill Gases According to Modified EPA Method 25C	VOA-EPA25CM
Determination of Hydrogen, Carbon Monoxide, Carbon Dioxide, Nitrogen, Methane, and Oxygen using Gas Chromatography with Thermal Conductivity Detection (TCD) in Accordance with EPA 3C or ASTM D 1946	VOA-EPA3C
Determination of Volatile Organic Compounds from Fugitive and Area Sources	VOA-EPA325B
Analysis of Hydrogen and Helium using Gas Chromatography with Thermal Conductivity Detection (TCD)	VOA-HHe
Analysis of Sulfur Compounds in a Gaseous Matrix by Gas Chromatography with Sulfur Chemiluminescence Detection per ASTM D 5504 and Modified SCAQMD Method 307	VOA-S307M_SCD
Analysis of Sulfur Compounds in Liquid Samples by Gas Chromatography with Sulfur Chemiluminescence Detection	VOA-SH$_2$O_SCD
Analysis of C1-C6+ using Gas Chromatography with Flame Ionization Detection (FID) in Accordance with a Modification of EPA Compendium Method TO-3	VOA-TO3C1C6
Analysis of Various Compounds using Gas Chromatography with Flame Ionization Detection (FID) in Accordance with a Modification of EPA Compendium Method TO-3	VOA-TO3MeOH
Analysis of Total Petroleum Hydrocarbons as Gasoline in Air by Gas Chromatography with Flame Ionization Detection	VOA-TPHG_TO3
Determination of Air-Phase Petroleum Hydrocarbons by Gas Chromatography/Mass Spectrometry (GC/MS)	VOA-MAPH
Determination of Volatile Organic Compounds in Air Samples Collected in Specially Prepared Canisters and Gas Collection Bags and Analyzed by Gas Chromatography/Mass Spectrometry (GC/MS)	VOA-TO15
Determination of Volatile Organic Compounds in Ambient Air Using Active or Passive Sampling Onto Sorbent Tubes	VOA-TO17

Semi-Volatile SOP Titles	SOP Code
Determination of Formaldehyde and Other Carbonyl Compounds in Ambient Air Using Adsorbent Cartridge Followed by High Performance Liquid Chromatography (HPLC) EPA Compendium Method T0-11A	SVO-11A
Determination of Volatile Amines in Ambient Air Using Gas Chromatography Equipped with a Nitrogen Phosphorus Detector (NPD)	SVO-AMINES
Determination of Carboxylic Acids in Ambient Air Using Gas Chromatography/Mass Spectrometry (GC/MS)	SVO-CACIDS
Analysis of Halogenated Volatile Organic Compounds in Emissions from Stationary Sources using GC/ECD in Accordance with a Modification of CARB Method 422	SVO-CARB422
NCASI Method RSC-02.02 Reduced Sulfur Compounds by Direct Injection GC/PFPD	SVO-NCASI_RSC
Preparation and Analysis of 2-Butoxyethanol on Coconut Shell Charcoal Tubes and Analyzed using GC/FID	SVO-NIOSH1403
Determination of P-9290 Target Compounds from a Chamber and Specific P-9290 Quality Control Parameters	SVO-P9290
Preparation and Analysis of Orthorhombic Cyclooctasulfur by Gas Chromatography/Electron Capture Detector (GC/ECD)	SVO-S8_ECD
Determination of Siloxanes in Biogas using Gas Chromatography/Mass Spectrometry (GC/MS)	SVO-SILOXANES

General Chemistry (WET) SOP Titles	SOP Code
Colorimetric Determination of Hydrogen Sulfide (H_2S) in Air	WET-H_2SAir
Ammonia in Air by Ion Selective Electrode	WET-NH_3Air

APPENDIX H – Data Qualifiers

CODE	CATEGORY	DESCRIPTION
BC	RESULT	Reported results are not blank corrected.
BH	RESULT	Results indicate breakthrough; back section of tube greater than front section.
BT	RESULT	Results indicated possible breakthrough; back section ≥10% front section.
DE	RESULT	Reported results are corrected for desorption efficiency.
RA	RESULT	Result not available.
G	GENERAL	Improper container.
G1	GENERAL	Unpreserved or improperly preserved sample.
X	GENERAL	See case narrative.
H1	HOLD TIME	Sample analysis performed past holding time. See case narrative.
H2	HOLD TIME	Initial analysis within holding time. Reanalysis for the required dilution was past holding time.
H3	HOLD TIME	Sample was received and analyzed past holding time.
H4	HOLD TIME	Sample was extracted past required extraction holding time, but analyzed within analysis holding time. See case narrative.
i	MATRIX	The MDL/MRL has been elevated due to matrix interference.
M	MATRIX	Matrix interference; results may be biased (high/low).
M1	MATRIX	Matrix interference due to coelution with a non-target compound. (TO-15 only)
Q	PETROLEUM	The chromatographic fingerprint of the sample resembles a petroleum product, but the elution pattern indicates the presence of a greater amount of lighter/heavier molecular weight constituents than the calibration standard.
Y	PETROLEUM	The chromatogram resembles a petroleum product but does not match the calibration standard.
Z	PETROLEUM	The chromatogram does not resemble a petroleum product.
#	QC	The control limit criterion is not applicable. See case narrative.
*	QC	The result is an outlier. See case narrative.
B	QC	Analyte detected in both the sample and associated method blank.
I	QC	Internal standard not within the specified limits. See case narrative.
L	QC	Laboratory control sample recovery outside the specified limits; results may be biased (high/low).
N	QC	The matrix spike sample recovery is not within control limits. See case narrative.
R	QC	Duplicate precision not met.

CODE	CATEGORY	DESCRIPTION
R1	QC	Duplicate precision not within the specified limits; however, the results are below the MRL and considered estimated.
S	QC	Surrogate recovery not within specified limits.
V	QC	The continuing calibration verification standard was outside (biased high/low) the specified limits for this compound.
C	RESULT	Result identification confirmed.
CE	RESULT	Co-elution.
D	RESULT	The reported result is from a dilution.
E	RESULT	Estimated; concentration exceeded calibration range.
J	RESULT	The result is an estimated concentration that is less than the MRL but greater than or equal to the MDL.
J1	RESULT	The analyte was positively identified below the method reporting limit prior to utilizing the dilution factor; the associated numerical value is considered estimated.
K	RESULT	Analyte was detected above the method reporting limit prior to normalization.
ND	RESULT	Compound was analyzed for, but not detected above the laboratory reporting/detection limit.
P	RESULT	The confirmation criterion was exceeded. The relative percent difference was greater than 40/25% between the two analytical results.
U	RESULT	Compound was analyzed for, but not detected (ND) at or above the MRL/MDL.
W	RESULT	Result quantified, but the corresponding peak was detected outside the generated retention time window.
UJ	RESULT	The analyte was not detected; however, the result is estimated due to discrepancies in meeting certain analyte-specific quality control criteria.
Ui	RESULT	The compound was analyzed for, but was not detected ("Non-detect") at or above the MRL/MDL; however, the MRL/MDL has been elevated due to matrix interference.
T	TIC	Analyte is a tentatively identified compound, result is estimated.

APPENDIX I – Master List of Controlled Documents

Controlled Documents*	Document Code
Health and Safety Manual	ALS-SIMI VALLEY
Quality Assurance Manual	ALSMV-QAM

*Refer to Appendix G for a list of the laboratory's controlled standard operating procedures.

QA Program Files	
Item	**Location / Name**
Approved Signatories List	QA Manual Appendix I
Approved Subcontract Laboratories	Q:\Approved Sub-Contract Labs\Subcontract Lab List
Control Limit\Chart Status	Q:\Control Charts\CntrlChrt(status1).xls
Job Descriptions	HR Department
Master List of Controlled Documents (Logbooks, SOPs, etc.)	Q:\Master List of Controlled Documents\Master List of Controlled Documents.xls
MDL,LOD,LOQ Status	Q:\MDL Status\MDL Status Table (EACH DEPT).xls
Personnel Resumes, Transcripts	HR and QA Departments
Simi Valley Certification Status	Q:\Certifications\Cert Status.xls
Simi Valley Data Quality Objectives	Q:\MDL_MRL\DQO Spreadsheet.xls
Technical Training Status	Q:\Training\TRAINING STATUS.xls

Approved Signatories	
Name	**Title**
Kelly Horiuchi, B.A.	Laboratory Director / Project Manager
Chaney Humphrey, B.S.	Quality Assurance Manager
Wade Henton, B.S.	Volatiles (GC) Technical Manager
Chris Parnell, B.S.	Technical Manager (Volatiles GC/MS & Semi-Volatiles)
Wida Ang, B.S., M.S.	Team Leader (Volatiles GC/MS)
Sue Anderson, B.S.	Project Manager / Technical Manager (General Chemistry)
Samantha Henningsen, B.S.	Project Manager
Kathleen Kaneko, B.A.	Client Services Manager / Project Manager

APPENDIX J – Laboratory Accreditations

State of Arizona, Department of Health Services

License No. AZ0694

Approved Method(s):

- EPA TO-15
- EPA 3C

Department of Defense, Environmental Laboratory Accreditation Program (DoD-ELAP)

Perry Johnson Laboratory Accreditation, Inc. Accreditation No. 65818

Approved Method(s):

- EPA TO-15
- EPA TO-17
- RSK 175
- EPA 3C
- ASTM D 1946-90
- SOP VOA-EPA3C (EPA 3C Modified)
- SOP VOA-TPHG_TO3 (TPHG by Modified EPA TO-3)
- SOP VOA-TO3C1C6 (Hydrocarbons and ranges by Modified EPA TO-3)
- SOP VOA-TO15 (EPA TO-15 Modified)
- SOP VOA-TO17 (EPA TO-17 Modified)

State of Florida, Department of Health (NELAP-Secondary)

Laboratory ID No.: E871020

Approved Method(s):

- EPA TO-15
- EPA TO-17

State of Louisiana, Department of Environmental Quality (NELAP-Secondary)

Certificate No.: 05071

Approved Method(s):

- EPA TO-15
- EPA 325B

State of Maine, Department of Health and Human Services

Certificate No.: 2016036

Approved Methods

- EPA TO-15
- MADEP APH

State of Minnesota, Department of Health, Environmental Laboratory Certification Program (NELAP-Secondary)

Laboratory ID: 006-999-456
Approved Method(s):

- EPA TO-15

Off-gas testing and gas sampling and analysis in support of U.S. Navy Deep Submergence Systems

SOPs:

- SMO-Can_Cert
- SMO-Can_Press
- SMO-Flow_Cntrl
- SMO-Smpl_Rec
- SVO-11A
- SVO-NIOSH1403
- SVO-P9290
- VOA-EPA25CM
- VOA-TO15

State of New Jersey, Department of Environmental Protection (NELAP-Secondary)

Laboratory ID: CA009
Approved Method(s):

- EPA TO-15

State of New York, Department of Health (NELAP –Secondary)

Laboratory ID No. 11221
Approved Method(s):

- EPA TO-15
- EPA TO-17

State of Oregon, Environmental Laboratory Accreditation Program (NELAP-Primary)

Laboratory ID: 4068
Approved Method(s):

- ASTM C471M-14
- ASTM D5504-12
- EPA 325B 2013
- EPA RSK-175
- EPA TO-15
- EPA TO-17
- MADEP APH

Commonwealth of Pennsylvania, Department of Environmental Protection Bureau of Laboratories
Registration Number: 68-03307

State of Texas, Texas Commission on Environmental Quality (NELAP-Secondary)
Certificate # T104704413-17-8
Approved Method(s):

- EPA TO-15

State of Utah, Department of Health, Environmental Laboratory Certification Program (NELAP-Secondary)
Certificate # CA016272017-8
Approved Method(s):

- EPA TO-15

State of Washington, Department of Ecology
Laboratory ID: C946
Approved Method(s):

- EPA TO-15
- EPA RSK-175
- EPA 25CM

Note 1: This Quality Assurance Manual is revised annually with DoD-ELAP and NELAP-Primary Certificates, and the Scope of Accreditations/Parameters are revised annually (where necessary). During this interim period Certificates may expire and the Scope of Accreditations/Parameters may change; therefore, these may not be updated until the next revision.

Note 2: Current Certificates and Scope of Accreditations/Parameters are on file and displayed in the front hallway. Updated or Specific Certificates and Scope of Accreditations/Parameters are available upon request.

PERRY JOHNSON LABORATORY ACCREDITATION, INC.

PJLA

Certificate of Accreditation

Perry Johnson Laboratory Accreditation, Inc. has assessed the Laboratory of:

ALS Environmental

2655 Park Center Drive, Suite A, Simi Valley, CA 93065

(Hereinafter called the Organization) and hereby declares that Organization has met the requirements of ISO/IEC 17025:2005 "General Requirements for the competence of Testing and Calibration Laboratories" and the DoD Quality Systems Manual for Environmental Laboratories Version 5.0 July 2013 and is accredited is accordance with the:

United States Department of Defense
Environmental Laboratory Accreditation Program
(DoD-ELAP)

This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (as outlined by the joint ISO-ILAC-IAF Communiqué dated January 2009):

This accreditation demonstrates technical competence for the defined scope:
Environmental Testing
(As detailed in the supplement)

Accreditation claims for such testing and/or calibration services shall only be made from addresses referenced within this certificate. This Accreditation is granted subject to the system rules governing the Accreditation referred to above, and the Organization hereby covenants with the Accreditation body's duty to observe and comply with the said rules.

For PJLA:

Tracy Szerszen
President/Operations Manager

Perry Johnson Laboratory
Accreditation, Inc. (PJLA)
755 W. Big Beaver, Suite 1325
Troy, Michigan 48084

Initial Accreditation Date:	*Issue Date:*	*Expiration Date:*
January 11, 2010	December 3, 2015	February 28, 2018

Accreditation No:	*Certificate No:*
65818	L15-398

The validity of this certificate is maintained through ongoing assessments based on a continuous accreditation cycle. The validity of this certificate should be confirmed through the PJLA website: www.pjlabs.com

Page 1 of 9

Certificate of Accreditation: Supplement

ISO/IEC 17025:2005 and DoD-ELAP

ALS Environmental
2655 Park Center Drive, Suite A, Simi Valley, CA 93065
Chaney Humphrey Phone: 805-526-7161

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard Method	Technology	Analyte
Air	ASTM D 1946-90	GC/TCD	Carbon Dioxide
Air	ASTM D 1946-90	GC/TCD	Carbon Monoxide
Air	ASTM D 1946-90	GC/TCD	Hydrogen
Air	ASTM D 1946-90	GC/TCD	Methane
Air	ASTM D 1946-90	GC/TCD	Nitrogen
Air	ASTM D 1946-90	GC/TCD	Oxygen
Air	EPA 3C	GC/TCD	Carbon Dioxide
Air	EPA 3C	GC/TCD	Methane
Air	EPA 3C	GC/TCD	Nitrogen
Air	EPA 3C	GC/TCD	Oxygen
Air	EPA TO-15	GC/MS	1,1,1-Trichloroethane
Air	EPA TO-15	GC/MS	1,1,2,2-Tetrachloroethane
Air	EPA TO-15	GC/MS	1,1,2-Trichloroethane
Air	EPA TO-15	GC/MS	1,1-Dichloroethane
Air	EPA TO-15	GC/MS	1,1-Dichloroethene
Air	EPA TO-15	GC/MS	1,2,3-Trimethylbenzene
Air	EPA TO-15	GC/MS	1,2,4-Trichlorobenzene
Air	EPA TO-15	GC/MS	1,2,4-Trimethylbenzene
Air	EPA TO-15	GC/MS	1,2 Dibromo-3-Chloropropane
Air	EPA TO-15	GC/MS	1,2-Dibromoethane
Air	EPA TO-15	GC/MS	1,2-Dichloro-1,1,2,2-tetrafluoroethane (Freon 114)
Air	EPA TO-15	GC/MS	1,2-Dichlorobenzene
Air	EPA TO-15	GC/MS	1,2-Dichloroethane
Air	EPA TO-15	GC/MS	1,2-Dichloropropane
Air	EPA TO-15	GC/MS	1,3,5-Trimethylbenzene
Air	EPA TO-15	GC/MS	1,3-Butadiene
Air	EPA TO-15	GC/MS	1,3-Dichlorobenzene
Air	EPA TO-15	GC/MS	1,4-Dichlorobenzene
Air	EPA TO-15	GC/MS	1,4-Dioxane
Air	EPA TO-15	GC/MS	1-Butanol
Air	EPA TO-15	GC/MS	2-Butanone (MEK)
Air	EPA TO-15	GC/MS	2-Hexanone
Air	EPA TO-15	GC/MS	3-Ethyltoluene
Air	EPA TO-15	GC/MS	4-Ethyltoluene
Air	EPA TO-15	GC/MS	4-Methyl-2-Pentanone
Air	EPA TO-15	GC/MS	Acetone

Issue: 12/2015 *This supplement is in conjunction with certificate #L15-398* *Page 2 of 9*

Certificate of Accreditation: Supplement

ISO/IEC 17025:2005 and DoD-ELAP

PJLA

ALS Environmental

2655 Park Center Drive, Suite A, Simi Valley, CA 93065
Chancy Humphrey Phone: 805-526-7161

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard Method	Technology	Analyte
Air	EPA TO-15	GC/MS	Acetonitrile
Air	EPA TO-15	GC/MS	Acrolein
Air	EPA TO-15	GC/MS	Acrylonitrile
Air	EPA TO-15	GC/MS	Allyl Chloride
Air	EPA TO-15	GC/MS	alpha-Methylstyrene
Air	EPA TO-15	GC/MS	alpha-Pinene
Air	EPA TO-15	GC/MS	Benzene
Air	EPA TO-15	GC/MS	Benzyl Chloride
Air	EPA TO-15	GC/MS	Bromodichloromethane
Air	EPA TO-15	GC/MS	Bromoform
Air	EPA TO-15	GC/MS	Bromomethane
Air	EPA TO-15	GC/MS	Carbon Disulfide
Air	EPA TO-15	GC/MS	Carbon Tetrachloride
Air	EPA TO-15	GC/MS	Chlorobenzene
Air	EPA TO-15	GC/MS	Chloroethane
Air	EPA TO-15	GC/MS	Chloroform
Air	EPA TO-15	GC/MS	Chloromethane
Air	EPA TO-15	GC/MS	cis-1,2-Dichloroethene
Air	EPA TO-15	GC/MS	cis-1,3-Dichloropropene
Air	EPA TO-15	GC/MS	Cumene
Air	EPA TO-15	GC/MS	Cyclohexane
Air	EPA TO-15	GC/MS	Cyclohexanone
Air	EPA TO-15	GC/MS	Dibromochloromethane
Air	EPA TO-15	GC/MS	Dichlorodifluoromethane (CFC 12)
Air	EPA TO-15	GC/MS	Diisopropyl Ether
Air	EPA TO-15	GC/MS	d-Limonene
Air	EPA TO-15	GC/MS	Ethanol
Air	EPA TO-15	GC/MS	Ethyl Acetate
Air	EPA TO-15	GC/MS	Ethyl-tert-Butyl Ether
Air	EPA TO-15	GC/MS	Ethylbenzene
Air	EPA TO-15	GC/MS	Hexachlorobutadiene
Air	EPA TO-15	GC/MS	Isooctane
Air	EPA TO-15	GC/MS	Isopropyl acetate
Air	EPA TO-15	GC/MS	Isopropyl Alcohol
Air	EPA TO-15	GC/MS	m-&, p-Xylenes
Air	EPA TO-15	GC/MS	Methyl Methacrylate

Issue: 12/2015 *This supplement is in conjunction with certificate #L15-398* *Page 3 of 9*

Certificate of Accreditation: Supplement

ISO/IEC 17025:2005 and DoD-ELAP

PJLA

ALS Environmental

2655 Park Center Drive, Suite A, Simi Valley, CA 93065
Chaney Humphrey Phone: 805-526-7161

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard Method	Technology	Analyte
Air	EPA TO-15	GC/MS	Methyl tert-Butyl Ether
Air	EPA TO-15	GC/MS	Methylene Chloride
Air	EPA TO-15	GC/MS	Naphthalene
Air	EPA TO-15	GC/MS	n-Butyl Acetate
Air	EPA TO-15	GC/MS	n-Butylbenzene
Air	EPA TO-15	GC/MS	n-Decane
Air	EPA TO-15	GC/MS	n-Dodecane
Air	EPA TO-15	GC/MS	n-Heptane
Air	EPA TO-15	GC/MS	n-Hexane
Air	EPA TO-15	GC/MS	n-Nonane
Air	EPA TO-15	GC/MS	o-Xylene
Air	EPA TO-15	GC/MS	sec-Butylbenzene
Air	EPA TO-15	GC/MS	tert-Amyl Methyl Ether
Air	EPA TO-15	GC/MS	tert-Butanol
Air	EPA TO-15	GC/MS	Tetrachloroethene
Air	EPA TO-15	GC/MS	trans-1,3-Dichloropropene
Air	EPA TO-15	GC/MS	Trichlorotrifluoroethane
Air	EPA TO-15	GC/MS	Vinyl Chloride
Air	EPA TO-15	GC/MS	2-Ethyltoluene
Air	EPA TO-15	GC/MS	n-Octane
Air	EPA TO-15	GC/MS	n-Propylbenzene
Air	EPA TO-15	GC/MS	n-Undecane
Air	EPA TO-15	GC/MS	p-Isopropyltoluene
Air	EPA TO-15	GC/MS	Propene
Air	EPA TO-15	GC/MS	Styrene
Air	EPA TO-15	GC/MS	tert-Butylbenzene
Air	EPA TO-15	GC/MS	Tetrahydrofuran
Air	EPA TO-15	GC/MS	Toluene
Air	EPA TO-15	GC/MS	trans-1,2-Dichloroethene
Air	EPA TO-15	GC/MS	Trichloroethene
Air	EPA TO-15	GC/MS	Trichlorofluoromethane
Air	EPA TO-15	GC/MS	Vinyl Acetate
Air	Simi Valley SOP VOA-EPA3C	GC/TCD	Carbon Dioxide
Air	Simi Valley SOP VOA-EPA 3C	GC/TCD	Carbon Monoxide
Air	Simi Valley SOP VOA-EPA 3C	GC/TCD	Hydrogen
Air	Simi Valley SOP VOA-EPA 3C	GC/TCD	Methane

Issue: 12/2015 *This supplement is in conjunction with certificate #L15-398* *Page 4 of 9*

Certificate of Accreditation: Supplement

ISO/IEC 17025:2005 and DoD-ELAP

ALS Environmental

2655 Park Center Drive, Suite A, Simi Valley, CA 93065
Chaney Humphrey Phone: 805-526-7161

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard Method	Technology	Analyte
Air	Simi Valley SOP VOA-EPA 3C	GC/TCD	Nitrogen
Air	Simi Valley SOP VOA-EPA 3C	GC/TCD	Oxygen
Air	Simi Valley SOP VOA TO-15	GC/MS	1,1,1-Trichloroethane
Air	Simi Valley SOP VOA TO-15	GC/MS	1,1,2,2-Tetrachloroethane
Air	Simi Valley SOP VOA TO-15	GC/MS	1,1,2-Trichloroethane
Air	Simi Valley SOP VOA TO-15	GC/MS	1,1-Dichloroethane
Air	Simi Valley SOP VOA TO-15	GC/MS	1,1-Dichloroethene
Air	Simi Valley SOP VOA TO-15	GC/MS	1,2,3-Trimethylbenzene
Air	Simi Valley SOP VOA TO-15	GC/MS	1,2,4-Trichlorobenzene
Air	Simi Valley SOP VOA TO-15	GC/MS	1,2,4-Trimethylbenzene
Air	Simi Valley SOP VOA TO-15	GC/MS	1,2-Dibromo-3-Chloropropane
Air	Simi Valley SOP VOA TO-15	GC/MS	1,2-Dibromoethane
Air	Simi Valley SOP VOA TO-15	GC/MS	1,2-Dichloro-1,1,2,2-tetrafluoroethane (Freon 114)
Air	Simi Valley SOP VOA TO-15	GC/MS	1,2-Dichlorobenzene
Air	Simi Valley SOP VOA TO-15	GC/MS	1,2-Dichloroethane
Air	Simi Valley SOP VOA TO-15	GC/MS	1,2-Dichloropropane
Air	Simi Valley SOP VOA TO-15	GC/MS	1,3,5-Trimethylbenzene
Air	Simi Valley SOP VOA TO-15	GC/MS	1,3-Butadiene
Air	Simi Valley SOP VOA TO-15	GC/MS	1,3-Dichlorobenzene
Air	Simi Valley SOP VOA TO-15	GC/MS	1,4-Dichlorobenzene
Air	Simi Valley SOP VOA TO-15	GC/MS	1,4-Dioxane
Air	Simi Valley SOP VOA TO-15	GC/MS	1-Butanol
Air	Simi Valley SOP VOA TO-15	GC/MS	2-Butanone (MEK)
Air	Simi Valley SOP VOA TO-15	GC/MS	2-Ethyltoluene
Air	Simi Valley SOP VOA TO-15	GC/MS	2-Hexanone
Air	Simi Valley SOP VOA TO-15	GC/MS	3-Ethyltoluene
Air	Simi Valley SOP VOA TO-15	GC/MS	4-Ethyltoluene
Air	Simi Valley SOP VOA TO-15	GC/MS	4-Methyl-2-Pentanone
Air	Simi Valley SOP VOA TO-15	GC/MS	Acetone
Air	Simi Valley SOP VOA TO-15	GC/MS	Acetonitrile
Air	Simi Valley SOP VOA TO-15	GC/MS	Acrolein
Air	Simi Valley SOP VOA TO-15	GC/MS	Acrylonitrile
Air	Simi Valley SOP VOA TO-15	GC/MS	Allyl Chloride
Air	Simi Valley SOP VOA TO-15	GC/MS	alpha-Methylstyrene
Air	Simi Valley SOP VOA TO-15	GC/MS	alpha-Pinene

Issue: 12/2015 *This supplement is in conjunction with certificate #L15-398* *Page 5 of 9*

Certificate of Accreditation: Supplement

ISO/IEC 17025:2005 and DoD-ELAP

ALS Environmental

2655 Park Center Drive, Suite A, Simi Valley, CA 93065
Chaney Humphrey Phone: 805-526-7161

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard Method	Technology	Analyte
Air	Simi Valley SOP VOA TO-15	GC/MS	Benzene
Air	Simi Valley SOP VOA TO-15	GC/MS	Benzyl Chloride
Air	Simi Valley SOP VOA TO-15	GC/MS	Bromodichloromethane
Air	Simi Valley SOP VOA TO-15	GC/MS	Bromoform
Air	Simi Valley SOP VOA TO-15	GC/MS	Bromomethane
Air	Simi Valley SOP VOA TO-15	GC/MS	Carbon Disulfide
Air	Simi Valley SOP VOA TO-15	GC/MS	Carbon Tetrachloride
Air	Simi Valley SOP VOA TO-15	GC/MS	Chlorobenzene
Air	Simi Valley SOP VOA TO-15	GC/MS	Chloroethane
Air	Simi Valley SOP VOA TO-15	GC/MS	Chloroform
Air	Simi Valley SOP VOA TO-15	GC/MS	Chloromethane
Air	Simi Valley SOP VOA TO-15	GC/MS	cis-1,2-Dichloroethene
Air	Simi Valley SOP VOA TO-15	GC/MS	cis-1,3-Dichloropropene
Air	Simi Valley SOP VOA TO-15	GC/MS	Cumene
Air	Simi Valley SOP VOA TO-15	GC/MS	Cyclohexane
Air	Simi Valley SOP VOA TO-15	GC/MS	Cyclohexanone
Air	Simi Valley SOP VOA TO-15	GC/MS	Dibromochloromethane
Air	Simi Valley SOP VOA TO-15	GC/MS	Dichlorodifluoromethane (CFC 12)
Air	Simi Valley SOP VOA TO-15	GC/MS	Diisopropyl Ether
Air	Simi Valley SOP VOA TO-15	GC/MS	d-Limonene
Air	Simi Valley SOP VOA TO-15	GC/MS	Ethanol
Air	Simi Valley SOP VOA TO-15	GC/MS	Ethyl Acetate
Air	Simi Valley SOP VOA TO-15	GC/MS	Ethyl tert-Butyl Ether
Air	Simi Valley SOP VOA TO-15	GC/MS	Ethylbenzene
Air	Simi Valley SOP VOA TO-15	GC/MS	Hexachlorobutadiene
Air	Simi Valley SOP VOA TO-15	GC/MS	Isooctane
Air	Simi Valley SOP VOA TO-15	GC/MS	Isopropyl acetate
Air	Simi Valley SOP VOA TO-15	GC/MS	Isopropyl Alcohol
Air	Simi Valley SOP VOA TO-15	GC/MS	m-&,p-Xylenes
Air	Simi Valley SOP VOA TO-15	GC/MS	Methyl Methacrylate
Air	Simi Valley SOP VOA TO-15	GC/MS	Methyl tert-Butyl Ether
Air	Simi Valley SOP VOA TO-15	GC/MS	Methylene Chloride
Air	Simi Valley SOP VOA TO-15	GC/MS	Naphthalene
Air	Simi Valley SOP VOA TO-15	GC/MS	n-Butyl Acetate
Air	Simi Valley SOP VOA TO-15	GC/MS	n-Butylbenzene
Air	Simi Valley SOP VOA TO-15	GC/MS	n-Decane

Issue: 12/2015 *This supplement is in conjunction with certificate #L15-398* *Page 6 of 9*

Certificate of Accreditation: Supplement

ISO/IEC 17025:2005 and DoD-ELAP

ALS Environmental
2655 Park Center Drive, Suite A, Simi Valley, CA 93065
Chaney Humphrey Phone: 805-526-7161

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard Method	Technology	Analyte
Air	Simi Valley SOP VOA TO-15	GC/MS	n-Dodecane
Air	Simi Valley SOP VOA TO-15	GC/MS	n-Heptane
Air	Simi Valley SOP VOA TO-15	GC/MS	n-Hexane
Air	Simi Valley SOP VOA TO-15	GC/MS	n-Nonane
Air	Simi Valley SOP VOA TO-15	GC/MS	n-Octane
Air	Simi Valley SOP VOA TO-15	GC/MS	n-Propylbenzene
Air	Simi Valley SOP VOA TO-15	GC/MS	n-Undecane
Air	Simi Valley SOP VOA TO-15	GC/MS	o-Xylene
Air	Simi Valley SOP VOA TO-15	GC/MS	p-Isopropyltoluene
Air	Simi Valley SOP VOA TO-15	GC/MS	Propene
Air	Simi Valley SOP VOA TO-15	GC/MS	sec-Butylbenzene
Air	Simi Valley SOP VOA TO-15	GC/MS	Styrene
Air	Simi Valley SOP VOA TO-15	GC/MS	t-Butanol
Air	Simi Valley SOP VOA TO-15	GC/MS	tert-Amyl Methyl Ether
Air	Simi Valley SOP VOA TO-15	GC/MS	tert-Butylbenzene
Air	Simi Valley SOP VOA TO-15	GC/MS	Tetrachloroethene
Air	Simi Valley SOP VOA TO-15	GC/MS	Tetrahydrofuran
Air	Simi Valley SOP VOA TO-15	GC/MS	Toluene
Air	Simi Valley SOP VOA TO-15	GC/MS	trans-1,2-Dichloroethene
Air	Simi Valley SOP VOA TO-15	GC/MS	trans-1,3-Dichloropropene
Air	Simi Valley SOP VOA TO-15	GC/MS	Trichloroethene
Air	Simi Valley SOP VOA TO-15	GC/MS	Trichlorofluoromethane
Air	Simi Valley SOP VOA TO-15	GC/MS	Trichlorotrifluoroethane
Air	Simi Valley SOP VOA TO-15	GC/MS	Vinyl Acetate
Air	Simi Valley SOP VOA TO-15	GC/MS	Vinyl Chloride
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	1,1,1-Trichloroethane
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	1,1,2,2-Tetrachloroethane
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	1,1,2-Trichloroethane
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	1,1-Dichloroethane
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	1,1-Dichloroethene
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	1,2,4-Trichlorobenzene
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	1,2,4-Trimethylbenzene
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	1,2-Dibromo-3-chloropropane
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	1,2-Dibromoethane
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	1,2-Dichloro-1,1,2,2-tetrafluoroethane (CFC 114)
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	1,2-Dichlorobenzene

Issue: 12/2015 *This supplement is in conjunction with certificate #L15-398* *Page 7 of 9*

Certificate of Accreditation: Supplement

ISO/IEC 17025:2005 and DoD-ELAP

ALS Environmental
2655 Park Center Drive, Suite A, Simi Valley, CA 93065
Chaney Humphrey Phone: 805-526-7161

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard Method	Technology	Analyte
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	1,2-Dichloroethane
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	1,2-Dichloropropane
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	1,3,5-Trimethylbenzene
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	1,3-Butadiene
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	1,3-Dichlorobenzene
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	1,4-Dichlorobenzene
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	1,4-Dioxane
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	2,2,4-Trimethylpentane (Isooctane)
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	2-Butanone (MEK)
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	2-Hexanone
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	2-Propanol (Isopropyl Alcohol)
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	4-Methyl-2-pentanone
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	Acetone
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	Acetonitrile
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	Benzene
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	Bromodichloromethane
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	Bromoform
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	Carbon Disulfide
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	Carbon Tetrachloride
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	Chlorobenzene
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	Chloroethane
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	Chloroform
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	Chloromethane
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	cis-1,2-Dichloroethene
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	cis-1,3-Dichloropropene
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	Cumene
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	Cyclohexane
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	Dibromochloromethane
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	Dichlorodifluoromethane (CFC 12)
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	Ethanol
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	Ethylbenzene
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	Hexachlorobutadiene
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	m,p-Xylenes
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	Methyl tert-Butyl Ether
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	Methylene Chloride
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	Naphthalene

Issue: 12/2015 *This supplement is in conjunction with certificate #L15-398* *Page 8 of 9*

Certificate of Accreditation: Supplement

ISO/IEC 17025:2005 and DoD-ELAP

ALS Environmental

2655 Park Center Drive, Suite A, Simi Valley, CA 93065
Chaney Humphrey Phone: 805-526-7161

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard Method	Technology	Analyte
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	n-Heptane
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	n-Hexane
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	n-Octane
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	o-Xylene
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	Styrene
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	Tetrachloroethene
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	Tetrahydrofuran (THF)
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	Toluene
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	trans-1,2-Dichloroethene
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	trans-1,3-Dichloropropene
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	Trichloroethene
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	Trichlorofluoromethane
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	Trichlorotrifluoroethane
Air	Simi Valley SOP VOA TO-17/EPA TO-17	GC/MS	Vinyl Chloride
Air	Simi Valley SOP VOA-TO3C1C6	GC/FID	C1 - C6+
Air	Simi Valley SOP VOA-TO3C1C6	GC/FID	Ethane
Air	Simi Valley SOP VOA-TO3C1C6	GC/FID	Methane
Air	Simi Valley SOP VOA-TO3C1C6	GC/FID	n-Butane
Air	Simi Valley SOP VOA-TO3C1C6	GC/FID	n-Hexane
Air	Simi Valley SOP VOA-TO3C1C6	GC/FID	n-Pentane
Air	Simi Valley SOP VOA-TO3C1C6	GC/FID	Propane
Air	Simi Valley SOP VOA-TO3C1C6	GC/FID	Total Volatile Petroleum Hydrocarbons (TVPH) as Hexane
Air	Simi Valley SOP VOA-TPHG_TO3	GC/FID	Total Petroleum Hydrocarbons Gasoline (TPHG)
Aqueous	RSK 175	GC/TCD	Carbon Dioxide
Aqueous	RSK 175	GC/FID	Ethane
Aqueous	RSK 175	GC/FID	Ethene
Aqueous	RSK 175	GC/FID	Methane

Issue: 12/2015 *This supplement is in conjunction with certificate #L15-398* *Page 9 of 9*

OREGON

Environmental Laboratory Accreditation Program

NELAP Recognized

ALS Environmental - Simi Valley

4068

2655 Park Center Drive, Suite A
Simi Valley, CA 93065

IS GRANTED APPROVAL BY ORELAP UNDER THE 2009 TNI STANDARDS, TO PERFORM ANALYSES ON ENVIRONMENTAL SAMPLES IN MATRICES AS LISTED BELOW :

Air	*Drinking Water*	*Non Potable Water*	*Solids and Chem. Waste*	*Tissue*
Chemistry		Chemistry		

AND AS RECORDED IN THE LIST OF APPROVED ANALYTES, METHODS, ANALYTICAL TECHNIQUES, AND FIELDS OF TESTING ISSUED CONCURRENTLY WITH THIS CERTIFICATE AND REVISED AS NECESSARY.

ACCREDITED STATUS DEPENDS ON SUCCESSFUL ONGOING PARTICIPATION IN THE PROGRAM AND CONTINUED COMPLIANCE WITH THE STANDARDS.

CUSTOMERS ARE URGED TO VERIFY THE LABORATORY'S CURRENT ACCREDITATION STATUS IN OREGON.

Scott Hoatson
Oregon State Public Health Laboratory
Interim ORELAP Program Manager
3150 NW. 229th Ave, Suite 100
Hillsboro, OR 97124

EFFECTIVE DATE : 02/16/2017

EXPIRATION DATE : 02/15/2018

Certificate No : 4068 - 004

OREGON

Environmental Laboratory Accreditation Program

ORELAP Fields of Accreditation

ORELAP ID: 4068

ALS Environmental - Simi Valley
2655 Park Center Drive, Suite A
Simi Valley, CA 93065

EPA CODE: CA01627

Certificate: 4068 - 004

Issue Date: 2/16/2017 Expiration Date: 2/15/2018

As of 2/16/2017 this list supersedes all previous lists for this certificate number.

MATRIX	Reference	Code	Analyte	Code	Description
Air					
	ASTM C471M-14 2014			30002256	Gypsum and Gypsum Products
		3964	Orthorhombic Cyclooctasulfur		
	ASTM D5504-12 2012			30032270	Sulfur Compounds in Natural Gas and Gaseous Fuels by GC and Chemiluminescence
		4842	1-Propanethiol		
		6113	2,5-Dimethylthiophene		
		4544	2-Ethylthiophene		
		4843	2-Propanethiol		
		5783	3-Methylthiophene		
		4450	Carbon disulfide		
		7215	Carbonyl sulfide		
		6078	Diethyl Disulfide		
		6081	Diethyl Sulfide		
		4729	Dimethyl disulfide		
		6116	Dimethyl Sulfide		
		7506	Ethanethiol		
		3840	Hydrogen sulfide		
		3725	i-Butanethiol		
		7507	Methanethiol		
		7509	Methyl ethyl sulfide		
		9508	n-Butanethiol		
		9556	t-Butanethiol		
		9574	Tetrahydrothiophene		
		9578	Thiophene		
	EPA 325B 2013			10277437	Sorbent Tubes Coupled with Thermal Desorption and GC/MS
		9318	1,3-Butadiene		
		4375	Benzene		
		4765	Ethylbenzene		
		5240	m+p-xylene		
		5250	o-Xylene		
		5140	Toluene		
	EPA TO-10A (GC/ECD)			10247504	Pesticides and PCBs with LV PUF by GC/ECD
		7355	4,4'-DDD		
		7360	4,4'-DDE		
		7365	4,4'-DDT		
		7025	Aldrin		
		7110	alpha-BHC (alpha-Hexachlorocyclohexane)		

Department of Agriculture, Laboratory Division
Department of Environmental Quality, Laboratory Division
Oregon Health Authority, Public Health Division

1 of 7

OREGON

Environmental Laboratory Accreditation Program

ORELAP Fields of Accreditation

ORELAP ID: 4068

ALS Environmental - Simi Valley
2655 Park Center Drive, Suite A
Simi Valley, CA 93065

EPA CODE: CA01627
Certificate: 4068 - 004

Issue Date: 2/16/2017 Expiration Date: 2/15/2018

As of 2/16/2017 this list supersedes all previous lists for this certificate number.

Air	EPA TO-10A (GC/ECD)	7240	alpha-Chlordane		
		8880	Aroclor-1016 (PCB-1016)		
		8910	Aroclor-1260 (PCB-1260)		
		7115	beta-BHC (beta-Hexachlorocyclohexane)		
		7105	delta-BHC		
		7470	Dieldrin		
		7510	Endosulfan I		
		7515	Endosulfan II		
		7520	Endosulfan sulfate		
		7540	Endrin		
		7530	Endrin aldehyde		
		7535	Endrin ketone		
		7120	gamma-BHC (Lindane, gamma-HexachlorocyclohexanE)		
		7245	gamma-Chlordane		
		7685	Heptachlor		
		7690	Heptachlor epoxide		
		7810	Methoxychlor		
	EPA TO-13A			10248405	Polycyclic Aromatic Hydrocarbons in Ambient Air by GC/MS
		5500	Acenaphthene		
		5505	Acenaphthylene		
		5555	Anthracene		
		5575	Benzo(a)anthracene		
		5580	Benzo(a)pyrene		
		5590	Benzo(g,h,i)perylene		
		5600	Benzo(k)fluoranthene		
		5585	Benzo[b]fluoranthene		
		5855	Chrysene		
		5895	Dibenz(a,h) anthracene		
		6265	Fluoranthene		
		6270	Fluorene		
		6315	Indeno(1,2,3-cd) pyrene		
		5005	Naphthalene		
		6615	Phenanthrene		
		6665	Pyrene		
	EPA TO-15			10248803	VOCs collected in Canisters by GC/MS
		5160	1,1,1-Trichloroethane		
		5110	1,1,2,2-Tetrachloroethane		
		5195	1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)		
		5165	1,1,2-Trichloroethane		
		4630	1,1-Dichloroethane		

Department of Agriculture, Laboratory Division
Department of Environmental Quality, Laboratory Division
Oregon Health Authority, Public Health Division

2 of 7

OREGON

Environmental Laboratory Accreditation Program

ORELAP Fields of Accreditation

ORELAP ID: 4068

ALS Environmental - Simi Valley
2655 Park Center Drive, Suite A
Simi Valley, CA 93065

EPA CODE: CA01627
Certificate: 4068 - 004

Issue Date: 2/16/2017 Expiration Date: 2/15/2018

As of 2/16/2017 this list supersedes all previous lists for this certificate number.

Air	EPA TO-15	4640	1,1-Dichloroethylene
		5182	1,2,3-Trimethylbenzene
		5155	1,2,4-Trichlorobenzene
		5210	1,2,4-Trimethylbenzene
		4570	1,2-Dibromo-3-chloropropane (DBCP)
		4585	1,2-Dibromoethane (EDB, Ethylene dibromide)
		4695	1,2-Dichloro-1,1,2,2-tetrafluoroethane (Freon-114)
		4610	1,2-Dichlorobenzene
		4635	1,2-Dichloroethane (Ethylene dichloride)
		4655	1,2-Dichloropropane
		5215	1,3,5-Trimethylbenzene
		9318	1,3-Butadiene
		4615	1,3-Dichlorobenzene
		4620	1,4-Dichlorobenzene
		4735	1,4-Dioxane (1,4- Diethyleneoxide)
		4836	1-Propene (Propylene)
		5220	2,2,4-Trimethylpentane
		4410	2-Butanone (Methyl ethyl ketone, MEK)
		4538	2-Ethyltoluene
		4860	2-Hexanone (MBK)
		4531	3-Ethyltoluene (1-Methyl-3-ethylbenzene)
		4542	4-Ethyltoluene
		4910	4-Isopropyltoluene (p-Cymene)
		4995	4-Methyl-2-pentanone (MIBK)
		4315	Acetone
		4320	Acetonitrile
		4325	Acrolein (Propenal)
		4340	Acrylonitrile
		4355	Allyl chloride (3-Chloropropene)
		4357	alpha-Methylstyrene
		6698	alpha-Pinene
		4375	Benzene
		5635	Benzyl chloride
		4395	Bromodichloromethane
		4400	Bromoform
		4450	Carbon disulfide
		4455	Carbon tetrachloride
		4475	Chlorobenzene
		4575	Chlorodibromomethane
		4485	Chloroethane (Ethyl chloride)
		4505	Chloroform

Department of Agriculture, Laboratory Division
Department of Environmental Quality, Laboratory Division
Oregon Health Authority, Public Health Division

3 of 7

OREGON

Environmental Laboratory Accreditation Program

ORELAP Fields of Accreditation

ORELAP ID: 4068

EPA CODE: CA01627

Certificate: 4068 - 004

ALS Environmental - Simi Valley
2655 Park Center Drive, Suite A
Simi Valley, CA 93065

Issue Date: 2/16/2017 Expiration Date: 2/15/2018

As of 2/16/2017 this list supersedes all previous lists for this certificate number.

Air	EPA TO-15	4645	cis-1,2-Dichloroethylene
		4680	cis-1,3-Dichloropropene
		4555	Cyclohexane
		4560	Cyclohexanone
		4625	Dichlorodifluoromethane (Freon-12)
		9375	Di-isopropylether (DIPE)
		6208	d-Limonene
		4750	Ethanol
		4755	Ethyl acetate
		4765	Ethylbenzene
		4770	Ethyl-t-butylether (ETBE) (2-Ethoxy-2-methylpropane)
		4835	Hexachlorobutadiene
		4890	Isopropyl acetate
		4895	Isopropyl alcohol (2-Propanol, Isopropanol)
		4900	Isopropylbenzene (Cumene)
		5240	m+p-xylene
		4950	Methyl bromide (Bromomethane)
		4960	Methyl chloride (Chloromethane)
		4990	Methyl methacrylate
		5000	Methyl tert-butyl ether (MTBE)
		4975	Methylene chloride (Dichloromethane)
		5005	Naphthalene
		4425	n-Butyl alcohol (1-Butanol, n-Butanol)
		4415	n-Butyl-acetate
		4435	n-Butylbenzene
		5875	n-Decane
		6235	n-Dodecane
		4825	n-Heptane
		4855	n-Hexane
		5026	n-Nonane
		5027	n-Octane
		5090	n-Propylbenzene
		6747	n-Undecane
		5250	o-Xylene
		4440	sec-Butylbenzene
		5100	Styrene
		4370	T-amylmethylether (TAME)
		4420	tert-Butyl alcohol
		4445	tert-Butylbenzene
		5115	Tetrachloroethylene (Perchloroethylene)
		5120	Tetrahydrofuran (THF)
		5140	Toluene

Department of Agriculture, Laboratory Division
Department of Environmental Quality, Laboratory Division
Oregon Health Authority, Public Health Division

OREGON

Environmental Laboratory Accreditation Program

ORELAP Fields of Accreditation

ORELAP ID: 4068

ALS Environmental - Simi Valley
2655 Park Center Drive, Suite A
Simi Valley, CA 93065

EPA CODE: CA01627
Certificate: 4068 - 004

Issue Date: 2/16/2017 Expiration Date: 2/15/2018

As of 2/16/2017 this list supersedes all previous lists for this certificate number.

Air	EPA TO-15	4700	trans-1,2-Dichloroethylene		
		4685	trans-1,3-Dichloropropylene		
		5170	Trichloroethene (Trichloroethylene)		
		5175	Trichlorofluoromethane (Fluorotrichloromethane, Freon 11)		
		5225	Vinyl acetate		
		5235	Vinyl chloride		
		5260	Xylene (total)		
	EPA TO-17			10312206	Determination of Volatile Organic Compounds in Ambient Air Using Active Sampling Onto Sorbent Tubes
		5160	1,1,1-Trichloroethane		
		5110	1,1,2,2-Tetrachloroethane		
		5195	1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)		
		5165	1,1,2-Trichloroethane		
		4630	1,1-Dichloroethane		
		4640	1,1-Dichloroethylene		
		5155	1,2,4-Trichlorobenzene		
		5210	1,2,4-Trimethylbenzene		
		4570	1,2-Dibromo-3-chloropropane (DBCP)		
		4585	1,2-Dibromoethane (EDB, Ethylene dibromide)		
		4695	1,2-Dichloro-1,1,2,2-tetrafluoroethane (Freon-114)		
		4610	1,2-Dichlorobenzene		
		4635	1,2-Dichloroethane (Ethylene dichloride)		
		4655	1,2-Dichloropropane		
		5215	1,3,5-Trimethylbenzene		
		9318	1,3-Butadiene		
		4615	1,3-Dichlorobenzene		
		4620	1,4-Dichlorobenzene		
		4735	1,4-Dioxane (1,4- Diethyleneoxide)		
		5220	2,2,4-Trimethylpentane		
		4410	2-Butanone (Methyl ethyl ketone, MEK)		
		4860	2-Hexanone (MBK)		
		4995	4-Methyl-2-pentanone (MIBK)		
		4315	Acetone		
		4320	Acetonitrile		
		4375	Benzene		
		4395	Bromodichloromethane		
		4400	Bromoform		
		4450	Carbon disulfide		
		4455	Carbon tetrachloride		
		4475	Chlorobenzene		

Department of Agriculture, Laboratory Division
Department of Environmental Quality, Laboratory Division
Oregon Health Authority, Public Health Division

5 of 7

OREGON

Environmental Laboratory Accreditation Program

ORELAP Fields of Accreditation

ORELAP ID: 4068

ALS Environmental - Simi Valley
2655 Park Center Drive, Suite A
Simi Valley, CA 93065

EPA CODE: CA01627
Certificate: 4068 - 004

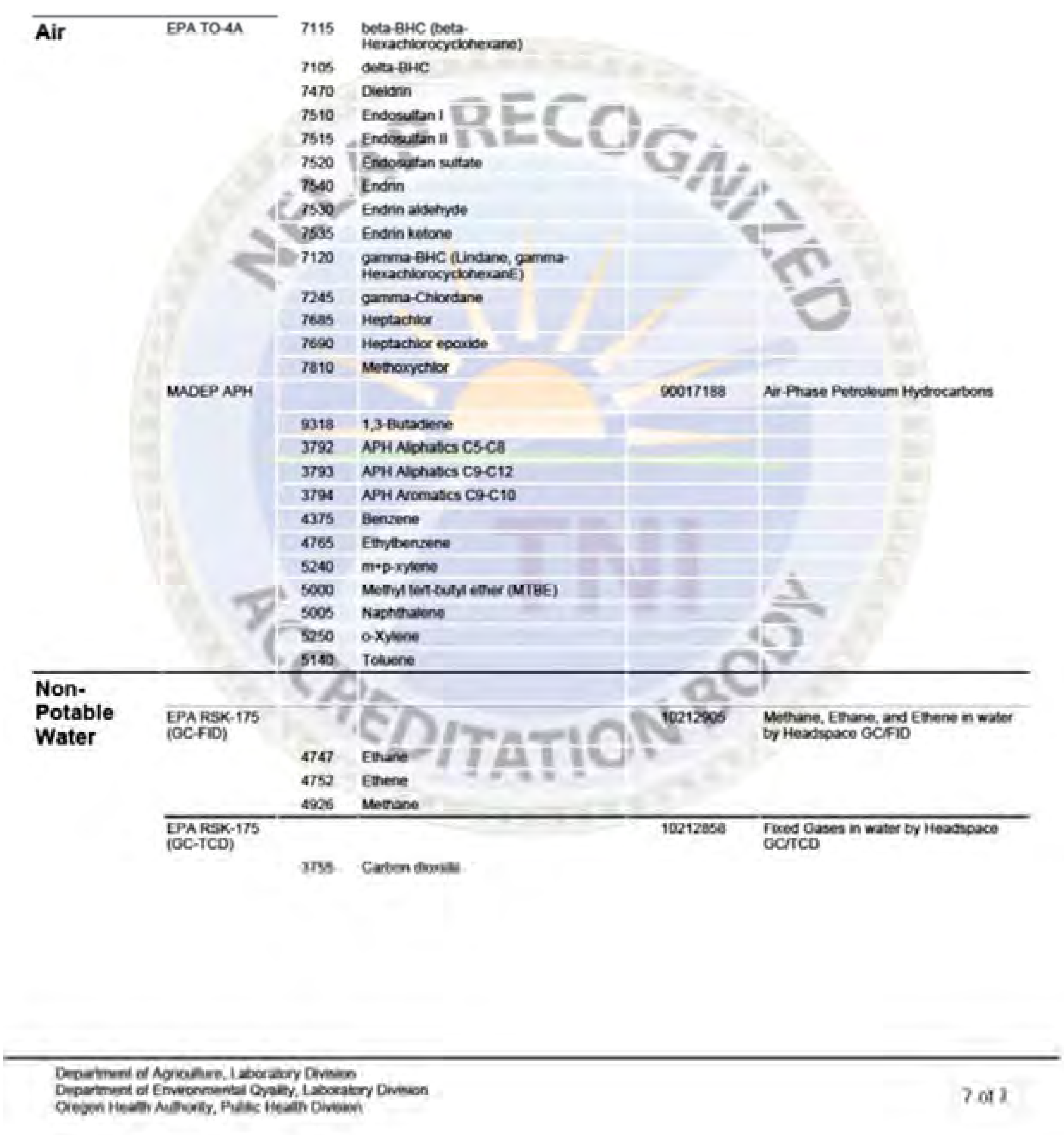
Issue Date: 2/16/2017 Expiration Date: 2/15/2018

As of 2/16/2017 this list supersedes all previous lists for this certificate number.

Air	EPA TO-17		4575	Chlorodibromomethane
			4485	Chloroethane (Ethyl chloride)
			4505	Chloroform
			4645	cis-1,2-Dichloroethylene
			4680	cis-1,3-Dichloropropene
			4555	Cyclohexane
			4625	Dichlorodifluoromethane (Freon-12)
			4750	Ethanol
			4765	Ethylbenzene
			4835	Hexachlorobutadiene
			4895	Isopropyl alcohol (2-Propanol, Isopropanol)
			4900	Isopropylbenzene (Cumene)
			5240	m+p-xylene
			4960	Methyl chloride (Chloromethane)
			5000	Methyl tert-butyl ether (MTBE)
			4975	Methylene chloride (Dichloromethane)
			5005	Naphthalene
			4825	n-Heptane
			4855	n-Hexane
			5027	n-Octane
			5250	o-Xylene
			5100	Styrene
			5115	Tetrachloroethylene (Perchloroethylene)
			5120	Tetrahydrofuran (THF)
			5140	Toluene
			4700	trans-1,2-Dichloroethylene
			4685	trans-1,3-Dichloropropylene
			5170	Trichloroethene (Trichloroethylene)
			5175	Trichlorofluoromethane (Fluorotrichloromethane, Freon 11)
			5235	Vinyl chloride
			5260	Xylene (total)
	EPA TO-4A	10249204		Pesticides and PCBs by HV PUF GC
			7355	4,4'-DDD
			7360	4,4'-DDE
			7365	4,4'-DDT
			7025	Aldrin
			7110	alpha-BHC (alpha-Hexachlorocyclohexane)
			7240	alpha-Chlordane
			8880	Aroclor-1016 (PCB-1016)
			8910	Aroclor-1260 (PCB-1260)

Department of Agriculture, Laboratory Division
Department of Environmental Quality, Laboratory Division
Oregon Health Authority, Public Health Division

6 of 7



Air	EPA TO-4A	7115	beta-BHC (beta-Hexachlorocyclohexane)		
		7105	delta-BHC		
		7470	Dieldrin		
		7510	Endosulfan I		
		7515	Endosulfan II		
		7520	Endosulfan sulfate		
		7540	Endrin		
		7530	Endrin aldehyde		
		7535	Endrin ketone		
		7120	gamma-BHC (Lindane, gamma-HexachlorocyclohexanE)		
		7245	gamma-Chlordane		
		7685	Heptachlor		
		7690	Heptachlor epoxide		
		7810	Methoxychlor		
	MADEP APH			90017188	Air-Phase Petroleum Hydrocarbons
		9318	1,3-Butadiene		
		3792	APH Aliphatics C5-C8		
		3793	APH Aliphatics C9-C12		
		3794	APH Aromatics C9-C10		
		4375	Benzene		
		4765	Ethylbenzene		
		5240	m+p-xylene		
		5000	Methyl tert-butyl ether (MTBE)		
		5005	Naphthalene		
		5250	o-Xylene		
		5140	Toluene		
Non-Potable Water					
	EPA RSK-175 (GC-FID)			10212906	Methane, Ethane, and Ethene in water by Headspace GC/FID
		4747	Ethane		
		4752	Ethene		
		4926	Methane		
	EPA RSK-175 (GC-TCD)			10212858	Fixed Gases in water by Headspace GC/TCD
		3755	Carbon dioxide		

Department of Agriculture, Laboratory Division
Department of Environmental Qyality, Laboratory Division
Oregon Health Authority, Public Health Division

7 of 7

APPENDIX D

EXAMPLE FIELD DATA RECORDS

DRUM MANAGEMENT RECORD

Project Site: CTS of Asheville, Inc. Superfund Site

Page ____ of ____

Project Activity: ERH installation activities

Project Number: 6252-16-2012.05

Drum ID	Date Generated	Contents	Source

FIELD INSTRUMENT CALIBRATION RECORD

Project Name: CTS of Asheville, Inc. Superfund Site

Date: ____

Project Number: 6252-16-2012.05

Name: ____

Water Quality Meter Calibration	Standard Value	Meter Value	Acceptance Criteria
Manufacturer: ____	pH: ____ SU (low)	pH: ____ SU	+/- 10% of standard
Model No.: ____	pH: ____ SU (med)	pH: ____ SU	+/- 10% of standard
Unit ID: ____	pH: ____ SU (high)	pH: ____ SU	+/- 10% of standard
	Conductivity: ____ mS/cm	Conductivity: ____ mS/cm	+/- 10% of standard
	ORP: ____ mV	ORP: ____ mV	+/- 10% of standard

Turbidity Meter Calibration	Standard Value	Meter Value	Acceptance Criteria
Manufacturer: ____	____ NTU (low)	____ NTU	+/- 10% of standard
Model No.: ____	____ NTU (med)	____ NTU	+/- 10% of standard
Unit ID: ____	____ NTU (high)	____ NTU	+/- 10% of standard
	____ NTU (high)	____ NTU	+/- 10% of standard

Photoionization Detector			Acceptance Criteria
Manufacturer: ____	Background: ____ ppmv	Meter: ____ ppmv	within 5 ppmv of Zero
Model No.: ____	Span Gas: ____ ppmv	Meter: ____ ppmv	+/- 10% of standard
Unit ID: ____			

Calibration Sources

	Source	Value	Lot Number	Expiration Date
pH (low)	____	____ SU	____	____
pH (med)	____	____ SU	____	____
pH (high)	____	____ SU	____	____
Conductivity	____	____ mS/cm	____	____
ORP:	____	____ mV	____	____
Turbidity (low)	____	____ NTU	____	____
Turbidity (med):	____	____ NTU	____	____
Turbidity (high):	____	____ NTU	____	____
Turbidity (high):	____	____ NTU	____	____
PID gas:	____	____ ppmv	____	____

NOTES:

If a meter reading is not within acceptance criteria, clean or replace probe and re-calibrate, or use a different meter if available. If project requiremen necessitate use of the instrument, clearly document on all data sheets and log book entries that the parameter was not calibrated to the acceptance criter

FIELD DATA RECORD - GROUNDWATER SAMPLING

PROJECT CTS of Asheville, Inc. Superfund Site **JOB NUMBER** 6252-16-2012 **DATE**

WELL / SAMPLE NUMBER **ACTIVITY TIME** Start End **TIME**

QC SAMPLES COLLECTED **ASSOCIATED TRIP BLANK**

WATER LEVEL / PUMP DATA

INITIAL DTW ft (toc) **FINAL DTW** ft (toc)

SCREENED INTERVAL ft (bgs) **DEPTH OF INTAKE** ft (toc)

PUMP TYPE

☐ Peristaltic

☐ Variable-speed submersible

☐ Bladder

AMOUNT PURGED gal.

PURGE DATA

TIME	DTW (ft)	PURGE RATE (L/min)	TEMP (C°)	SPECIFIC CONDUCTIVITY (mS/cm)	pH	DO (mg/L)	TURBIDITY (NTU)	ORP (mV)	COMMENTS

ANALYSES:

NOTES: **SIGNATURE:**

MONITORING WELL DEVELOPMENT DATA

Project Name: CTS of Asheville, Inc. Date: ______

Project Number: 6252-16-2012.05 Personnel: ______

Well Number: ______

Date of Installation: ______

Installation Method: ______

Screen Length: ______ feet

Stick-up ______ feet bgs

Static Water Level: ______ feet toc

1 Well Volume: ______ gallons

5 Well Volumes: ______ gallons

Depth to Sediment Before Development: ______ feet toc

Depth to Sediment After Development: ______ feet toc

Development Technique: ______

Development Equipment: ______

PARAMETER	**BEFORE**	**DURING**		**AFTER**
pH				
Temperature (°C)				
Specific Conductance (mS/cm)				

Quantity of Water Removed: ______ gallons

Character of Water After Development: ______

Additional Comments: ______

LNAPL Measurement Record

Project Site: CTS of Asheville, Inc. Superfund Site

Project Number: 6252-16-2012.05

Name of Person Completing Form: ____________

Monitoring Well ID	Depth to Top of LNAPL	Depth to Bottom of LNAPL	LNAPL Thickness	Sampled Collected?

Depths to be referenced to top of casing and measured in feet.
Thickness measurements in feet.

ROLL-OFF MANAGEMENT RECORD

Page ____ of ____

Project Site: CTS of Asheville, Inc. Superfund Site

Project Activity: ERH installation activities (soil cuttings)

Project Number: 6252-16-2012.05

Roll-Off ID	Date Generated	Haz or Non-Haz	Source Depth	Manifest ID

SOIL BORING RECORD

BORING ID

Project Name: ________________ **Drilling Contractor:** ________________
Project Number: ________________ **Equipment:** ________________
Date: ________________ **Logged By:** ________________

DEPTH (ft)	RECOVERY	STRATA/ UNIT	USCS	SOIL DESCRIPTION	PID (ppm)
	0 - 5				
1					
2					
3					
4					
5	5 - 10				
6					
7					
8					
9					
10	10 - 15				
11					
12					
13					
14					
15	15 - 20				
16					
17					
18					
19					
20	20 - 25				
21					
22					
23					
24					
25					

Recovery (%) = Run Interval / Amount Recovered **PID = photoionization detector, ppm = parts per million**
Strata/Unit = deposition/formation (e.g., fill, alluvial, floodplain, residuum, bedrock, etc.)

DEPTH TO WATER MEASUREMENT RECORD

Project Site: CTS of Asheville, Inc. Superfund Site

Project Number: 6252-16-2012

Personnel: ______________________

Date: ______________________

Monitoring Well	Depth to Water from Reference Point	Well Condition	Comments
MW-2			
MW-3			
MW-23			
MW-23A			
MW-24			
MW-24A			
MW-25			
MW-25A			
MW-26			
MW-26A			
MW-27			
MW-27A			
MW-28			
MW-28A			
MW-29			
MW-29A			
MW-30			
MW-30A			
MW-31			
MW-31A			
MW-32			
MW-32A			

Depth to water measurement in feet.

MONITORING WELL CONSTRUCTION DETAIL

CTS of Asheville, Inc. Superfund Site

Amec Foster Wheeler Project 6252-16-2012.05

WELL ID

Date of Installation:

Drilling Method:

Contractor:

Driller:

Depth to Water:

Northing:

Easting:

Completed By:

Measuring Point (MP)

Type:

Elevation (ft msl):

Item	**Depth below MP (ft)**	**Description**

Riser Pipe:

Top of Seal:

Top of Filter Pack:

Top of Screen:

Bottom of Screen:

End Cap:

Drilled Depth:

Surface Seal Type:

Backfill/Grout Type:

Riser Pipe Type:
Riser Pipe ID:

Borehole Diameter:

Type of Seal:

Screen Type:
Screen ID:
Screen Slot Size:
Screen Length:

Filter Pack Type:

Fallback/Backfill:

Notes:

AIR SAMPLING FIELD DATA RECORD

Project Name: ______________________ **Project Nubmer:** ______________________

Sampling Personnel: ______________________ **Sample ID:** ______________________

Sample Address: ______________________ **Sample Location:** ______________________

Canister ID: ______________________ **Flow Controller ID:** ______________________

Gauge ID: ______________________ **Intake Height (ft):** ______________________

	Start	**Stop**
Sample Date:	________	________
Sample Time:	________	________
Canister Vacuum ("Hg):	________	________
Outdoor Temperature (^{o}F):	________	________
Interior Temperature (^{o}F):	________	________
PID Reading (ppm):	________	________
Wind Direction:	________	________

Antecedent weather conditions:

____

Weather conditions during sample period:

____

Sketch of sampling area: