Quality Assurance Project Plan for the Brownfields Phase II Assessment of the former Willowbrook Mill Site Addendum 2A, Revision 01

United States Environmental Protection Agency (EPA) Brownfields Assessment Cooperative Agreement
Lincolnton, North Carolina

This document and work performed under this Site-Specific QAPP Addendum 2A is prepared in accordance with the EPA Region 4 Brownfields Program and the Generic QAPP document for the City of Lincolnton approved on TBD.

EPA Brownfields Cooperative Agreement BF-00D72318-0

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A3. DISTRIBUTION LIST

The following individuals will receive copies of the approved QAPP and subsequent revisions:

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- Cardno Field Team Technicians

A4. PROJECT/TASK ORGANIZATION

Cardno is responsible for conducting and overseeing the Phase II Environmental Site Assessment at former Willowbrook Mill site in Lincolnton, Lincoln County, North Carolina. The information presented in this document represents the minimum standards required for the site assessment under the Town of Lincolnton Brownfields program. A project organization chart is provided as **Appendix A**. The following are the individuals participating in the project and their specific roles and responsibilities:

Sara Janovitz, EPA Region 4 Brownfields Project Officer - The EPA Project Officer is responsible for overseeing and monitoring the grant. As part of that responsibility, he ensures the processes described in the work plan are followed and the terms and conditions of the grant are met.

Sara Janovitz, EPA Region 4 Brownfields Designated Approving Official – The Brownfields Region 4 Quality Assurance Manager's DAO provides technical assistance to the Region 4 Project Officer working on Brownfields sites. The DAO's role is to provide technical reviews of the Generic QAPPs and Site-Specific QAPP Addenda that are generated. This includes the approval of the Generic QAPP and Site-Specific QAPP Addenda and any revisions.

Laura Elam, AICP, City of Lincolnton Brownfields Project Director – The Lincolnton Brownfields Project Director is responsible for the overall strategic direction of the project. The Director ensures project activities are executed in accordance with the approved Work Plan and the Terms and Conditions of the Cooperative Agreement.

Brian Kvam, PG, Cardno Project Manager – The Project Manager will be the primary decision maker for the project and the primary user of the data to determine whether or not further action is required at the site. He will also coordinate the project activities and his specific responsibilities are:

1. Approving the QAPP and subsequent revisions in terms of Brownfields specific requirements;
2. Overall responsibility of the investigation;
3. Coordinating field and laboratory activities;
4. Conducting project activities in accordance with the QAPP and work order;
5. Validating field data;
6. Reporting to the City of Lincolnton Brownfields Project Director regarding the project status per the work order;
7. Making final project decisions with the authority to commit the necessary resources to conduct the project;
8. Instituting corrective actions for problems encountered in the field sampling activities;
9. Communicating corrective actions to the Field Team Leader to remedy problems encountered in the field and coordinating with the lab director to correct any corresponding problems encountered in the chemical analyses; and
10. Compiling documentation detailing any corrective actions.

Charles Saunders, PG, Cardno QA/QC Reviewer – The Cardno QA/QC Reviewer provides documentation audits and technical review to assist in promoting, implementing, and documenting QA compliance. The Cardno QA/QC Officer is isolated from the implementation Cardno Project Manager. This allows lateral support as a peer to the Cardno Project Manager without introducing unintentional biases from conducting the work.

Brian Kvam, PG, Cardno Field Team Leader, – The field team leader will perform the following duties:

1. Select the field sampling team;
2. Conduct the field activities per the approved QAPP and supervise the field sampling

team;

3. Distribute the approved QAPP and subsequent revisions to the members of the field sampling team;
4. Report problems in the field to the Project Manager;
5. Implement corrective actions in the field as directed by the Project Manager. Corrective actions will be documented in the field logs and provided to the Project Manager in the final report.

Cardno Field Team Technicians – These individuals will perform the actual fieldwork per the QAPP and at the direction of the Field Team Leader and Project Manager.

Pace Laboratory Project Manager – The Laboratory Project Manager is responsible for the following:

1. Coordinating the analysis of the samples and selecting the analytical team.
2. Coordinating the receipt of the samples at the laboratory.
3. Ensuring internal laboratory audits are conducted per the Laboratory's Quality Assurance Manual (QAM), and distributing the applicable sections of the QAPP and subsequent revisions to members of the analytical team.
4. Instituting corrective actions for problems encountered in the chemical analyses and reporting laboratory problems affecting the project data to the Project Manager. Corrective actions for chemical analyses will be detailed in a lab report that will be provided via electronic mail.

Air Water & Soil (AWS) [Enthalpy] Laboratories Project Manager - – The Laboratory Project Manager is responsible for the following:

1. Coordinating the analysis of the samples and the laboratory validation of the data;
2. Coordinating the receipt of the samples at the laboratory, selecting the analytical team, ensuring internal laboratory audits are conducted per the Laboratory's Quality Assurance Manual (QAM), and distributing the applicable sections of the QAPP and subsequent revisions to members of the analytical team;
3. Instituting corrective actions for problems encountered in the chemical analyses and reporting laboratory problems affecting the project data to the Cardno Project Manager and Cardno QA/QC Reviewer. Corrective actions for chemical analyses will be detailed in a QA report that will be provided via electronic and conventional mail.

A5. PROBLEM DEFINITION/BACKGROUND

The City of Lincolnton, North Carolina has been issued a Brownfields Assessment Grant under the USEPA Cooperative Agreement No. BF-00D72318-0. Funding from this grant will be utilized to conduct an environmental site assessment (ESA). The City of Lincolnton is pursuing assessment at the subject property in order to assess the possibility of historical releases, verifying remaining reported contamination, and to facilitate property transfer at the site. The proposed end use of the site includes potential light manufacturing and commercial use.

A5.1 Site Location and Description

The site is comprised of three contiguous parcels, generally located at 215 Bonview Avenue, in

a predominately residential and industrial area of Lincolnton, Lincoln County, North Carolina. The site is a former textile mill site that is currently vacant. Access to the site is provided from the north, along Bonview Avenue.

A Site Location Map, consisting of the relevant portion of the United States Geological Survey (USGS) topographic map, Lincolnton West, NC Quadrangle, is included as **Figure 1**. The aerial layout of the site and surrounding properties are depicted on **Figure 2**. The site is located with an approximate center location (decimal degrees) of 35.473019 latitude and -81.260234 longitude.

A5.2 Site Hydrogeology

According to the USGS Groundwater Atlas of the United States (2000), the primary aquifer system in the area of the subject property is the Piedmont Crystalline Rock Aquifer System. The system is composed principally of crystalline bedrock overlain by unconsolidated regolith. Included in the regolith are the following: a) saprolite, which is a layer of earthy, decomposed rock developed by weathering of the bedrock that is largest component of the regolith; b) soil that develops on the upper part of the saprolite; and c) alluvium, which is mainly confined to stream valleys. Typically, the regolith contains both saturated and unsaturated zones. Groundwater in the regolith is stored in and transmitted through openings (pores) between the soil and rock particles. Local flow systems exist within the regolith often providing preferential flow paths in coarser lenses and relic geological structural features in the weathered rock. The crystalline rocks underlying the regolith have an extremely low permeability and porosity. As a result, groundwater is typically found in interconnected vertical or horizontal fractures and within foliations in the rock itself.

Groundwater flow through the saprolite is generally controlled by primary and relic secondary porosity features. Secondary porosity features such as fractures, faults, and weathered zones dictate movement of groundwater in the transition zone. Groundwater movement is generally along short paths from interstream recharge areas to the nearest stream. Surficial groundwater flow direction in this region tends to mimic the overlying topography and is expected to have a predominate flow towards the north-northwest. Previous environmental reports conducted on the site reported a facility-wide groundwater depth of approximately 5.5 feet below ground surface (bgs).

A5.3 Current and Historic Uses of the Site

The site is currently owned by Capitol Funds, Inc., and was observed as vacant.

The subject property has been associated with nearly 10 separate textile companies, since its development as the Willowbrook Manufacturing Company in Ca. 1888. Textile and manufacturing activities appear to have ceased at the site sometime in the 1980s where the property was used for warehousing until approximately 1999. The former mill appears to have been vacant since that time.

A5.4 Previous Site Assessments

A Phase II Environmental Site Assessment (ESA) was completed for the subject property by Trigon Engineering Consultants, Inc. (Trigon). The Phase II ESA report was prepared for Miller & Martin, in Chattanooga, Tennessee, dated August 8, 1991. The assessment included the

advancement of seven soil borings, three monitoring wells, two hand-augured soil borings, and the removal of three underground storage tanks located along the southeastern portion of the site. The Phase II ESA identified the following conclusions:

- The area adjacent the former underground storage tanks (USTs) does not appear to be significantly impacted and therefore, no additional environmental assessment is recommended for this area. However, one soil sample obtained from the vicinity of the stormwater catch basin contained 160 milligrams per kilogram (mg/kg) of total petroleum hydrocarbons (TPH), which is above its respective regulatory threshold of 10 mg/kg. Therefore, a “small amount” of soil should be removed from this area, and properly remediated.

- Analytical results from the soil borings advanced throughout the remainder of the site did not identify contaminant concentrations above regulatory thresholds.

- Analytical results from the installed groundwater monitoring wells did not identify contaminant concentrations above regulatory thresholds. However, the concentrations of analytical compounds were below the practical laboratory quantitation limit. Therefore the contaminant concentrations reported were approximate values, and should be resampled.

Additionally, Cardno conducted a recent Phase I ESA on the subject property in March 2019. A summary of the findings of this report are presented below:

- As evidenced in historical Sanborn maps from 1929 - 1941, electrical transformers were historically present in the area of the current-day water tank, and were present well before regulations banning PCBs came into effect. The historical presence of these transformers is considered to be a REC.

- The site’s historical general use as a textile manufacturing facility for approximately 80 years from circa 1920 – circa 2000, is considered to be a REC.

- The presence of one (1) aboveground storage tank (AST) of approximately 100-gallon capacity in the western mechanical room is considered to be a REC.

- The presence of former boiler systems and associated petroleum storage in the southeastern boiler room is considered to be a REC.

- A former 20,000-gallon fuel oil AST was present to the west of the main mill building, near the parking area, at the time of the 1991 Trigon Phase II ESA. Based on site reconnaissance, the tank has since been removed. Though a soil boring was taken in the area during the 1991 report, no records of tank removal or closure assessment were provided to Cardno personnel, and it is possible that an undocumented petroleum release occurred between the time of the 1991 report and tank closure. The historical presence a 20,000-gallon fuel oil AST on the subject property is considered a REC.

- The extensive presence of asbestos containing materials (ACM) and lead-based paints (LBP) throughout the main mill building is considered a REC.

Cardno’s Phase I ESA also identified the following Historical RECs:

- According to information provided by EDR and an August 1991 Trigon Phase II ESA, a petroleum release occurred at the subject property in 1991 from three former fuel oil USTs

of approximately 4,000, 10,000, and 12,000-gallon capacity, respectively. During site assessment it was revealed that site soil had been impacted by historical petroleum release, showing elevated concentrations of total petroleum hydrocarbons (TPH) in the area of a former stormwater drain near the former UST location. The 1991 report indicates that the former USTs have been closed via removal from the ground. As of December 2015, the incident is considered to be "closed out." Based on a review of the provided information, Cardno personnel consider this listing to be a Historic Recognized Environmental Condition (HREC).

- The Lincolnton City Hall is located two city blocks to the southeast of the site, in an upgradient location. According to information provided by EDR, a petroleum release occurred from an above-ground generator in April 2004. During site assessment, it was revealed that site soils had been impacted with concentrations of gasoline-range organics (GRO), diesel-range organics (DRO), and oil and grease range organics (OGRO) TPH above regulatory criteria. As a remedial action, 1,700 tons of impacted soil was excavated. After the remedial action confirmation sampling revealed that the contamination had been remediated effectively. As of July 2004, the site is considered to be "closed out." Based on review of the provided information, Cardno personnel consider this listing to be a HREC.

A5.5 Contaminants of Potential Concern

Based upon environmental data gathered during Trigon's Phase II ESA, as well as findings from Cardno's Phase I ESA, contaminants of concern include volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), and the eight Resource Conservation and Recovery Act (RCRA) Metals. Additionally, the former presence of a transformer house on the subject property for at least 50 years prior to the United States ban on Polychlorinated Biphenyls (PCBs), indicates that site media have also been impacted by potential historical release of PCBs.

A5.6 Conceptual Site Model

The purpose of this Phase II ESA is to verify previously identified on-site contamination, as well as to assess potential contamination that could have originated from RECs identified in Cardno's Phase I ESA. Cardno will be collecting soil, groundwater, and sub-slab soil gas (SSSG) samples as part of this assessment.

A6. PROJECT/TASK DESCRIPTION AND SCHEDULE

This scope of work has been designed to address the RECs identified in the findings from Cardno's Phase I ESA. In addition to the laboratory analysis of surficial and subsurface soils (critical determinations); non-critical determinations, including soil lithology, and general observations will also be made to aid in the decision making process.

The scope of work described in subsequent sections will be completed in two phases.

1. The initial phase will include assessment of potentially impacted subsurface soils, groundwater, and sub-slab soil gas for presence of contamination.
2. In the final phase, the data collected will be evaluated to determine the need for a second phase of assessment to include additional soil sampling and/or the installation of temporary groundwater monitoring wells. The need for additional assessment will be evaluated with input from all project stakeholders as described in the Section A6.9 of the QAPP. If needed, additional assessment work scopes will be detailed in revisions to this QAPP.

A6.1 Sampling Plan

Soil, groundwater, and vapor phase samples will be collected in accordance with any applicable local, state, and federal laws, and the judgement of qualified Cardno personnel. If field conditions do not allow for pre-determined sampling locations to be utilized, the field team leader will utilize the Decision Tree (included in the Generic QAPP) to determine the appropriate action. All deviations and decisions will be documented in the final Phase II ESA report. Proposed soil and groundwater sample locations and are illustrated on **Figure 3**. Proposed sub-slab soil gas sample locations and are illustrated on **Figure 4**.

Table 2 provides a summary of the analysis criteria for each sample including QA/QC samples. The field staff will be provided a copy of this plan for reference while in the field. Boring (if needed) and soil sample collection activities will be conducted in accordance with the USEPA Region 4 Science and Ecosystem Support Division (SESD) Field Branches Quality System and Technical Procedures.

A6.2 Field Measurements

Seven (7) soil borings will be advanced to approximately six (6) feet bgs, or until groundwater is encountered, in order to collect a subsurface soil sample. During boring advancement, soil cores will be collected at two-foot intervals and analyzed via a Photoionization Detector (PID). Sub-surface soil samples will be collected from the sample interval at which the highest PID reading is detected. If no elevated PID readings are identified, then a sample will be collected between one (1) and five (5) feet bgs, or above the zone of saturation. Soils collected from borings will be logged according to the Unified Soil Classification System (USCS).

Temporary groundwater monitoring wells will be installed at four (4) of the soil borings and groundwater samples will be gathered from each installed well. During purging, groundwater will be screened in general accordance with environmental consulting industry standards in North Carolina and the SESD procedures. The groundwater quality parameters temperature, conductivity, pH, dissolved oxygen (DO), and turbidity will be measured and recorded during purging at maximum intervals of one measurement per standing well volume removed.

Ten (10) SSSG points will be installed throughout the basement level of the main onsite structure. These points will be sampled in general accordance to NCDEQ 2018 DWM guidance. Installation of vapor pins will be conducted in accordance to Cox-Calvin Vapor Pin® Standard Operating Procedure (SOP). These documents are included within Appendix B.

A6.3 Laboratory Testing

Based on the previously identified RECs, full reportable lists of compounds within the following analytical method categories have been identified for this assessment in the soil, SSSG, and groundwater samples, and include the following:

- VOCs by EPA Method 8260;
- SVOCs by EPA Method 8270;
- Resource Conservation and Recovery Act (RCRA) Metals by EPA Methods 6020 and 7470/7473; and
- PCBs by EPA Method 8082A

- Toxic Organics (TO-15) – vapor analysis

The listing of accredited analyses, detailing all analytes, is provided in the lab Quality Assurance Manuals (QAMs) included as **Appendix A**.

A6.4 Sub-Slab Soil Gas (Critical)

To assess potentially hazardous contaminants intruding the Subject Property, ten (10) SSSG samples will be collected from vapor pins spaced throughout the basement level of the Site. The numbers and locations of the vapor pins may vary depending upon actual conditions observed in the field at the time of the assessment activities (concrete thickness, access, etc. The proposed location of each SSSG sampling point is depicted on **Figure 4**. Subfloor conditions will be inspected prior to sampling in order to make sure that sub-slab samples are collected in the appropriate locations. Adjustments may be made in the field based on conditions.

There are no critical sampling conditions (e.g. storm event, seasonal flow conditions, etc.) under which these samples should be collected. Data from these samples will be used to determine the absence or presence of COCs in Site vapor and will identify the need for additional assessment and/or remediation.

A6.5 Soil Samples (Critical)

As a part of assessment, approximately one (1) soil sample (between 1’ - 5’ bgs) will be collected from each of the proposed soil boring location locations throughout the subject property. The numbers and locations may vary depending upon actual conditions (e.g. subsurface utilities, etc.). **Figure 3** depicts the proposed sample locations.

There are no critical sampling conditions (e.g. storm event, seasonal flow conditions, etc.) under which these data should be collected. These data will be used to determine the absence or presence of contaminants of concern (COC) in site soils and will identify the need for additional assessment and/or remediation.

A6.6 Groundwater Samples (Critical)

Groundwater samples will be collected from each temporary groundwater monitoring well (MW-1 through MW-4), as depicted on **Figure 3**.

Groundwater levels will be gauged with an electric water level meter capable of measuring the depth to the air/liquid interface to within +/- 0.01 foot. Water level measurements will be collected from all wells on the Site within a 24-hour period to ensure that the groundwater flow gradient and direction can be accurately determined and are not affected by temporal variability.

Prior to groundwater sample collection, each monitoring well will be purged via the low-flow method using a variable speed peristaltic pump and new dedicated tubing, or with a variable speed, electric submersible pump if groundwater depths prohibit the use of peristaltic pumps. Purging will continue until consistent values (i.e., less than 10% variance between consecutive readings) are obtained for dissolved oxygen (DO), specific conductivity, and temperature, and consecutive pH measurements are within ± 0.2 pH units; or, if drawdown cannot be controlled during low-flow sampling, the monitoring well formation fails to recharge (i.e. the well runs dry). Turbidity will be monitored during purging with a calibrated turbidity meter. These measurements will be collected during the purging process to ensure that representative groundwater samples are obtained.

Monitoring wells will be sampled using low-flow techniques with a variable speed peristaltic pump (or with a variable speed, electric submersible pump if groundwater depths inhibit the use of peristaltic pumps). Groundwater samples will be collected and submitted for laboratory analysis as described above. Sample bottles for VOCs will be filled first, followed by bottles for the remaining additional analyses in order of decreasing volatility. Sample containers will be supplied by the analytical laboratory, and will be pre-preserved by the laboratory in accordance with the analytical method to be performed.

A6.7 Non-Critical Determination

Non-critical determinations made during the soil boring installation/soil sample collection activities will include describing soil characteristics, such as lithology, using the Unified Soil Classification System (USCS) (from ASTM D 2487). This information will be used to supplement the critical data; it is not needed to make the decision of whether or not remediation is necessary.

Non-critical determinations made during the SSSG sample collection activities will include describing ambient air humidity, temperature, PID readings, barometric pressure and precipitation. This information will be used to supplement the critical data; it is not needed to make the decision of whether or not remediation is necessary.

A6.8 Regulatory Standards

Soil gas data will be compared to the NCDEQ Vapor Intrusion Screening Levels (VISLs) contained in the DEQ Risk Calculator – January 2021 version.

Soil sampling data will be compared to NCDEQ Maximum Soil Contaminant Concentrations (MSCCs) and non-residential preliminary site remediation goals (PSRGs) – January 2021 version.

Groundwater sampling data will be compares to NCDEQ 2L groundwater standards as well as VISLs contained in the DEQ Risk Calculator – January 2021 version.

A6.9 Data Use

Vapor phase, soil, and groundwater samples will be collected to provide analytical data site assessment. The significance and nature of impacts to the areas of concern will be determined by direct evaluation of the analytical data generated. If analytes are not detected above EPA-mandated residential and/or industrial Regional Screening Levels (RSLs), then no further action will be required.

If analytes are found above regulatory criteria in the media sampled, then the degree to which these impacts affect redevelopment of the site must be evaluated. Further assessment and/or an Analysis of Brownfields Cleanup Alternatives (ABCA), which may evaluate remedial actions and/or institutional controls, would then be recommended.

A6.10 Schedule

The anticipated start date for sample collection will be based on the final approval of this Site-Specific QAPP. The field activities will commence within 30 days of QAPP approval. Sample collection and associated field work should take approximately one day to complete. Samples will be shipped overnight to the laboratory throughout the duration of the project. Laboratory

results will be sent to the Project Manager (PM) within fourteen (14) business days of sample receipt. The draft Phase II ESA report will be completed within 30 days after receipt of the laboratory results.

A7. QUALITY OBJECTIVES AND CRITERIA FOR MEASUREMENT DATA

The project-specific data quality objectives (DQOs), detailing quantitative and qualitative objectives and limits, as well as measurement quality objectives, are included in **Table 1.**

A8. SPECIAL TRAINING REQUIREMENTS/CERTIFICATION

The following are the minimum training requirements for personnel conducting project activities. Current training records and certificates are kept in personnel files located at the respective headquarters of the project personnel. Deficiencies and the need for new training are identified during annual personnel evaluations. Personnel deficient in any of the following requirements will not conduct project activities.

Hazardous Waste Operations and Emergency Response (HAZWOPER):

The Field Team Leader will ensure that all on-site project personnel have current certificates of training for the 40-hour Occupational Safety and Health Administration (OSHA) HAZWOPER Training Class with annual 8-hour refresher courses. All personnel mobilizing to the site shall carry a Certificate of Training identification card.

Field Team Training:

Field Team Technicians are provided hands-on training in graduated phases of explaining, observing, demonstrating, and performing field sampling techniques and standard operating procedures by experienced field personnel. Additional training in field equipment technologies, quality assurance, ethics, and other skills are provided through in-house instruction, online, and external workshops and courses. Field competency is checked through personnel evaluations with direct input from the field team leaders and project managers.

Certifications:

- Assessment work must be overseen by a NC-licensed professional, and the final assessment reports will be signed and sealed by either a professional geologist (P.G.) or a professional engineer (P.E.) licensed in the State of North Carolina;

- A North Carolina-licensed driller will perform the drilling tasks for this project. Licensure of the subcontracted drilling operator will be confirmed during the solicitation for the drilling services;

- Laboratory services will be provided by North Carolina approved/licensed labs. QAMs are included in **Appendix B**.

Quality assurance training is of utmost importance for valid handling of data. As such, staff members receive QA training on an as-needed basis by taking online courses as well as attending professional training when offered.

City of Lincolnton will be responsible for ensuring that their Brownfields program personnel have

valid and current specialized training required by the OSHA regulations as a pre-requisite for site visit(s). Additional specific certifications have not been identified as necessary during the planning of this project.

A9. DOCUMENTS AND RECORDS

Documentation and Records requirements are provided under the Generic QAPP document.

B1. SAMPLING DESIGN PROCESS

The assessment will evaluate the possibility of historical release related to the former on-site industrial activities. Proposed sampling locations may be adjusted in the field based on site conditions and features. A proposed Sample Location Map for the subject property is included as **Figure 3**. **Figure 4** shows the proposed locations of the sub-slab vapor collection points. The type and number of samples required, including the rationale, locations, and sample media are provided in **Table 2**.

B1.1 Soil Sampling

Seven (7) soil samples will be collected during the Phase II ESA activities via a direct-push technology (DPT) rig using disposable cellulose acetate butyrate (CAB) core barrel liners and/or a decontaminated stainless steel hand auger.

B1.2 Groundwater Sampling

Groundwater monitoring wells will be installed in four (4) locations across the site. Monitoring wells will be installed under the direct supervision of a North Carolina certified well contractor and will be constructed in accordance with 15A NCAC 2N.0504. The borings will be installed using a rotary drill rig advancing 4.25 inch inside diameter hollow-stem augers (HSAs). The groundwater monitoring wells will be constructed using 2 inch diameter, Schedule 40, polyvinyl chloride (PVC) casing fitted with a 2 inch diameter, Schedule 40 PVC, factory milled, 0.01-inch slot size, screened section. The screened section will be at least ten feet in length and will be placed at a depth that ensures the water table will be bracketed, with the majority of the screen submerged. After placing the well screen and riser in the borehole, an artificial filter pack will be placed from the terminus of the borehole to approximately two feet above the screened section. The filter pack will be followed by a bentonite seal a minimum of two feet in thickness. The seal will be hydrated and the borehole will be sealed to a depth of approximately six inches below ground surface (bgs) using a Portland cement/bentonite grout to allow for the placement of a flush-mount, manhole-type, steel protective casing and the completion of a six inch thick, two foot by two foot, concrete well pad. The monitoring well will be fitted with a steel well tag providing, at a minimum, the well ID, total depth, screened interval, and date installed. As-built construction logs of the groundwater monitoring wells will be generated after installation and will be included in the final report.

Post installation, the monitoring wells will be developed by over-pumping and the use of a surge block (if warranted by the presence of an excessive amount of fines) until clear, relatively sediment-free water is produced. Prior to groundwater sample collection, water levels will be allowed to be stabilize for approximately 24 hours and each monitoring well will be purged with a variable speed peristaltic pump and new dedicated tubing until the monitoring well formation fails to recharge (i.e., the well runs dry) or consistent values (i.e., less than 10% variance

between consecutive readings) are obtained for pH, temperature, and specific conductivity. Turbidity will be monitored during purging with a calibrated turbidity meter.

The monitoring wells will be sampled using a variable speed peristaltic or low flow controllable submersible pump. Groundwater samples will be collected and submitted for laboratory analysis as described in Section A6. Sample containers will be supplied by the contract analytical laboratory and will be pre-preserved in accordance with the analytical method to be performed.

The laboratory will provide preservation methods for the various analytics. If needed, the results of the groundwater sampling event will determine the need for additional assessment.

B1.3 Sub-Slab Soil Gas (SSSG) Sampling

A total of ten (10) vapor pins are proposed to be installed throughout the basement level of the Subject Property. All vapor points are to be installed into a concrete slab-on-grade (SOG). A 5/8 inch carbide drillbit will be advanced approximately 0.5 inches beneath the existing slab, into the underlying soil or fill, at each location. A brass vapor pin, fitted with an air-tight silicon sleeve will driven into each hole until a tight seal is former between the concrete and metal pin.

Sampling points will be allowed to stabilize for a minimum of 20 minutes prior to sampling. All sampling points will be purged a minimum of three volumes of tube and pore space with the use of a peristaltic air-sampling pump at rate below 100 milliliters per minute (ml/min) to remove any additional ambient air that may have entered the sub-slab atmosphere. New, dedicated Teflon™ tubing will be connected to the barb fitting at the top of the pin. Tubing tightness will be tested using negative pressure and a lab-supplied vacuum gauge. Temperature, humidity, barometric pressure, and precipitation will be recorded prior to, during, and after sampling activities have occurred. Ambient air screening will be conducted at each sampling location by drawing ambient air into a PID over a period of approximately one minute and recording the range of readings occurring that specific time interval.

In order to verify the integrity of the seal, leak tests will be conducted using a shroud filled with 10 - 20% lab-grade helium gas, encasing the vapor pin assembly, sampling train, and Summa™ canister (or similar product). This shroud may be a plastic enclosure supplied by AWS Enthalpy labs, or supplied by Cardno staff. This leak test will be completed by screening soil gas with a helium detector while purging using a peristaltic pump. Prior to leak detection activities, Cardno staff will purge approximately 3 volumes of the vapor pin and sampling train at an approximate rate of 100ml/min. A leak is considered to occur when the helium concentration is greater than 10% of the concentration within the shroud. If identified, Cardno staff will remove and re-attach the vapor pin assembly, then conducting the helium leak testing procedures again. If the leak persists, the equipment utilized specifically at that location will be dismissed, and if available, replacement valves, trains, and/or pins will be applied. Field notes recorded during sampling activities will note variations in the prescribed sampling plan.

Following purging, SSSG samples will be collected into a laboratory supplied one (1) liter Summa™, or other similar brand canister at each test location. Each canister will be equipped with an in-line particulate filter and a vacuum gauge. Each flow controller will be pre-calibrated by the laboratory for an approximate sample collection rate of 100 ml/min. At each location, the

protective brass plug will be removed and the pre-calibrated flow controller will be disconnected from the canister.

Identification numbers for each canister and flow controller will be recorded. The initial canister pressure on the vacuum gauge will be recorded and compared to the lab-recorded pressure to ensure a loss of canister pressure above 10% during transit hasn't occurred. If a pressure loss of 10% the initial recording is observed prior to sampling, then the assembly will not be utilized. The SSSG sampling tube will be connected to the flow controller, the valve will be completely opened, and the start time and canister pressure will be recorded. The stop time and final vacuum pressure will also be recorded in field notes and presented on Chain of Custody forms. Additionally, prior flow controller calibration data provided by the lab will be included in the field notes.

The SSSG samples will be labelled and logged on a Chain-of-Custody form and submitted to AWS Laboratories for VOC analysis in accordance with USEPA Method TO-15.

B1.4 Quality Assurance/Quality Control Samples

Quality Assurance/Quality Control samples to be submitted for laboratory analysis will include one field blank, one duplicate soil sample, one duplicate groundwater sample, and one duplicate SSSG sample. One temperature blank per sample cooler will be provided by the laboratory. The field blank (aqueous) will be analyzed for concentrations of VOCs and SVOCs. The quality control samples will be labelled on the sample bottles and Chain-of-Custody (COC) forms as appropriate.

B1.5 Authorizations, Permits, and Clearances

On-site activities associated with this project will not commence until the proper authorizations, permits, and clearances are obtained, as applicable. These may include, but are not limited to, the following items:

- The Project Manager will ensure that the property owners have given written legal access to the property prior to accessing the properties.

- At least 72 hours prior to the field activities, the North Carolina 811, Underground Utility Locating Center will be contacted to conduct a utility survey of the subject property. Where possible, a hand auger or post-hole digger will be used for the first three to four feet of borehole advancement before initiating mechanical drilling in order to minimize the potential for hitting underground utilities. In addition, any site maps available will be reviewed and a geophysical survey will be conducted, if necessary, to locate any underground pipelines, utilities, or structures.

B2. SAMPLING AND ANALYTICAL METHODS REQUIREMENTS

To ensure that potential chemicals/contaminants of concern are identified, the samples will be analyzed for the parameters as detailed in Section A6.3. The proposed sample locations for the subject property are depicted on **Figure 3** and **Figure 4**. **Table 2** provides a summary of sample locations and analytical methods for the respective location. Based on conditions observed during implementation of the field activities, adjustments may be required to the sampling plan.

Cardno anticipates that investigation derived waste (IDW) in the form of soil cuttings from boring

installation and groundwater from well purging and sampling will be generated during the assessment activities. Profiling of the IDW will be conducted in accordance with disposal facility permit requirements, including, if necessary, Toxicity Characteristic Leaching Procedure (TCLP) testing if analytical results of soil and groundwater suggest that the materials could be deemed hazardous waste. Based on profiling, the waste will be disposed of properly.

B3. SAMPLE HANDLING AND CUSTODY REQUIREMENTS

The laboratory QAMs are provided in **Appendix B**. All other information pertaining to sample handling and custody requirements is provided in the Generic QAPP document.

B4. ANALYTICAL METHODS AND REQUIREMENTS

Once the samples are received and logged in at the laboratory, the samples will be analyzed by EPA Methods as specified in **Table 2**. The laboratory will supply results of analyses within 14 calendar days (standard turnaround time).

The laboratory will follow the procedures outlined in their QAM (**Appendix B**). The laboratory director will be responsible for overseeing the laboratory analysis and coordinating any corrective actions necessary with the Project Manager.

B5. FIELD QUALITY CONTROL REQUIREMENTS

Quality control samples will be collected during field studies for various purposes which include the isolation of site-effects (control samples) and the evaluation of field/laboratory variability (spikes and blanks, trip blanks, duplicates). One field blank, one duplicate soil sample and one duplicate groundwater sample will be collected. One temperature blank per sample cooler and one trip blank per cooler containing samples for VOC analysis will also be submitted (provided by the lab).

The equipment blank and field blanks will be analyzed for VOCs, and SVOCs. Duplicate sample analyses will mirror the analyses requested for their respective base samples. The trip blanks will be analyzed for VOCs only. Proposed blanks and duplicate samples are referenced in **Table 2**. All other field quality control requirements are provided in the Generic QAPP document.

B6. LABORATORY QUALITY CONTROL REQUIREMENTS

Laboratory QAMs are included in **Appendix B**. All other laboratory quality control requirements are provided in the Generic QAPP document.

B7. FIELD EQUIPMENT AND CORRECTIVE ACTION

This information is provided in the Generic QAPP document.

B8. LAB EQUIPMENT AND CORRECTIVE ACTION

The laboratory QAM is provided in **Appendix B**, and all other information is provided in the Generic QAPP document.

B9. ANALYTICAL SENSITIVITY AND PROJECT CRITERIA

Method detection limits and reporting limits for each analytical method are provided in the laboratory QAM in **Appendix B**. Additional information is provided in the Generic QAPP document.

B10. DATA MANAGEMENT AND DOCUMENTS

Laboratory QAMs are provided in **Appendix B**. Additional information is provided in the Generic QAPP document.

C1. ASSESSMENT AND CORRECTIVE ACTIONS

Information pertaining to Assessment and Corrective Actions is provided in the Generic QAPP document.

C2. PROJECT REPORTS

Information pertaining to project reports is provided in the Generic QAPP document.

D1. FIELD DATA EVALUATION

Information pertaining to Field Data Evaluation is provided in the Generic QAPP document.

D2. LABORATORY DATA EVALUATION

Data qualifiers are assigned by the laboratory if necessary. ESC's data evaluation process can be found in their respective QAM provided in **Appendix B**. All other information is provided in the Generic QAPP document.

D3. DATA USABILITY AND PROJECT VERIFICATION

Lab representatives will review and verify the laboratory data generated for accuracy according to their QAMs. Information on QC procedures is provided in the QAM. The QAM is provided in **Appendix B**. All other information is provided in the Generic QAPP document.

REFERENCES

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LIST OF ABBREVIATIONS

ABCA	Analysis of Brownfield Cleanup Alternatives
ACM	Asbestos containing material
AICP	American Institute of Certified Planners
AST	Aboveground Storage Tank
ASTM	American Society for Testing and Materials
BF	Brownfields
bgs	Below Ground Surface
BS	Blank Spike
BSD	Blank Spike Duplicate
BSA	Brownfields Site Assessment
BSRA	Brownfields Site Rehabilitation Agreement
BTEX	Benzene, Toluene, Ethylbenzene, and Total Xylenes
CD	Compact Disc
COC	Contaminants of Concern; Chain of Custody
CTL	Cleanup Target Levels
DAO	(EPA) Designated Approving Official
DEFT	Decision Error Feasibility Trials
DO	Dissolved Oxygen
DPT	Direct Push Technology
DRO	Diesel Range Organics
DQO	Data Quality Objective
e.g.	exempli gratia - for example
ECD	Electron Capture Device
EPA	United States Environmental Protection Agency
ESA	Environmental Site Assessment
FID	Flame Ionization Detector
GC	Gas Chromatography
GC-MS	Gas Chromatography – Mass Spectrometry
GIS	Geographic Information Systems
GPS	Global Positioning Satellite
GRO	Gasoline Range Organics
HAZWOPER	Hazardous Waste Operations and Emergency Response
HPLC	High Performance Liquid Chromatography
HREC	Historic Recognized Environmental Condition
ICP	Inductively Coupled Plasma
ID	Identification
IDW	Investigation derived waste
i.e.	*id est* - that is
IUPAC	International Union of Pure and Applied Chemistry
kg	kilogram
L	Liter
LBP	Lead based paint
LIMS	Laboratory Information Management System

LIST OF ABBREVIATIONS

MDLs	Method Detection Limits
mg/kg	Milligram/kilogram
MIP	Membrane Interface Probe
mL	Milliliter
MTBE	Methyl tert-butyl ether
MW	Monitor Well
MS	Matrix Spike
MSD	Matrix Spike Duplicate
NA	Not Applicable
NC	North Carolina
NELAC	National Environmental Laboratory Accreditation Conference
NCDEQ	North Carolina Department of Environmental Quality
OGRO	Oil and Grease Range Organics
ORP	Oxidation Reduction Potential
OSHA	Occupational Safety and Health Administration
OVA	Organic Vapor Analyzer
PAHs	Polycyclic Aromatic Hydrocarbons
PCBs	Polyclorinated Biphenyls
PE	Performance Evaluation
P.E.	Professional Engineer
P.G.	Professional Geologist
PID	Photo-ionization Detector
PM	Program Manager
P.O.	Post Office
PQLs	Practical Quantification Limits
QA	Quality Assurance
QAM	Quality Assurance Manual
QAP	Quality Assurance Plan
QAPP	Quality Assurance Project Plan
QC	Quality Control
RAP	Remedial Action Plan
RCRA	Resource Conservation and Recovery Act
REC	Recognized Environmental Condition
RPD	Relative Percent Difference
RQAO	Regional Quality Assurance Designated Approving Official
RSL	Regional Screening Level
SC	South Carolina
SESD	Science and Ecosystem Support Division
SPLP	Synthetic Precipitate Leaching Procedures
SS	Soil Sample
SSSG	Sub-Slab Soil Gas
SW	Solid Waste
SVOC	Semi-Volatile Organic Compounds

LIST OF ABBREVIATIONS

SOP	Standard Operating Procedure
TAL	Target Analyte List
T.B.D.	To Be Determined
TCL	Target Compound List
TCLP	Toxicity Characteristic Leaching Procedure
TN	Tennessee
TPH	Total Petroleum Hydrocarbons
TQM	Total Quality Management
USCS	Unified Soil Classification System
U.S. EPA	United States Environmental Protection Agency
USGS	United States Geological Survey
UST	Underground Storage Tank
µg	microgram
ug	microgram
VA	Virginia
VOC	Volatile Organic Compounds

Tables

Table 1
Project-Specific Data Quality Objectives
for the former Willowbrook Mill
City of Lincolnton, North Carolina
Brownfield Assessment

Data Quality Objective	Project Specific Action
State Problem	Real or perceived environmental contamination exists at the subject property associated with recognized environmental conditions (*RECs*), identified as the former presence of a transformer house on the subject property, historical industrial usage, and bulk petroleum storage.
Identify the Decision	The principal objective of this investigation is to provide analytical data to evaluate potential contaminant source areas and exposure pathways. The data and data interpretation will answer the question: "Have the RECs identified on the subject property adversely impacted soil or groundwater at the site?"
Identify Inputs to the Decision	Subsurface soil samples, shallow groundwater samples, and SSSG samples will be collected to provide analytical data for site characterization as detailed in Sections A6 and B1. Samples will be analyzed for VOCs, SVOCs, RCRA 8 metals, and PCBs.
Define the Boundaries of the Study	Spatial Boundaries: The investigation will be confined to the subject property and will focus on areas and items of concern observed during previous assessment activities. Temporal Boundaries: This assessment must be completed prior the expiration of the Town's funding on September 30, 2021. Financial Boundaries: The assessment of the subject property is being conducted under USEPA Cooperative Agreement Number BF-00D72318-0 and shares funding with other high priority sites. Therefore, the investigative activities must be performed in as cost effective a manner as possible to ensure that all of the sites have adequate funding.

Data Quality Objective	Project Specific Action
Develop a Decision Rule	The significance and nature of impacts to the areas of concern will be determined by direct evaluation of the analytical data generated. If analytes are not detected or are detected in the soil samples at concentrations above EPA-mandated residential and/or industrial RSLs, then the site is eligible for no further action. If analytes are found above regulatory criteria in the soil, then the degree to which these impacts affect redevelopment of the site must be evaluated. Further assessment and/or an Analysis of Brownfields Cleanup Alternatives (*ABCA*), which may evaluate remedial actions and/or institutional controls, would then be recommended.
Specify Limits on Decision Errors	Since variance of the data cannot be estimated at this time and the number of samples is restricted by financial considerations, a confidence limit of the data cannot be established. Results of the sampling data will be reviewed by Cardno to determine if additional sampling and/or remediation will likely be required by the NCDEQ. Cardno will work with the NCDEQ to identify any areas where data gaps may exist before it can be determined how to render the subject property suitable for the intended re-use.
Optimize Design	The work plan is cost-effective and meets the needs of both the stakeholders and the regulatory authority. The scope of work is sufficient to determine levels of contamination present in different environmental media at the site and the receptors they may affect. The sampling is designed to assess areas of environmental concern having the highest probability of environmental impairment based on available information. Each planned data point has justifiable reason for collection. The design was optimized to collect sufficient data to characterize the areas of concern while staying within budget and time constraints.

Table 2
Sampling Locations and Analyses Summary
Willowbrook Mill
Lincolnton, NC

Area of Concern	Sample Schedule				
	Sample Media	Total Samples	Analyses	Rationale	Standard Operating Procedure
Duke Power Substation *(B-3)*	Soil	1	PCBs by EPA Method 8082A VOCS by EPA Method 8260 SVOCs by EPA Method 8270 RCRA 8 metals by EPA Method 6010	Assessment of subsurface soils for evidence of potential historical releases	SESDPROC-300-R4 Soil Sampling
Former UST Pit *(B-4 & B-7)*	Soil / groundwater	2	PCBs by EPA Method 8082A VOCS by EPA Method 8260 SVOCs by EPA Method 8270 RCRA 8 metals by EPA Method 6010	Verification of historical contamination and assessment of subsurface soils/groundwater of potential undocumented releases	SESDPROC-300-R4 Soil Sampling / SEDSPROC-301-R4 SEDSPROC-301-R1 Groundwater Sampling
Former 10,000 AST *(B-5)*	Soil / groundwater	1	VOCS by EPA Method 8260 SVOCs by EPA Method 8270 RCRA 8 metals by EPA Method 6010	Assessment of subsurface soils/groundwater for evidence of potential undocumented releases	SESDPROC-300-R4 Soil Sampling / SEDSPROC-301-R4 SEDSPROC-301-R1 Groundwater Sampling
Former 20,000 AST *(B-1)*	Soil / groundwater	1	VOCS by EPA Method 8260 SVOCs by EPA Method 8270 RCRA 8 metals by EPA Method 6010	Assessment of subsurface soils/groundwater for evidence of potential undocumented releases	SESDPROC-300-R4 Soil Sampling / SEDSPROC-301-R4 SEDSPROC-301-R1 Groundwater Sampling
General onsite soil conditions *(B-2)*	Soil	1	VOCS by EPA Method 8260 SVOCs by EPA Method 8270 RCRA 8 metals by EPA Method 6010	Assessment of subsurface soils for evidence of potential undocumented releases	SESDPROC-300-R4 Soil Sampling
General Sub-slab Vapor Conditions	Sub-slab vapor	10	VOCs EPA Method TO-15	Assess sub-slab vapor conditions at the site	NCDEQ DWM 2018 Guidance
General offsite soil conditions *(B-6)*	Soil / groundwater	1	VOCS by EPA Method 8260 SVOCs by EPA Method 8270 RCRA 8 metals by EPA Method 6010	Assessment of subsurface soils/groundwater for evidence of potential undocumented releases	SESDPROC-300-R4 Soil Sampling / SEDSPROC-301-R4 SEDSPROC-301-R1 Groundwater Sampling

Area of Concern	Sample Schedule				
	Sample Media	Total Samples	Analyses	Rationale	Standard Operating Procedure
SSSG Duplicate	Sub-slab Vapor	1	VOCs EPA Method TO-15	QA/QC	NCDEQ DWM 2018 Guidance
Soil Duplicate	Soil	1	VOCS by EPA Method 8260 SVOCs by EPA Method 8270 RCRA 8 metals by EPA Method 6010	QA/QC	SESDPROC-300-R4 Soil Sampling / SEDSPROC-301-R4 SEDSPROC-301-R1 Groundwater Sampling
Groundwater Duplicate	Groundwater	1	VOCS by EPA Method 8260 SVOCs by EPA Method 8270 RCRA 8 metals by EPA Method 6010	QA/QC	SESDPROC-300-R4 Soil Sampling / SEDSPROC-301-R4 SEDSPROC-301-R1 Groundwater Sampling
Field Blank	Aqueous	1	VOCs, SVOCs	QA/QC	SESDPROC-012-R4 Field Sampling Quality Control

Notes:
Number of samples may vary due to actual subsurface conditions.

Figures

Notes: Imagery from topoView (https://ngmdb.usgs.gov/topoview//viewer/#4/40.00/-100.00)

Lincolnton West Quadrangle

FIGURE 1: TOPOGRAPHIC SITE LOCATION

Former Willowbrook Mill
Lincolnton, NC

Cardno
1812 Lincoln St., Suite 301
Columbia, SC 29201
803-929-6060

Notes: Imagery from Google Earth

FIGURE 2: AERIAL SITE LAYOUT

Former Willowbrook Mill
Lincolnton, NC

Cardno
1812 Lincoln St., Suite 301
Columbia, SC 29201
803-929-6060

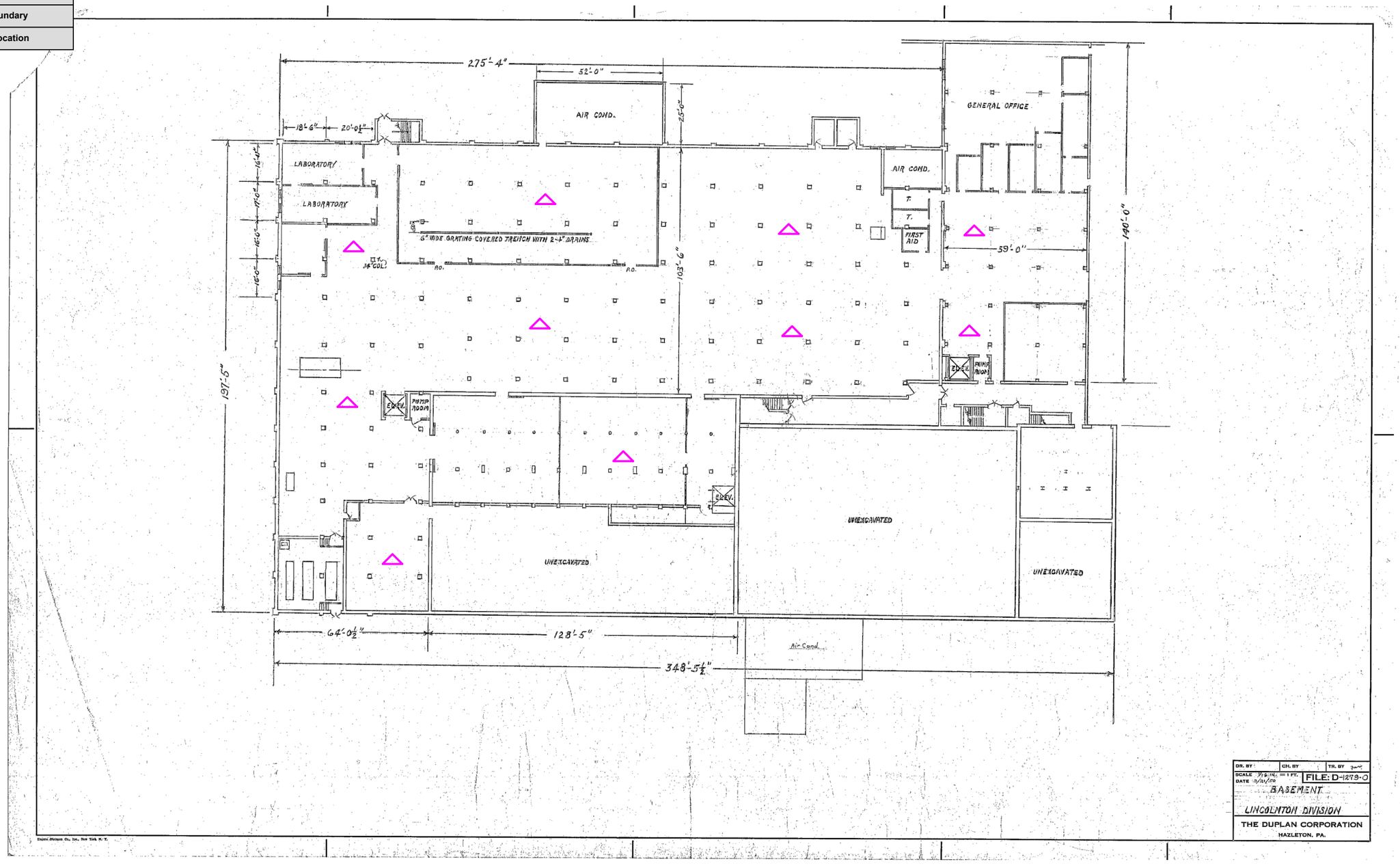
Notes: Imagery from Lincoln County, NC GIS website (https://arcgisserver.lincolncounty.org/taxparcelviewer/)

FIGURE 3: PROPOSED SAMPLE LOCATION MAP

Former Willowbrook Mill
Lincolnton, NC

Cardno
1812 Lincoln St., Suite 301
Columbia, SC 29201
803-929-6060

LEGEND	
	Approximate Property Boundary
△	Sub-slab Vapor Sample Location



Notes: Image not to scale

FIGURE 4: PROPOSED SUB-SLAB VAPOR SAMPLE LOCATION MAP

Former Willowbrook Mill
Lincolnton, NC

Cardno
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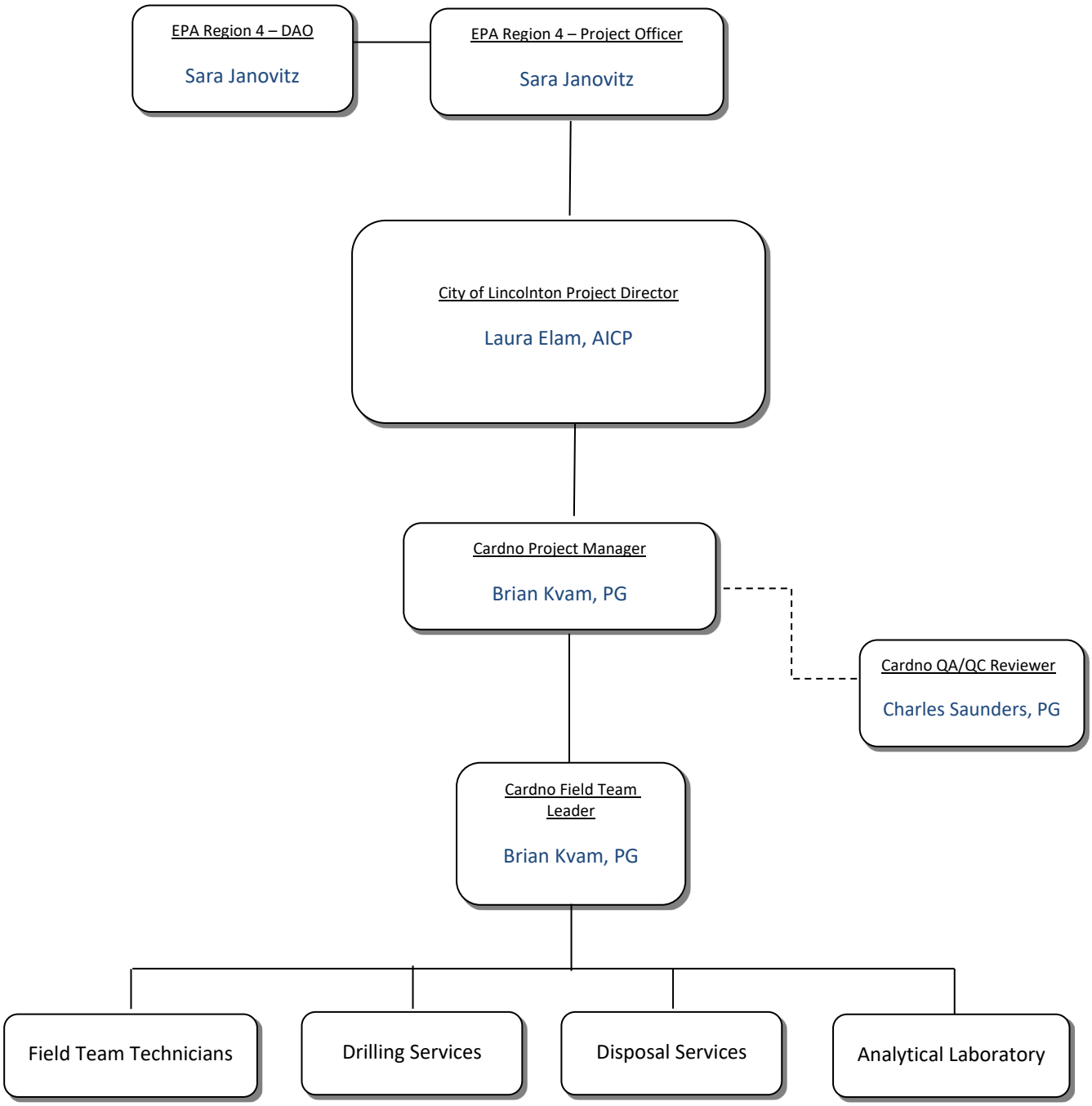
Columbia, SC 29201
803-929-6060

Appendix A
Project Organizational Chart

Project Organizational Chart



Appendix B
Laboratory QAMs

Standard Operating Procedure Installation and Extraction of the Vapor Pin™

Updated February 27, 2015

Scope:

This standard operating procedure describes the installation and extraction of the Vapor Pin™ for use in sub-slab soil-gas sampling.

Purpose:

The purpose of this procedure is to assure good quality control in field operations and uniformity between field personnel in the use of the Vapor Pin™ for the collection of sub-slab soil-gas samples or pressure readings.

Equipment Needed:

- Assembled Vapor Pin™ [Vapor Pin™ and silicone sleeve(Figure 1)]; Because of sharp edges, gloves are recommended for sleeve installation;
- Hammer drill;
- 5/8-inch (16mm) diameter hammer bit (Hilti™ TE-YX 5/8" x 22" (400 mm) #00206514 or equivalent);
- 1½-inch (38mm) diameter hammer bit (Hilti™ TE-YX 1½" x 23" #00293032 or equivalent) for flush mount applications;
- ¾-inch (19mm) diameter bottle brush;
- Wet/Dry vacuum with HEPA filter (optional);
- Vapor Pin™ installation/extraction tool;
- Dead blow hammer;
- Vapor Pin™ flush mount cover, if desired;
- Vapor Pin™ drilling guide, if desired;
- Vapor Pin™ protective cap; and
- VOC-free hole patching material (hydraulic cement) and putty knife or trowel for repairing the hole following the extraction of the Vapor Pin™.

Figure 1. Assembled Vapor Pin™

Installation Procedure:

1) Check for buried obstacles (pipes, electrical lines, etc.) prior to proceeding.

2) Set up wet/dry vacuum to collect drill cuttings.

3) If a flush mount installation is required, drill a 1½-inch (38mm) diameter hole at least 1¾-inches (45mm) into the slab. Use of a Vapor Pin™ drilling guide is recommended.

4) Drill a 5/8-inch (16mm) diameter hole through the slab and approximately 1-inch (25mm) into the underlying soil to form a void.

5) Remove the drill bit, brush the hole with the bottle brush, and remove the loose cuttings with the vacuum.

Vapor Pin™ protected under US Patent # 8,220,347 B2

6) Place the lower end of Vapor Pin™ assembly into the drilled hole. Place the small hole located in the handle of the installation/extraction tool over the Vapor Pin™ to protect the barb fitting, and tap the Vapor Pin™ into place using a dead blow hammer (Figure 2). Make sure the installation/extraction tool is aligned parallel to the Vapor Pin™ to avoid damaging the barb fitting.

Figure 2. Installing the Vapor Pin™.

During installation, the silicone sleeve will form a slight bulge between the slab and the Vapor Pin™ shoulder. Place the protective cap on Vapor Pin™ to prevent vapor loss prior to sampling (Figure 3).

Figure 3. Installed Vapor Pin™

7) For flush mount installations, cover the Vapor Pin™ with a flush mount cover, using either the plastic cover or the optional stainless-steel Secure Cover (Figure 4).

Figure 4. Secure Cover Installed

8) Allow 20 minutes or more (consult applicable guidance for your situation) for the sub-slab soil-gas conditions to re-equilibrate prior to sampling.

9) Remove protective cap and connect sample tubing to the barb fitting of the Vapor Pin™. This connection can be made using a short piece of Tygon™ tubing to join the Vapor Pin™ with the Nylaflow tubing (Figure 5). Put the Nylaflow tubing as close to the Vapor Pin as possible to minimize contact between soil gas and Tygon™ tubing.

Figure 5. Vapor Pin™ sample connection.

10) Conduct leak tests in accordance with applicable guidance. If the method of leak testing is not specified, an alternative can be the use of a water dam and vacuum pump, as described in SOP Leak Testing the Vapor Pin™ via Mechanical Means (Figure 6). For flush-mount installations, distilled water can be poured directly into the 1 1/2 inch (38mm) hole.

Figure 6. Water dam used for leak detection

11) Collect sub-slab soil gas sample or pressure reading. When finished, replace the protective cap and flush mount cover until the next event. If the sampling is complete, extract the Vapor Pin™.

Extraction Procedure:

1) Remove the protective cap, and thread the installation/extraction tool onto the barrel of the Vapor Pin™ (Figure 7). Continue turning the tool clockwise to pull the Vapor Pin™ from the hole into the installation/extraction tool.

2) Fill the void with hydraulic cement and smooth with a trowel or putty knife.

Figure 7. Removing the Vapor Pin™.

3) Prior to reuse, remove the silicone sleeve and protective cap and discard. Decontaminate the Vapor Pin™ in a hot water and Alconox® wash, then heat in an oven to a temperature of 265° F (130° C) for 15 to 30 minutes.

The Vapor Pin™ to designed be used repeatedly, however, replacement parts and supplies will be required periodically. These parts are available on-line at VaporPin.CoxColvin.com.

Region 4 U.S. Environmental Protection Agency Laboratory Services and Applied Science Division Athens, Georgia	
Operating Procedure	
Title: Soil Gas Sampling	ID: LSASDPROC-307-R4
Issuing Authority: LSASD Field Branch Chief	
Effective Date: February 7, 2020	Review Date: February 7, 2024

Purpose

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

Scope/Application

The procedures contained in this document are to be used by field personnel when collecting and handling soil gas samples in the field. On the occasion that LSASD 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 gas sample, the variant 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 does not constitute endorsement or recommendation for use.

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1 General Information

1.1 Documentation/Verification

This procedure was prepared by persons deemed technically competent by LSASD 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 LSASD 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.

1.2 General Precautions

1.2.1 Safety

Proper safety precautions must be observed when collecting soil gas samples. Refer to the LSASD 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 should 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.

1.2.2 Procedural Precautions

The following precautions should be considered when collecting soil gas samples.

1.2.2.1 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.

1.2.2.2 Samples shall be custody sealed during long-term storage or shipment.

1.2.2.3 Custody seals should not be placed on the canisters due to VOCs that may out-gas from the adhesives. Custody seals should be placed on the outside of canister shipping containers.

1.2.2.4 Sample identification tags shall be attached to the canister using wire, cable tie, or string. Adhesive labels should be affixed to the tag and not be placed directly on the canister.

1.2.2.5 Collected samples are in the custody of the sampler or sample custodian until the samples are relinquished to another party.

1.2.2.6 If samples are transported by the sampler, they will remain under his/her custody or be secured until they are relinquished.

1.2.2.7 Shipped samples shall conform to all U.S. Department of

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Transportation (DOT) and/or International Air Transportation Association (IATA) hazardous materials shipping requirements.

1.2.2.8 Documentation of field sampling is done in a bound logbook.

1.2.2.9 Chain-of-custody (COC) documents shall be filled out and remain with the samples until custody is relinquished.

1.2.2.10 Canister Sample Identification Tags and COC and Field Logbook should list the unique canister serial number and the starting time that the sample was collected.

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

2.0 Special Sampling Considerations

2.1 Special Considerations for Sampling

The tubing used as part of either of the described sampling systems should be Teflon® or stainless steel. As most current soil gas sampling will be conducted to investigate the presence or extent of organic compounds (not including PFAS compounds), Teflon® tubing is required to ensure the integrity of the sample.

Extreme care should be taken to protect all VOC sampling equipment whose surfaces will come in direct contact with the collection of the sample. For instance, a Geoprobe® or other drilling rig should not be used to carry or transport sampling equipment because of diesel and other VOC emissions. In addition, other field support vehicles should not be operated in the proximity of the sampling site shortly before or during sampling.

2.2 Special Precautions for Soil Gas Sampling

2.2.1 A clean pair of new, non-powdered, disposable gloves (gloves) will be worn each time a different location is sampled, and the gloves should be donned immediately prior to sampling. The gloves should be changed any time during sample collection when their cleanliness is compromised.

2.2.2 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.

2.2.3 Using O-rings on all PRT tooling, adapters, and probe rods will ensure that the entire sampling train is air-tight. This will prevent soil ingress during installation and to maintain sample integrity by ensuring that no ambient air is introduced into the sample during collection.

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2.3 Sample Handling Requirements

2.3.1 Soil gas samples will typically be collected by directly filling an evacuated, 6-liter passivated stainless-steel canister after sample delivery line purging.

2.3.2 The canister will be labeled and identified according to LSASD Operating Procedure for Packaging, Marking, Labeling and Shipping of Environmental and Waste Samples (LSASDPROC-209).

2.4 Quality Control

Quality control sampling for soil gas sampling investigations will consist of collection of the following types of samples, as appropriate.

2.4.1 Control Sample: If applicable to the study or investigation, a control (or background) sample should be collected from a location not affected by the possible contaminants of concern and submitted with the other samples.

2.4.2 Trip Blank: A canister trip blank, prepared prior to the investigation by LSB personnel, should follow alongside the traditional samples and be submitted with the sample set during the investigation.

2.4.3 Equipment rinsate blank: Equipment rinsate blanks should be collected if equipment, such as PRT adapters, probe rods, or other sampling equipment is field cleaned and re-used in the sample train to document that low-level contaminants were not introduced into the sample by the decontaminated equipment.

2.4.4 Field Split: Field split samples, at a minimum frequency of one for every ten samples should be collected. Split samples are collected from one single sample port or installation by attaching the center leg of a Swagelok® "Tee" to the end of the sample tubing. The remaining legs of the "Tee" are connected to two sample containers (usually two flow controllers with roughly the same calibrated flow) which are opened and filled simultaneously.

2.5 Records

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

3 Geoprobe® PRT System Installation

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3.1 General

Single event or grab sampling may be conducted using the Post-Run Tubing System (PRT). Using this system, soil gas samples can be collected quickly and with a high degree of assurance that the samples are representative of the targeted depth.

The downhole components of the PRT system include:

3.1.1 Sample delivery tubing
3.1.2 Probe rods
3.1.3 PRT Adapter
3.1.4 Expendable point holder
3.1.5 Expendable point

O-ring seals are used on the PRT Adapter and the expendable point holder. O-rings can also be used at all rod joints, preventing soil ingress which can prevent air-tight docking of the PRT adapter.

3.2 PRT System Installation Procedures

The following procedures are used to collect soil gas samples using the Geoprobe® PRT system. The PRT system is available for 1.0-inch, 1.25-inch and 1.5-inch diameter probe rods. In LSASD practice, 1.25-inch rods are used. All parts or accessories used in the PRT system must be selected with the appropriate diameter probe rod in mind to ensure compatibility of all components.

3.2.1 Ensure that the sampling location has been cleared using the procedures detailed in the Site Safety Plan. The plan should stipulate that: prior to site arrival the proposed soil gas sampling locations will be cleared using the One Call utility locating service. Upon arrival at the site each individual soil gas sampling location will be cleared using a pipe scanner and metal locater.

3.2.2 Cut a 4-foot by 4-foot section of disposable plastic sheeting and place on the ground next to the sampling location.

3.2.3 Hand auger a 4-foot deep hole using a clean stainless-steel hand auger emptying the soil cuttings on the plastic sheeting.

3.2.4 Don a clean set of gloves. To ensure there is no thread damage to the internal threads of the expendable point holder or the PRT adapter, hand screw the PRT adapter counter-clockwise into the expendable point holder using only your fingertips. The two components should screw together smoothly. If they do not replace them and repeat the test. Note: PRT fittings are left-hand threaded; turn counterclockwise to tighten.

3.2.5 Place O-ring on PRT expendable point holder and attach to initial section of probe rod.

3.2.6 Place O-ring on expendable point and press into expendable point holder.

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3.2.7 Add drive cap to probe rod and push PRT system through the augured hole into ground to the bottom of the sampling interval. Take special care to assure that the rods are in line with the push axis of the probe machine.

3.2.8 It is important to leave at least a 2-foot interval of undisturbed native soil between the augured hole and the top of the sampling interval. The native soil layer will be used to support the bentonite/soil layers described in Step 11.

3.2.9 At the bottom of the desired sampling depth, attach a point popper to an extension rod and insert extension rod string into rods so that the point popper rests on the expendable point. Using the rod puller and taking special care to maintain probe alignment with the rods, begin pulling the rods while maintaining pressure on the extension rods. The extension rods should drop when the pull is started, indicating that the expendable point has been ejected. The rods can then be pulled to expose the desired open sampling interval.

3.2.10 Using a properly decontaminated water level sounder, check, if conditions warrant, to make sure groundwater is not present at the bottom of the rod string. If groundwater is present, the sampling location should be properly abandoned, and an alternate sampling location determined. Soil gas samples should never be collected if there is a high possibility that groundwater may enter the sampling equipment. The groundwater will ruin the sampling and analysis equipment and invalidate the soil gas sample.

3.2.11 The drive rods that are contained in the augured hole will be "sealed" by first adding 12 inches of bentonite clay crumbles (not pellets) and hydrating with de-ionized water. Second, the augured hole will be filled with alternating layers of soil cuttings and hydrated bentonite clay crumbles while being hand packed with a clean stainless-steel auger handle or similar device.

3.2.12 Secure the PRT adapter to a length of Teflon® tubing sufficient to reach from the sampling interval to the surface, with several feet of excess tubing extending beyond the top of the probe rod to facilitate sampling. Straighten the first two feet of tubing above the adapter by pulling it between your thumb and forefinger. This will ease the docking of the tubing.

3.2.13 Run the tubing and adapter into the probe rod and, using steady downward pressure turn the tubing counter-clockwise to dock the adapter into the top of the expendable point holder. Tug gently on the tubing to ensure that the adapter engaged with the expendable point holder. Continue rotating the tubing until the adapter is firmly seated. Failure to dock could indicate that soil intruded during the push or that the expendable point was lost during the push.

3.2.14 At this point, the PRT system has been installed and is ready to be helium leak tested (Section 6) before sampling. If the sample cannot be collected immediately, the end of the tubing should be capped with a stainless-steel Swagelok® cap or crimped by bending over and securing with a cable tie. Sampling is conducted using one of the procedures described in Section 7.

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3.3 Decommissioning PRT Sample Locations

Because it is impractical to pump grout through the PRT adapter on the lead probe rod, the entire string of rod must be removed before decommissioning can commence. The following methods are available, depending on conditions related to sample depth and post-removal probe hole wall stability:

3.3.1 Direct Placement of Pellets or Grout - If the sampling depth was relatively shallow, on the order of ten feet or less, or the bore hole did not penetrate a water table, grouting/sealing the open hole can be accomplished by directly placing bentonite pellets, hydrated in lifts or pouring a 30% solids bentonite grout mixture from the surface. The acceptable maximum depth for this option is somewhat dependent on the stability of the hole and these methods may be used at slightly greater depths if the holes do not collapse after removal of the rod.

3.3.2 Re-entry Grouting - For locations where sampling was conducted at somewhat greater depths, where groundwater was penetrated, or where the surficial formations tend to collapse, the only viable option for grout placement may be to re-probe the entire depth with a new expendable point. After reaching the original sample depth, the expendable point is ejected and the hole is grouted by directly injecting grout through the inside of the rod string, as it is removed. Use of this option is dependent on the relative degree of hole stability.

4 Geoprobe® Permanent Soil Gas Implant Installation

4.1 General

Long-term soil gas sampling may be conducted using permanent soil gas sampling implants installed with the Geoprobe®. Stainless steel implants may be installed at any depth achievable by the Geoprobe® and may be installed using various diameters of probe rod. In LSASD practice, 2.25-inch probe rods are used. The implants may be installed in custom lengths, configured using a wide assortment of available implant lengths and connections. The implant screens are double-woven stainless steel mesh with 0.0057-inch (0.15 mm) pore openings.

Permanent soil gas sampling implants may also be installed using 2.125-inch diameter rods utilizing an advancing thin-walled corer to facilitate placement of the implant (see Geoprobe Systems, Direct Push Installation of Devices for Active Soil Gas Sampling & Monitoring, Technical Bulletin No. MK3098 for details of this application).

4.2 Installation of Permanent Soil Gas Sampling Implants (Typical)

The following procedures are used by LSASD to install a permanent soil gas sampling implant using the Geoprobe®. These are the general procedures which are used with 2.25-inch diameter probe rod.

4.2.1 Ensure that the sampling location has been cleared using the procedures detailed in the Site Safety Plan. The plan should stipulate that: prior to site arrival the proposed soil gas sampling locations will be cleared using the One Call utility locating service. Upon arrival at the site each individual soil gas sampling

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location will be cleared using a pipe scanner and metal locater.

4.2.2 Cut a 4-foot by 4-foot section of disposable plastic sheeting and place on the ground next to the sampling location.

4.2.3 Hand auger a 4-foot deep hole using a clean stainless-steel hand auger emptying the soil cuttings on the plastic sheeting.

4.2.4 Don a clean set of gloves. To ensure there is no thread damage to the internal threads of the expendable implant anchor or the implant, hand screw the implant counter-clockwise into the expendable implant anchor using only your fingertips. The two components should screw together smoothly. If they do not replace them and repeat the test. Note: implant fittings are left-hand threaded; turn counterclockwise to tighten.

4.2.5 Place o-ring on PRT expendable implant anchor and attach to initial section of probe rod.

4.2.6 Add drive cap to probe rod and push PRT system through the augured hole into ground to the bottom of the sampling interval. Take special care to assure that the rods are in line with the push axis of the probe machine. Do not retract rod or removed expendable point yet.

4.2.7 Using a properly decontaminated water level sounder, check, if conditions warrant, to make sure groundwater is not present at the bottom of the rod string. If groundwater is present, the sampling location should be properly abandoned, and an alternate sampling location determined. Soil gas samples should never be collected if there is a high possibility that groundwater may enter the sampling equipment. The groundwater will ruin the sampling and analysis equipment and invalidate the soil gas sample.

4.2.8 Install an o-ring on the docking end of the implant. Next, secure the implant to a length of 1/4"Teflon® tubing sufficient to reach from the sampling interval to the surface, with several feet of excess tubing extending beyond the top of the probe rod to facilitate sampling. Use electrical tape or a cable tie to temporarily cap the end of the tubing. Straighten the first two feet of tubing above the adapter by pulling it between your thumb and forefinger. This will ease the docking of the tubing.

4.2.9 Run the tubing and implant into the probe rod and, using steady downward pressure turn the tubing counter-clockwise to dock the adapter into the top of the expendable point holder. Tug gently on the tubing to ensure that the adapter engaged with the expendable point holder. Continue rotating tubing until the adapter is firmly seated. If docking is difficult, try running the implant and tubing thru an appropriate length of 1/2" PVC tremie pipe to better align the implant with the expendable point to facilitate docking. Remove the tremie pipe once docking is achieved. Failure to dock could indicate that soil intruded during the push or that the expendable point was lost during the push. If the implant does not dock, it is possible to salvage the installation by removing the implant and sealing the small hole on the bottom of the implant, if present, with foil or with a small sheet metal screw, then returning the implant to the hole.

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4.2.10 After the implant has been docked, use a pull cap and pull the probe rod approximately one foot while applying slight downward pressure on the tubing connected to the implant. This should start to expose the implant in the sampling interval. Take care while moving the rod and observe the tubing to make sure that the anchor and implant remained in place and is not being pulled with the rod.

4.2.11 If the implant remained in place, slowly pour a measured amount of 60-100 mesh glass beads down the inside of the probe rod. The glass beads are used as a filter pack around the implant. The implant should be covered with beads to approximately six inches above the top of the implant. The volume of beads should be calculated based on the length of implant used, alternatively, a water level sounder can be used to measure the top of the bead layer. While pouring the beads, it is advisable to gently shake the tubing to prevent the beads from bridging inside the probe rod.

4.2.12 After placing the beads, the implant is sealed using a flowable mixture of the glass beads and fine-powdered bentonite. To accomplish this, at least 6 inches of rod is pulled, and the mixture is slowly poured into the rod above the bead-packed implant. As with the bead placement, similar care should be taken to avoid bridging of this mixture.

4.2.13 After placement of the seal, the rod string is removed, and the resultant annular space is grouted using the following procedures which are dependent on the depth and stability of the open hole.

4.2.14 If the resultant open hole is shallow (ten feet or less) and the hole walls are stable, the hole may either be filled with bentonite pellets, hydrated in lifts or grouted using a 30% solids bentonite grout, poured from the surface.

4.2.15 If the hole is deeper than ten to fifteen feet, better results may be obtained by using a tremie pipe to place a pumpable grout. One half inch PVC tremie pipe or Geoprobe nylon grout tubing is threaded down the annulus to the top of the bead/bentonite seal. The tremie is pulled off the bottom to prevent jetting out the seal and grout is pumped until the annulus is filled. Procedures are similar to those for well annular seals described in LSASDGUID-101, Section 2.3.5.

4.2.16 For permanent or long-term installations, the tubing should be protected by an appropriate surface completion, such as a flush vault or well protective casing, similar to well protective casings, as described in LSASDGUID-101. After the installation of the vault, cut off the end of the tubing with the previously installed electrical tape or cable tie and cap with a stainless-steel capping fitting.

4.2.17 After installation is complete the soil gas implant is sampled using one of the methods described in Section 7.

4.2.18 Helium leak testing is not practical nor required for permanent soil gas installations.

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5 Sub-Slab Soil Gas Sampling Port Installations

5.1 General

For soil gas samples that need to be collected under a current structure, sub-slab soil gas ports should be installed. Temporary or long-term installations may be installed depending on the project needs. Stainless steel screens may be installed if loose or unconsolidated soils lie underneath the slab. Extreme care should be taken in the location of the drilled sample ports.

5.2 Installation of Temporary Sub-slab Soil Gas Sampling Ports

The following procedures are used to install a temporary sub-slab soil gas sampling port.

5.2.1 Ensure that the sampling location has been cleared using the procedures detailed in the Site Safety Plan. As most if not all of these applications will be inside, a One Call utility locating service might not help. Upon arrival at the site, each individual sub-slab sampling location should be cleared verbally and visually with a site engineer or home owner, whoever is available with the most knowledge on the structure.

5.2.2 Don a clean pair of gloves and drill in the desired location with a 1/2" masonry bit. After drilling, make sure the bit is completely through the slab either by running something rigid along the inside of the borehole to feel the slab end or by visually observing soil cuttings on or from the drill bit. Ensure there is no water in the borehole before moving on. Again, soil gas samples should never be collected if there is a high possibility that groundwater may enter the sampling equipment. The groundwater will ruin the sampling and analysis equipment and invalidate the soil gas sample. If so, choose another sample location.

5.2.3 Cut a piece of Teflon® tubing to a length of the slab thickness, plus two feet for room to reach sampling equipment. Straighten the end of the tubing and place it down the borehole to a height just above the bottom of the slab. If there is unconsolidated soil present that could potentially clog the sampling inlet, a clean stainless-steel screen can be fastened to the end of the tubing.

5.2.4 After brushing away concrete dust, a VOC-free clay or putty like media is then used to secure the tubing and create an air tight seal at the slab interface. After a leak test is conducted according to Section 6.3, the end of the sampling tube is then connected to the sampling device or crimped and secured if sampling is to happen later.

After sample collection according to a method described in Section 7, the holes are immediately abandoned by filling the borehole with cement. A slightly thin mixture of cement will ensure no bridging of the mixture as it pours and makes a more solid patch. A small diameter piece of wire is good for working cement into hole. Check the cement patch for effectiveness before leaving the site.

5.3 Installation of Permanent Sub-slab Soil Gas Sampling Ports

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The following procedures are used to install a permanent sub-slab soil gas sampling port.

5.3.1 Each sample location should be cleared to the best of the sampling team's ability following step 1 in Section 5.2 above.

5.3.2 Don a clean pair of gloves and drill in the desired location with a 1" masonry bit to a depth needed to just submerge the permanent sample port body into the concrete to have a flush final product. Finish drilling the remainder of the slab thickness with a 1/2" masonry bit. After drilling, make sure the bit is completely through the slab either by running something rigid along the inside of the borehole to feel the slab end or by visually seeing soil cuttings on the drill bit. Ensure there is no water in the borehole before moving on. If so, choose another sample location.

5.3.3 The port should be made of stainless steel with an air tight connection to a length of stainless steel 1/4" tubing long enough to reach down to just above the bottom of the slab and have a cap or plug that can make an air tight seal when left between sampling events. Again, a clean stainless-steel screen can be added to the end of the sample tube if needed to prevent soil from penetrating the sample inlet.

5.3.4 Place the permanent sample port into the drilled borehole with a piece of malleable VOC-free media to seal the hole where it narrows (to keep the cement off the sample inlet). Seal the sample port in place using anchor cement and allow to set overnight.

5.3.5 After port is set, perform a leak test as described in Section 6.3. If the sample port passes the leak test, samples may then be collected by one of the methods described in Section 7. Leak tests should be completed for every sampling event, as torquing the plug can crack the anchor cement over time.

6 Helium Leak Testing of PRT Soil Gas Sampling Installations

6.1 General

Leak testing of soil gas sampling installations should be conducted if the sampling equipment has a connection that if compromised would emit ambient air into the soil gas sample. For sub-slab soil gas sample ports, it is most important to leak test temporary sample ports as the integrity of the seal made by the malleable VOC-free media used can be easily damaged.

6.2 Helium Leak Testing Procedures for PRT Soil Gas Sampling Installations

6.2.1 The sampling system will be leak checked by inserting a 1/8" diameter Teflon® tubing into the drive rod next to the 1/4-inch diameter Teflon® sampling tubing, until it bottoms out a few inches above PRT adaptor. The 1/8" diameter tubing will be connected to a 99.999% pure helium source.

6.2.2 A second length of 1/4" Teflon® tubing will be inserted into the drive rod to a point approximately one foot below the top of the rod. The free end of this tubing will be connected to a helium meter that will monitor the helium content of the drive rod during

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the leak test.

6.2.3 The top of the drive rod and tubing will be sealed with Parafilm® to retain the helium for the leak test. The drive rod will be filled with helium to a concentration of greater than 90%, while a soil gas sample is collected into a Tedlar® bag through the 1/4" Teflon® sample tube for on-site sample analysis of helium content. When the Tedlar® bag is disconnected from the sample tubing the sample tubing is crimped and held with a rubber band or cable tie, to prevent ambient air from entering the sample tube. The helium concentration in the Tedlar® bag must be less than 10% of the helium concentration in the drive rod to insure integrity of the soil gas sampling well. When the leak test is complete, the Parafilm®, helium supply, and monitoring tubes will be removed, leaving the sample tube.

6.3 Helium Leak Testing Procedures for Sub-slab Soil Gas Sample Ports

6.3.1 The sampling system will be leak checked by covering the sample port with a shroud that can be filled from a 99.999% pure helium source. The shroud will allow two other ports where the leak check sample can be pulled and the helium concentration in the shroud can be testing similar to the set-up in Section 5.2 above.

6.3.2 The shroud will be filled with helium to a concentration of greater than 90%, while a soil gas sample is collected into a Tedlar® bag through the 1/4" Teflon® sample tube for on-site sample analysis of helium content. When the Tedlar® bag is disconnected from the sample tubing the sample tubing is crimped and held with a rubber band or cable tie, to prevent ambient air from entering the sample tube. The helium concentration in the Tedlar® bag must be less than 10% of the helium concentration in the shroud to insure integrity of the soil gas sampling port. When the leak test is complete, the shroud, helium supply, and monitoring tubes will be removed, leaving the sample tube connected to the port.

6.3.3 For temporary sub-slab sample ports, if the leak test fails, the malleable VOC-free media can be reinserted, added to, or shifted and tested again. After the sample port passes, take care in not moving or shifting the seal media before sample collection.

7 Sampling Soil Gas Installations

7.1 Soil gas samples may be collected from PRT and permanent soil gas implant installations using one of several methods, listed below. Canister sampling is the most common method utilized by LSASD.

7.1.1 Canister Sampling for Laboratory Analysis – After installation is complete and immediately prior to sampling, a flow-limiting device, consisting of a Nupro® 7-micron sintered stainless steel filter, a critical orifice and gauge is attached to an evacuated canister for sampling. A sampler leak check is conducted by plugging the inlet of the flow control device and opening the canister valve momentarily. After the valve has been closed the needle on the gauge should not move (remain at full vacuum) indicating that at the sampler is leak free.

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7.1.2 Once the PRT installation or the sub-slab sample port has passed the helium leak test as described in Section 5 and the sampler leak check has been completed, the Teflon® sample tube is connected to the flow-limiting device using a Swagelok® or other suitable secure connection. After connection, the rubber band (if used) is cut and the crimp in the Teflon® tubing straightened and the valve on the canister is opened, pulling soil gas from the implant into the canister. Typically, the sample is collected over a one-hour period (depending on soil conditions), at which time the canister valve is closed, and the canister tagged with pertinent sampling information. When using this type of device, it is advisable to check the canister vacuum throughout the sampling period to verify filling. The initial and final gauge pressure/vacuum reading should be recorded in the project logbook.

7.1.3 Real-time Field Analytical Methods – Real-time analytical measurements may be obtained from PRT, soil gas implant, or sub-slab port installations using appropriate instrumentation. The soil gas to be analyzed may be drawn directly into the instrument by the instrument pump or the instrument may be placed in line and the sample drawn into the instrument using a suitable pump connected to the discharge side of the instrument. Results may be qualitative, such as those obtained with flame ionization or photoionization detectors, or they may be quantitative, for instruments which can be calibrated to specific compounds.

8 References

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9 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 LSASD Quality Assurance Coordinator on the LSASD local area network (LAN).

History	Effective Date
LSASDPROC-307-R4, *Soil Gas Sampling*, replaces LSASDPROC-307-R3 **General:** Corrected any typographical, grammatical, and/or editorial errors. Soil gas sampling procedures were updated, and helium leak testing and sub-slab sampling procedures were added to the document. SESD updated to LSASD. **Cover Page:** Changed the Author from Tim Slagle to Landon Pruitt. Changed Enforcement and Investigation Branch to Applied Sciences Branch. Changed Science and Ecosystem Support Division to Laboratory Services and Applied Science Division. Quality manager Bobby Lewis was changed to Stacy Masters. **Revision History:** Changes were made to reflect the current practice of only including the most recent changes in the revision history.	February 7, 2020
LSASDPROC-307-R3, *Soil Gas Sampling*, replaces LSASDPROC-307-R2	May 14, 2014
LSASDPROC-307-R2, *Soil Gas Sampling*, replaces LSASDPROC-307-R1	September 8, 2010
LSASDPROC-307-R1, *Soil Gas Sampling*, replaces LSASDPROC-307-R0	November 1, 2007
LSASDPROC-307-R0, Soil Gas Sampling, Original Issue	February 05, 2007

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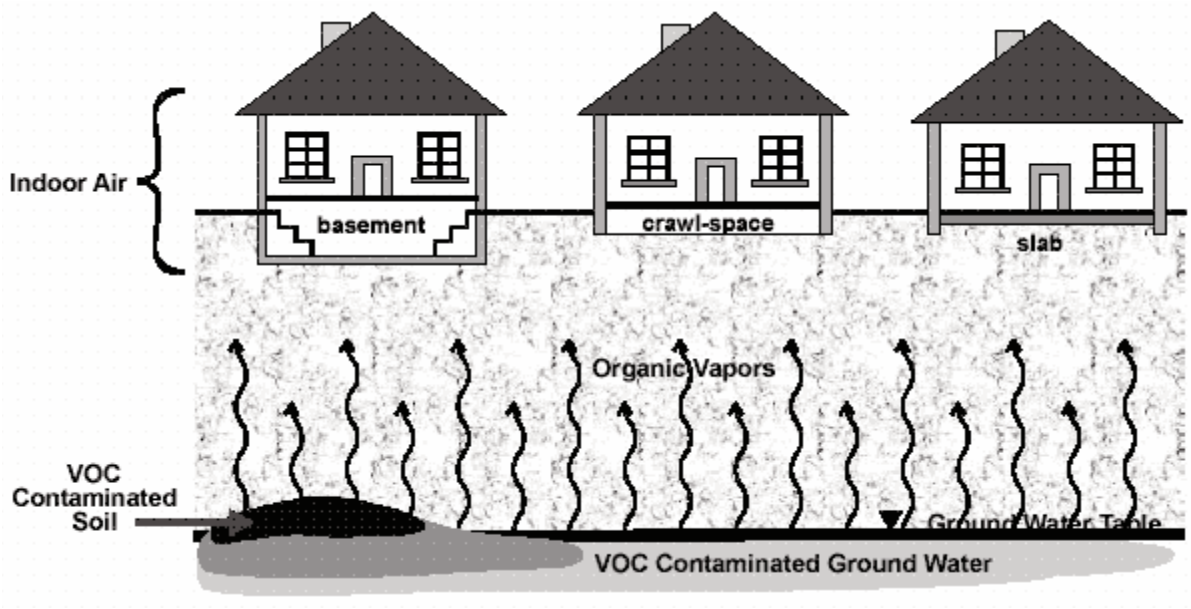
VAPOR INTRUSION GUIDANCE



DIVISION OF WASTE MANAGEMENT
NORTH CAROLINA DEPARTMENT OF ENVIRONMENTAL QUALITY

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Version 2

ACKNOWLEDGEMENTS

The Division of Waste Management (DWM) Vapor Intrusion Guidance document was developed using established guidance from U.S. EPA, the Interstate Technology and Regulatory Council (ITRC) and other states, modified for the purposes of DWM. Special thanks to New Jersey Department of Environmental Protection (DEP) for permission to use the NJ DEP's October 2005 Vapor Intrusion Guidance and subsequent updates as a template. In some instances, exact phrasing from the NJ DEP October 2005 Vapor Intrusion Guidance or other updates was used.

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APPENDICES

APPENDIX A ***ITRC Conceptual Site Model Checklist***

APPENDIX B ***Inactive Hazardous Sites Branch (IHSB) Structural Vapor Intrusion Evaluation Steps***

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ABBREVIATION LIST

ATSDR	Agency for Toxic Substances and Disease Registry
BTEX	benzene, toluene, ethylbenzene and xylenes
COC	chemicals of concern
CSM	conceptual site model
DEQ	North Carolina Department of Environmental Quality
DWM	Division of Waste Management
GC	gas chromatography
GC/MS	gas chromatography/mass spectrometry
GWSL	Groundwater Screening Level
HVAC	heating, ventilation and air conditioning
IASL	Indoor Air Screening Level
ITRC	Interstate Technology and Regulatory Council
µg/m3	microgram per cubic meter
MTBE	methyl tertiary-butyl ether
NAPL	non-aqueous phase liquid
OSHA	Occupational Safety and Health Administration
ppb	parts per billion
ppbv	parts per billion by volume
PCE	tetrachloroethylene (also called perchloroethylene)
QA/QC	quality assurance/quality control
RSL	Regional Screening Level
SGSL	Soil Gas Screening Level
SSD	Sub-slab depressurization
TCE	trichloroethene
UST	underground storage tank
USEPA	United States Environmental Protection Agency
VI	vapor intrusion
VOC	volatile organic compound(s)

1.0 PURPOSE AND APPLICABILITY

The DWM VI guidance document addresses the evaluation and mitigation of vapor intrusion (VI) issues that may be present at sites under cleanup programs in the Division of Waste Management (DWM). This document primarily addresses VI issues resulting from volatile organic compounds (VOCs). **Separate petroleum vapor intrusion guidance is being developed by the Underground Storage Tank (UST) Section for use at petroleum sites under their jurisdiction. Screening and testing for petroleum vapor intrusion (PVI) risks in adjacent structures associated with UST sites may be addressed as presented in the *Guidelines for Assessment and Corrective Action for UST Releases*, *[in development]*, based upon the Interstate Technology and Regulatory Council (ITRC) guidance on the topic entitled: *Petroleum Vapor Intrusion: Fundamentals of Screening, Investigation, and Management*, dated October 2014 (available at http://www.itrcweb.org/PetroleumVI-Guidance/). If petroleum constituents are comingled with VOCs at a site being managed by a DWM program other than the UST Section, this guidance document should be used.** If site conditions or chemical constituents vary greatly from those discussed in this guidance document, the specific cleanup program within DWM that regulates the site should be consulted on how to proceed with the VI investigation. Individual cleanup programs in DWM may have additional requirements for VI investigations; therefore, the appropriate regulatory cleanup program should always be consulted before performing a VI investigation.

The potential for current and future VI impacts shall be evaluated if volatile contaminated media are present at a site, either in a residential or nonresidential setting. In addition, this evaluation shall be considered for sites where active soil and/or groundwater remediation systems are proposed or being undertaken that may affect the potential for VI to occur.

The evaluation and mitigation of the VI pathway is an evolving science. DWM will attempt to update this document when significant advances regarding VI science occur, including methodologies, analytical procedures and associated analytical reporting limits. DWM intends to modify the screening level tables twice a year (if necessary) based on updates to the USEPA Region 3 Regional Screening (RSL) Tables used in the development of the DWM screening levels.

An excel-based Risk Calculator and User Guide is available for download from the DEQ Risk-Based Remediation website (https://deq.nc.gov/permits-rules/risk-based-remediation/risk-evaluation-resources) to determine health risks from volatile contaminants. Rather than screening individual contaminants against their respective screening level, the Risk Calculator can determine the cumulative health risk of all site contaminants from all environmental pathways, including structural vapor intrusion.

The current document, along with updates to the screening levels and other sections of the document are, or will be, presented on the DWM website at http://deq.nc.gov/about/divisions/waste-management/waste-management-permit-guidance/dwm-vapor-intrusion-guidance or by going to the North Carolina Department of Environmental Quality web site at http://deq.nc.gov and searching for vapor intrusion guidance in the search bar. The Risk Calculator will, in turn, be updated with the most recent screening levels. It is recommended that interested parties refer to the websites to ensure that they are using the most current information in the evaluation of a site.

2.0 INTRODUCTION

This document will present a brief introduction to VI, but assumes that the user will have a more in-depth knowledge of the issues related to VI. It is highly recommended that users of this document also use the following references for background information and to obtain further information regarding VI issues in general. Please note that specific investigative, screening or technical guidance in this DWM guidance document supersedes that in these reference documents.

- *Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance)* – 2002a – United States Environmental Protection Agency (USEPA)
- *Vapor Intrusion Pathway: A Practical Guideline* – 2007 – Interstate Technology and Regulatory Council (ITRC)

Any VOC-contaminated site has the potential for VI; however, sites contaminated by chlorinated solvents and petroleum releases represent the two most common VI scenarios. VI occurs when volatile chemicals with sufficient volatility (Henry's Law Constant > 10^{-5} atm m^3/mol) and toxicity are present in the subsurface and migrate from contaminated soils and/or groundwater to the indoor air of buildings. VI can occur even when the contaminated groundwater or soil is not directly beneath a building. Contaminated soil gas can travel along preferential pathways in the subsurface, including geologic formations and utility corridors, to reach buildings located away from the subsurface contaminant source. Soil gas can enter buildings new or old, whether on a slab or with a crawl space or basement.

Even if structures are not currently present, contaminated soil and groundwater can present potential VI issues for future structures.

VI is a complicated pathway to evaluate for human exposure. Buildings may have other sources of indoor air contaminants that do not result from vapor intrusion. Examples include common household cleaning products, dry-cleaned clothes, petroleum fuels, hobby supplies, paints, new carpets, and industrial chemicals used in the workplace. Additionally, changing atmospheric conditions such as wind, pressure, temperature and precipitation affect indoor air concentrations, as well as the type of structure, building characteristics, heating/air conditioning type, and other building specific parameters. Outdoor or ambient air commonly has detectable levels of VOCs, which further complicates the evaluation of VI.

2.1 Conceptual Site Model

Buildings with sensitive populations such as residences, child care facilities and schools should be identified early in the investigation and prioritized for VI evaluation

Assessing the potential for VI to indoor air should begin with visualizing a simplified version of the site or physical setting: this simplified idea, picture, or description is a conceptual site model (CSM). The CSM serves to identify currently complete or potentially complete pathways to receptors and the potential for future risks. The CSM should identify potential sources of contamination, types of contaminants and affected media, release mechanisms and potential contaminant pathways, and actual/potential human and environmental receptors.

The vapor intrusion pathway is referred to as 'complete' if three conditions are met:

- a source of hazardous vapors is present beneath a building,
- vapors form and have a pathway to migrate toward the building and,
- entry routes and driving forces for the vapors to enter the building must exist.

Figure 2-1 is an illustration of a simple, preliminary CSM for the VI pathway.

Figures, maps, flow charts, tables and graphs can be used to summarize and illustrate the overall CSM, its various components, and the associated data. These visual aids are often the most effective tools for communicating complex information to interested parties. The narrative should clarify which CSM components are site-specific, measured or known, and which include assumptions or general information. The Interstate Technology & Regulatory Council's (ITRC) document, titled Vapor Intrusion Pathway: A Practical Guideline (January 2007) provides further discussion of the site conceptual model and provides a Conceptual Site Model Checklist (included in Appendix A) that can be used by investigators when developing the CSM.

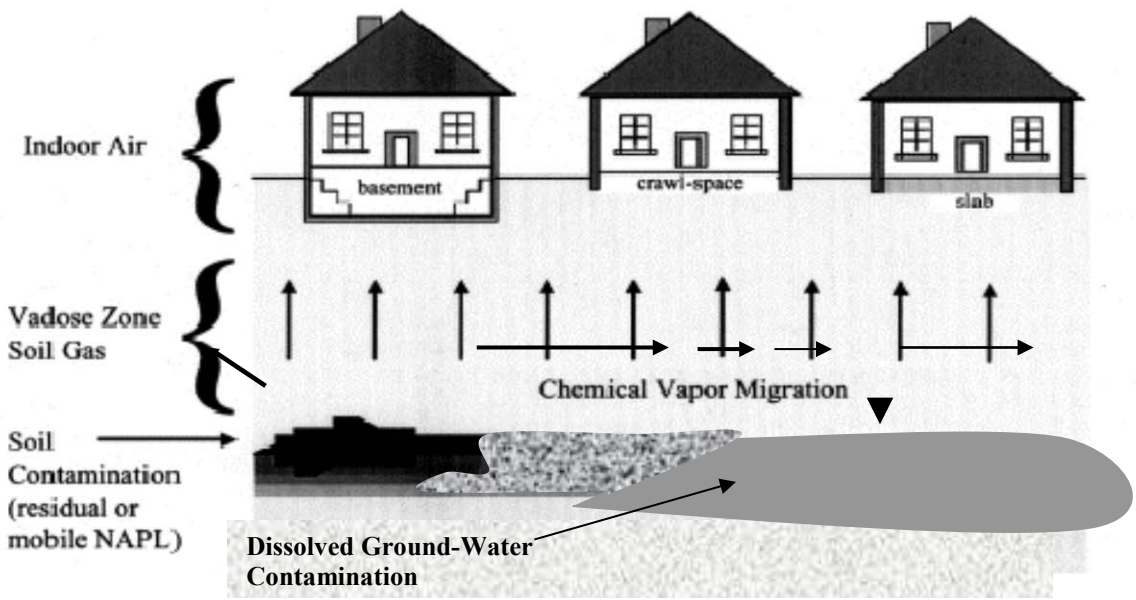

Figure 2-1. General Vapor Intrusion Conceptual Model
Source: USEPA 2002a

2.2 Factors Affecting Vapor Migration

Predicting the extent of vapor intrusion and the potential for human exposure is complicated by various environmental and building factors that can affect vapor migration. The main transport mechanisms by which contaminants can migrate are:

- Diffusion - Diffusion occurs as a result of a concentration gradient between the source and the surrounding area; it can result in the upward, lateral or downward migration of vapors through the vadose zone.

- Advection/convection - The horizontal and vertical movement of vapors located near a building foundation is often affected within an area referred to as the "zone of influence." Chemicals entering this zone are drawn into the building via soil gas advection and convection resulting from building interiors that exhibit a negative pressure relative to the outdoors and the surrounding soil.

  The reasons for this pressure differential include: 1) factors relating to operation of the HVAC system; 2) the use of fireplaces and other combustion sources; 3) the use of exhaust fans in bathrooms and kitchens; and 4) higher temperatures indoors relative to outdoors during the heating season. The combination of these actions/conditions results in a net convective flow of soil gas from the subsurface through the building foundation to the building interior.

- Vapor migration through preferential pathways - Vapors can rapidly migrate from a source to a receptor through natural (e.g. fractured rock) and manmade (e.g. buried utilities) pathways in the subsurface.

Variations in building construction, use, maintenance, site-specific stratigraphy, sub-slab composition and temporal variation in atmospheric pressure, temperature, precipitation, soil moisture, water table elevation, and other factors, combine to create a complex and dynamic system. General aspects of several of these processes and site settings/conditions are described in Tables 2-1 and 2-2.

2.3 Receptors

A receptor is any human or other ecological component which is or may be affected by a contaminant from a contaminated site. The primary VI receptors are the human occupants of enclosed spaces or buildings overlying subsurface volatile contamination. The exposure route of general interest for vapor intrusion is inhalation of contaminated vapors present in indoor air. Vapor intrusion can occur in all types of buildings and any foundation type (e.g. basement, crawl space, slab-on-grade, earthen floor). To account for possible changes in future use, VI is of potential concern in buildings/enclosed spaces whether or not they are currently occupied, including future buildings that may be constructed. Buildings with significant air exchange rates (e.g., commercial garages/spaces with large doors/openings) or significantly limited use (e.g., small utility sheds) should be evaluated on a site-specific basis.

Human exposure typically can take place under a residential (unrestricted use) or nonresidential (restricted use) exposure scenario. Residential settings include single family homes, townhouses, and apartment buildings, and receptors include both adults and children who are expected to spend a greater period of time in a residential setting than those individuals in a nonresidential setting. Other exposure scenarios may be considered residential use based on site-specific factors that should be discussed with DWM if appropriate.

It is DWM policy that day care facilities, schools and any other similar structures where children (under 18) are the primary occupants are evaluated as residential use due to the potentially sensitive nature of the exposed population.

Nonresidential settings include office buildings and commercial/industrial facilities, and receptors consist of adult workers in these buildings or facilities. Nonresidential settings with sensitive populations (e.g., working pregnant women) should be handled on a site-specific basis. Occupational settings that fall under the purview of the Occupational Safety and Health Administration (OSHA) may be handled differently than those not subject to OSHA regulations when indoor air concentrations from normal operating practices cannot be ruled out.

Table 2-1 Environmental factors that may affect VI

(Source: NYSDOH CEH BEEI Soil Vapor Intrusion Guidance 2006)

Environmental Factor	Description
Soil conditions	Generally, dry, coarse-grained soils facilitate the migration of subsurface vapors and wet, fine-grained or highly organic soils retard migration.
Volatile chemical concentrations	The potential for vapor intrusion generally increases with increasing concentrations of volatile chemicals in groundwater or subsurface soils, as well as with the presence of NAPL.
Source location	The potential for vapor intrusion generally decreases with increasing distance between the subsurface source of vapor contamination and overlying buildings. For example, the potential for vapor intrusion associated with contaminated groundwater decreases with increasing depth to groundwater.
Groundwater conditions	Volatile chemicals dissolved in groundwater may off-gas to the vadose zone from the surface of the water table. If contaminated groundwater is overlain by clean water (upper versus lower aquifer systems or significant downward groundwater gradients), then vapor phase migration or partitioning of the volatile chemicals is unlikely. Additionally, fluctuations in the groundwater table may result in contaminant smear zones. The "smear zone" is the area of subsurface soil contamination within the range of depths where the water table fluctuates. Chemicals floating on top of the water table, such as petroleum components, can sorb onto soils within this zone as the water table fluctuates. Sorption of chemicals can influence their gaseous and aqueous phase diffusion in the subsurface, and ultimately the rate at which they migrate.
Surface confining layer	A surface confining layer (e.g., frost layer, pavement or buildings) may temporarily or permanently retard the migration of subsurface vapors to outdoor air. Confining layers can also prevent rainfall from reaching subsurface soils, creating relatively dry soils that further increase the potential for soil vapor migration.
Fractures in bedrock and/or tight clay soils	Fractures in bedrock and desiccation fractures in clay can increase the potential for vapor intrusion beyond that expected for the bulk, unfractured bedrock or clay matrix by facilitating vapor migration (in horizontal and vertical directions) and movement of contaminated groundwater along fractures.
Underground conduits	Underground conduits (e.g., sewer and utility lines, drains or tree roots, septic systems) with highly permeable bedding materials relative to native materials can serve as preferential pathways for vapor migration due to relatively low resistance to flow.
Weather conditions	Wind and barometric pressure changes and thermal differences between air and surrounding soils may induce pressure gradients that affect soil vapor intrusion.
Biodegradation processes	Depending upon environmental conditions (e.g., soil moisture, oxygen levels, pH, mineral nutrients, organic compounds, and temperature), the presence of appropriate microbial populations, and the degradability of the volatile chemical of concern, biodegradation in the subsurface may reduce the potential for vapor intrusion. For example, readily biodegradable chemicals in soil vapor may not migrate a significant distance from a source area while less degradable chemicals may travel farther.

Table 2-2 Building factors that may affect VI
(Source: NYSDOH CEH BEEI Soil Vapor Intrusion Guidance 2006)

Building Factor	Description
Operation of HVAC systems, fireplaces, and mechanical equipment (e.g., clothes dryers or exhaust fans/vents)	Operation may create a pressure differential between the building or indoor air and the surrounding soil that induces or retards the migration of vapor-phase contaminants toward and into the building. Vapor intrusion can be enhanced as the air vented outside is replaced.
Heated building	When buildings are closed up and heated, a difference in temperature between the inside and outdoor air induces a stack effect, venting warm air from higher floors to the outside. Vapor intrusion can be enhanced as the air is replaced in the lower parts of the building.
Air exchange rates	The rate at which outdoor air replenishes indoor air may affect vapor migration into a building as well the indoor air quality. For example, newer construction is typically designed to limit the exchange of air with the outside environment. This may result in the accumulation of vapors within a building.
Foundation type	Earthen floors and fieldstone walls may serve as preferential pathways for vapor intrusion.
Foundation integrity	Expansion joints or cold joints, wall cracks, or block wall cavities may serve as preferential pathways for vapor intrusion.
Subsurface features that penetrate the building's foundation	Foundation perforations for subsurface features (e.g., electrical, gas, sewer or water utility pipes, sumps, and drains) may serve as a preferential pathway for vapor intrusion.

2.4 Factors Affecting Indoor Air Quality

Many different chemicals are used and found in buildings as part of our everyday lives that contribute to indoor air quality and are not attributable to VI. Cleaning products, glues, paints, cigarette smoke and dry-cleaned clothes are examples of common indoor air contaminants. Volatile chemicals can be found in the outdoor ambient air from sources such as gas stations, dry cleaners and vehicle exhaust that may enter buildings. Commonly found concentrations of these indoor and outdoor chemicals not attributed to VI are referred to as "background levels". Background sources of contamination are typically determined from the results of samples collected in homes, offices and outdoor areas not known to be affected by external sources of chemicals and are considered when evaluating the results of VI investigations. Table 2-3 contains examples of alternate sources of volatile chemicals in indoor air.

Table 2-3 Alternate sources of volatile chemicals in indoor air

(Source: NYSDOH CEH BEEI Soil Vapor Intrusion Guidance 2006)

Source	Description
Outdoor air	Outdoor sources of pollution can affect indoor air quality due to the exchange of outdoor and indoor air in buildings through natural ventilation, mechanical ventilation or infiltration. Outdoor sources of volatile compounds include automobiles, lawn mowers, oil storage tanks, dry cleaners, gasoline stations, industrial facilities, etc.
Attached or underground garages	Volatile chemicals from sources stored in the garage (e.g., automobiles, lawn mowers, oil storage tanks, gasoline containers, etc.) can affect indoor air quality due to the exchange of air between the garage and indoor space.
Off-gassing	Volatile chemicals may off-gas from building materials (e.g., adhesives or caulk), furnishings (e.g., new carpets or furniture), recently dry-cleaned clothing, or areas (such as floors or walls) contaminated by historical use of volatile chemicals in a building. Volatile chemicals may also off-gas from contaminated groundwater that infiltrates into the basement (e.g., at a sump) or during the use of contaminated domestic well water (e.g., at a tap or in a shower).
Household products	Household products include, but are not limited to, cleaners, mothballs, cigarette smoke, paints, paint strippers and thinners, air fresheners, lubricants, glues, solvents, pesticides, fuel oil storage, and gasoline storage.
Occupant activities	For example, in non-residential settings, the use of volatile chemicals in industrial or commercial processes or in products used for building maintenance. In residential settings, the use of products containing volatile chemicals for hobbies (e.g., glues, paints, etc.) or home businesses. People working at industrial or commercial facilities where volatile chemicals are used may bring the chemicals into their home on their clothing.
Indoor emissions	These include, but are not limited to, combustion products from gas, oil and wood heating systems that are vented outside improperly, as well as emissions from industrial process equipment and operations.

3.0 SCREENING LEVELS

DWM has developed Indoor Air Screening Levels (IASLs), Groundwater Screening Levels (GWSLs), and Soil Gas Screening Levels (SGSLs) for residential and nonresidential exposures to assist in the evaluation of potential VI impacts. Exceedances of the screening levels indicate that VI is possibly a concern and that further evaluation and/or potential remediation of the pathway is necessary.

In addition to screening individual contaminants, health risk associated with vapor intrusion into current and potential future structures can be calculated using the DEQ Risk Calculator to determine whether it is acceptable for the structure's current or planned use.

To allow for flexibility in updating the tables on a frequent basis, an explanation of how the screening levels were derived and the screening level tables are separate from this document and can be found

on the DWM website at http://portal.ncdenr.org/web/wm/ https://deq.nc.gov/about/divisions/waste-management/waste-management-permit-guidance/dwm-vapor-intrusion-guidance.
It is recommended that users refer to the DWM website directly rather than rely on printed versions of the tables to ensure that the most current information is used.

4.0 INVESTIGATION

When investigating the potential for vapor intrusion, each site should be evaluated on a site-by-site basis since no two sites are exactly alike. The guidance in this section contains general steps and procedures that should be applied in most situations; however, site-specific and building specific conditions should be taken into account. Investigators should also check with the specific DWM cleanup program addressing the site before conducting VI investigations since some programs may have supplemental VI guidance. **A flow chart of steps for conducting a structural vapor intrusion evaluation has been developed for Inactive Hazardous Sites Branch (IHSB) sites and is included in Appendix B.**

DWM recommends a phased approach proceeding in a stepwise manner when investigating the VI pathway. A preliminary assessment should determine if immediate action is required, followed by an investigation phase where existing or new analytical data from groundwater, sub-slab or near slab soil gas, and indoor air are compared to DWM screening levels to further evaluate whether the VI pathway is complete.

4.1 Preliminary Evaluation

For the VI pathway to be complete, there must be a source of hazardous vapors present beneath a building, vapors must form and have a pathway to migrate toward the building, and entry routes and driving forces for the vapors to enter the building must exist. The investigator should first confirm that one or more contaminants of concern represent a potential risk due to VI. Chemicals that are sufficiently volatile (Henry's Law Constant > 10^{-5} atm m^3 /mol) to result in potential vapor intrusion and sufficiently toxic to result in potentially unacceptable indoor air inhalation risks should be considered a contaminant of concern. A list of these chemicals can be found in USEPA's *Draft Subsurface Vapor Intrusion Guidance* (2002a).

Certain site conditions may require an immediate VI investigation or implementation of an interim mitigation measure. They include:

- Known contaminant spill in a structure.
- Physiological effects (dizziness, nausea, vomiting, confusion, etc.) reported by occupants (with a known or suspected source nearby).
- Wet basement or sump with contaminated groundwater nearby.
- Odors reported in a structure (with a known or suspected source nearby).
- NAPL at the water table under or immediately adjacent to a structure.
- Indoor air samples exceeding DWM IASLs.

If immediate action is warranted, a workplan should be submitted to DWM for approval, if required. If immediate action is not necessary, but there is a potential VI concern, a VI investigation should be performed.

4.2 General Considerations

4.2.1 Investigation Area

Vapor concentrations are generally expected to decrease with distance from a subsurface vapor source. The distance at which structures will not be threatened by vapor intrusion is a site-specific determination that relies on many factors including preferential pathways, surface cover, geologic setting, biodegradability of contaminant, etc. However, a vapor inclusion zone of 100-feet is generally considered an adequate starting point for looking at buildings that may be threatened by vapor intrusion.

The VI pathway should initially be considered a potential threat for all current or future buildings located within 100 feet horizontally or vertically of a soil or groundwater source area or of a soil vapor or groundwater plume exceeding the DWM screening levels. For landfills that are or could potentially be producing methane, the distance should be extended to 500 feet.

For sites with deeper, larger contaminant sources or where sources are intersected by utilities or other preferential pathways, the distance may need to be increased based on professional judgment. If the depth to the shallowest groundwater exceeds 100 feet, a VI investigation is not required unless vertical preferential pathways exist and the CSM indicates there is a significant VI risk.

The 100-foot distance criterion for investigating the VI pathway does not consider the aerobic biodegradation of petroleum hydrocarbons, particularly the benzene, toluene, ethylbenzene, xylenes (BTEX) compounds. Depending on the site conditions, the criterion is likely to be too conservative for petroleum hydrocarbons when that is the only source of contamination. Typically, an inclusion distance of less than 100-feet is recommended for petroleum hydrocarbon-only VI investigations. Investigators should consult with the appropriate DWM cleanup program addressing the site regarding modifications to this distance criterion in cases involving **only** petroleum hydrocarbon contamination. If NAPL is present or a VOC plume is co-mingled with petroleum hydrocarbons, the 100-foot distance criterion should be used.

The VI investigation should start in the known worst-case area and progress outward as warranted. **It may not be necessary to evaluate soil vapor or indoor air at all structures within 100 feet of known contamination as described above.** Typically, VI sampling should begin near the source areas or 'worst' case areas and move outward to adjacent properties, especially toward the down-gradient side of contamination. However, the investigator should also identify structures within the inclusion zone that may have building-specific characteristics or occupant activities that increase the potential for VI and may require investigation.

4.2.2 Chemicals of Concern

All subsurface contaminants that have the greatest potential to pose a health concern via vapor intrusion, based upon their volatility, should be evaluated. A chemical generally is considered to be 'volatile' if:

- Vapor pressure is greater than 1 millimeter of mercury (mm Hg), or
- Henry's law constant is greater than 10^{-5} atmosphere-meter cubed per mole (atm m^3 mol^{-1})

Aside from typical analytes on a volatile organic compound scan, chemicals of concern (COCs) should include mercury, ammonia, hydrogen sulfide and other semi-volatile compounds if present at the site.

If a COC (present in soil or groundwater) is a chemical currently in use in a place of employment, [e.g. perchloroethylene (PCE) in a dry-cleaner, trichloroethylene (TCE) in a machine shop], the chemical is subject to Occupational Safety and Health Administration (OSHA) regulations. In these cases, OSHA regulatory limits may apply if the employer is in compliance with OSHA regulations governing the chemical's use. It is very difficult to determine how much of the chemical in indoor air is due to use of the chemical in day-to-day operations or from vapor intrusion. There are instances when sampling inside these structures may be conducted to compare to indoor air samples in adjacent spaces or to investigate the downward migration of vapors from a structure into the subsurface.

DWM does not recommend collecting indoor air samples that analyze for a chemical in use at a structure as part of day-to-day operations without DWM approval prior to sampling.

If OSHA standards currently govern the amount of chemical allowed in indoor air, future exposures from subsurface contamination should be evaluated using soil gas to account for changes in use of the building or changes in land use. Land use controls may be used to protect future occupants of the building once OSHA standards no longer apply. Alternatively, remediation of subsurface contamination to SGSLs or GWSLs may be required to prevent future vapor intrusion.

DWM recommends that initial groundwater or soil gas samples be analyzed for the full suite of volatiles based on the approved method. The analyte list may be reduced for further soil gas, crawl space or indoor air testing with the approval of the specific DWM program with oversight of the project. Reducing the analyte list may assist with eliminating or assessing background sources.

4.2.3 Underground Utilities

Many accidents in subsurface investigations are due to encountering subsurface utilities. Prior to mobilizing for any groundwater or soil gas investigation, health and safety concerns must be answered. Of greatest concern would be to locate any underground utilities. NC811 is a free one-call utility location service and can be contacted at 1-800-632-4949 or http://www.nc811.org. They will contact all utility companies in the area that are members of their service. It is the investigator's responsibility to directly contact any utilities that are not affiliated with NC811. Typically, calls must not be made less than 48 hours prior to the planned work.

4.2.4 Landfills and Methane Gas

(This section adapted from New Jersey Department of Environmental Protection's Vapor Intrusion Guidance, 2013)

A landfill gas investigation may be required by the program with jurisdiction when a solid waste landfill is located on or adjacent to a structure. The presence of methane-generating conditions that may cause an explosion will require an investigation. Landfills and the gas generated from them can greatly influence the investigative approach.

A landfill is defined as a solid waste that is deposited on or into the land as fill for the purpose of permanent disposal.

While the concern for the migration of naturally produced or anthropogenic methane and the potential for the concentration of methane to exceed the lower explosion limit in a building are similar, the investigation of these issues requires the consideration of site-specific conditions.

4.2.4.1 Methane

Methane is a flammable, potentially explosive gas that alone is non-toxic and is not a long-term human health risk due to exposure. It is a colorless, odorless hydrocarbon combustible at concentrations of 5-15% by volume in air. A methane investigation is initiated when of methane values of 2% by volume or greater are present in a gas probes/wells. Methane may be generated under natural conditions or from an anthropogenic source. Organic-rich soils, sediments or methane associated with natural petroleum reserves are examples of natural methane-producing conditions.

4.2.4.2 Landfill Gases

Landfill gas (LFG) is the natural by-product of the anaerobic decomposition of biodegradable material that is placed in landfills. The composition of LFG produced under anaerobic conditions is typically in the range of 45-60% methane and 40-60% carbon dioxide. Additional components of LFG include trace amounts of ammonia, hydrogen sulfide and other non-methane organic compounds including VOCs. Nearly 30 organic hazardous air pollutants have been identified in LFG including, but not limited to, benzene, toluene, ethylbenzene, vinyl chloride, chloroform, carbon tetrachloride and trichloroethene (TCE). A useful source of information on this subject is the USEPA publication, Guidance for Evaluating Landfill Gas Emissions for Closed or Abandoned Facilities (USEPA, 2005).

Because of its combustible nature, methane is a product of interest at landfills along with the volatile compounds that are carried along in the LFG plume. It should be noted that collection and venting may be necessary to prevent offsite migration and control the accumulation of any methane gas at any concentration in any building.

4.2.4.3 Landfill Gas Production and Flow

The rate and volume of LFG production depends upon the characteristics of the waste material and the environmental factors. They include the following:

- Waste composition - The greater the amount of biodegradable organic materials present in the waste (typically from municipal waste), the more LFG is produced by bacteria during decomposition. In addition, the more industrial waste that is disposed in the landfill, the higher the levels of non-methane organic compounds that will be produced through volatilization and chemical reactions.

- Age of the waste – Generally waste buried for less than 10 years produces more LFG than older waste. Peak gas production is generally between 5-7 years after the waste is buried. Note that many of the larger (and some smaller) pre-regulatory municipal solid waste landfills have been found to produce methane.
- Presence of oxygen – Methane is produced in anaerobic regions of the landfill and can be consumed in aerobic regions. If the buried waste is disturbed, then conditions may become more aerobic limiting the microbial process until it again becomes oxygen reduced.
- Moisture content – The presence of moisture increases the gas production because it supports and enhances bacterial decomposition. Moisture may also promote chemical reactions that produce LFG.
- Temperature – As temperature increases the rate of bacterial activity will increase, which increases gas production. Increasing temperatures also promote volatilization and increase the rate of chemical reactions.

Migration of LFG may occur because of diffusion or advection. Gas flow due to diffusion is in the direction which the concentration decreases. When LFG concentrations are higher in a landfill than the surrounding area, LFG will tend to move out of the landfill to the surrounding area with a lower gas concentration. Gas flow by advection occurs when a pressure gradient exists; flow is in the direction of decreasing pressure - from high pressure to low pressure.

Factors that influence the flow of LFG in the subsurface include the following:

- Landfill cap – If the landfill is cap constructed of a liner or silts and clays that are impermeable to gas flow; LFG gas will tend to migrate laterally.
- Landfill liners – If the landfill has an impermeable liner system, LFG will not migrate into the surrounding subsurface area by advection.
- Ground water levels – Gas movement is influenced by the movement of the ground water table. As the ground water table rises, it forces the LFG upward.
- Barometric pressure – The difference in the soil gas pressure and the barometric pressure will guide the LFG to move laterally or vertically, depending upon the pressure gradient.
- Preferential pathways – Pathways for the movement of LFG can be either natural or anthropogenic. The geology provides natural pathways such as sand or gravel zones, fractured bedrock and old stream channels. Anthropogenic pathways include buried utilities, drains, trenches and tunnels.
- Seasonal Variations – The time of year (winter, summer) will cause variations in lateral LFG movement due to saturated soils from precipitation acting as a cap for vertical LFG migration and increased LFG production.

It is often difficult to predict the specific patterns and directions of LFG movement due to the many variables for gas flow and generation. LFG can migrate up to 1,000 feet or more in the subsurface from the footprint of the disposed waste (landfill source).

4.2.4.4 Methane Investigations and Analytical Methods

When methane may likely be present (see Section 3.1.4.1), conduct an initial assessment of the buildings identified through the receptor evaluation for fire and explosion hazards. The

characterization should focus on below grade floors, ground level floors (when no basement present), crawl spaces, sumps, utility penetrations, utility vaults, and enclosed spaces. If explosive conditions are present, immediate notification of emergency responders is required followed by program notification.

Once the investigator determines that an explosive condition does not currently exist at the building, an evaluation of vapor intrusion (VI) for volatile compounds and non-emergency methane concentrations should follow. The absence of methane does not eliminate the possibility of volatile compounds in a building.

For structures located on or near a landfill, the following methods may be used as part of a LFG assessment.

1. Probes can be installed at several levels in the vadose zone between the structure and the landfill to allow for measurements of subsurface pressure and methane concentrations to evaluate the attenuation and migration potential of methane in the soil column. Install the deepest probe at the approximate depth of the landfill refuse, or at least two feet above the seasonal high-water table and at least five feet below ground surface. The investigator uses professional judgment to determine the number of vertical profiles. Collect readings using a field instrument capable of directly measuring methane (e.g., landfill gas analyzer, combustible gas meter, infrared sensor) can be used. Evaluate preferential pathways that may serve as migration routes to buildings. Based on the results, the investigator can determine if LFG is reaching the structure.
2. Where possible obtain initial information regarding LFG migration from the landfill owner/operators if they were required to monitor for LFG at the perimeter the landfill. Information on the periodic LFG measurements should give an indication of the potential (pressure) and concentrations of LFG migrating away from the landfill. Other factors listed in Section 3.1.4.3 may assist the investigator, including the type and age of the landfill, landfill construction (e.g., cap, liner), and the presence of an active methane gas venting system.

The trigger distances do not necessarily reflect the distance LFG can travel from a landfill, often carrying site-related contaminants of concern.

The investigator should establish a clean zone beyond the limits of LFG contamination; a clean zone would have 0% LEL (or no more than global background).

Consider sources of methane in buildings (sewage systems, natural gas equipment). As previously stated, the measurement of methane from LFG may also indicate the presence of other volatile compounds in the absence of other screening conditions such as dissolved volatile compounds in ground water or volatile compounds in soil.

4.3 Groundwater

DWM recommends groundwater (in most circumstances) as the first medium to be investigated for the VI pathway. Most site investigations require the characterization and delineation of groundwater contamination; therefore, in most cases, there will be existing groundwater data available to begin evaluation of the VI pathway. If soil gas and/or indoor air data has already been collected, using screening levels for those media are more appropriate, however, groundwater data may still be used to screen other areas of the site that may need to be investigated for potential VI.

In situations where there is urgency regarding a potential human exposure or when NAPL is located close to buildings, it may be necessary to collect sub-slab soil gas and/or indoor air samples prior to acquisition of sufficient groundwater data.

There are several factors that should be considered when utilizing groundwater data for VI investigations:

- Clean Water Lens - As groundwater moves away from the source area, infiltrating water (precipitation, irrigation, septic systems, leaking water lines, etc.) that reaches the water table will lie on top of the contaminated groundwater and, gradually, a lens of clean groundwater may form above a contaminant plume. The overlying groundwater can impede or prevent volatiles in deeper groundwater from reaching the unsaturated zone, thus possibly preventing a vapor intrusion situation.

- Depth to Saturated Zone - The water table can be described as the shallowest depth at which groundwater will freely flow into wells, or other groundwater sampling devices. The depth to the regional water table and/or any perched saturated zone(s) needs to be determined in the vicinity of buildings at risk for VI.

- Stratigraphy - A low permeability layer in the unsaturated zone can impede the upward migration of vapors from an underlying source and prevent VI impacts in areas where it might otherwise occur. It is important to have a good understanding of the stratigraphy of a site where VI is being investigated since these features can have a tremendous effect on the presence or absence of VI impacts.

- Fluctuations in Water Table Elevation - A significant drop in water table elevation (e.g., during a prolonged drought) can expose an area of contaminated groundwater previously separated from the vadose zone by a clean water lens resulting in a potential VI situation.

Changes in water table elevation may increase or decrease the risk of VI.

- NAPL - Where NAPL reaches the capillary fringe and/or soil is contaminated with residual NAPL in the zone surrounding the capillary fringe, fluctuations in the water table could smear the product vertically and greatly enhance vertical mixing between vapor and dissolved contamination, resulting in much higher volatile concentrations near the water table than in deeper intervals not within the zone of fluctuation.

4.3.1 Groundwater Sampling

Groundwater sampling methods are not discussed in detail because DWM assumes investigators are relatively experienced and trained to collect samples that meet data quality needs. However, DWM has a few recommended guidelines for groundwater sampling as related to vapor intrusion investigations.

DWM recommends groundwater samples be taken from wells screened across the top of the water table and samples should be collected as close as possible to the top of the water table. A monitoring well should be considered adequate for evaluating the appropriate depth interval(s) if the screen/open borehole intersects the water table throughout the year (i.e., a water table well), and the thickness of the water column in the well is approximately 10 feet or less.

Groundwater samples should be collected as close as possible to the structures under investigation.

4.4 Soil Gas

If the GWSLs are exceeded, soil gas testing will need to be conducted in most cases. Three alternative approaches are possible for this initial step, source area soil gas, sub-slab soil gas or exterior soil gas as outlined below. **Site-specific conditions may dictate which approach is appropriate, therefore, please ensure that the DWM program with oversight is consulted regarding the approach chosen and the associated sampling plan.**

Note that underground storage tank sites or where chlorinated solvents are used in buildings may have contamination in the vadose zone solely due to vapor releases. In these cases, soil and groundwater data may not identify the VI source. Soil gas sampling is the preferable investigative tool in these circumstances.

4.4.1 Source Area Soil Gas

Soil gas samples collected within one foot above the capillary fringe in the area of highest groundwater contamination may be an acceptable screening procedure to estimate 'worst case' conditions even if the samples are not located on the property with the structures of concern.

4.4.2 Sub-slab Soil Gas

The collection of sub-slab soil gas is an effective investigative tool when assessing the VI pathway, especially combined with concurrent indoor air sampling. When combined with a conservative attenuation factor (as used in the development of the DWM SGSLs), sub-slab soil gas can be used to estimate potential indoor air concentrations. For commercial/industrial buildings, sub-slab soil gas is preferred over exterior soil gas sampling. Typically, sub-slab soil gas samples should be collected at the structure representing the worst-case scenario and move outward. Not all structures must be investigated, but site-specific conditions should be considered when developing a sampling plan.

4.4.2.1 Sampling Considerations

To evaluate potential VI from soil gas, DWM recommends that laboratory analyses for sub-slab soil gas samples be limited to chemicals of concern present in the subsurface, typically in groundwater or other soil gas samples.

When sub-slab samples are collected, DWM recommends that the *Indoor Air Building Survey and Sampling Form* (Appendix C) be completed to document site-specific conditions associated with the sampling. At a minimum, the following information should be collected:

- Building conditions that are pertinent to assessing potential soil gas entry such as conduits, cracks or floor drains, utilities, basements, type of sub-slab backfill, thickness of flooring.
- The location of the HVAC system and outdoor air intake.
- Areas that may create over- or under- pressurization in the building such as vent hoods, fans, attic vents. Note that over-pressurization of a building could cause indoor sources to contribute to subslab soil gas.
- Meterological data such as recent precipitation, changes in barometric pressure, wind speed, temperature, humidity.

4.4.2.2 Number, Location and Frequency of Sampling

Prior to conducting sub-slab sampling, evaluate whether any special conditions exist that should be taken into consideration including, but not limited to:

- The presence of a vapor barrier.
- Underground utilities.
- Cables or rebar in concrete floors.
- If there are entry points for vapors in basements through sidewalls.
- If the water table or capillary fringe extends into the fill material beneath the slab.

Due to spatial variability in sub-slab soil gas concentrations over a slab, DWM generally recommends the collection of one sample per 1000 square feet of first floor building area. However, other site-specific conditions should be considered when determining the number of samples including:

- Multi-family residential units and commercial or retail buildings that may have more than one tenant.
- Subsurface structures that may degrade indoor air quality in one portion of the building and not another such as basements, sumps, elevator pits, earthen floors.
- Past usage such as dry cleaners, underground storage tanks, industrial.
- Different exposure scenarios (e.g., day care, medical facilities) that exist within the building and any sensitive populations that may be exposed.
- Very large or small buildings.

DWM recommends that sub-slab samples be collected towards the center of the slab, at least 5 feet from an outer wall, since concentrations in the center are typically higher than concentrations near the perimeter of the building.

To minimize potential damage to flooring, it may be necessary to select a location in a closet or utility room (where carpeting or tiles are less visible or not present at all). The selected location(s) should be chosen in consultation with the property owner during the building walkthrough.

If sub-slab soil gas samples are being collected as a stand-alone determination of the VI pathway, more than one round of sampling is recommended. Supplemental environmental data (e.g., groundwater, indoor air, or near slab soil gas data) may eliminate the need for multiple rounds of sub-slab soil gas sampling. In addition, DWM may accept a single round of sampling in those cases where the analytical results are an order of magnitude below the appropriate screening level.

4.4.3 Exterior Soil Gas

For the evaluation of structures, it is not always possible to obtain the building occupants and/or owner's approval to drill a hole in the basement/foundation slab or a slab may not be present. In these situations, exterior soil gas sampling is often the best alternative to evaluate whether VI is a concern.

4.4.3.1 Number, Location and Frequency of Sampling

Unless soil gas samples are being collected just above the water table in the area of highest groundwater contamination, soil gas samples should be collected as close as possible to the structures being investigated for potential VI. Soil gas concentrations are typically greater beneath the building than at the same depth adjacent to the building in an open area, especially for shallow soil gas samples. Deeper soil gas samples collected immediately above the source of contamination (groundwater or soil) are likely to be more representative of what may be in contact with the structure's sub-slab, especially for chlorinated hydrocarbons. Samples should be collected on the side of the building closest to the groundwater contaminant plume. For petroleum only investigations, consult with the UST section or other DWM Program providing oversight regarding soil gas collection depths.

For chlorinated hydrocarbons and most VOC releases, DWM recommends the collection of soil gas in the vadose zone at the depth within one foot above the capillary fringe and a minimum of 5 feet below ground surface as close as possible to the structure being investigated.

Vertical profiling and multiple depth soil gas sampling can better clarify the source(s) of VI by evaluating the distribution of chemical concentrations over a defined depth. If a groundwater plume under a structure is the suspected source, soil gas concentrations should typically increase as the depth of the sample collection increases. Deviations from this general assumption may suggest an alternative source, such as preferential pathways, vapor leaks or vadose zone soil contamination.

The investigator should rely on the conceptual site model to determine an appropriate number and location of soil gas sample points. For example, if there are indications that groundwater could have large lateral concentration changes over short distances near a building, then more sample points may be necessary.

Precise sample locations will be dictated by the existing conditions around the building perimeter (e.g., other structures, landscaping, access issues) and the location of the groundwater plume. Generally, samples should be spaced horizontally along the perimeter of the building, at two to three times the depth to groundwater. If two soil gas sample locations have two to three orders of magnitude difference in concentration, it is recommended that at least one additional soil gas sample be collected between the two points.

Due to spatial variability and other uncertainties associated with soil gas and VI, it may be necessary to collect multiple rounds of near-slab soil gas to demonstrate that the concentrations are stable and not increasing, especially when soil gas concentrations are near the SGSLs.

4.4.3.2 Undeveloped Land and Future Use

Undeveloped land without existing structures presents a unique situation for the investigation of the VI pathway. The collection of sub-slab soil gas or indoor air samples is not possible without a structure on the parcel. However, subsurface vapor concentrations may be changed with the construction of a new building, excavation or installation of utilities, garages or subsurface structures.

If contaminated groundwater is located under the undeveloped parcel, the maximum groundwater concentration within the parcel should be compared to the GWSLs. If the groundwater concentration exceeds the GWSL, DWM recommends a soil gas survey be conducted to assess the potential for VI under a future use scenario. If the site is uncapped with concrete or other impervious cover, the soil gas samples should be collected in the vadose zone at the depth within one foot above the capillary fringe and a minimum of 5 feet below ground surface for chlorinated hydrocarbon or VOC releases. For petroleum-only investigations, consult with the UST section or other DWM program providing oversight regarding soil gas collection depths.

A grid sampling approach should be employed across the site and biased towards the highest concentrations within the groundwater plume.

If the soil gas results exceed the SGSLs, remediation of contaminated media to levels that will prevent vapor intrusion in future buildings may be required. Alternatively, the property owner can record appropriate land use restrictions that require evaluation of the VI pathway when buildings are constructed or may include engineering or institutional controls on the property to address future vapor intrusion concerns. In situations where the future use is already restricted by an institutional control, VI investigations may be postponed to some point in the future when development is being considered.

4.4.4 Sampling Procedure

Active soil gas sampling is typically conducted using permanent or temporary sampling points. Permanent sample points with stainless steel, nylon or Teflon tubing are recommended to assess the changing concentration of contaminants of concern over time for long term monitoring of sub-slab soil gas as part of a remedial action or operation of a sub-slab depressurization system. Temporary sample points using Teflon, metal, nylon, PVC or similar tubing are more appropriate during the initial phases of investigation when the VI pathway is being evaluated.

The primary sample container recommended for the collection of soil gas samples is stainless steel canisters. Either 1-Liter or 6-Liter canisters may be employed. The soil gas samples can be analyzed using USEPA Method TO-15 (or other appropriate certified methods). Smaller canisters and sample volumes are permissible with DWM approval.

Sample containers other than stainless steel canisters can be employed when screening or preliminary results are appropriate or with DWM approval. The investigator can utilize a Tedlar® bag for sample collection and analyze the samples with a field gas chromatograph (GC) or mobile laboratory. Alternately, a glass or Teflon® syringe can be used. As with the Tedlar® bags, syringe samples should be analyzed with a field GC or mobile laboratory. It should be noted that the holding time for Tedlar® bags should not exceed 3 hours. USEPA SW-846 Method 8260B and TO-14 are the most common methods utilized for field screening of soil gas samples.

The soil gas sampling points should be installed in such a manner to provide a tight seal around the sampling point and allow for collection of samples which are representative of sub-slab vapor conditions. **Perform leak tests on all soil gas probes and fittings of the sampling train prior to collecting a soil gas sample.** The ITRC document, *Vapor Intrusion Pathway: A Practical Guideline* (2007), Appendix D provides additional information on leak testing.

Whenever possible, DWM recommends on-site field analysis for leak check compounds using a helium tracer. On-site analysis will allow adjustments to be made immediately and may avoid a remobilization to the site for additional sampling. The investigator should discuss leak test methods with the appropriate DWM program with oversight of the project to ensure that specific requirements are being met. DWM recommends the use of helium as the tracer compound introduced through a shroud over the probe and sampling train. With the canister valve closed, collect a soil gas sample using a Tedlar® bag. A leak is considered to occur when the helium concentration is greater than 10% of the concentration within the shroud.

When a Tedlar® bag or syringe is utilized in combination with a field GC or mobile laboratory, the length of time for sample collection should be based on the professional judgment of the investigator but should not exceed 200 milliliters per minute to avoid short circuiting. In addition, a proper seal between the sample point and slab must be established to prevent indoor air from mixing with the soil gas sample.

For stainless steel canisters, typically, the sample flow rate should be a maximum of 200 milliliters per minute, which corresponds to a sample time of five minutes for 1-Liter canisters and 30 minutes for 6-Liter canisters. This maximum flow rate has been established due to the larger volume of stainless steel canisters and the concern over short circuiting. Smaller canisters and sample volumes are permissible with DWM approval.

Prior to attaching the sample container, the vapor probe should be purged by drawing 3.0 volumes through the probe and sampling train. The investigator should use a low purge rate with a maximum of 200-ml per minute.

4.4.5 Passive Sample Collection Methodologies

Passive sample collection includes two general sample collection techniques: the passive collection of contaminants onto sorbent material placed in the vadose zone and, a whole air passive collection

technique for collecting vapors emissions from the soil surface using an emission isolation flux chamber.

Passive sorbent sample collection utilizes diffusion and adsorption for soil gas collection onto a sorbent collection device over time. The soil gas data will delineate the nature and extent of subsurface contamination. The soil gas data at one location can be compared relative to the soil gas data from other sample locations in the survey. The mass levels will show patterns of the spatial distribution indicating areas of greatest subsurface impact. These areas can then be targeted for further investigation.

Since the passive sorbent samplers provide results in mass concentration, their use is limited to field screening only during the investigation of the VI.

The flux chamber is an enclosure device used to sample gaseous emissions from a defined surface area. The data can be used to develop emission rates for a given source for predictive modeling of population exposure assessments or emission factors for remedial action designs.

The emission isolation flux chamber is a dome superimposed on a cylinder. This shape provides efficient mixing since no corners are present and thereby minimizing dead spaces. Clean dry sweep air is added to the chamber at a controlled volumetric flow rate. The gaseous emissions are swept through the exit port where the concentration is monitored by a real time or discrete analyzer. Real time measurements are typically performed with portable survey instruments to determine relative measurements of flux chamber steady state operation and areas of high contamination. Discrete samples are taken when absolute measurements are required for steady state concentrations and emission rate levels. The emission rate is calculated based upon the surface area isolated, sweep airflow rate, and the gas concentration. An estimated average emission rate for the source area is calculated based upon statistical or biased sampling of a defined total area. The ITRC document, *Vapor Intrusion Pathway: A Practical Guideline* (2007), in Appendix D provides additional information on flux chamber sampling.

Flux chamber sampling should not be used without first receiving approval from DWM. Justification should be provided as to why the emission isolation flux chamber method is more appropriate for this particular phase of the investigation.

4.5 Building Survey and Pre-Sampling Evaluation

A building survey and pre-sampling evaluation are critical elements of any VI investigation that includes indoor air and/or sub-slab soil gas sampling as an investigative tool. There are several components that should be addressed:

- Detection of potential background sources of volatile organic compounds.
- Determination of the building construction.
- Recognition of points of VI in a structure.
- Identification of possible sample locations.
- Education of the occupants on VI and sampling procedures.

Ideally, the building walkthrough should be conducted at least one week before the actual indoor air or sub-slab soil gas sampling event. This advance timeframe allows the investigator to identify and eliminate (to the extent practical) potential background sources of indoor air contamination. It also

permits the investigator to confirm the sample locations with the occupants ahead of the scheduled sampling episode.

If crawl space samples are being collected, it is also important to survey the entire crawl space to identify any potential background sources of contamination. Often, sources of volatiles such as gas cans, small engine equipment, paint, etc. are stored in the crawl space. A survey of the crawl space will also assist in identifying potential VI entry points related to building construction and perforations in the floor.

4.5.1 Detection of Potential Background Sources

The VI pathway is greatly complicated by the impact of background contaminant sources and differentiating the common household sources of poor indoor air quality from those associated with contaminated groundwater or subsurface. DWM recommends the use of the *Indoor Air Building Survey and Sampling Form* (Appendix C) to assist with identifying background sources in the indoor air environment. The survey form allows the investigator to document various information on the building, occupants, and potential sources of indoor air contamination.

Another essential tool for pinpointing background sources of indoor air contaminants is the use of handheld field screening instruments which are now providing parts per billion (ppb) detection, making them appropriate for building walkthroughs and surveys during VI investigations. With a field screening instrument capable of detecting volatiles on a ppb range, areas of high VOC concentrations or individual items, paint or solvent cans for example, can be identified as vapor sources and removed from the building in advance of the sampling event.

When household or background sources of indoor air contamination are identified and removed from a building, it may be necessary to ventilate the rooms affected in advance of the air sampling event. **This ventilation should be completed at least 24 hours before the commencement of the indoor air sampling event.**

4.5.2 Recognition of Points of Vapor Intrusion in a Building

When elevated concentrations of soil gas are present below the foundation of a building, VI can occur through cracks in the walls and floors, sumps, penetrations in the foundation or around the wall/floor juncture of floating floor construction or other breaches in the basement walls or slab. Vulnerability to soil gas entry should be assessed for the building under investigation. Some of the tools that may be used include, but are not limited to:

- Use of a handheld field screening instrument capable of detecting parts per billion by volume (ppbv) levels to survey suspected entry locations.
- Visual inspection for cracks, holes and penetrations in the slabs or basement walls.
- Assess the effects of the HVAC system by monitoring pressure differences between the building and subsurface.
- Inject a tracer element in the subsurface and monitor for its presence in indoor air. Similarly, radon can be monitored in indoor air and compared to outdoor levels as an additional line of evidence.

Collecting relevant information regarding the HVAC system for the building is important for the VI investigation. HVAC systems bring outdoor air into the building, sometimes creating building over-pressurization, especially in commercial buildings. When the building is over-pressurized, the potential for VI is decreased.

It may be useful to evaluate the potential for VI by collecting indoor air samples when HVAC systems are often turned off, typically during the evening

4.5.3 Education of the Occupants on Vapor Intrusion and Sampling Procedures

One of the investigator's responsibilities when collecting samples within a structure is to educate the occupants on the VI pathway. Unlike other environmental matrices (soil, groundwater, surface water, or sediments), indoor air quality can have an immediate and possibly long term affect on human health that is not easily addressed by simple avoidance of the contaminated material.

During the building walkthrough, occupants are likely to raise a number of issues that the investigator should be prepared to answer. Refer to Section 7.0 for a discussion on how to conduct community outreach during the investigation of the VI pathway. In addition, two fact sheets, *What You Should Know About Vapor Intrusion* (Appendix D) and *Subsurface Depressurization Systems* (Appendix E) may provide further assistance.

A one page advisory paper entitled *Instructions for Occupants - Indoor Air Sampling Events* (Appendix F) should be provided to the occupants during the building walkthrough and at least one week prior to the sampling event. This sheet provides the occupants with a list of actions that should be avoided before and during the sampling event. Any deviation from the instructions noted during the sampling event should be documented on the *Indoor Air Building Survey and Sampling Form*.

4.6 Crawl Space

Before collecting indoor air samples, DWM recommends the collection of crawl space samples since it is less intrusive and typically does not involve other indoor air sources. Crawl space sampling results should be compared to the IASLs. For chlorinated hydrocarbons and VOC releases, the collection of crawl space air is often recommended in lieu of or in conjunction with soil gas sampling near buildings. Crawl space samples should be collected following soil gas or indoor air sampling procedures depending on the type of sample to be collected. The crawl space should be inspected for background sources before sampling, just as described for indoor air sampling. If a crawl space does not exist, or if crawl space air results exceed IASLs, indoor air samples should be collected.

When time allows, crawlspace samples should be collected during the time of year the structure is most prone to vapor intrusion. The following conditions should be evaluated when determining the sample collection time period:

- Cold weather: When the exterior of the building is colder than the interior, the heating of the indoor space can produce a chimney effect and cause air below the structure to rise into the structure. Cold weather sample collection should occur when the high temperature for the day will be less than 60 degrees (Fahrenheit). Generally, that means mid-November through

mid-March for the mountains and upper piedmont and mid-December through mid-February for the lower piedmont and coastal plain.

- During seasonal high-water table: For areas with shallow water tables, sampling during the time of the seasonal high-water table should also be conducted.

- Positive pressure HVAC off: During the fair-weather periods of the year, an HVAC system may not cycle or will cycle less. If windows are opened, there will be more fresh air exchange. If windows remain closed, the structure may not be under positive pressure conditions, allowing vapors to enter from the subsurface. This for structures with positive pressure HVAC systems, periods of milder weather may allow more vapor intrusion than during the summer and winter months when the system is running more frequently.

- High concentrations initially detected may call for immediate retesting with another sample to follow during worst case conditions.

4.7 Indoor Air

If groundwater and/or soil gas concentrations exceed the screening levels, typically, the next step should be the collection of crawl space or indoor air samples. Site-specific conditions may warrant the collection of indoor air samples prior to characterizing groundwater, sub-slab gas or soil gas if immediate health hazards exist. Indoor air sampling results can be used to assess risk to human health by comparing the concentrations to the IASLs which are based upon EPA derived screening levels. The results can also be used alone or in conjunction with other lines of evidence such as groundwater and soil gas concentrations to determine if VI is occurring.

Indoor air sampling is generally the last investigative step in the evaluation of the VI pathway. Indoor air samples should typically be collected after other types of sampling, including groundwater, sub-slab gas, soil gas and crawl space air have indicated that there is a potential VI impact to a structure. Data from soil gas sampling employs an attenuation factor that can **estimate** indoor air concentrations resulting from VI; however, these procedures do not provide actual analytical data on the indoor air quality.

Indoor air quality is affected by a multitude of sources that originate both inside and outside any building that are not associated with VI. This complication may be unavoidable especially when products containing the same volatile chemicals that are under investigation can be found in the building under investigation. Therefore, it is important to develop multiple lines of evidence to evaluate indoor air.

DWM recommends that indoor air samples are collected concurrently with sub-slab soil gas samples. Sub-slab gas sampling results are used in conjunction with indoor air sampling results when evaluating human exposures, determining site-specific attenuation factors and evaluating potential indoor air background sources. Concurrent measurement of sub-slab and indoor air radon gas concentrations may be used in order to estimate building specific sub-slab to indoor air attenuation factors with the approval of the DWM program with oversight of the project (see Appendix G). Radon measurement may be particularly useful where indoor sources of contaminants of concern make it difficult to determine the proportion of indoor air contamination that is

attributable to vapor intrusion. A radon-derived attenuation factor should be used as an additional line of evidence and not as the sole factor in determining if vapor intrusion is occurring.

When collecting indoor air and sub-slab soil gas concurrently, collect the indoor air samples prior to the sub-slab gas samples to prevent the sub-slab soil gas sampling from potentially affecting the indoor air samples.

4.7.1 Background Indoor Air Sources

Sources of background indoor air contamination can be broken down into several categories – household activities, consumer products, building materials and furnishings, and ambient air pollution. Smoking tobacco products, parking a car in an attached garage, using a kerosene heater, burning scented candles, dry cleaning clothes - all these household activities contribute to potentially unhealthful contaminant concentrations in the indoor air. The searchable household products database found at http://householdproducts.nlm.nih.gov can help identify potential indoor air sources.

Consumer products represent a second source of indoor air contamination that should be evaluated when assessing the contribution from VI. Mothballs (1,4-dichlorobenzene), nail polish remover (acetone), rug spot cleaner (tetrachloroethene), floor polish (xylenes), drain cleaner (1,1,1-trichloroethane), and gasoline (benzene, toluene, ethylbenzene, and xylenes) are just a few of the examples. (Refer to Table 2-3 for additional information). With the proprietary nature of consumer products today, it is often impossible to determine what chemicals are contained in most products. Either the labels do not list the ingredients or they will refer to some generic constituent, such as "petroleum products."

Building materials and furnishings are another source of indoor air contamination, particularly when they are new. Whether it's carpeting, shower curtains, fabrics and draperies, furniture, building insulation, or pressed wood products (particleboard, hardwood plywood, and medium density fiberboard), indoor air quality can be significantly affected by volatile organic compounds and formaldehyde emanating from these products.

DWM relies on a multiple lines of evidence approach when assessing potential background sources of indoor air contamination. Some of the tools that can be used to assist in differentiating or eliminating potential background sources include, but are limited to:

- Having a well-delineated groundwater plume (or subsurface soil contamination) with identified chemical contaminants including potential degradation products.
- Collecting sub-slab soil gas samples. When sub-slab sampling is not possible, the collection of exterior soil gas may be useful.
- Identification of preferential pathways.
- Collecting an outdoor air sample when conducting indoor air sampling to identify any outdoor influences.
- Use of the *Indoor Air Building Survey and Sampling Form* (Appendix C) when collecting sub-slab soil gas and indoor air samples to identify building characteristics, indoor

contaminant sources, miscellaneous items (such as "do you smoke or dry clean clothes?"), sampling information, and weather conditions.

- Providing occupants, the *Instructions for Occupants - Indoor Air Sampling Events*, found in Appendix F to possibly eliminate potential background sources.
- Utilization of local, regional, national, or international indoor air background. The USEPA's document Background Indoor Air Concentrations of Volatile Organic Compounds in North American Residences (1990-2005): A Compilation of Statistics for Assessing Vapor Intrusion (USEPA 2011) is one resource for determining typical background concentrations in buildings.

If contaminants are detected that are not associated with the chemicals of concern under investigation at the site and are present in local ambient air or associated with activities or products in use in the building, they will not be included when determining whether final risk levels are met. Background determinations are made on a site-specific basis in consultation with DWM and as part of the overall multiple lines of evidence approach. A DWM toxicologist may advise the occupants of a building, as part of a health risk evaluation, of the additional risk posed by background sources and other detected contaminants that are not associated with the chemicals of concern under investigation at the site.

DWM recommends that indoor air sample analyses be limited to the chemicals of concern found or expected to be found in the subsurface to eliminate potential background sources. For example, if benzene was not found in groundwater or soil gas, it may be eliminated from indoor air sampling since it could originate indoors from other sources such as gasoline, cigarette smoke or adhesives.

4.7.1.1 Outdoor Air

An outdoor ambient air sample provides background concentrations outside of the building being investigated at the time of the indoor air sampling event. The investigator should clearly designate where the sample is collected and the site conditions at the time of sampling. The investigator also should be aware of the weather conditions during the sampling event. It is highly recommended that the sampling device be placed in a secure outside location and not in front of a building. Ambient air samples should be taken upwind of the building being investigated, at breathing zone height and as far from auto traffic or other potential sources as possible.

The ambient air sample should have the same sample collection time and be analyzed in the same manner as the interior sample.

The recommended number of ambient samples is one per sampling event. DWM may determine that subsequent sampling events do not require additional ambient sampling. If the sampling event occurs over multiple days, additional ambient samples may be recommended at the discretion of DWM. If the spatial arrangement of the sampling points is dispersed and background cannot be easily defined, additional ambient samples may be recommended.

It is highly recommended that suitable precautions be taken whenever VI investigations include outside air sampling. The sampling equipment (e.g., stainless steel canisters) and related devices are not familiar to most individuals and may be misinterpreted as a safety concern; therefore, the

investigator may consider notifying the local police and fire departments, in addition to the municipal officials. It may be necessary to demonstrate the operations of the sampling equipment to these officials. A label should be affixed to the sampling device explaining the nature of the equipment and all appropriate contact information in case there are further questions. The individuals collecting the indoor air samples should be prepared to provide proper identification to the building occupants.

4.7.2 Sampling Considerations

In situations where ambient indoor levels for contaminants of concern are expected to be elevated based on the nature of the commercial/industrial/retail operation, the investigator should consider avoiding the collection of indoor air samples. For example, at active dry-cleaners, if groundwater contaminant concentrations exceed the GWSL, DWM recommends the collection of sub-slab soil gas samples where possible in lieu of indoor air samples.

When sampling indoor air or sub-slab soil gas, DWM recommends removing potential indoor air sources that may contain similar chemicals to those being investigated if possible. It may not be possible to remove all sources, especially in an industrial setting. An attempt to remove any potential indoor air sources will help ensure that indoor air results will be more indicative of VI than indoor air sources. After removal of any indoor air sources, DWM typically recommends that the investigator wait 24-72 hours before collecting indoor air samples.

4.7.3 Number, Location, Duration and Frequency of Sampling

For a typical residential or non-residential building, DWM recommends a one time-integrated sample per 1500 square feet directly above the floor or crawl space. In general, samples should be collected from the breathing level zone of the most sensitive occupant population. The investigator should determine the appropriate number of sample locations based on several factors including, but not limited to:

- Very large or small buildings.
- Subsurface structures. For example, it may be appropriate to collect an indoor air sample from a basement or elevator pit in addition to the first floor.
- Buildings with multiple uses. For example, a commercial building may also have a day care center, and it would be appropriate to collect indoor air samples from both areas of the building.
- Buildings with different tenants separated by wall partitions. Some tenant spaces may share the same HVAC air space and have a false ceiling.
- Areas of the building may have cracks or perforations in the floor that make that area more susceptible to VI.

Indoor air samples are generally collected from the lowest floor in the building. Samples may also be collected from more than one floor within a structure to address varying exposures and as part of the process to distinguish contaminants related to VI from background sources. Thus, the location and position of the sample container will vary depending on which floor the sampling event takes place. Ground floor (living space) samples should be located to approximate human exposure. These indoor air samples are generally placed at breathing zone height (3-5'). Consideration should also be given on a case specific basis to those situations (such as a day care facility) where a different

sampling height may be appropriate to evaluate a unique setting or population. The basement sample(s) are primarily designed to investigate "worst case" situations within a building. Therefore, basement samples should be positioned as close as possible to the source area (e.g., sumps, major cracks in foundation).

The use of passive samplers allows the collection of indoor air samples over a longer time, up to 30 days, thereby providing an average indoor air concentration over a longer exposure period.

Sample duration should be determined by the potential receptors and the detection limits necessary to reach the IASLs. Typically, for residential exposure, a minimum 24-hour sample is required since residents are in the home 24 hours a day. For nonresidential exposure, a minimum 8-hour sample is required since workers typically have an 8-hour work day. Depending on the sample type, it may be necessary to collect samples over longer periods of time to reach the IASLs.

Indoor air samples should be collected concurrently with ambient air and sub-slab soil gas samples. The analytical results are useful in the differentiation of background contamination in indoor air. By comparing the site-specific contaminants of concern detected in the soil gas sample with the indoor air and ambient air results, the investigator can validate the designation of background contaminants and thus limit any remedial action.

Depending on the site conditions, the volatile concentrations in groundwater, and seasonal variability, one round of indoor air samples will likely not be sufficient to verify the presence/absence of the VI pathway. A second (or confirmation) round of indoor air samples may be appropriate. At a minimum, a confirmation sample is necessary to eliminate the VI pathway when the initial sample is collected outside the winter or summer timeframe when structures can be expected to be closed up with the HVAC running. Additionally, higher indoor air concentrations might be expected when a building is sealed up and the HVAC is not running. **A single round of sampling is acceptable (irrespective of the seasonal timing of the sampling event) when the results are an order of magnitude below the appropriate IASL.** Modifications to this provision may be appropriate based on site-specific information and with DWM approval.

It may be necessary to collect several rounds of indoor air samples based upon the season and operation of the HVAC system.

4.7.3.1 Co-Located Properties

Often, indoor air samples are collected where other residential or nonresidential spaces are co-located with the site being investigated (e.g. strip centers, duplexes, mixed-use developments). If indoor air samples are collected in one building space and the results exceed IASLs for the appropriate setting (residential or nonresidential), indoor air and concurrent sub-slab soil gas samples (if on a ground floor) should immediately be collected in the immediately adjacent building spaces. When indoor air results exceed IASLs at a site being investigated on a ground floor and separate building spaces are located above the site, indoor air samples should be collected from the spaces above and adjacent to the site. Based upon the results from the adjacent building spaces, the investigation should continue outward as necessary.

4.7.4 Sampling Procedures

Time-integrated sampling methods are generally recommended for indoor air to account for variability.

Analytical method TO-15 employs stainless steel canisters to collect whole air samples. Volatile organic compounds (both polar and non-polar) are concentrated on a solid multisorbent trap, refocused on a second trap, separated on a gas chromatograph column, and passed to a mass spectrometer for identification and quantitation. TO-15 is the principal method used for indoor air samples primarily due to the ease of use for the investigator and the limited obstruction for the occupants of the building (compared to other sampling equipment).

Method TO-17 uses adsorbent tubes for the collection of air samples in the field. There is a large selection of sorbents that can be matched to the contaminants of concern. The tubes are thermally desorbed into a gas chromatogram/mass spectrometer instrument system. The method requires specific collection procedures and states that after desorption on to the column the samples are to be analyzed in accordance with USEPA Method TO-15.

4.7.4.1 Passive Samplers

In recent years, a variety of passive diffusion samplers have been gaining popularity for indoor air sampling since they provide some advantages over traditional canister sampling, especially for screening purposes. They are typically small, easy to deploy and can be used for various sampling periods up to 30 days. Previous experience has shown that occupants are more likely to allow deployment of passive samplers rather than a canister, due to its appearance and the ability to place them in a less conspicuous location. Using passive samplers avoids the problems associated with leak testing and flow regulators that often accompany canister sampling.

Before using passive samplers, the investigator should understand the limitations of the sampler and ensure that proper detection limits can be obtained. There are different reporting limits for different sampling times. The reporting limits should be low enough for adequate comparison to the IASLs. Additionally, passive samplers should be appropriate for the chemicals of concern be investigated since some compounds are less reliably detected with passive samplers due to unknown uptake rates.

If using passive samplers, it is recommended that the first sampling event be conducted with both passive samplers and traditional canister methods to compare results and determine if there is acceptable correlation between the results. The chemicals of concern may dictate the sampling type since passive samplers are not capable of quantifying certain chemicals. Passive samplers may be used with prior approval from DWM.

4.8 Quality Assurance/Quality Control

Detailed Quality Assurance/Quality Control (QA/QC) procedures are not provided in this guidance document. The investigator should be familiar with sampling procedures, analytical methods and QA/QC requirements prior to conducting any sampling event. Standard operating procedures for the collection of samples should be included with any reports or sample results documentation submitted to DWM.

Analyses should be performed by an accredited laboratory that has demonstrated competence and compliance with the methods for the matrix being analyzed. The investigator should have confidence in the QA/QC requirements enforced at the accredited laboratory being utilized. The

investigator should verify the vacuum when using stainless steel canisters, before and after the sample collection. The investigator should verify the canister's initial vacuum prior to collecting a sample. If the initial vacuum prior to sampling is in excess of 10% lower than the vacuum documented by the laboratory upon shipment, the canister should not be used. The post-sampling vacuum in the canister should be recorded. A residual vacuum of up to -5 inches mercury must exist in the canister upon completion of the sampling event and laboratories should report the received vacuum. Since the sample is designed to be collected over a specified period of time (i.e., 8 to 24 hours), the residual vacuum ensures that the sample was collected over that time period and ensures that the samples are not damaged or altered during transport. If no vacuum remains, the validity of the data is questionable.

For soil gas and indoor air samples collected via Summa canister, a particulate filter should be used over the probe to avoid clogging. Summa canisters can be batch or individually certified for specific needs. The certification process ensures the canisters are first cleaned then evacuated to achieve the appropriate negative pressure. A batch certification process is appropriate for routine ambient air application, soil vapor and landfill gas monitoring, but canisters should be individually certified for indoor air testing. Analytical labs should be contacted in advance to be sure that canisters are available and appropriately certified for the type of sampling and potential contaminants that may be atypical or unusual. VI evaluation reports should include a summary of the lab procedures used to decontaminate and certify equipment.

5.0 DATA EVALUATION AND SCREENING

DWM recommends a multiple lines of evidence approach for determining whether the VI pathway is complete or incomplete, whether levels of contaminants in indoor air are likely caused by VI versus an indoor or ambient air source, whether indoor air concentrations pose an unacceptable health risk, and whether an interim response is needed to mitigate VI. The vapor intrusion pathway should be evaluated using multiple lines of evidence that may include, but are not limited to:

- Presence of contamination in the subsurface that could be a source of VI.
- Potential for vapors to migrate from the source to current or future buildings.
- Groundwater data and comparison to the GWSLs.
- Soil gas data and comparison to the SGSLs.
- Data on site geology and hydrology that supports groundwater and soil gas migration.
- Preferential pathways for subsurface vapor migration.
- Building conditions that demonstrate susceptibility for soil gas entry.
- Pressure data to demonstrate the driving force for soil gas entry.
- Crawl space or indoor air data and comparison to the IASLs.
- Comparison of soil gas and indoor air data, including evaluation of attenuation factors.
- Background indoor air sources of contamination.
- Outdoor air data to assess potential ambient air contributions to indoor air data.
- Indoor air results comparing when HVAC is operational and non-operational.
- Evaluation of tracer elements or naturally occurring radon.

Ideally, the investigator will have enough lines of evidence to support a decision regarding the VI pathway. Not all lines of evidence will be definitive. The investigator must use scientific and professional judgment to determine when the VI pathway is complete or incomplete. In general,

when lines of evidence are inconsistent, DWM recommends collecting a new line of evidence or collecting additional data to add weight to the existing evidence.

When evaluating sampling results to assess the VI pathway, it is important to first determine that the samples were collected appropriately. After verification, the sample results can be compared to the appropriate medium-specific DWM screening levels. Risk-based screening is used to identify sites or buildings likely to pose a health concern, to identify buildings that may warrant immediate action, to help focus site-specific investigation activities or to provide support for building mitigation and other risk management options including remediation.

Generally, if all sample results for a given building or area are below the respective screening levels, then VI is less likely to pose an unacceptable health risk to occupants. When sample results exceed the screening levels, additional evaluation, assessment or mitigation are warranted. However, if any individual sampling result exceeds the screening level, that does not mean VI will pose an unacceptable health risk. Sample results can be expected to be variable spatially and temporally, and the DWM screening levels are very conservative and assume a long period of exposure at that level. The Risk Calculator can be used to directly calculate risk associated with multiple chemicals either using groundwater, soil gas, crawl space or indoor air data.

The following sections discuss medium-specific data evaluation considerations and screening procedures.

5.1 Groundwater

The investigator should compare the highest groundwater concentration present within 100 feet of any structure to the appropriate GWSLs (residential or nonresidential). If a particular chemical is not found on the GWSL tables, contact the appropriate DWM cleanup program about developing a screening number for that chemical.

If the groundwater concentrations do **NOT EXCEED** the GWSLs, typically no further VI investigation is necessary unless the investigator has knowledge of site-specific conditions (i.e. preferential pathways, structural features, etc.) that may warrant further investigation. If the groundwater concentrations do **NOT EXCEED** the GWSLs (or calculated risk) but there is near-slab soil gas that exceeds the SGSLs, the VI investigation should proceed with additional soil gas, crawl space or indoor air sampling.

If the groundwater concentrations **EXCEED** the GWSLs (or calculated risk), further investigation should proceed in a step-wise fashion, typically with the collection of soil gas samples. However, it should not be assumed that elevated groundwater concentrations automatically indicate that unacceptable levels of vapors are currently entering the structure. Groundwater concentrations that are slightly above the GWSLs or are fluctuating above/below the GWSLs may warrant further monitoring before proceeding with additional sample collection. **Soil gas may be collected immediately above the water table near the highest groundwater concentration and compared to the SGSLs to demonstrate that groundwater concentrations do not pose a potential for vapor intrusion.**

The plume should be shown to be stable or shrinking to indicate that the potential for VI will not increase in the future.

The groundwater data shall be evaluated to determine whether the contaminant plume has been delineated to the extent needed to assess the VI pathway. If it is determined that the plume has not been sufficiently delineated, additional groundwater samples will be required to complete the delineation as it pertains to this pathway. Any newly obtained groundwater data within 100 feet of structures should be compared to the appropriate GWSLs. Depending on the soil type, the presence of preferential pathways, and/or certain hydrogeologic features, the distance criteria may have to be modified. The results of this effort will highlight those structures that will necessitate further investigation for the VI pathway.

In cases where soil contamination represents a potential source of VI, the use of groundwater data and the GWSL alone are NOT appropriate. The investigator should employ soil gas and/or indoor air samples to assess whether soil contamination is a source of VI.

5.2 Soil Gas

The analytical results from exterior soil gas samples should be compared to the SGSLs. If exterior soil gas results **EXCEED** the SGSLs (or calculated risk), typically it is recommended that sub-slab soil gas samples be collected, if possible, before proceeding to the collection of indoor air samples. If soil gas results **EXCEED** the SGSLs (or calculated risk), crawl space or indoor air samples should be collected (except at operating facilities where the chemical of concern is in use). The investigator may propose a site-specific approach involving the use of alternative attenuation factors that may be acceptable to DWM in lieu of crawl space or indoor air sampling. Based on the soil gas results and professional judgment, a determination may be made that implementing an interim or permanent mitigation measure may be the most cost-effective and proactive approach prior to proceeding with further sampling.

DWM does not typically allow the results of the soil gas samples to be averaged across a slab or the subsurface around a building. Individual results should be compared to the SGSLs.

Passive soil gas sampling is often useful in the preliminary delineation of the groundwater plume or as a screening tool to direct active soil gas investigations. Passive soil gas results should **NOT** be compared to SGSLs.

If soil gas concentrations do **NOT EXCEED** the SGSLs (or calculated risk), typically no further investigation is necessary and the VI pathway may be considered incomplete if the investigator is confident in the CSM and the data collected are adequate to evaluate the VI pathway. The SGSLs are expected to be conservative due to a generic default attenuation factor. Additionally, soil gas samples are expected to be highly variable spatially and temporally and the SGSLs assume exposure to a conservative concentration over long periods of time.

In those situations where the soil gas results do <u>not</u> exceed the SGSLs (or calculated risk) but groundwater concentrations exceed the GWSL, a site-specific determination can potentially be made that no additional VI investigation is needed. This determination should be based on an accurate CSM and representative groundwater data which indicates:

- The shallow groundwater plume is stable or shrinking,
- NAPL is not present,

- Other site conditions at the time of sampling (e.g., soil moisture, % oxygen in vadose zone) are unlikely to change enough to result in higher soil gas volatile levels.

Analytical data from soil gas samples should be assessed to identify any patterns in particular chemicals, groups of chemicals, and/or their concentrations (both individually and collectively). When combined with data from other matrices (e.g., groundwater, indoor air, and ambient air), these patterns may assist in distinguishing likely sources of indoor air contaminants and their pathways. This is important when background sources located within the structure generate the same volatile organic compounds identified as contaminants of concern associated with the site investigation. **By comparing the specific chemicals detected in the soil gas sample with the groundwater or soil contaminants associated with the site investigation, a verification of the contaminants of concern can be made. The compounds should be similar. If additional compounds are seen in the soil gas results, a background indoor air source may be present.**
This determination validates the designation of background contaminants and thus limits any remedial action to site related contaminants.

The presence of elevated contaminant vapors in the sub-slab soil gas is generally a positive indicator of VI when applying an attenuation factor. However, the reverse circumstances (low contaminant levels in the sub-slab soil gas) do not automatically imply that the vapor pathway is incomplete. Site-specific conditions, such as distance from any vadose zone sources and depth of those sources should be evaluated before reaching any conclusions on the VI pathway.

With soil gas sampling, it is important to understand the stratigraphy in the area of the building. Low permeability layers under buildings (either natural or as part of construction) may act as an impediment to significant vertical vapor migration from the groundwater contamination. The presence of such a layer may explain why random or irregular soil gas results occur when comparing data from several sample locations around a building or why clean sub-slab samples can occur even though underlying groundwater is contaminated. Soil gas results may not be consistent with the concentrations found in the underlying groundwater plume. Soil gas may still enter the building through utility trenches or other preferential pathways if they bisect or circumvent the low permeability layer.

5.3 Crawl Space

The analytical results from crawl space air samples should be compared to the IASLs since DWM recognizes NO attenuation between crawl space and indoor air. If the crawl space air results exceed the applicable IASL, additional investigation of the VI pathway is necessary to confirm the results. Typically, indoor air samples should then be collected with confirmation soil gas and/or crawl space samples.

5.4 Indoor Air

All indoor air concentrations should be compared to the IASLs (or cumulative risk can be directly calculated with the Risk Calculator). The investigator should check with the appropriate DWM cleanup program to determine the applicable IASL. Various DWM programs use IASLs at different target risk levels ranging from $1x10^{-4}$ to $1x10^{-6}$ and a Hazard Index of 1. DWM does not subtract ambient (outdoor) air or background concentrations before comparison to the IASLs.

DWM does not accept averaging of the results of the indoor air samples within a building. Therefore, each data point should be evaluated independently of each other.

Indoor air sampling results exceed the IASL (or calculated risk) for a cumulative target risk of 1E-04 or Hazard Index of 1 - a confirmation sample should be collected immediately. Based upon the degree of indoor air contamination, mitigation may be initiated before obtaining the results of the confirmation sample. If the confirmation sample exceeds the IASL (target risk 1E-04 or Hazard Index of 1), mitigation and/or remediation of the VI source is required.

For all DWM programs, a confirmed exceedance of a cumulative risk of $1x10^{-4}$ or Hazard Index of 1 will require mitigation and/or remediation of the VI source.

Indoor air sampling results between the IASL for a target risk of 1E-04 and 1E-06 and Hazard Index less than 1 - at least one additional confirmation sample is required. DWM recommends that one of the samples be collected in winter or summer conditions, typically when it would be expected that the structure would be closed up and the HVAC system operating. However, worst case conditions may also be considered when the building is closed up and the HVAC system is not running. It may be necessary to collect samples under different HVAC operation scenarios for comparison. If the results of the confirmation sampling during worst case conditions confirm the results of the first sample, typically, no further sampling is required. If the confirmation sample indicates indoor air concentrations that exceed the IASL for a target risk of 1E-04 or Hazard Index of 1, additional sampling and mitigation should be conducted.

Indoor air sampling results are below the IASL (or calculated risk) for a target risk of 1E-06 and Hazard Index of 1 - no further sampling is required.

Multiple Sampling Locations on the Same Floor - If multiple samples were collected from different locations on the same floor of a building, the results may identify probable background sources when combined with a building walkthrough and survey. Compare the locations of suspect consumer products (e.g., paints, thinners) or household activities (e.g., hobbies, smoking) with the indoor air sample results. Evaluate whether particular volatile organic compounds are higher or lower in certain portions of a building and if they correlate with identified background sources. In addition, compare the analytical results with potential VI routes through the building slab or foundation (e.g., sumps, utility lines, major cracks). Depending on the ventilation system in the basement or crawl space, differences in concentrations of site-specific contaminants of concern between multiple sample points may be related to their relative position near VI points (and not background sources).

Compare the results for individual compounds on each floor. In general, the concentrations should decrease as you move away from the source.

Sampling Locations on Multiple Floors - If indoor air samples were collected from at least two separate floors within a structure, preferably the basement (or lowest floor) and the level immediately above it, the results may assist in the assessment of potential background contaminant sources. This is critical in situations where sub-slab soil gas samples are not collected. **If VI from contaminated groundwater or subsurface soil is the main source, the highest concentrations should be in the basement (or lowest floor) and decrease as you move up to the first or second floor.** Conversely, if the higher concentrations are found in the upper floors (when compared to the basement results), a background source unrelated to the site is probably located within the building on the floor with the highest concentrations. Deviations from this general understanding of vapor movement may exist in situations where a vertical pathway allows vapors to move quickly from one floor to the next (e.g., elevator shafts, laundry chutes).

Co-Located Spaces - When the site under investigation is co-located with other businesses or separate building spaces, it is often necessary to collect sub-slab and/or indoor air samples from the adjacent spaces. DWM recommends that a step-wise approach be utilized. **If IASLs are exceeded in any co-located building space, then sub-slab sample and indoor air samples should be collected from the immediately adjacent building spaces.** If samples from the immediately adjacent building spaces exceed the IASLs, then the next building spaces should be sampled and so on.

Indoor air contaminants from a site may impact adjacent building spaces due to building construction, environmental factors and business practices. In nonresidential buildings such as strip centers, businesses often share HVAC systems, common walls with perforations for piping, conduit, etc. and drop ceilings that allow air flow over walls. Some businesses, for example dry-cleaners, may leave doors open and run fans during the summer, pushing indoor air into adjacent spaces. **The investigator should document business practices, building construction details and any other factors that may be important to evaluate if indoor air contaminants from a site are impacting adjacent spaces.**

Typically, if vapor intrusion is impacting adjacent spaces, evidence can be found by examining the ratio of sub-slab gas to indoor air.

The results from all sub-slab soil gas and indoor air sampling should be evaluated to determine if vapor intrusion is occurring in adjacent spaces. Some of the indications that vapor intrusion is **NOT** occurring and indoor air contaminants are from other indoor sources are: decreasing indoor air concentrations further away from the investigation site and low sub-slab concentrations and high indoor air concentrations in the adjacent space.

In some cases, it has been observed that the investigation site will have low sub-slab concentrations and indoor air concentrations, but the adjacent building space will have higher sub-slab and indoor air concentrations. In these instances, additional source areas have been found that extend under shared walls, creating a greater vapor intrusion concern in the adjacent building space.

5.5 Comparing Indoor Air and Sub-Slab Soil Gas Samples

DWM recommends that the collection of indoor air and sub-slab soil gas samples be conducted concurrently during the investigation of the VI pathway whenever possible. The combination of indoor air and sub-slab soil gas results will assist in identifying likely background indoor air sources

and verify whether a VI source exists below the building (instead of extrapolating contaminated groundwater or subsurface soil results from indoor air).

Compare the indoor air and soil gas sample results to see if the same chemicals of concern are found in both samples. If the same contaminants are found in indoor air at lower levels than they are present in soil gas, this is an indication that VI may be occurring if background sources are not contributing to indoor air.

Frequently, contaminants will be found in the indoor air, but not the sub-slab soil gas samples. The compounds are likely originating from background sources unrelated to VI (especially if they are not site-specific contaminants of concern). In these cases, the investigator should evaluate vadose zone (soil) contamination and preferential pathways as potential contributors to indoor air contamination that might not be detected in the subsurface soil gas results. Once it is established that VI is not contributing to the indoor air contamination, no further action is necessary for this pathway.

When the indoor air concentrations are below the IASLs, but the sub-slab soil gas results are elevated, this could indicate a potential source in the subsurface. In these situations, DWM recommends the following:

- For sub-slab soil gas results that are 10 times or less the SGSL, the options are no further action or continued monitoring.
- If the sub-slab soil gas results are greater than 10 times the SGSL, continued monitoring of sub-slab soil gas can be implemented or a remedial action investigated. Changes in site conditions may create the potential for vapor intrusion in the future if the soil gas concentrations or source are not addressed.

The investigator should use professional judgment when determining if continued monitoring or remedial action is appropriate. Factors to be considered include:

- The relative exceedance of the screening level,
- The ratio of the sub-slab soil gas and indoor air results,
- The current building construction (e.g., 1st floor garages, sub-slab vapor barriers, etc.),
- Possible effects of background sources of contamination, and
- Sampling errors.

In many situations, both the sub-slab soil gas and the indoor air results will exceed the applicable screening levels (or calculated risk). In this case, it is likely that the VI pathway is complete and appropriate mitigation or remedial action is required.

Frequently, contaminants will be found in the indoor air, but not the sub-slab samples. In these cases, the compounds are likely originating from background sources unrelated to VI. The occupants will be directed to consult with the local health department on ways to reduce background contamination.

A concentration gradient between the sub-slab and indoor air samples (greater than 20x higher in the sub-slab) strongly suggests that the VI pathway is complete. Conversely, higher concentrations within the structure (when compared to sub-slab results) would indicate that a

secondary background source is likely present inside. This scenario, however, doesn't eliminate the fact that the VI pathway may still be contributing to the poor indoor air quality within the structure.

5.6 Official Notification

Although investigators may elect to forward results (or be bound to do so by property access agreements), it is DWM's policy to officially notify property owners and tenants about their indoor air and/or soil gas analytical results. However, it is ultimately the property owner's responsibility to ensure that all potentially impacted current and future building occupants are informed. The notification from DWM will consist of a cover letter explaining the findings and summary of the analytical results.

In cases where the compounds are concluded to be originating from background sources unrelated to VI, the occupants will be directed to consult with the local health department on ways to reduce background contamination.

5.7 Report Requirements

The results of the VI investigation are typically documented in a report that should, at a minimum include the following:

1. Copies of the Indoor Air Building Survey and Sampling form.
2. Scaled site maps identifying the site, adjacent streets, buildings sampled (soil gas/indoor air), ambient air sample locations.
3. Photographs of sample locations (as appropriate) or other pertinent site features.
4. Readings from field instrumentation.
5. Laboratory analytical results.
6. Sampling procedures.
7. Names and addresses of all property owners and current tenants to be notified of results.
8. Any documentation, including scaled maps, on the assessment of preferential pathways.
9. Scaled floor plans that note location of indoor air and sub-slab soil gas samples, observed stains and major cracks in slabs/foundations, sumps, French drains, existing radon systems, chemical storage areas (or other potential background sources), HVAC systems, utility entrances into buildings, etc.

6.0 REMEDIATION AND MITIGATION

Ultimately, the DWM's primary goal is to remediate the source of the vapor contamination (groundwater and/or subsurface soil) such that the risk of VI is eliminated. Excavation and/or treatment of soil sources and groundwater remediation have proven effective in reducing contaminant levels associated with VI. However, it is often not technically possible or feasible to complete such remediation in a timely manner. Therefore, appropriate preventative or mitigation measures may be necessary.

One preventative measure that may be considered is an institutional control, such as deed restrictions or zoning, that may eliminate the potential for VI to occur under current or future conditions. Restrictions may incorporate measures to be taken for new building construction that can address

any potential VI issues or specify engineering controls that may be required to mitigate current or future VI potential.

Mitigation needs to be considered when it is determined that the VI pathway is complete and may adversely impact human health. **When the indoor air concentrations are confirmed and exceed the IASLs at a target risk of 1 x 10^{-4} or Hazard Index of 1, mitigation is required.** The objective of these mitigation techniques is to eliminate the pathway between the source (contaminated groundwater and/or subsurface soils) and the receptors (building occupants).

In some circumstances, monitoring only may be appropriate in lieu of active mitigation. For example, when sub-slab soil gas results exceed the SGSLs but the indoor air results are below IASLs, it may be more appropriate to collect indoor air samples on a semi-annual or annual basis to ensure that indoor air levels are still below IASLs.

If mitigation is required by the Brownfields Program, or if pre-emptive mitigation is chosen by the Prospective Developer, all design submittals must adhere to the format outlined in the *Vapor Intrusion Mitigation System (VIMS) Design Submittal New Construction Minimum Requirements Checklist* found in Appendix H.

Since there are many documents regarding mitigation, this section only briefly discusses the various mitigation actions appropriate for VI and the operations, monitoring and maintenance provisions associated with these remedial actions.

It is highly recommended that investigators refer to the following documents for more detailed information regarding mitigation:

ITRC document titled Vapor Intrusion Pathway: A Practical Guideline (January 2007) (http://www.itrcweb.org/Documents/VI-1.pdf)

USEPA's Radon Reduction Techniques for Existing Detached Houses - Technical Guidance (http://epa.gov/radon/pubs)

6.1 Mitigation Methods

While remedial investigation and remedial action of the vapor source are ongoing, mitigation techniques should be implemented to prevent VI. DWM generally does not review engineering design specifications for VI remedial systems. The investigator or entities responsible for implementing the VI remedial system shall demonstrate the effectiveness of the remedial action by collecting verification samples. Some mitigation methods are listed below; the first three of which are typically implemented at a minimum:

- Sealing openings and cracks with caulk or expanding foam (preferably volatile-free).
- Repairing compromised areas of the slab or foundation.
- Covering and sealing exposed earth and sump pits.
- Installing a sealed vapor barrier (e.g., plastic sheeting, liquid membrane) over earthen, gravel, etc. floors or crawlspaces.

- Utilizing natural ventilation.
- Installing a subsurface depressurization system.
- Adjusting HVAC systems/air exchange rates.
- Utilizing house pressurization.
- Installing a soil vapor extraction system.

Certain field instruments may be useful in detecting locations where VI is occurring to further identify cracks and openings that need to be sealed. Subsurface depressurization systems are the most common mitigation method and are discussed below.

6.1.1 Subsurface Depressurization Systems

The objective of the subsurface depressurization system is to apply a negative pressure field or vacuum beneath and/or around the building of concern, thereby preventing VI into the building. Subsurface depressurization systems can be either passive or active. A fact sheet regarding sub-slab depressurization can be found in Appendix E.

Sub-Slab Depressurization (SSD) - can be used when a building has a slab (e.g., concrete) floor. Typically, piping and/or suction points are installed in the subsurface beneath the slab and a fan is used to create a negative pressure field in the sub-slab area and discharge any vapor outside the building. Depending on the size of the slab and the characteristics of the sub-slab material, piping may have to be installed beneath the slab in multiple locations in order to create a negative pressure field across the entire sub-slab area.

Sub-Membrane Depressurization (SMD) - can be used when a building has an earthen (or gravel, etc.) floor or crawlspace, as opposed to a slab. A membrane such as plastic sheeting is used to cover the earthen floor or crawlspace area and, similar to SSD, a negative pressure field is created beneath the membrane thereby preventing VI across the membrane. The membrane needs to be properly sealed to the building walls, etc. and kept intact in order to maintain the negative pressure field.

Block-Wall Depressurization - can be utilized when a building has a block wall foundation. In this scenario the negative pressure field is typically created via piping inserted through the voids in the block wall. Any openings in the top of the block wall and all openings or cracks on the interior surface of the wall should be sealed. This technique is typically used in conjunction with one of the other depressurization techniques.

Drain Tile Depressurization - can be utilized when a building has a loop of perforated drain tiles (piping) adjacent to the building footers for water drainage. If the drain tiles discharge to a sump pit, the sump pit is sealed and the negative pressure field is applied to the sump pit. If the drain tiles discharge to an outdoor location the negative pressure field is applied to the drain tile loop at an outdoor location.

Passive Mitigation Methods - examples include vapor barriers, perforated piping to collect vapors and exhaust piping through a building discharging above the roof. Passive mitigation methods do not use a fan or blower to move air from the subsurface. Passive techniques often work by utilizing pressure gradients, wind and thermal effects to develop a natural vacuum effect. These systems are not as effective as active subsurface depressurization systems and are not recommended for existing buildings. **Typically, passive methods are best applied to new building construction or in**

existing buildings where it has been demonstrated that site-specific conditions exist that will allow a passive system to be as effective as an active system.

6.1.2 Other Mitigation Methods

The use of any mitigation method must be approved by the appropriate DWM cleanup program overseeing the remediation of the site. When subsurface depressurization systems are not appropriate based on-site conditions or technical considerations, other alternative mitigation approaches may include:

- Flooring systems such as Cupolex® that create voids beneath the slab for ventilating vapors.
- HVAC modifications.
- Source removal.
- Sub-slab pressurization.
- Soil vapor extraction systems.
- Limiting access to the affected building(s).

6.2 Mitigation Design and Implementation

6.2.1 Pre-Construction Considerations

DWM's primary goal is to remediate the source of the vapor contamination (groundwater and/or subsurface soil) such that the risk of VI is eliminated. However, it is often not technically possible or feasible to complete such remediation in a timely manner. **Therefore, if a property designated for development has a potential for vapor intrusion risk, DWM recommends that proactive measures (vapor barrier, vapor barrier with passive depressurization system, active depressurization system, etc.) be designed into the building.** These proactive measures are relatively inexpensive, especially compared to the cost of retrofitting them after the building is constructed.

The ITRC document titled, Vapor Intrusion Issues at Brownfield Sites (December 2003) (http://www.itrcweb.org/Documents/BRNFLD-1.pdf) provides a discussion regarding redevelopment of property and ways to prevent vapor intrusion in new construction.

6.2.2 Design Considerations

The installer of any mitigation system should visually inspect the site where the system will be installed prior to installation to assess any impediments or unusual circumstances that may affect the installation and to determine the best location for the system.

Cracks or openings in the slab should typically be sealed prior to system installation. Some areas that are commonly sealed are openings in walls or the slab where pipes or utility lines exist, floor drains, areas around sumps and any portions of the floor that are not covered by the slab.

The subsurface depressurization system should be designed to prevent backdrafting of combustion products into a structure. As a safety precaution, the depressurization system fan should be located

outside of the building as the fan housing is the most likely location for a leak to occur in the system. DWM recommends subsurface depressurization systems contain the following:

- A pressure gauge (u-tube manometer) for determining operational efficiency.
- An alarm that informs building occupants in case the system malfunctions.
- Labeling that indicates the purpose of the system along with the name, address and telephone number of the entity to contact for questions, repairs, etc.

Diagnostic testing should be performed prior to, during and/or after installation to make sure that there are sufficient suction points to achieve the required vacuum levels over the entire slab. Also, a communication test is recommended to determine the number and locations of the suction points and fan size. Suction fields beneath the slab can be interrupted by subsurface features such as foundation walls, footings, or other man-made features.

6.3 Operation, Monitoring and Maintenance

6.3.1 Institutional and Engineering Controls

Mitigation actions (or interim remedial measures) that involve the installation of subsurface systems, vapor barriers, or other similar devices or engineering controls may require an institutional control to ensure that the protection remains in place, if necessary. DWM or the responsible party may be accountable for the system verification sampling, monitoring and maintenance requirements described below. **The appropriate DWM cleanup program should be consulted regarding the use of institutional or engineering controls.**

For undeveloped properties/parcels that contain source concentrations above the screening levels (GWSL or SGSL), official notification of the property owner is required and institutional controls are typically necessary prior to closure to ensure that vapor intrusion will not occur for future exposures.

If nonresidential screening levels (SGSL or IASL) or OSHA values are used, an institutional control may be necessary to address future modifications in the land use (e.g., conversions to residential use).

Nonresidential properties may require institutional controls when future use may differ from the current use under which closure was issued. For example, a property used for dry-cleaning may be issued a no further action letter based on current conditions, but depending on remaining contaminant levels, an institutional control may be required to prevent vapor intrusion if the property is used for anything other than dry-cleaning in the future.

If site-specific building parameters (e.g., ventilation rate changes, building size modifications, positive pressure controls) are used to address VI concerns, an institutional control may be necessary to ensure that the property owner maintains these building controls at the affected structure/property and allows periodic monitoring.

Depending on the type of institutional control employed, the responsible party may have to monitor change in ownership and building conditions annually and inform DWM of these observations

through an annual certification. This is critical in situations where nonresidential screening levels or site-specific building parameters are utilized.

6.3.2 System Verification Sampling, Monitoring and Maintenance

6.3.2.1 Verification Procedures

After the mitigation system is operational, confirmation indoor air sampling should be conducted. Indoor air sampling should be conducted approximately two to four weeks after the system is operational to verify its effectiveness. Indoor air sampling events that do not occur during the winter or summer months when the structure is closed with the HVAC running should necessitate a second round of indoor air sampling during this timeframe. However, DWM will accept a single round of sampling (irrespective of the seasonal timing of the sample event) in those cases where the results are an order of magnitude below the appropriate screening level.

Samples should be analyzed for the site-specific COCs and their breakdown products – analysis for the full suite of chemicals is not necessary.

If the indoor sampling data for the contaminants of concern are above the IASLs (with consideration of background sources), modifications or supplementation to the existing mitigation system will be required. Additional indoor air sampling will be necessary to verify the effectiveness of the system if it has been modified. Once indoor air data collected during the winter or summer (if previously shown to have higher indoor air concentrations) are below the IASLs (or site-specific background concentrations), additional indoor air sampling may not be necessary until system termination sampling takes place.

If subsurface depressurization systems are chosen for mitigation, immediately after system startup, indoor air sampling should be conducted and it should be demonstrated that a negative pressure field exists beneath the building. These diagnostic provisions should be incorporated into the original design of the subsurface depressurization system to avoid modifications to the system after installation.

6.3.2.2 Monitoring and Maintenance

A monitoring and maintenance plan shall be submitted for DWM review and approval. **For subsurface depressurization systems, inspection of the system and pressure gauge (typically a U-tube manometer) is recommended quarterly for the first year.** Additional sub-slab pressure monitoring may be necessary. A reduced monitoring frequency, typically annual monitoring, may be appropriate after one year of successful operation of the mitigation system. If the pressure gauge indicates the system is not operating efficiently the system should be diagnosed and repaired. The pressure gauge measurements should be recorded over time in tabular format and updated with each submittal to DWM.

For passive subsurface depressurization systems, an inspection should be conducted semiannually to determine if any new or existing areas (e.g., cracks, holes, sump pit covers, earthen crawlspaces) need to be sealed, caulked, and/or covered, etc. If repairs are necessary they should be conducted and documented in the next submission to DWM. A reduced inspection frequency may be appropriate after one year.

The investigator should consult with the appropriate DWM cleanup program regarding requirements for any additional indoor air or sub-slab monitoring after the mitigation system has been verified to be operating effectively.

6.3.2.3 System Termination Sampling

Once the investigator concludes that the VI source (groundwater, soil gas, etc.) has been properly remediated to the point where the VI pathway is not complete, a proposal may be submitted to DWM to cease operation of the VI remedial system. Upon approval from DWM, system termination sampling of indoor air and sub-slab soil gas should be conducted. The system termination sampling should occur during the winter and summer months when the structure could be expected to be closed up with the HVAC running. The system termination indoor air and sub-slab analytical results should be submitted for DWM review. Note subsequent sampling rounds may be required on a case by case basis to verify the appropriateness of system termination. Analytical parameters for the system termination samples should include the contaminants of concern analyzed after the initial startup of the mitigation system. However, additional analytical parameters may be required on a case by case basis.

7.0 COMMUNITY OUTREACH FOR VAPOR INTRUSION SITES

7.1 Why Do Community Outreach?

Early, two-way communication with residents, business owners and local officials affected by a contaminated property can be critical to a successful investigation and cleanup. When citizens are well-informed about the issues surrounding a site, their questions and concerns can be more easily addressed. This builds trust and credibility and allows the remedial process to proceed most efficiently.

An effective outreach strategy that anticipates the needs and concerns of the community will be particularly important to a VI investigation. In most cases, the parties conducting the investigation will need to arrange sampling appointments with residents/property owners, collect indoor air and soil gas samples, and report the findings. At some properties, sub-surface depressurization systems may be required. Information sessions may be necessary to ensure the general public is properly informed about the investigation and remedial actions. Those involved in a VI investigation will want to develop their community outreach strategy before the actual work begins to ensure the most successful outcome.

DWM strongly recommends that parties investigating VI sites familiarize themselves with the concepts in USEPA's guidance, The Seven Cardinal Rules of Risk Communication (www.epa.gov/superfund/tools/pdfs/37riskcom.pdf), when preparing their community outreach activities for VI sites.

7.2 Communicating with the Public about Vapor Intrusion

When initiating a VI investigation and during an investigation, there are different key groups of people that may be involved at varying points in the investigation. Typically, local officials and the general public are not notified when soil gas or indoor air testing is being conducted as part of the

site investigation unless they are directly involved and must give access for sampling. **In large, high profile cases, it is often beneficial to notify local officials and the general public prior to conducting the VI investigation.** The media may emerge as a third group if the site becomes high profile. Below are some tips on how and when to communicate with parties for maximum effectiveness.

The DWM Public Information Officer should be consulted when preparing to hold a public meeting or interacting with the media.

7.2.1 General Public

When communicating with the general public about the investigation, remember that the nature of VI, how it is evaluated, sources of background contamination, possible health effects and potential remedies will likely be unfamiliar concepts. Expect to expend significant effort educating residents/property owners and local officials about these topics during and sometimes before conducting an indoor air investigation. **If there is a large population of sensitive individuals (e.g., small children in school or daycare) in the area being investigated, or if there has already been significant media attention or community interest focused on the site, it may be helpful to hold an information session before the VI investigation work begins.**

7.2.1.1 Information Sessions with the Public

Information sessions can be useful forums for disseminating information and answering questions. These sessions are usually held in coordination with DWM at a municipal building, school, church or other public building in the area near the site. Consult with interested parties to determine the best day and time and give the public several weeks' notice of the session date. Weekday evenings are usually the most convenient times for such sessions. After a date and time has been selected, mail notices of the session to interested parties, property owners and occupants near the site. DWM recommends notification of the local health department when health and risk issues are likely to be discussed.

The informational session may include a short presentation regarding the site history and investigation and a question-and-answer period. Typically, these sessions take place in an informal setting and allow the public to speak one-to-one with the professionals involved in the investigation in a relatively private setting.

When presenting data about the site to the public, remember that confidentiality may be an issue for some residents/property owners. For this reason, maps or other documents identifying specific homes with indoor air contamination may not be suitable presentation materials.

During the session, note concerns and issues raised by the public and local officials that cannot be answered or addressed immediately. Provide responses to these concerns and issues as quickly as possible once the session is over. In the weeks and months following the session, continue to periodically update the residents and local officials on the VI investigation and any remedial actions through fact sheets, letters and telephone calls.

When discussing VI, be sure to define technical jargon and explain complex concepts in a manner that can be easily understood. Provide supplemental literature, such as fact sheets, or identify a website they can go to for more information about the site. A generic fact sheet, *What You Should*

Know About Vapor Intrusion can be found in Appendix D. Ask for feedback to ensure the public understands the information. In addition, find out how they would like to be notified about developments in the future. Since people living in indoor air contamination areas are directly affected by the site, the investigator should be prepared to engage in frequent contact with the residents/property owners (phone calls, letters, meetings, etc.).

7.2.2 Local Officials

In some cases, it may be beneficial to notify the municipal officials (e.g., municipal clerk, township administrator, mayor) and the local health officer that indoor air and/or soil gas sampling is going to be conducted in their area and why it is being done. **When performing notifications of officials, always work with the appropriate DWM cleanup program overseeing work at the site and the DWM public information officer.** As the elected or appointed leaders of the community, the media or residents will likely contact them for information. (If site activities include going door-to-door to collect information from residents or any other type of canvassing, the local police department should also be notified.)

Establish a working relationship with local officials early in the process so they can be involved as needed later on. Provide local officials with copies of the *What You Should Know About Vapor Intrusion* fact sheets in Appendix D and inform them of the availability of this guidance document on DWM's web site, http://portal.ncdenr.org/web/wm/. Let them know that you may be copying them on correspondence to residents regarding the VI investigation.

7.2.3 Media

A site does not have to be particularly large or complex to garner attention from local newspapers, television stations, or other media outlets. In cases where the media have focused on the VI investigation, it is always advisable to make background material available (if the confidentiality of individual test results is maintained).

The DWM Public Information Officer should be made aware of any media inquiries regarding activities at a site.

7.3 Arranging Sample Appointments

DWM recommends a two-step approach when initially contacting residents/property owners to obtain permission to conduct a VI investigation at their buildings. First, send an introductory letter to the residents/property owners to inform them of the proposed VI investigation at their buildings. The DWM Public Information Officer should be allowed to review the letter prior to sending it out whenever possible. Follow up with phone calls to the residents to arrange sampling appointments. Often, face-to-face meetings with residents/property owners offer a better opportunity to explain the investigation and what the sample results may mean.

Send the introductory letters several weeks ahead of the sampling event. For rental properties, send the letters to both the property owners and tenants. Write the letters in non-technical terms and include the following information:

- An explanation for the reason for the sampling.
- The name of the contaminant(s) of concern.

- The anticipated sampling date (or approximate timeframe).
- Who will be doing the sampling.
- What the sampling will involve.
- The phone numbers of DWM project manager.

Also include the following attachments, which are available from this guidance document and on the DWM web (http://portal.ncdenr.org/web/wm/):

- *Indoor Air Building Survey and Sampling Form* (Appendix C)
- *What You Should Know About Vapor Intrusion* (Appendix D)
- *Instructions for Occupants – Indoor Air Sampling Events* (Appendix F)

It may also be helpful to enclose specific information about the contaminant(s) of concern, such as ToxFAQ™ fact sheet(s) about the chemical(s) from the Agency for Toxic Substance and Disease Registry (ASTDR) web page [http://www.atsdr.cdc.gov/atsdrhome.html].

Finally, if plans include collecting soil gas or crawl space/indoor air samples, attach an access agreement for the recipient to sign and return. For rental properties, the access agreement need only be attached to the letter to the property owner.

Note: If working with local officials, it is important to keep them apprised of your activities at this stage. Provide them with a sample introductory letter and a list of the names and addresses of the residents/property owners that have been contacted to request an indoor air investigation.

After sending the introductory letters, call the occupants of the buildings to arrange the sampling appointments at least one to two weeks prior to the scheduled sampling event. Ask local contacts to help get in touch with occupants that are not available or responsive. When calling to arrange the appointments, be prepared to discuss the following:

- The contaminant(s) of concern.
- General health issues - direct specific health questions to the local health department.
- How the sample(s) will be collected and analyzed.
- When the analytical results will be available and possible remedial actions.
- How to prepare for the sampling and what to avoid when sampling is being conducted, as outlined in *Instructions for Occupants – Indoor Air Sampling Events* (Appendix F).

In addition, discuss the *Indoor Air Building Survey and Sampling Form* Appendix C with the occupant. Inform the occupant that someone knowledgeable about the property should be available on the day of sampling to help the sampling team to fill out the form. If that is not possible, try to fill out the form over the phone with the occupant.

When arranging follow-up indoor testing appointments (such as confirmation sampling or sampling to check the effectiveness of a remedial action), it is only necessary to contact the residents/property owners by telephone. As a courtesy, try to give residents/property owners at least two weeks notice of the planned sampling. When scheduling follow-up appointments, always review the recommendations outlined in *Instructions for Occupants – Indoor Air Sampling Events* Appendix F with the residents/property owners to remind them about how to prepare for the sampling and what to avoid while the sampling is being conducted.

7.4 Collecting Samples

When entering homes and other private buildings to conduct air sampling, DWM recommends sending a team of two people. Each sampling team member should bring identification for verification by the residents should it be requested. The sampling team should be prepared to provide the occupants with the name and telephone number of a DWM contact person to whom they can direct questions.

Note: It is highly recommended that precautions be taken whenever the VI investigation includes outside air sampling. If using stainless steel canisters (i.e. Summas), the sampling equipment and related devices are not familiar to most people and may be misinterpreted as a safety concern. Therefore, the local police and fire departments should be notified of the sampling event in addition to the municipal officials. It may be useful to demonstrate the operation of the sampling equipment to these officials. A label should be affixed to the sampling device explaining the nature of the equipment and contact information in case there are further questions.

7.5 Reporting Sample Results

Although investigators may elect to forward results (or be bound to do so by an access agreement), DWM is responsible for officially notifying property owners/occupants about their sampling results.

In addition to written results, the DWM may first call the residents/property owners to report results under the following scenarios:

- The analytical results indicate that VI is causing one or more contaminants of concern to exceed the DWM IASLs. This will give the occupant/property owner the opportunity to discuss the results as soon as they become aware of them.
- Very high levels of background contaminants are found in the indoor air. This may allow the resident/property owner to take immediate measures to reduce their exposure to these contaminants by addressing the source. Occupants/property owners should be referred to their local health department if they have specific health questions about non-site related contaminants.
- A significant period of time has elapsed (more than eight weeks) since the testing was conducted. Residents who are anxious about their results will appreciate receiving them verbally if it speeds the process.

Verbal Reports - When reporting indoor air results verbally, DWM will provide the results directly to the property owner, resident and/or tenant, since leaving the information on an answering machine or with another person can lead to a misunderstanding of the findings and/or breach confidentiality.

Once property owners/residents/tenants know their indoor air testing results, DWM will explain the next action, if any, and when they can expect to receive written copies of their results. DWM will also provide the name and phone number of a DWM contact person in case the resident/property owner has follow-up questions.

Written Reports - The written reports from DWM should consist of a cover letter explaining the findings and a summary of the analytical results. The purpose of the cover letter is to put the results

in a context that the property owner, resident and/or tenant can easily understand. In the case of rental properties, the findings should be reported in writing to both the tenant and the property owner. If local officials or local health officers have been involved, they should also be copied on all letters.

The cover letter should be written in non-technical terms and include the information listed below.

- The date the sampling was conducted.
- Who conducted the sampling (e.g., name of government agency or private contractor).
- The site for which the sampling was conducted (if applicable).
- The sample location/address.
- An explanation of the findings with the contaminant(s) of concern highlighted.
- The next action, if any, for the property (e.g., another round of sampling or a remedial action).
- A brief discussion of the indoor air contaminants detected that are not related to the site. (Refer the property owner/resident/tenant to their local health department if they have questions about non-site related indoor air contaminants.)
- Name and telephone number of a DWM contact person.

Also attach a copy of the *Subsurface Depressurization Systems* fact sheet (Appendix E), if applicable.

The summary of analytical results should be in a format that is easy to understand. Enclosing the summary tables from the laboratory analytical data package is **NOT** recommended, as these are often very technical. It is recommended that a separate table be constructed to include the concentration of each compound that was detected during the indoor air sampling and the IASL for each compound (both reported in $\mu g/m^3$).

7.6 Community Outreach during Mitigation

Most of the community outreach conducted during the mitigation phase will entail acting as a point of contact between the occupant/property owner and the contractor or state regulators. This can include scheduling the installation of the mitigation system, relaying the property owner's concerns to the appropriate individuals, and ensuring that every effort is made to resolve issues or concerns related to the remedial action.

As stated earlier, some people may feel that owning a home with vapor intrusion carries a stigma. Before beginning the mitigation work, make sure the occupant/property owner is comfortable with the final design. In all cases, the finished mitigation system should be as inconspicuous as possible.

Finally, as part of the community outreach for a VI investigation/remedial action, measures should be taken to ensure that the property owner understands that it is his responsibility to inform current and future occupants of the building about the vapor intrusion issues at the property.

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APPENDIX A

ITRC Conceptual Site Model Checklist

CONCEPTUAL SITE MODEL CHECKLIST

The information included in this checklist may be useful for developing a site-specific conceptual migration model and in planning soil gas sampling. The investigator may use this checklist to compile information for each site.

Utilities and Process Piping

☐ Locate and map out all underground utilities near the soil or groundwater impacts. Pay particular attention to utilities that connect impacted areas to occupied buildings.

☐ Locate and map out all underground process piping near the soil or groundwater impacts.

Buildings (Receptors)

☐ Locate and map out existing and potential future buildings.

☐ Identify the occupancy and use of the buildings (e.g., residential, commercial). You may need to interview occupants to obtain this information.

☐ Describe the construction of the building including materials (e.g., wood frame, block), openings (e.g., windows, doors), and height (e.g., one story, two story, multistory). Determine whether there is an elevator shaft in the building.

☐ Describe the foundation construction:

- Type (e.g., basement, crawl space, slab on grade)
- Floor construction (e.g., concrete, dirt)
- Depth below grade

☐ Describe the HVAC system in the building:

- Type (e.g., forced air, radiant)
- Equipment location (e.g., basement, crawl space, utility closet, attic, roof)
- Source of return air (e.g., inside air, outside air, combination)
- System design considerations relating to indoor air pressure (e.g., positive pressure is often the case for commercial buildings)

- ☐ Describe subslab ventilation systems or moisture barriers present on existing buildings, or identify building- and fire-code requirements for subslab ventilation systems (e.g., for methane) or moisture barriers below foundations.

Source Area

- ☐ Locate and map out the source area for the vapor-phase contaminants related to the subsurface vapor intrusion pathway.
- ☐ Describe the presence, distribution, and composition of any NAPL at the site.
- ☐ Identify the vapor-phase contaminants that are to be considered for the subsurface vapor intrusion pathway.
- ☐ Describe the status and results for the delineation of contamination in environmental media, specifically soil and groundwater, between the source area and the potential impacted buildings.
- ☐ Describe the environmental media (e.g., soil, groundwater, both) containing contaminants.
- ☐ Describe the depth to source area.
- ☐ Describe the potential migration characteristics (e.g., stable, increasing, decreasing) for the distribution of contaminants.

Geology/Hydrogeology

- ☐ Review all boring logs, monitoring well construction, and soil sampling data to understand the following:
  - Heterogeneity/homogeneity of soils and the lithologic units encountered and the expected/observed contaminant migration:
    - Depth and lateral continuity of any confining units that may impede contaminant migration
    - Depth and lateral continuity of any highly transmissive units that may enhance contaminant migration
  - Depth of vadose (unsaturated) zone, capillary fringe, and phreatic (saturated) zone:
    - Note any seasonal water table fluctuations and seasonal flow direction changes (hydraulic gradient).
    - Note the depth interval between the vapor source and the ground surface.

- Note the presence of any perched aquifers.
- Note where the water table intersects the well screen interval or the presence of submerged screen.

☐ Describe distinct strata (soil type and moisture content, e.g., moist, wet, dry) and the depth intervals between the vapor source and ground surface.

☐ Describe the depth to groundwater.

☐ Describe groundwater characteristics (e.g., seasonal fluctuation, hydraulic gradient).

Site Characteristics

☐ Estimate the distance from edge of groundwater plume to building.

☐ Determine nearby potential sources.

☐ Estimate the distance from vapor source area to building.

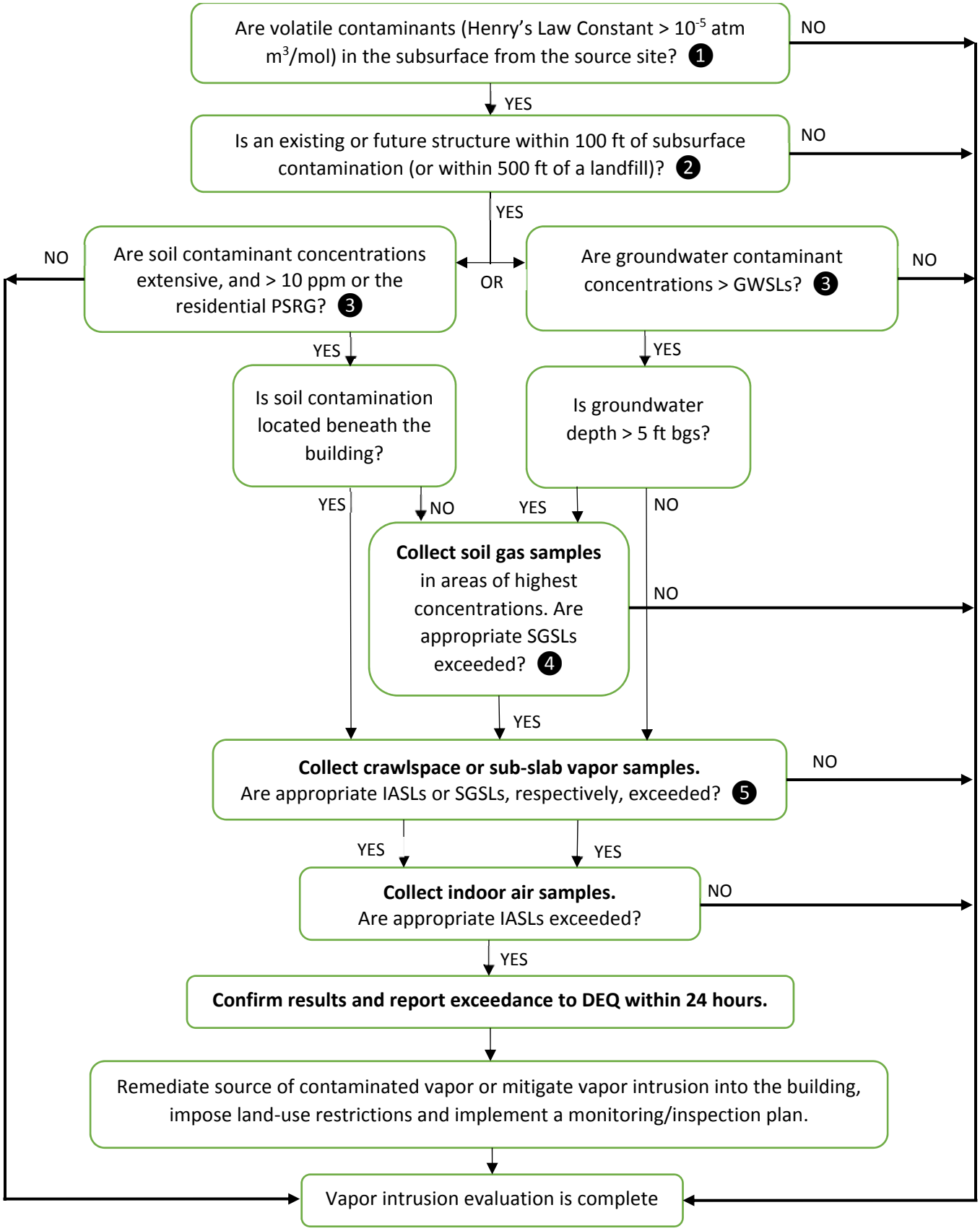
☐ Describe the surface cover between the vapor source area and the potentially impacted building.

APPENDIX B

IHSB Structural Vapor Intrusion Evaluation Steps

IHSB FLOWCHART OF STRUCTURAL VAPOR INTRUSION EVALUATION STEPS

An understanding of extent of contamination and groundwater flow patterns is needed prior to planning a vapor intrusion evaluation



1 See notes on following page.

FLOWCHART NOTES

❶ Contaminants of concern may include not only the typical analytes on a volatile organic scan, but also mercury, hydrogen sulfide, ammonia and some semivolatile compounds.

❷ Existing and future structures located outside the contaminated areas could also be affected because contaminated soil gas can travel along preferential pathways in the subsurface caused by geologic formations, fractures, lithologic lenses and utility corridors.

❸ All child-occupied spaces such as schools and day care facilities should be screened using the residential screening values.

❹ Consider both current buildings and potential future development (see note 2 above).

- For deeper soil contamination (> 5 ft bgs), sample depth with max concentrations and 5 ft depth.
- For shallow soil contamination (< 5 ft bgs), passive sampler emplacement or other method may be needed.
- For groundwater contamination, collect soil gas samples close to the building and just above the water table or between 5-10 ft bgs.

Where soil gas testing fails to meet SGSLs at a vacant lot or any portion of an affected property planned for development, contamination must be reduced to levels that pose no risk for the planned use of the property, and/or land-use restrictions will be required to prevent exposure from potential vapor intrusion into future structures.

❺ Time-integrated, passive sampling methods can provide an average soil gas or indoor air concentration over a longer exposure period (e.g., several days to several weeks) to account for variability. Passive sampling methods have proven to be less intrusive to building occupants and often more convenient to implement. It is recommended that at a minimum the first sampling event include traditional canister methods for comparison and correlation of results.

DEFINITIONS

ft bgs feet below ground surface

PSRG Preliminary Soil Remediation Goals

GWSL Groundwater Screening Level

SGSL Soil Gas Screening Level

IASL Indoor Air Screening Level

APPENDIX C

Indoor Air Building Survey and Sampling Form

INDOOR AIR BUILDING SURVEY
and SAMPLING FORM

Site Name: _____ ID#: _____

Preparer's name: _____ Date: _____

Preparer's affiliation: _____ Phone #: _____

Part I - Occupants

Building Address: _____

Property Contact: _____ Owner / Renter / other: _____

Contact's Phone: home ( )_____ work ( )_____ cell ( )_____

# of Building occupants: Children under age 13 _____ Children age 13-18 _____ Adults _____

Part II – Building Characteristics

Building type: residential / multi-family residential / office / strip mall / commercial / industrial

Describe building: _____ Year constructed: _____

Sensitive population: day care / nursing home / hospital / school / other (specify): _____

Number of floors below grade: _____ (full basement / crawl space / slab on grade)

Number of floors at or above grade: _____

Depth of basement below grade surface: _____ ft. Basement size: _____ ft^2

Basement floor construction: concrete / dirt / floating / stone / other (specify): _____

Foundation walls: poured concrete / cinder blocks / stone / other (specify) _____

Basement sump present? *Yes / No* Sump pump? *Yes / No* Water in sump? *Yes / No*

Type of heating system (circle all that apply):

hot air circulation	hot air radiation	wood	steam radiation
heat pump	hot water radiation	kerosene heater	electric baseboard

other (specify): _____

Type of ventilation system (circle all that apply):

central air conditioning	mechanical fans	bathroom ventilation fans
individual air conditioning units	kitchen range hood fan	outside air intake

other (specify): _____

Type of fuel utilized (circle all that apply):

Natural gas / electric / fuel oil / wood / coal / solar / kerosene

Are the basement walls or floor sealed with waterproof paint or epoxy coatings? *Yes / No*

Is there a whole house fan? *Yes / No*

Septic system? *Yes / Yes (but not used) / No*

Irrigation/private well? *Yes / Yes (but not used) / No*

Type of ground cover outside of building: grass / concrete / asphalt / other (specify) _____

Existing subsurface depressurization (radon) system in place? *Yes / No* *active / passive*

Sub-slab vapor/moisture barrier in place? *Yes / No*
Type of barrier: _____

Part III - Outside Contaminant Sources

Other stationary sources nearby (gas stations, emission stacks, etc.): _____

Heavy vehicular traffic nearby (or other mobile sources): _____

Part IV – Indoor Contaminant Sources

Identify all potential indoor sources found in the building (including attached garages) and crawlspace (if present), the location of the source (floor and room), and whether the item was removed from the building 48 hours prior to indoor air sampling event. Any ventilation implemented after removal of the items should be completed at least 24 hours prior to the commencement of the indoor air sampling event.

Potential Sources	**Location(s)**	**Removed** (Yes / No / NA)
Gasoline storage cans		
Gas-powered equipment		
Kerosene storage cans		
Paints / thinners / strippers		
Cleaning solvents		
Oven cleaners		
Carpet / upholstery cleaners		
Other house cleaning products		
Moth balls		
Polishes / waxes		
Insecticides		
Furniture / floor polish		
Nail polish / polish remover		
Hairspray		
Cologne / perfume		
Air fresheners		
Fuel tank (inside building)		NA
Wood stove or fireplace		NA
New furniture / upholstery		
New carpeting / flooring		NA
Hobbies - glues, paints, etc.		

Part V – Miscellaneous Items

Do any occupants of the building smoke? *Yes / No* How often? _____

Last time someone smoked in the building? _____ hours / *days ago*

Does the building have an attached garage directly connected to living space? *Yes / No*

If so, is a car usually parked in the garage? *Yes / No*

Are gas-powered equipment or cans of gasoline/fuels stored in the garage? *Yes / No*

Do the occupants of the building have their clothes dry cleaned? *Yes / No*

If yes, how often? weekly / monthly / 3-4 times a year

Do any of the occupants use solvents in work? *Yes / No*

If yes, what types of solvents are used? _____

If yes, are their clothes washed at work? *Yes / No*

Have any pesticides/herbicides been applied around the building or in the yard? *Yes* / No

If so, when and which chemicals? _____

Has there ever been a fire in the building? *Yes / No* If yes, when? _____

Has painting or staining been done in the building in the last 6 months? *Yes / No*

If yes, when _____ and where? _____

Part VI – Sampling Information

Sample Technician: _____ Phone number: ( ) _____ - _____

Sample Source: Indoor Air / Crawlspace Air / Sub-Slab / Near Slab Soil Gas / Exterior Soil Gas

Sampler Type: Tedlar bag / Sorbent / Stainless Steel Canister / Other (specify): _____

Analytical Method: TO-15 / TO-17 / other: _____ Cert. Laboratory: _____

Sample locations (floor, room):

Field ID # _____ - _____ Field ID # _____ - _____

Field ID # _____ - _____ Field ID # _____ - _____

Were "Instructions for Occupants" followed? Y*es / No*

If not, describe modifications: _____

Provide Drawing of Sample Location(s) in Building

Part VII - Meteorological Conditions

Was there significant precipitation within 12 hours prior to (or during) the sampling event? *Yes / No*

Describe the general weather conditions: _____

_____

Part VIII – General Observations

Provide any information that may be pertinent to the sampling event and may assist in the data interpretation process (e.g., observed that drycleaner operated with door or windows propped open for ventilation).

_____

_____

_____

(Adapted from the NJDEP Vapor Intrusion Guidance, October 2005)

APPENDIX D

What You Should Know About Vapor Intrusion Fact Sheet

United States Environmental Protection Agency

What You Should Know About Vapor Intrusion

EPA has developed this fact sheet to answer some of the most commonly asked questions about an important health issue called vapor intrusion. Vapors and gases from contaminated groundwater and soil have the potential to seep into indoor spaces and cause health problems.

What is vapor intrusion?

When chemicals or petroleum products are spilled on the ground or leak from underground storage tanks, they can give off gases, or vapors that can get inside buildings. Common products that can cause vapor intrusion are gasoline or diesel fuel, dry cleaning solvents and industrial de-greasers. The vapors move through the soil and seep through cracks in basements, foundations, sewer lines and other openings. Vapor intrusion is a concern because vapors can build up to a point where the health of residents or workers in those buildings could be at risk. Some vapors such as those associated with petroleum products have a gasoline odor, others are odor-free.

Can vapors in my home come from household sources?

Common household products can be a source of indoor air problems. Vapors and gases can come from: paints; paint strippers or thinners; moth balls; new carpeting and furniture; stored fuel; air fresheners; cleaning products; dry cleaned clothing and even cigarette smoke.

What are the health concerns related to vapor intrusion?

When vapor intrusion does occur, the health risk will vary based on the type of chemicals, the levels of the chemical found, the length of exposure and the health of exposed individuals. Some people may experience eye and respiratory irritation, headaches and/or nausea. These symptoms are temporary and should go away when the vapors are addressed. Low-level chemical exposures over many years may raise the lifetime risk of cancer or chronic disease.

How is vapor intrusion discovered?

Samples of gas in the soil or groundwater are first collected near a contaminated site. If no contamination is found near a site, then vapor intrusion should not be a problem. If contamination is found, depending on the type, the search may be widened to include samples closer to or on individual properties. The next step is to take vapor samples from the soil under the home's foundation; these are called slab, or sub-slab samples. EPA does not generally recommend indoor air sampling before slab or sub-slab sampling, because indoor air quality varies widely day to day. Also, household products may interfere with sampling results.

What happens if a problem is found?

The most common solution is to install systems often used to reduce naturally occurring radon that seeps into homes in some geographic areas. These systems, called radon mitigation systems, remove soil vapors from below basements or foundations before they enter homes. Vapors are vented outside of the homes where they become dispersed and harmless. These systems use minimal electricity and do not affect heating and cooling efficiency. They also prevent radon from entering homes – an added health benefit especially in radon prone areas. Once the source of the vapors is eliminated, the systems should no longer be needed.

Vapor Intrusion: Tightly seal common household products after use and seal them in an area that is well ventilated to avoid the release of vapors

What can I do to improve indoor air quality?

- Don't buy more chemicals than you need.
- Store unused chemicals in appropriate tightly-sealed containers.
- Don't make your home too air tight. Fresh air helps prevent chemical build-up and mold growth.
- Fix all leaks promptly, as well as other moisture problems that encourage mold.
- Check all appliances and fireplaces annually.
- Test your home for radon. Test kits are available at hardware and home improvement stores or you can call the Radon Hotline at 800-458-1158 in New York State, or 800-648-0394 in New Jersey.
- Install carbon monoxide detectors in your home. They are available at hardware and home improvement stores.

Sub-slab mitigation system: This system draws radon and other vapors out of the soil and vents them outside

For more information:

- For health related questions regarding vapor intrusion, contact your local health department or the federal Agency for Toxic Substances and Disease Registry at:
  1-888-422-8737 or visit their Web site at www.atdsr.cdc.gov

- For more detailed information on EPA's vapor intrusion sampling, visit the EPA's Web site at:
  www.epa.gov/correctiveaction/eis/vapor/guidance.pdf

- For more information on indoor air quality, visit EPA's Web site at:
  www.epa.gov/air/topics/comoria.html or call the indoor air Quality Information hotline at 1-800-438-4318

APPENDIX E

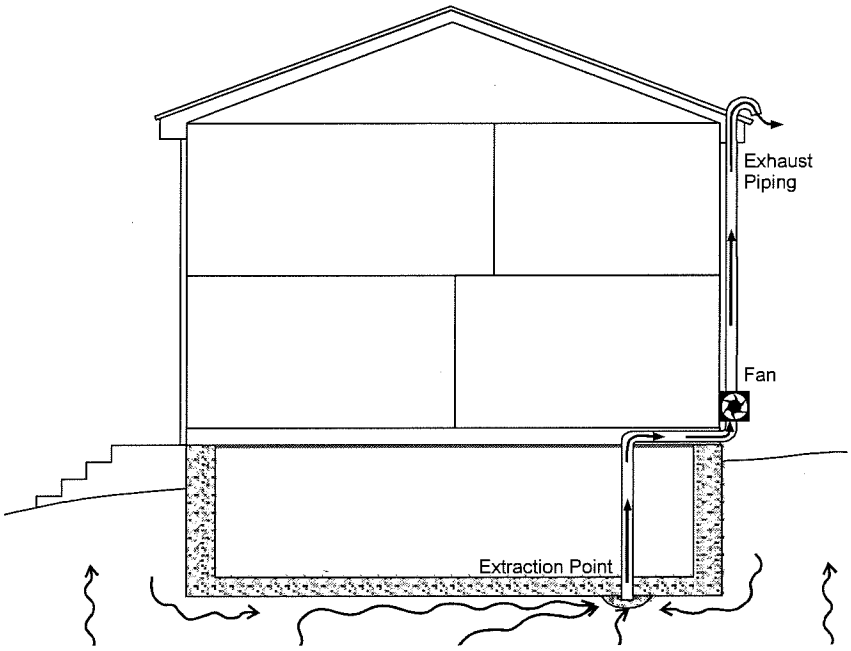
Subsurface Depressurization Systems Fact Sheet

Fact Sheet

Subsurface Depressurization Systems

Vapor intrusion occurs when vapors from volatile organic contamination in soil or ground water enter nearby buildings through cracks and holes in the foundations or slabs or via crawl spaces. In general, the goal at these sites is to remove the source of the vapors by cleaning up the contaminated soil or ground water. Since this can be a lengthy process, interim measures are often needed to protect occupants of the buildings from breathing the vapors while the cleanup is underway.

An effective method to prevent vapor intrusion during the cleanup process is to install subsurface depressurization systems at the affected buildings. The two most common types are the **sub-slab depressurization system** and the **sub-membrane depressurization system.**



A subsurface depressurization system prevents vapor intrusion by directing hazardous vapors in the soil to the exterior of the building.

A subsurface depressurization system fan on the exterior of a building.

Sub-slab depressurization systems are installed in buildings with slab (concrete) floors. Sub-membrane depressurization systems are installed at buildings with earthen or gravel crawl spaces or floors instead of slabs.

A sub-slab depressurization system consists of PVC piping installed through the slab floor and a fan connected with the piping. When the system is on, the fan applies a vacuum beneath the slab and the vapors in the soil beneath the building are directed outside, as shown above.

With sub-membrane depressurization systems, an impermeable membrane (such as plastic sheeting) is placed over the earthen or gravel area and the ventilation piping is installed through the membrane.

Subsurface depressurization systems are also used throughout the country to prevent naturally occurring radon gas from entering buildings.

Sub-slab and sub-membrane depressurization systems must operate continuously to be effective. They use little electricity, are relatively quiet and require little maintenance. A professional contractor should periodically check your system to ensure it is working properly.

(From New Jersey Department of Environmental Protection, Vapor Intrusion Guidance, 2005)

APPENDIX F

Instructions for Occupants – Indoor Air Sampling Events (English and Spanish)

Instructions for Occupants
Indoor Air Sampling Events

In order to collect an indoor air sample in your structure that is both representative of indoor conditions and avoids the common sources of background air contamination associated with household activities and consumer products, the Division of Waste Management (DWM) requests your assistance.

To the extent possible, please follow the instructions below starting at least 48 hours prior to and during the indoor air sampling event:

- Operate your heating and/or whole-house air conditioner as appropriate for the current weather conditions
- Do not use wood stoves, fireplaces or auxiliary heating equipment
- Do not open windows or keep doors open
- Avoid using window air conditioners, fans or vents
- Do not smoke in the building
- Do not use air fresheners or odor eliminators
- Do not use paints or varnishes (up to a week in advance, if possible)
- Do not use cleaning products (e.g., bathroom cleaners, furniture polish, appliance cleaners, all-purpose cleaners, floor cleaners)
- Do not use cosmetics, including hair spray, nail polish remover, perfume, etc.
- Avoid bringing freshly dry-cleaned clothes into the building
- Do not engage in indoor hobbies involving the use of solvents
- Do not apply pesticides
- Do not store containers of gasoline, oil or petroleum-based or other solvents within the building or attached garages (exception: fuel oil tanks)
- Do not operate or store automobiles in an attached garage
- Do not operate gasoline-powered equipment within the building, attached garage or around the immediate perimeter of the building

You will be asked a series of questions about the structure, consumer products you store in your building, and household activities typically occurring in the building. These questions are designed to identify "background" sources of indoor air contamination. While this investigation is looking for a select number of chemicals related to the subsurface contamination, the laboratory may be analyzing the indoor air samples for a wide variety of chemicals. Thus, tetrachloroethene used in dry cleaning or acetone found in nail polish remover might be found in your sample results.

Typical air sampling equipment

Your cooperation is greatly appreciated.
If you have any questions about these instructions, please feel free to contact:

_____

_____

(Adapted from NJDEP Vapor Intrusion Guidance, October 2005)

Instrucciones Para Habitantes
Con Respecto al Muestreo del Aire Ambiental

Quicieramos que las muestra del aire ambiental del interior de su edificio sea a la vez representativa de las condiciones del interior y eviten las fuentes comunes de antecedentes de contaminación de aire asociado con actividades de la casa y productos de consumo.

Por favor siga las instrucciones abajo mencionadas comenzando por lo menos 48 horas antes de y durante el evento de muestreo:

- Opere su horno y el aire acondicionado de toda la casa apropiadamente a las actuales condiciones del tiempo
- No use estufas de leña, chimeneas o equipos auxiliares de calefacción.
- No abrir las ventanas o mantener las puertas abiertas.
- Evite usar aires acondicionados, abanicos o ventiladores de ventanas
- No fume dentro del edificio
- No use refrescantes de aire o eliminadores de olor
- No use pinturas o barniz (hasta una semana por adelantado, si es posible)
- No use productos de limpieza (ej. Limpiadores de baño, cera para muebles, limpiadores de aparatos electrodomésticos, limpiadores para "todo propósito", limpiadores del piso)
- No use cosméticos, incluyendo fijador del cabello, removedor de esmalte de uñas, perfume
- Evite traer ropa recientemente limpiada en seco (de la tintorería) al edificio
- No participe en pasatiempos en el interior del edificio que usen solventes
- No aplique pesticidas
- No almacene envases de gasolina, aceite o derivados de petróleo u otros solventes dentro del edificio o garajes adjuntos (con exepción de tanques de aceite de combustible -"fuel oil")
- No opere o almacene automoviles en un garaje adjunto
- No opere equipos impulsados por gasolina dentro del edificio, garaje adjunto o alrededor de los perímetros inmediatos del edificio

Equipo típica para muestreo de aire

Se le hara una serie de preguntas acerca de la estructura, productos de consumo que usted almacena en su edificio, y actividades de la casa típicamente ocurriendo dentro del edificio. Esas preguntas son diseñadas para identificar "antecedentes" de fuentes de contaminación de aire dentro del edificio. Mientras esta investigación esta buscando unos químicos selectos y relacionados a la contaminación de la sub-superficie, el laboratorio estará analizando las muestras de aire del interior por una variedad de químicos. Así, "tetrachloroethene" usado en tintorerías o acetona encontrada en el removedor de esmalte de uñas podría ser encontrado en los resultados de su muestra.

Su cooperación es grandemente apreciada. Si usted tiene alguna pregunta acerca de estas instrucciones, por favor de contactar a:

_____

(Adaptado de NJDEP Vapor Intrusion Guidance, October 2005)

APPENDIX G

Radon Sampling for Attenuation Factor

Radon Sampling to Estimate Sub-Slab to Indoor Air Attenuation Factors

Concurrent measurement of sub-slab and indoor air radon gas concentrations may be used in order to estimate building specific sub-slab to indoor air attenuation factors. Radon measurement may be particularly useful where indoor sources of contaminants of concern make it difficult to determine the proportion of indoor air contamination that is attributable to vapor intrusion.

The following procedures should be followed when using radon concentrations to estimate a building specific sub-slab to indoor air attenuation factor.

- Sub-slab sample procedures outlined Sections 5.4 of this document should be followed for preparation of the sub-slab sampling point when preparing to collect sub-slab radon gas samples.
- Sub-slab radon gas samples should be collected using "Pump/Collapsible Bag Devices" protocols described in section 2.6.3.2 of "Indoor Radon and Radon Decay Product Measurement Device Protocols". [1]
- Grab sampling should be used for sub-slab radon sampling. Sorbent samples should not be used for sub-slab radon sampling.
- Indoor air sampling procedures outlined in Section 5.6 of this document should be followed when collecting indoor air radon samples.
- In order to account for variability in indoor radon concentrations caused by building use and ventilation operations changes in the building, and in order to provide a conservative attenuation factor estimate, indoor radon sampling should be conducted under conditions that approximate worst case conditions for radon and vapor intrusion into the building.
- Indoor and sub-slab sampling radon should be conducted concurrently.
- The number and location of sub-slab samples should be chosen on the basis of site-specific parameters and objectives. Sub-slab samples should generally be collected from locations where there is exposure concern (e.g., occupied spaces), and in proximity to the spatial extent of groundwater or soil contamination.
- The mean of sub-slab radon concentrations should be divided by the mean of indoor radon concentrations in order to estimate the sub-slab to indoor air attenuation factor.
- The results of sub-slab VOC results may be multiplied by the attenuation factor in order to estimate an indoor air concentration resulting from vapor intrusion. Individual sub-slab vapor concentration results should be multiplied by the slab attenuation factor in order to obtain an estimated indoor vapor concentration resulting from vapor intrusion.
- If indoor vapor concentrations estimated using a radon derived attenuation factor, are less than indoor screening limits at the 1.0E-06 target cancer risk or Hazard Quotient =1, and if DENR is satisfied with the sampling conditions and methods, then the vapor intrusion pathway may be considered incomplete.

REFERENCES

1. USEPA, EPA 402-R-92-004, July 1992. Office of Air and Radiation: "Indoor Radon and Radon Decay Product Measurement Device Protocols ". http://www.epa.gov/radon/pubs/devprot3.html#2.6

APPENDIX H

Brownfields Program Vapor Intrusion Mitigation System (VIMS) Design Submittal New Construction Minimum Requirements Checklist

Vapor Intrusion Mitigation System (VIMS) Design Submittal New Construction Minimum Requirements Checklist

NCDEQ Brownfields Program – March 2018

If required by the Brownfields Program, or if pre-emptive mitigation is chosen by the Prospective Developer (PD), all Vapor Intrusion Mitigation System (VIMS) design submittals must adhere to the following format and to the NCDEQ Vapor Intrusion (VI) Guidance Document (March 2018). Note that this document is intended for submittals of a VIMS design for new construction; design submittals for retrofitting existing structures have different considerations and requirements based on site-specific factors such as the presence of gravel or clay below the existing slab, interior sources of contamination, damaged utilities, etc. and should be discussed with the Brownfields Project Manager. In order to avoid construction schedule delays, designs should be submitted to the Project Manager on a schedule that allows for adequate review/revision time. Following review and revisions of the VIMS design submittal, a N.C. licensed Professional Engineer (P.E.) must sign and seal the design document prior to installation. Close coordination and consultation with the Brownfields Program must be established and maintained between the PD, VIMS contractors, and all general contractors for the Brownfields Property to avoid installation issues or construction delays. Also note that testing of the VIMS is a key component of the design that must also be reviewed.

____Section 1. Introduction

Provide a brief background of the Brownfields Property and basis for installing a VIMS (e.g. off-site migration of contaminants, on-site releases, chlorinated solvents, etc.). Document the type of foundation design required by construction plans (e.g. waffled construction, ground floor post-tension cabling, build-to-suit construction, or other unique construction plans).

Note: if a VIMS is not installed for certain portions of a Brownfields Property due to open-air 'podium' construction or parking decks, a VIMS may still be required for features such as elevator shafts, stairwells, and areas with utility penetrations that exchange air with occupied areas.

____Section 2. Design Basis

Specify which type(s) of VIMS is intended for the planned structures:

Passive System. Develop a 'trigger' by which the system will be made active, which may include pressure measurements, soil gas and/or indoor air sampling, or changes in site conditions. Note that a passive system should be designed and installed such that the passive system is as effective as an active system at preventing vapor intrusion.

Active System. A pressure differential resulting in depressurization below the slab of 4 pascals or greater at remote extents of each VIMS area is considered sufficiently depressurized (perhaps as low as 1 to 2 pascals if employed with continuous pressure measurement during varied HVAC situations, weather events, and climate for winter and summer months). An alarm that informs building occupants in case the system malfunctions should be included.

For passive and active systems, both of the following design specifications must be included as exhibits:

Sub-slab Venting Construction Materials and Installation. Design specifications must be included as an exhibit (Section 8). All accessible piping must be labeled (at internals no greater than 10 linear feet) stating the purpose of the system along with contact information for questions or repairs.

Membrane Vapor Barrier Construction Materials and Installation. Design specifications must be included as an exhibit (Section 8). Particular attention should be paid to the design and diagrams for sealing barriers at slab penetrations and edges.

Note: Brownfields Property contaminants of concern (COC) must not be present in building materials.

____Section 3. Quality Assurance / Quality Control

Inspections are **required** for all gravel & piping prior to installing the vapor barrier, and are **required** for all sections of the vapor barrier prior to pouring the slab. These inspections must be conducted by qualified personnel under the supervision of the design P.E. and include field logs and photographs. Provide a minimum of 48 business hours advance notification to the Brownfields Program prior to inspections.

Smoke Testing and/or Thickness (Coupon) Measurements are recommended (and may be required by the manufacturer of certain vapor barrier systems).

____Section 4. Post-Construction / Pre-Occupancy System Effectiveness Testing

Pilot/Influence Testing is **required for passive and active systems prior to occupancy** with the objective to document that all areas below the slab can be effectively influenced by the current piping network. Pressure monitoring points should be placed at locations remotely distant from where each suction point transitions to below the slab in addition to locations near each suction point and associated horizontal piping. Based on pilot testing results and review by the Brownfields Program, the number of pressure monitoring points installed for pilot testing may ultimately reduce the number of permanent pressure monitoring points. As noted below in bold, results of the pilot/influence testing must be submitted to the Brownfields Program for conditional occupancy consideration as per our standard VI provisions.

Soil Gas and/or Indoor Air Sampling may be required based on site conditions (regardless of whether a passive or active VIMS is installed) as part of reviewing compliance with the Brownfields Agreement with regards to occupancy under our standard VI provisions.

Note: These two items (Pilot/Influence Testing & Soil Gas and/or Indoor Air Sampling) must be submitted to the Brownfields Program for conditional occupancy consideration as per our standard VI provisions.

____Section 5. Post-Occupancy Testing – Should be specified with the design submittal and not at a later date.

Pressure Testing is **required for active systems** (and may be required for passive systems) to be conducted on a monthly basis for the first year with collected information submitted to the Brownfields Project Manager on a quarterly basis. Based on the first year of pressure readings, and with approval of the Brownfields Program, pressure testing may be collected quarterly and data would be submitted with the annual Land Use Restriction Update (LURU). Note that the Brownfields Program utilizes a 'sliding scale' of pressure reading collection frequency vs. the stated depressurization goal or observed depressurization (e.g., if a VIMS is designed (or observed) to obtain a pressure differential less than 4 pascals, more frequent depressurization measurements will be necessary and may include continuous data logging).

Note: Pressure monitoring points should be placed at locations remotely distant from where each suction point transitions to below the slab in addition to locations near each suction point and associated horizontal piping.

Soil Gas and/or Indoor Air Sampling may be required by the Brownfields Project Manager as part of long-term post-occupancy testing based on site conditions regardless of whether a passive or active VIMS is installed.

____Section 6. Future Tenants & Building Uses

This section must address plans to prevent future tenants or occupants from exposing/damaging the VIMS without the oversight of a qualified P.E. Note that if the VIMS is exposed (for installation of new utilities, etc.), the same inspection requirements and reporting from initial installation is required.

____Section 7. Reporting

Upon completion of post-construction testing, a report must be prepared and submitted to the Brownfields Program under a N.C. licensed P.E. seal for review and approval. The report must summarize the installation, QA/QC measures, post-construction/pre-occupancy system effectiveness testing, and provide an opinion of whether the VIMS was delivered in a condition consistent with the VIMS design and objectives. Certain components of these reporting requirements including pressure measurements, soil gas sampling, and indoor air sampling can be conducted and reported under a N.C. licensed Professional Geologist seal. In the appendix section, the report must include as-built drawings, all inspection logs including photographs and field logs, and safety data sheets for materials used during construction that could contribute to background indoor air contamination. Note that the inspection logs do not need to be addressed in the text of the report unless information pertinent to the operation of the VIMS was discovered.

____Section 8. Design Submittal Exhibits

Drawings: Site Map; System layout including piping network and proposed monitoring point locations; Cross-section details

Design Specifications: Sub-Slab Venting Construction Materials and Installation; Membrane Vapor Barrier Construction Materials and Installation

Materials Sheets for all items associated with the VIMS (vapor barrier, piping, mastic, tape, sealants, cleaners, etc.)

Useful Reference(s):

ANSI/AARST CC-1000, “Soil Gas Control Systems in New Construction of Buildings”.

Note: CC-1000 includes companion guidance that is not part of the ANSI/AARST American National Standard (ANS) and may contain material that has not been subjected to public review or a consensus process.

QUALITY ASSURANCE MANUAL

For

Air Water & Soil Laboratories, Inc.

1941 Reymet Rd
Richmond, Virginia 23237
Phone: 804-358-8295

Responsible Parties			
Name	**Function (Unit)**	**Signatures**	**Date**
Mandy Mishra	Quality Assurance Manager	M. Mishra	4/5/19
Carmela Tombes	President/CEO/Laboratory Director	Carmela Tombes	4-5-19
Emile Shaw	Director of Operations	Emile Shaw	4-5-19
Ted Soyars	Technical Director	T. Soyars	4-5-19

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Acronyms

A list of acronyms generally used in quality systems and their definitions are:

AA	–	Accrediting Authority or Atomic Absorption
ANSI	–	American National Standards Institute
ASQC	–	American Society for Quality Control
ASTM	–	American Society for Testing and Materials
Blk	–	Blank
°C	–	degrees Celsius
cal	–	calibration
CAS	–	Chemical Abstract Service
CCV	–	Continuing calibration verification
COA	-	Certificate of Analysis
COC	–	Chain of custody
DO	–	Dissolved oxygen
DoD	-	Department of Defense
DOC	–	Demonstration of Capability
EPA	–	Environmental Protection Agency
g/L	–	grams per liter
GC	–	gas chromatography
GC/MS	–	gas chromatography/mass spectrometry
ICP	–	inductively coupled plasma
ICV	–	Initial calibration verification
ISO/IEC	–	International Organization for Standardization/International Electrochemical Commission
lb/in2	–	pound per square inch
LCS	–	Laboratory control sample
LFB	–	Laboratory fortified blank
LIMS	-	Laboratory Information Management System
LOD	-	Limit of Detection
LOQ	-	Limit of Quantitation
MDL	–	method detection limit
mg/Kg	–	milligrams per kilogram
mg/L	–	milligrams per liter
MS	–	matrix spike
MSD	–	matrix spike duplicate
NELAC	–	National Environmental Laboratory Accreditation Conference
NELAP	–	National Environmental Laboratory Accreditation Program
NIST	–	National Institute of Standards and Technology
PT	–	Proficiency Test(ing)
PTOB	–	Proficiency Testing Oversight Body
PTPA	–	Proficiency Testing Provider Accreditor
QA	–	Quality Assurance
QC	–	Quality Control
QM	–	Quality Manual
QCS	-	Quality Control Sample
QAM	–	Quality Assurance Manager
RL	–	Reporting level
RPD	–	Relative percent difference
RSD	–	Relative standard deviation
SOPs	–	Standard operating procedures

spk	–	spike
SVOC	–	Semivolatile organic compound
std	–	standard
TCLP	–	Toxicity Characteristic Leachate Procedure
TNI	–	The NELAC institute
µg/L	–	micrograms per liter
UV	–	Ultraviolet
VOC	–	Volatile organic compound
WET	–	Whole effluent toxicity

1 INTRODUCTION

The purpose of this manual is to outline the organization, specify the procedures, and define the technical requirements utilized by Air Water & Soil Laboratories, Inc. The goal is to ensure that all data generated is of the required quality, is reproducible, and is generated in a timely manner. This manual details a Quality Assurance/Quality Control program encompassing the entire analytical efforts at Air Water & Soil, from project initiation to report generation. Some areas are covered with only a cursory discussion, while others are covered in detail, or are included in more than one section, depending on their importance. This manual describes the realistic functions of the quality programs in place, with an understanding that not every situation is covered nor every contingency explored.

1.1 QUALITY POLICY AND DATA INTEGRITY STATEMENT

The objective of Air Water & Soil Laboratory's quality system, and the commitment of management, is to understand and meet the requirements of clients while exceeding their service expectations; to provide services and deliverables that are technically sound, of known and documented quality, and are responsive to client's needs; and to maintain a focus on continuous quality improvement. Our policy is to use sound professional practices, to incorporate data integrity procedures into all processes, to maintain client confidentiality, and to comply with NELAP, ISO/IEC17025, and DoD QSM guidance documents. Air Water & Soil Laboratory ensures that personnel are free from any commercial, financial, and other undue pressures, which might adversely affect the quality of their work, and that they avoid involvement in any activity that might diminish confidence in Air Water & Soil Laboratory's competence, impartiality, judgment or operational integrity. This policy is implemented and enforced through the unequivocal commitment of management, at all levels, to the Quality Assurance principles and practices outlined in this manual.

The primary responsibility for quality rests with each individual within the laboratory. Every Air Water & Soil Laboratory employee ensures that the generation and reporting of quality data are a fundamental priority. Employees familiarize themselves with the quality documentation to implement the policies and procedures in their work. All employees are trained annually on principles of ethics and procedures surrounding the data that are generated.

2 ORGANIZATIONAL ROLES AND RESPONSIBILITIES

2.1 Organization and Responsibilities

Standard of quality refers to a specific, pre-established level of excellence, which is defined by organizations such as the National Environmental Accreditation Program (NELAP), Department of Defense (DOD), and ISO 17025.

A pre-defined standard of quality is maintained for every Air Water & Soil Laboratory project and work element. The vehicle through which this standard is documented and communicated is this Quality Assurance Manual, in conjunction with a Project Technical Profile and/or Quality Assurance Project Plan (QAPP). Quality planning, contract review, and project management, are inherently interrelated processes and addressed by laboratory specific standard procedures.

The Project Technical Profile, in conjunction with project setup in the Laboratory Information Management System (LIMS), summarizes specific project requirements, including quality control and deliverable requirements, analyte lists, certification requirements, turnaround times, the project manager, subcontracting restrictions, and hazard restrictions. The requirements can also be customized in the Quality Assurance Project Plan (QAPP), Analytical Quote, Proposal, and/or Contract, as applicable; which all together comprise the quality plan for the laboratory deliverable. This allows the client to add,

supersede or take exception to basic laboratory QA Manual guidance in order to satisfy the needs of individual projects or programs with specialized requirements. Laboratory personnel are available to develop and/or discuss advantages and disadvantages of quality control options for inclusion in QAPPs.

Typical information included in QAPPs is listed below, but inclusion is dependent on project scope, program requirements and client needs.

- Project description
- Project organization and responsibility
- Quality assurance objectives
- Sample custody
- Analytical methods
- Analytes, compounds and MDL/LOD/LOQs
- Internal quality control checks
- Corrective action
- Reporting requirements

Air Water & Soil Laboratory provides environmental services to private, industrial and governmental clients including the Virginia Department of Environmental Quality, US Department of Defense, as well as many other projects overseen by various U.S. EPA Regions.

Analytical programs and methods are based on the following:

- Clean Air Act (CAA)
- Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)
- U.S. EPA Contract Laboratory Program (CLP)
- Clean Water Act (CWA)
- National Pollutant Discharge Elimination System (NPDES)
- Resource Conservation and Recovery Act (RCRA)
- Safe Drinking Water Act (SDWA)
- Toxic Substances Control Act (TSCA)

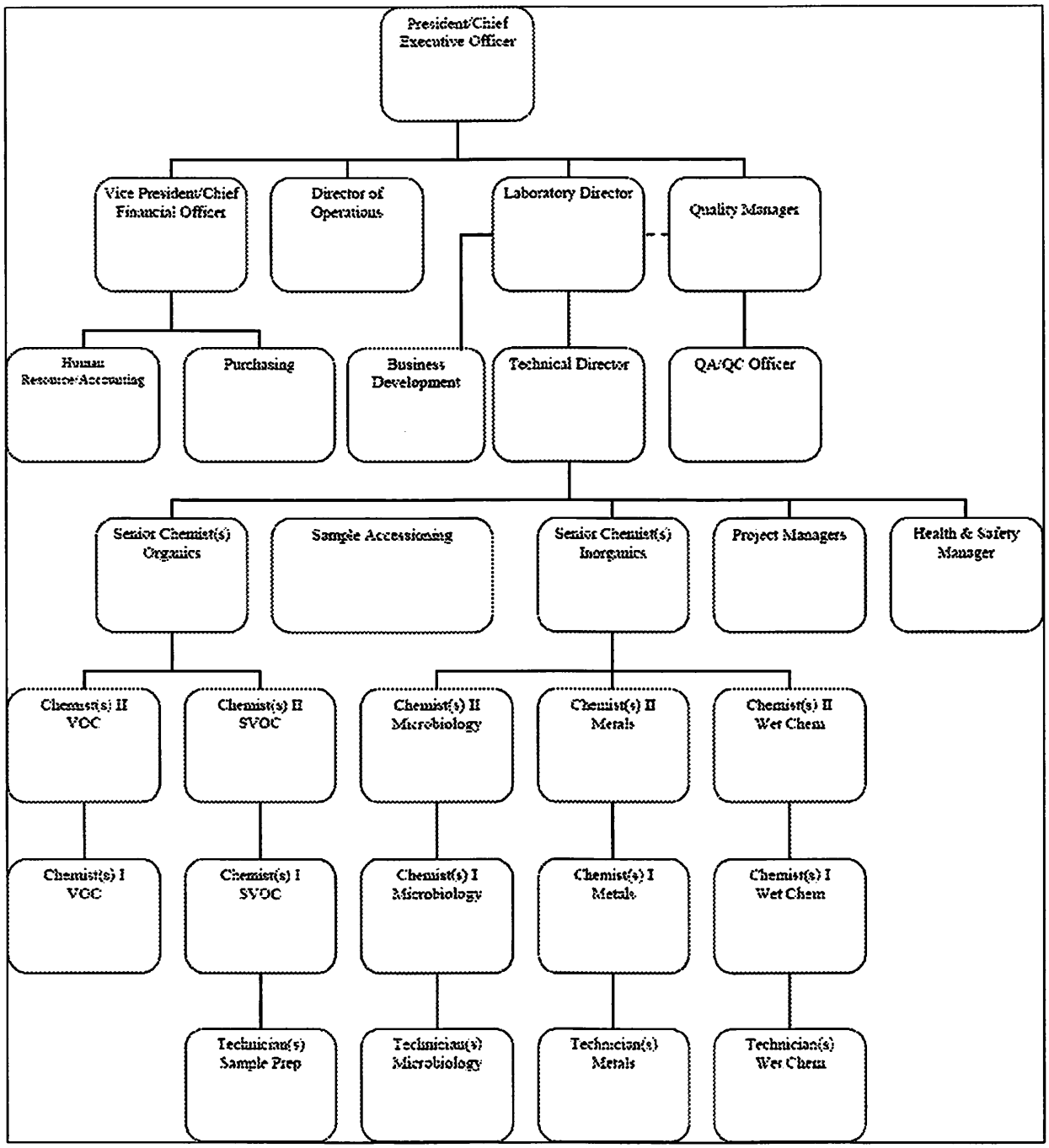
2.2 Laboratory Organizational Structure

The organizational structure indicated minimizes the potential for conflicting or interests that might influence the technical judgment of analytical personnel.

Air Water & Soil Laboratories, Inc. is a commercial laboratory incorporated as a C-Class Corporation in 1994 in the State of Virginia with approximately 30 professionals on staff. Our federal tax ID number is available upon request.

The laboratory operates in Richmond, Virginia and currently has no other locations.

Figure 1: Laboratory Organization



2.3 Responsibility and Authority

The specific duties and responsibilities of key positions and personnel are listed below. Position descriptions for all personnel are maintained in their training files. The quality assurance/quality control program depends on the commitment of the entire organization, including management and every individual on the laboratory staff. Each individual is responsible for the quality of his/her work. Management processes have been reviewed to ensure that personnel are free from commercial, financial, and other undue pressures that might adversely affect the quality of the work.

In the absence of any one individual, the staff within each department, who have the required skills and/or training, perform the function of the absent personnel. This allows for the continuance of the day-to-day operations of the laboratory. The Technical Director provides backup during the absence of either the Laboratory Director or the QA Manager.

2.3.1 Laboratory Director

The ultimate responsibility for the generation of reliable laboratory data rests with the Laboratory Director. The Laboratory Director has the authority to affect those policies and procedures to ensure that only data of the highest level of excellence are produced. It is the Laboratory Director responsibility to see that all tasks performed in the laboratory are conducted according to the requirements of this Quality Assurance Manual, the Project Technical Profile and/or the appropriate QAPP; to assure that the quality of service provided complies with the project's requirements. The Laboratory Director is also responsible for the overall direction of a project, has primary responsibility for project quality assurance, and is accountable for the following:

- Assuring the preparation of a tailored Project Technical Profile and/or Quality Assurance Project Plan (QAPP) as applicable,
- Ensuring peer review of the adequacy of QAPPs as applicable,
- Ensuring allocation of proper quality control budgets,
- Attaining concurrence with Technical Managers on performance and/or results objectives,
- Achieving acceptable project implementation performance, and
- Approving the quality of the project results (final data deliverable).
- Oversees Waste Management Programs

Laboratory Director has line authority over those performing the work. The Laboratory Director provides support and authority for policies maintained by the QA/QC Department. If the Laboratory Director is absent for a period exceeding 15 calendar days, the Deputy Laboratory Director will temporarily perform the function. The QA Manager will notify the Accreditation Body in writing if the absence exceeds 35 calendar days (NELAP) or 65 calendar days (DoD).

2.3.2 Quality Assurance Manager

The Quality Assurance Manager for Air Water & Soil Laboratory is responsible for ensuring that the quality system is established, implemented and maintained. He/she is the focal point for QA/QC activities and is responsible for oversight and/or review of QC data. Data are evaluated objectively and assessments are performed without

managerial influence. The QA Manager has documented training and/or experience in QA/QC procedures, as well as knowledge of the quality system as defined under NELAP and DoD QSM.

The QA Manager assists with proposals, contract review, and the preparation, compilation, and review of client quality assurance plans. These are reviewed for consistency with organizational and/or contractual requirements. Appropriate personnel (e.g., the Laboratory Director or Project Manager) are advised of deficiencies or areas needing further attention.

The QA Manager has the authority to stop work until any condition affecting the quality of the data is resolved. Should a situation arise where acceptable resolution of identified problems cannot be agreed upon at the laboratory level, the QA Manager has the support of senior management, as needed, to ensure that QA policies and procedures are enforced.

The Quality Assurance Manager reports to the President/Chief Executive Officer (CEO) on the performance of the quality system for review and continuous improvement. The QA manager has sufficient authority, access to work areas, and organizational freedom (including sufficient independence from cost and schedule considerations) to:

- Ensure that quality documentation is available to, understood by, and implemented by all laboratory personnel,
- Monitor the Quality System,
- Assist in the preparation of Standard Operating Procedures (SOPs) and quality assurance documentation for the laboratory,
- Assist in the identification and initiation of preventative or corrective actions for any problems affecting the product, process and Quality System,
- Assure that further work is stopped or controlled until proper resolution of a non-conformance, deficiency, or unsatisfactory condition has occurred and the deficiency or unsatisfactory condition has been corrected,
- Tracks performance evaluation studies, personnel training (including Initial and Continuing Demonstrations of Capability), and MDL/IDL (LOD/LOQ) studies,
- Manages document control, and
- Maintains certifications and approvals.

If the QA Manager is absent for a period exceeding 15 calendar days, the Deputy QA Manager (Technical Director) will temporarily perform the function. The laboratory will notify the Accreditation Body in writing if the absence exceeds 35 calendar days (NELAP) or 65 calendar days (DoD).

2.3.3 Technical Director

The Technical Director is responsible for coordinating receipt of data from the various service groups within the laboratory, daily operations, including all activities pertaining to operational and technical performance of the laboratory. The laboratory gives the data to the Technical Director for final approval. The Technical Director assures there are sufficient equipment, space, resources, and personnel to conduct analyses and implement the Laboratory Quality Assurance Program. The Technical Director:

- Requires effective implementation of the Laboratory Quality Assurance Program to ensure the overall quality of all data and laboratory reports generated,

- Ensures appropriate corrective action is taken when analytical systems are out-of-control or questionable,
- Ensures timeliness of data reporting through coordination of work schedules and assignment of target completion dates for analyses,
- Resolves technical problems with Inorganic and Organic personnel.

If the Technical Director is absent for a period exceeding 15 calendar days, the Deputy Technical Director (QA Manager) will temporarily perform the function. The laboratory will notify the Accreditation Body in writing if the absence exceeds 35 calendar days (NELAP) or 65 calendar days (DoD).

2.3.4 Senior Chemists

To assist the Technical Director in achieving section goals, senior laboratory personnel are responsible for the implementation of established policies and procedures. They possess authority commensurate with their responsibilities for the day-to-day enforcement and monitoring of laboratory activities.

Senior personnel and the Quality Assurance Department have the responsibility for ensuring that personnel are adequately trained to perform analyses; that equipment and instrumentation under their control is calibrated and functioning properly; and that system and performance audits are performed on an as-needed basis. These performance audits include the analysis of external check samples to determine the analyst/instrument capability to identify and quantify routine analyses.

Senior personnel report to the Technical Director and serve as technical experts on assigned projects, provide technical liaison, and assist in resolving any technical issues within the area of their expertise. They are responsible for providing input and review in the development and implementation of project-specific QA/QC requirements; and for providing the critical review of proposal and project work for programs as directed by the Technical Director. They coordinate these activities with the Project Manager and Quality Assurance Manager.

2.3.5 Project Managers

Air Water & Soil Laboratory recognizes the importance of efficient project management. The laboratory Project Managers (PMs) are responsible for preparing the Project technical profile, summarizing QA/QC requirements for the project and setting up the project specific requirements in the LIMS; informing the laboratory and management of the project schedule; ensuring that technical requirements are understood by the laboratory; and advising the client, Laboratory Director of all variances. The laboratory PM provides technical guidance and the necessary laboratory related information to the preparer of project-specific Quality Assurance Project Plans (QAPP) (usually the client), and provides peer review of the final document to ensure accuracy of the laboratory information. They also produce and review electronic data deliverables (EDDs). An additional function is tracking and maintaining the archival and retrieval of Quality Records.

2.3.6 Health and Safety Personnel

The Health and Safety Manager is responsible for the safety and well-being of all employees while at the laboratory. This includes, but is not limited to, developing a safety plan that complies with federal regulations, conducting laboratory safety tours for all new employees, providing instructions on safety equipment, cleaning up laboratory spills, and instructing personnel of laboratory procedures for emergency situations. The Health and Safety Manager or designee is on-call for all laboratory emergency situations.

2.3.7 Director of Operations

The Operations Director is responsible for planning, organizing, directing and managing resources for laboratory services in all departments. These responsibilities include: budget, recruitment and effective/efficient management of assigned staff; achieving quality outcomes, cost and productivity management, process improvement and positive working relationships with staff, departments and managers.

The Director of Operations in conjunction with the Laboratory Director maintains responsibility for waste management of laboratory-generated hazardous waste in accordance with appropriate regulations. This includes maintenance of required documentation, such as waste manifests, segregation of waste in accordance with requirements, and training of personnel in proper segregation of waste.

At AWS Labs, the Operations Director is responsible for providing data security by controlling access and providing disaster recovery of the Network and the security of the data stored on the LIMS. The Operations Director is also responsible for providing procedures and training to all laboratory computer related operations, as appropriate, to assist in making backup copies of local data within the respective operating unit. Other responsibilities include;

- Tracks and maintains the archival and retrieval of Records
- Oversees the Health and Safety and Waste Management Programs.
- Supports Customer Service by advising project managers regarding suggested test methods and regulations.

2.3.8 Chemists/Technicians

The Chemists and Technicians are responsible for the performance of analyses using approved methods and procedures. Each analyst is responsible for the quality of his/her work. The initial review for acceptability of analytical results rests with the analyst conducting the test. Observations made by the analyst during the performance of an analytical method may indicate that the analytical system is not in control. Therefore, quality control indicators are used to assure that the method is in-control before results are reported.

3 QUALITY SYSTEMS

The laboratory's Quality System is documented in this *Quality Manual* and associated quality system documents. Together they describe the policies, objectives, principles, organizational authority, responsibilities, accountability, and implementation plan of the organization for ensuring quality in its work processes, products, and services.

3.1 Quality Objectives

It is the objective of Air Water & Soil Laboratory to be known as an organization that has effectively implemented its Quality Policy. Air Water & Soil Laboratory recognizes that it is essential to:

- Develop a reputation for dependability by maintaining the highest standards of professionalism and ethical business practices.
- Deal fairly at all times with suppliers, competitors, and clients in accordance with those standards.
- Protect confidential and proprietary rights.
- Protect electronic storage and transmission of results.
- Offer environmental analyses that demonstrate compliance with high quality, traceability, and legally defensible performance standards.
- Practice complete honesty in the production and reporting of data. To avoid any possible misrepresentation of data, Air Water & Soil Laboratory prohibits the use of either the TNI or ILAC logos in advertising.

Air Water & Soil Laboratory's principal focus is the analysis of environmental samples. Associated with this activity are services to assure client requirements are known, communicated, and satisfactorily addressed, and to provide a complete self-explanatory deliverables package presenting the analytical results. Air Water & Soil Laboratory is committed to ensuring that resources are available and deployed to meet client expectations. All bids are signed or approved by the President/Chief Executive Officer, thus verifying that the laboratory has the appropriate facilities and resources in place to perform the work. Other project information is gathered prior to sample receipt to ensure client expectations will be met with respect to:

- Sampling containers
- Analytical methods employed
- Accuracy and precision
- Limit of Detection (LOD) and Quantitation (LOQ)
- Personnel qualifications, training, and experience
- Calibration and quality control measures employed
- Regulatory requirements
- Report contents
- Supporting documentation, records and evidence
- Validation of data
- Applicable accreditation

Organizational support for implementing the quality policy and achieving the quality objectives is derived from the Quality Assurance Manual and Standard Operating Procedures. Within these documents, management with executive responsibilities ensures that the quality policy is understood, implemented, and maintained at all levels of the organization. The development and implementation of appropriate accountabilities, duties, and authority by organizational positions are clearly delineated.

4 DOCUMENT MANAGEMENT

Air Water & Soil Laboratory maintains a quality system to ensure that analytical products and services conform to client specified requirements. The quality system is documented by this Quality Assurance Manual and associated standard operating procedures (SOPs). The QA department maintains a master listing or index of standard operating procedures. The Quality Assurance Manual provides an outline and structure of the documentation used in the quality system, and is reviewed annually for accuracy and adequacy and revised as necessary to remain current with laboratory operations.

External Reference Materials come from sources other than the laboratory, but are used within the context of the quality system.

4.1 Controlled Documents

The Air Water & Soil, document control procedures describes the mechanisms used to maintain control and accountability of laboratory controlled distribution documents.

All SOPs and Forms are assigned a unique procedure identifier. Other information included in every SOP is the effective date, revision number, total number of pages, and identification of any individual page revisions.

Approved SOPs are scanned and stored securely on the network "Library" drive. This drive is accessible to all laboratory personnel. Copies of all outdated SOPs and Forms are destroyed (or marked as obsolete), and the scanned copy of the SOP and Form is removed from the Library and moved to a secure "Obsolete" Network drive for archiving. Printed documents are considered uncontrolled.

The QA Manager coordinates the laboratory's controlled distribution electronic document system. QA/QC department is responsible for maintaining the document's change, record sheet and the document in complete and current form. The Master List of Air Water SOPs are available upon request, as presented in Appendix-B.

4.2 Standard Operating Procedures

STANDARD OPERATING PROCEDURES (SOPs) are used to ensure consistency of application of common procedures, are written procedures that describe in detail how to accurately reproduce laboratory processes, and are of two types: 1) test method SOPs, which have specifically required details, and 2) general use SOPs which document the more general organizational procedures.

SOPs are reviewed annually and are the bases for internal method audits. If no changes are made to an SOP during review, an SOP review form is completed and appended to the last page of the original SOP kept on file. Specific details of writing/developing an internal SOP are out lined in Air Water and Soil's SOP Preparation procedure D1100.

Analytical SOPs must incorporate or reference the following topics:

1. Identification of test method
2. Applicable matrix or matrices
3. Detection limit
4. Scope of application

5. Summary of test method
6. Definitions
7. Interferences
8. Safety
9. Equipment and supplies
10. Reagents and standards
11. Sample collection, preservation, storage, and handling
12. Quality control
13. Calibration
14. Procedure
15. Calculations
16. Method performance
17. Pollution prevention
18. Data assessment and acceptance criteria
19. Corrective action for out-of-control data
20. Handling out-of-control data
21. Waste management and
22. References
23. Tables, Diagrams, Flowcharts, and Validation Data.

5 REVIEW OF REQUESTS, TENDERS AND CONTRACTS

The review of all new work assures that oversight is provided so that requirements are clearly defined, the laboratory has adequate resources and capability, and the test method is applicable to the customer's needs. This process assures that all work will be given adequate attention without shortcuts that may compromise data quality.

Contracts for new work may be formal bids, signed documents, verbal, or electronic.

5.1 Procedure for the Review of Work Requests

Management and project managers take part in determining if the laboratory has the necessary accreditations and resources; including schedule, equipment, deliverables, and personnel, to meet the work request.

Management or project managers take part in informing the client of the results of the review if it indicates any potential conflict, deficiency, lack of accreditation, or inability of the lab to complete the work satisfactorily.

The client is informed of any deviation from the contract including the test method or sample handling processes. All differences between the request and the final contract are resolved and recorded before any work begins. It is necessary that the contract be acceptable to both the laboratory and the client.

The review process is repeated when there are amendments to the original contract by the client. The participating personnel are given copies of the amendments. Any suspensions, revocations, or voluntary withdrawals of accreditation, affecting the scope of the project, are reported to the client.

For routine projects and other simple tasks, a review by the project managers is considered adequate. The project manager confirms that the laboratory has any required certifications, that it can meet the client's data quality and reporting requirements, and that the lab has the capacity to meet the clients turn around needs.

For new, complex or large projects, the proposed work contract is given to Management.

- Management will in turn forward the work contract to the appropriate personnel to evaluate such items as:
- contractual obligations, bonding issues and payment terms
- method capabilities, analyte lists, reporting limits, and quality control limits
- turnaround time feasibility
- QA/QC issues, including certification/accreditation
- formal laboratory quote
- final report formatting and electronic deliverable documents
- time required to keep sample in house
- final sample disposal requirements
- review PT sample results

Management or Project Managers submit the bid and formal quote to the client. The accounting department maintains copies of all signed contracts.

5.2 Documentation of Review

Records are maintained for every contract or work request. This includes pertinent discussions with a client relating to the client's requirements or the results of the work during the period of execution of the contract. These records are maintained by the project manager and filed according to client project.

6 SUBCONTRACTING OF TESTS

When subcontracting analytical services, the laboratory assures work requiring accreditation is placed with an appropriately accredited laboratory or one that meets applicable statutory and regulatory requirements for performing the tests. When requested by the client, samples for analyses outside the analytical scope of Air Water & Soil can be subcontracted to another laboratory. Unless otherwise specified or required by the client, samples will be subcontracted to a NELAP, DoD-ELAP accredited or ISO-17025 certified laboratory.

6.1 Procedure

Air Water & Soil Project Manager's maintain a list of approved subcontractors. Subcontracting records include evidence of compliance to NELAP, DoD-ELAP and/or ISO17025 accredited and are reviewed annually.

The laboratory notifies the client of the intent to subcontract the work either verbally or in writing. The laboratory makes all efforts to gain the approval of the client preferably in writing to subcontract their work prior to implementation.

The laboratory performing the subcontracted work is identified in the final report non-accredited work performed is clearly identified. The laboratory is responsible to the client for the subcontractor's work except in the case where a client or a regulating authority specified which subcontractor is to be used. Subcontracted work will be reported on the respective laboratory letterhead but is included in Air Water & Soil's Certificate of Analysis.

7 PURCHASING SERVICES AND SUPPLIES

The laboratory ensures that purchased supplies and services that affect the quality of environmental tests are of the required or specified quality by using 17025 approved suppliers and products.

Management and/or the Chief Financial Officer reviews and approves the supplier of services and supplies and approves technical content of purchasing documents prior to ordering. The evaluation of suppliers is accomplished by ensuring the supplier ships the product or material ordered and that the material is of the appropriate quantity by signing packing slips or other supply receipt documents. The purchasing documents contain the data that adequately describe the services and supplies ordered.

The laboratory keeps a list of approved suppliers in the network database.

7.1 Procedure for Purchases

The analyst requests supplies using a supply form found in the laboratory. The analyst initials this request and verifies that the items requested meet quality specifications.

The Technical Director or personnel designated by the management places the orders with the vendor, using a Purchase Order Number for tracking purposes.

7.2 Procedure for Receipt of Supplies

Supplies received are reconciled against the packing list and inspected for damage. Supplies, reagents and chemical standards are checked-in (date, initial and expiration date where appropriate) and distributed to the appropriate individuals, departments or storage areas. All documents received with supplies attesting to their use compliance (sterility, purity, cleanliness, etc.) are kept on LIMS.

7.3 Procedure for Storage of Supplies

Supplies received are stored according to manufacturer's instructions, laboratory SOP, or test method specifications.

7.4 Laboratory Grade Water

Laboratory grade deionized water is especially important for quality results. The laboratory maintains a vendor to supply and service the DI system for the lab. The water is monitored to determine when the tanks require changing.

8 SERVICE TO THE CLIENT

The laboratory collaborates with clients and/or their representatives in clarifying their requests and in monitoring of the laboratory performance related to their work. Each request is reviewed to determine the nature of the request and the laboratory's ability to comply with the request within the confines of prevailing statutes and/or regulations without risk to the confidentiality of other clients.

8.1 Client Confidentiality

The laboratory confidentiality policy is to not divulge or release any information to a third party without proper authorization.

All electronic data (storage or transmissions) are kept confidential, based on technology and laboratory limits, as required by client or regulation.

The following confidentiality notice is to be included with each email or fax transmission to our clients.

- CONFIDENTIALITY NOTICE

The information contained in this document is privileged, confidential, and protected under applicable law. It is intended solely for the individual or entity to whom it is addressed. If you are not the intended recipient, you are hereby notified that any dissemination, distribution or copying of the communication is strictly prohibited. If you have received this communication in error, please notify the sender immediately by telephone and destroy the document

9 CUSTOMER INQUIRIES/COMPLAINTS

Air Water & Soil laboratory is committed to customer service and assures that when a customer complaint arises, it is addressed immediately and resolved as quickly as possible. This includes requests to verify results of analtyical data. Both positve and negative feedback provide an opportunity to improve laboratory operation and client satisfaction. The laboratory provides an electronic survey link to each client in the form of "Survey Monkey" with each final report. This gives our clients the opportunity to assess our service with each project. Complaints by customers or other parties are reviewed by the management and an appropriate action is determined.

All customer complaints are documented in the LIMS Non-Conformance Tracking form, by the person receiving the complaint. A member of management is immediately notified of the Non-Conformance and an investigation is initiated. During the complaint resolution process, managemement and the analysts and/or staff member involved will meet to discuss the situation that gave rise to the complaint. This investigation can include but is not limited to a complete review of the raw data and/or reanalysis of the sample. The client will be notified of the outcome of the investigation and the necessary actions being implemented. If required, the Certificate of Analysis will be revised and resubmitted upon determination that the data is affected and the reason for the resubmittal is documented in the case narrative. If it is determined that the complaint has merit, the procedures outlined in Section 11 – Corrective Action are utilized and documented in the LIMS Non-Conformamce Tracking System. If it is determined that a complaint is without merit, the Non-Conformance Tracking Form can be closed immediately as no further investigation or review is required.

A complaint such as a concern that data is repeatedly late is reviewed for preventative action (see Section 12 – Preventaive Action") to minimize a future occurrence.

10 CONTROL OF NON-CONFORMING WORK

When a non-conforming event or process deviation has occurred, corrective action is required. A written standard operating procedure (plan for corrective action) provides the steps for dealing with an out-of-control testing situation. The assessment of whether the process is out-of-control is based on predetermined limits for laboratory operations.

Non-conformances based on statistical analysis or quality control samples are readily apparent and easy to identify. A process deviation, which does not have a directly observable impact on data quality, is more difficult to discern. Examples of the latter, subtler types of non-conformances include volatile samples not properly stored; oily layers in certain types of samples that may interfere with analysis; or a water-soaked sample label whose information is barely legible. Discovery of a non-conforming event or process deviation can result from the observations of a staff member, a review of laboratory data at any level, the result of an audit, or a client complaint. A corrective action will be initiated within one week of the discovery of any nonconformance investigation.

The time frame required to resolve a specific deficiency and implement the corrective action is dependent on the magnitude of the problem and the defensibility and use of the data. Most non-conformances should be resolved within 30 days from the initiation date. Non-conformances that specifically impact sample results should be resolved within 5 days.

The client must be contacted as soon as practical upon the discovery of any event that may cast doubt on the validity of a sample result.

11 CORRECTIVE ACTION

To consistently achieve technical and regulatory requirements, the data produced by Air Water & Soil Laboratory is supported by an effective corrective and preventive action system. The system is capable of isolating and correcting both random and systematic errors. Problems requiring corrective action are identified through nonconformance corrective action reports, internal and external audits and surveillances; data review, and client inquiries. When evaluation of performance against established criteria for good laboratory practices shows a condition that could adversely affect the quality of services provided, or when there are departures from documented policies, procedures or applicable Standards, corrective action is initiated. Procedures for Nonconformances (NCR), and corrective actions, are detailed in SOP D1517. Preventative action procedures are discussed in this manual.

All corrective actions, whether immediate or long-term, will contain the following steps to ensure a closed-loop process:

1. Definition of the problem,
2. Assignment of responsibility for investigating the problem,
3. Determination of a corrective action to eliminate the problem,
4. Assignment of responsibility for implementing the corrective action (and commitment of responsible party,
5. Implementation of the correction, and
6. Assessment of the effectiveness of the corrective action, including verification that the problem has been eliminated and that the solution will prevent reoccurrence.

11.1 Non-Conformances

Quality indicators are evaluated against method, client specified, or laboratory established QA/QC requirements. The initial responsibility to monitor the quality of a function or analytical system lies with the analyst performing the task or procedure. Laboratory quality control procedures usually identify the situations that require immediate correction. In these cases, the analyst has relatively quick feedback that a problem exists, e.g., calibration does not meet or quality control check samples exceed allowable criteria, and can take immediate action to repair the system. Types of quality control check samples, their frequency, acceptance criteria, and corrective action can be found in the method SOPs.

When an acceptable resolution cannot be met or data quality is negatively affected, the analyst notifies the Technical Director, QA, or project manager and initiates a Nonconformance Report in the LIMS based on SOP D1517. Data generated during an out-of-control situation are evaluated for usability. If the deficiency does not affect the usability of the results, data are reported and the deficiency noted in the case narrative. For DoD projects, a copy of the NCR is included in the data package, if requested by the client. Data that are negatively impacted by an out-of-control system are not released without approval of either the QA Manager, or Laboratory Director, and the client. If the validity of results is in question, the project manager will contact the client within 48 hours of the determination that there is a negative impact to the data.

If QA receives a large number of NCRs, or further action is required, a Corrective Action Report (CAR) (SOP D1517) is initiated in LIMS. A CAR may also be initiated by any laboratory employee for problems not suited to or broader in scope than NCRs. These reports are a key tool for monitoring trends.

Any analyst, with the concurrence of the Quality Assurance Manager has the authority to stop the analysis if there is a failure to meet method or project requirements. The QA Manager may

authorize holding all analyses of samples affected by an out-of-control situation. The analysis cannot be restarted without appropriate documentation including the QA Manager's approval.

11.2 Long Term Corrective Action

Long-term corrective actions are generally initiated for QA issues that have been identified through internal and external audits. A long term corrective action requires a deeper investigation into the root cause of the nonconformance, and the problem may take much longer to identify and resolve. Staff training, method revision, replacement of equipment, and LIMS reprogramming, are examples of long-term corrective action.

Technical and Operations Directors are responsible for elevating correction of out-of-control situations to the highest priority. Associated corrective actions, once verified for effectiveness, are incorporated into standard procedures. Ineffective actions are re-evaluated and the process repeated until acceptable resolution is achieved. Senior analysts are accountable to the Technical Director to ensure that final acceptable resolution is achieved.

Any out-of-control situations that are not addressed adequately at the laboratory level may be elevated to the Laboratory Director and/or President/CEO, indicating the nature of the out-of-control situation and problems encountered with resolution. This provides the QA Manager with support outside direct laboratory supervision, if needed; to ensure QA policies and procedures are enforced.

11.3 Exceptionally Permitting Departures from Documented Policies and Procedures

Air Water & Soil allows the release of non-conforming data only with approval by the Laboratory Director or their designee on a case-by-case basis. Planned departures from procedures or policies do not require audits or investigations.

Permitted departures for non-conformances are fully documented and include the reason for the departure.

12 PREVENTIVE ACTION

12.1 Preventative Action

Air Water & Soil Laboratory maintains preventive action programs to define, improve, or eliminate potential causes of nonconforming product and/or nonconformance to the quality system. The preventive action process is a proactive continuous process improvement activity that can be initiated by clients, employees, business providers, and affiliates. The QA department has the overall responsibility to ensure that the preventive action process is in place, and that relevant information on actions is submitted for management review.

Preventive action opportunities may be identified from information obtained through activities related, but not limited, to the corrective action process, performance evaluation program, internal audits, and management review. Established standard procedures for preventive action are included in Air Water & Soil Laboratory SOPs. Examples include, but are not limited to, annual refresher training for analysts, instrument maintenance, document control, and communicating client requirements to analysts and project set-up in the LIMS. Corrective action reports document on going preventive actions to insure that non conformities do not recur.

13 CONTROL OF RECORDS

The laboratory will retain all records related to sample analysis including raw test data, calculations, derived data, calibrations and copies of test reports. These records will be stored in systematic manner for a minimum of five years. Longer periods of storage shall be arranged at the request of the client. If the laboratory ceases operations, clients will be notified at least 60 days (if time permits) prior to closure of the laboratory and will receive a final report for all submitted samples. The client notification will request instructions on the retention or distribution of laboratory records and will provide contact information for after the closure. Software/hardware permitting the access of electronic data must be maintained.

The copy of client reports is stored electronically on a secured network. Archived reports are available through limited tracked access on LIMS. All archived logbooks, corrective actions, PT results, training records, and other QA/QC reports are also stored on a secure Air Water & Soil Laboratory network. Written and printed data records (bench sheets, logbooks, electronic printouts, etc.) are boxed and placed in the storage area. Electronic data is stored on a dedicated server. Air Water & Soil Laboratory data are removed from the servers using tape and/or optical media and stored at a secure location and but can be reloaded by submitting a request to IT. The safety officer keeps safety and disposal information. The Human Resources keeps personnel information in locked files.

Archived electronic and paper copies of data are stored on-site until capacity is met. The oldest archived data is then moved to a secure storage facility. The storage and on-site facility are monitored and protected from fire and theft, loss, environmental deterioration, vermin and in the case of electronic records, electronic or magnetic sources.

13.1 Legal Chain of Custody Records

Evidentiary Sample Data are used as legal evidence.

Procedures for evidentiary samples are documented in **Manual for Certification of Laboratories Analyzing Drinking Water, 2005 Appendix A.**

14 AUDITS & MANAGEMENT REVIEW

Audits measure laboratory performance and verify compliance with accreditation/certification and project requirements. Audits specifically provide management with an on-going assessment of the quality system. They are also instrumental in identifying areas where improvement in the quality system will increase the reliability of data. Audits are of four main types: internal, external, performance, and system.

Notification of clients for events that cast doubt on the validity of the results is completed as soon as practical.

Air Water & Soil considers management reviews and internal reviews as separate activities.

14.1 Management Reviews

Air Water & Soil's management conducts periodic meetings as a review of the laboratory's quality system and environmental testing activities to ensure their continuing suitability and effectiveness, and to introduce necessary changes or improvements. This is a system wide assessment upon the review at least once annually; the Laboratory Director writes a report summarizing the monthly meeting findings and any new policy decisions. The Management Review procedures are detailed in SOP D1112 Management Reviews.

The review will include at least the following over the course of one year:

- The suitability of policies and procedures;
- Reports from managerial and supervisory personnel;
- Corrective and preventive actions;
- Assessments and audits (external and internal respectively)
- The results of proficiency tests;
- Changes in the volume and type of the work;
- Client feedback;
- Complaints; and
- Adequacy of staff, equipment, and facility resources.

14.2 Internal Audits

Internal audits are conducted using a predetermined schedule, documented by the QA Department and include all methods included in the laboratories scope of accreditation. A member of the QA Department or designee performs the audits as described below. As part of the scheduling, all technologies and Departments must be reviewed at least annually. Audits are documented with records maintained in the QA Department. The goal of internal audits is to determine if lab activities meet the requirements of the quality system and the DoD ELAP/NELAC and ISO 17025 standards.

System audits are performed to determine if all aspects of the QA program are operational through use of an internal checklist. The QA Manager reviews all information pertaining to QA system, summarizes the situation and notes any deficiencies. A report is prepared based on the audit and is distributed to management in a timely manner. The report is also discussed with laboratory personnel

so that a concerted effort can be made to correct any deficiencies as well as provide positive feedback. The QA Manager reviews the following elements of the program:

- Sample handling, including custody and storage procedures
- Sample analysis
- Records
- Preventive maintenance
- Check sample programs (proficiency testing)
- Training
- Project Management

Method audits are performed throughout the year. These audits focus on a specific method or technology. An analyst is observed performing the method including QC and client samples. The goal of the audit is to determine if the SOP is being followed and traceability of the standards and documentation is maintained. Additionally, the SOP is reviewed for method compliance and is updated as necessary. Part of the system audit is performed at this time including training of analyst performing the tests and performance in the PT program. After the audit a report is issued to the Technical Director. Follow-up audits are necessary to determine if changes are being implemented.

Monthly audits are performed to check support system compliance. A member of QA staff performs these audits and a report is issued to the Laboratory Director. Follow-up and corrective action is performed as necessary. At least the following items are reviewed:

- Calibration of support equipment.
- Temperature checks of ovens, incubators, refrigerators, and freezers are performed daily.
- Logbook documentation and review, and use of strikeout corrections. Expiration of standards used.
- Sample chain of custody and tracking of samples.
- Certificate of analysis.
- Scheduled equipment maintenance is performed.
- Tag-out policy is used.
- Storage blank analysis.
- Safety equipment is being maintained.

- Labeling of Standards and Reagents
- Chain of Custody Procedures.

14.3 External Audits

External audits and assessments are scheduled through the QA Manager with accrediting bodies, regulators and clients. It is the policy of Air Water & Soil that all information pertaining to that client or scope of accreditation be available for review by the auditor(s). Client confidentiality must be maintained throughout the audit process. The QA Manager is responsible for monitoring the audit, reviewing all findings, issuing a corrective action plan within the timeframe specified and follow-up to ensure approved changes are implemented. All documentation pertaining to the audit is kept on file.

14.4 Performance Audits

Performance audits may be Proficiency Test Samples, internal single-blind samples, double-blind samples through a provider and/or client, or anything that tests the performance of the analyst and method.

The policy and procedures for Proficiency Test Samples are discussed in Section 23.7 of this manual.

15 TRAINING AND DATA INTEGRITY

15.1 Data Integrity and Ethics

DATA INTEGRITY is the result of the processes that together assure valid data of known and documented quality.

Data integrity and ethics procedures in the laboratory include training, signed and dated integrity documentation for all laboratory employees, periodic monitoring of data integrity, and documented data integrity procedures.

15.2 Ethics Policy

Air Water & Soil utilizes a clearly stated ethics policy in the Ethics and Data Integrity Statement. This agreement is discussed with all new employees during orientation and signed and retained with the employee's training file. Violation of the agreement is basis for termination of employment. In addition, each employee receives training in data integrity and signs the ethical policy and Air Water & Soil Laboratory's Code of Ethics and Data Integrity Agreement in (Appendix C) annually.

Examples of unethical behavior include but are not limited to:

- Fabricating Results
- Altering an Instrument computer, such as clock for any inappropriate purpose
- Altering the Chain of Custody
- Altering Calculations
- Altering Approved Standard Operating Procedure
- Lack of reporting unethical behaviors by others

15.3 Training Orientation

The human resources in conjunctions with QA department initiate training orientation for each new employee on the first day of employment. Orientation includes completion of various training items listed on the New Employee Checklist (Appendix D). This checklist provides documentation of the orientation after being signed by the new analyst and the trainer and become a part of the employee's permanent training record.

15.4 Ethics/Data Integrity Training

Data integrity training is provided for all employees initially upon hire and annually thereafter.

Attendance at an initial data integrity training (part of new employee orientation) and the annual refresher training is recorded with a signature attendance sheet or other form of documentation that demonstrates all staff have participated and understand their obligations related to data integrity.

Training records regarding data integrity and ethics are signed and dated by individual employees.

When contracted technical or support personnel are used, management is responsible for ensuring that they are trained to the laboratory's quality system and data integrity procedures, competent to perform the assigned tasks, and appropriately supervised.

Key topics covered during data integrity training include: the organizational mission and its relationship to the need for honesty and full disclosure in all analytical reporting; how and when to report data integrity issues; recordkeeping; discussion regarding all data integrity procedures; data integrity training documentation; in-depth data monitoring; data integrity procedure documentation; improper data manipulations; adjustments of instrument time clocks; inappropriate changes in concentrations of standards; 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; written ethics agreements; examples of improper practices; examples of improper chromatographic manipulations; requirements for external ethics program training; any external resources available to employees; and consequences for data integrity infractions.

It is the intent of Air Water & Soil to consistently report data of the highest quality. For this to be possible, analysts are instructed in accordance with the level of data quality desired and are provided with an environment conducive to its achievement. Besides providing the analyst with all necessary supplies and equipment, the work environment is maintained as free from undue pressures as possible. Such pressures may be through internal peer pressure or deadlines, or through external customer complaints or priority requests. It is the responsibility of management to insulate the analyst from such pressures as much as possible. Data quality cannot be compromised without reason and the analyst will not be reprimanded for adhering to established quality protocols in the face of such pressures. During the orientation with human resources, these policies will be explained and the employee asked to review and sign a Code of Ethics/Data Integrity Policy Agreement. This agreement documents the understanding between management and the new employee concerning management's position on data quality, sample analysis and data reporting, and the consequences of improper actions. The signed agreement is retained as part of the employee's permanent record.

15.5 General Training

It is the policy of Air Water & Soil to hire employees with an educational background and/or experience in an analytical field. On-the-job training takes place for all new employees based on needs identified by the respective job description and tasks of the position.

Selection of qualified candidates for laboratory employment relies on documentation of minimum education, training, and experience prerequisites needed to perform the prescribed task.

All personnel who are involved in activities related to sample analysis, evaluation of results or who sign test reports, must perform demonstration of capabilities in their area of responsibility. Appropriate supervision is given to any personnel in training and the person supervising an analyst in training is accountable for the quality of the analytical data and must review and approve data and associated corrective actions. See DOC SOP (D1532) for elaborated procedure to document training.

Personnel are qualified to perform the tasks they are responsible for, based on education, training, experience and demonstrated skills as required for their area of responsibility (Note: some states/agencies require additional training experience and documentation. These will be addressed on a case-by-case basis during the proposal process or contract review.)

The laboratory provides goals with respect to education, training and skills of laboratory staff. Training needs are identified at the time of employment and when personnel are moved to a new position or new responsibilities are added to their job responsibilities. Ongoing training, as needed, is also provided to personnel in their current positions. The effectiveness of the training must be evaluated before the training is considered complete.

Each employee participates in a comprehensive training program tracked by the laboratory's quality manager. This program is designed to provide an introduction to laboratory policies and procedures and document the processes that provide proof of an analyst's proficiency. Data Integrity is stressed in all areas of training. Highlights of the program include an orientation process that includes Air Water & Soil Laboratory's commitment to quality, ethical standards and data integrity; initial training to attain requisite proficiency; continual monitoring of the employee's progress; opportunity for career enhancement seminars or training courses; and documentation files to track each analyst's progress. Training for Health and Safety and Waste Management procedures include handling of samples containing mixed/hazardous waste. Annual refresher training reviews the Quality Assurance Manual and Quality Systems, Ethics Policy and Data Integrity, and Health & Safety.

Demonstration of Capability (DOC) Appendix E & F documentation is included in the analyst training files to document qualifications for method performance. For methods where a DOC is not applicable, e.g., solids, paint filter test; a PE sample and/or training with an experienced analyst will satisfy the requirement. The successful analysis of routine quality control indicators (e.g., calibrations, method qc) are demonstrative of ongoing demonstrations of capability.

16 ACCOMMODATIONS & ENVIRONMENTAL CONDITIONS

Laboratory facilities are designed and organized to facilitate testing of environmental samples. Factors affecting tests include but are not limited to energy sources, lighting, temperature, humidity, and cleanliness. These conditions are monitored to ensure that they do not invalidate results or adversely affect the required quality of any measurement.

Environmental analyses are stopped when the environmental conditions jeopardize these analyses.

Access to, and use of areas affecting the quality of the environmental tests is controlled by restriction of areas to authorized personnel only.

The laboratory work spaces are adequate for their use, and appropriately clean to support environmental testing and ensure an unencumbered work area.

Procedure

Laboratory space is arranged to minimize cross-contamination between incompatible areas of the laboratory.

Extraction room: Negative pressure
Metals: Negative pressure
Volatiles Lab: Positive pressure with discreet air handling system

If the laboratory environment is required to be controlled by method or regulation, the adherence is recorded.

Procedure for Unencumbered Work Area

- The laboratory is cleaned once a week by a contracted janitorial service
- Each employee is responsible for straightening up their work area at the end of the day
- All samples are returned to sample refrigerators at the end of each day
- All reagents and solvents are properly capped and returned to appropriate storage location at the end of each day
- All glassware is cleaned and put away
- All counter tops are wiped down

Procedure for Environment Control

- Testing occurs only within the laboratory.
- Laboratory space is maintained and monitored to the specifications required for laboratory space and the testing performed.
- Electronic balances are located away from drafts and doorways and mounted on marble slabs in areas where their use is protected by vibrations.
- Biological work areas are sterilized between uses. Neighboring test areas of incompatible activities are effectively separated.
- Specific work areas are defined and access is controlled. (Only authorized laboratory personnel and escorted signed-in visitors may enter the work area.)
- Good housekeeping measures are employed to avoid the possibility of contamination.
- Smoking is prohibited.

- All equipment and reference materials required for the accredited tests are available in the laboratory.
- Records are maintained for all equipment, reference measurement materials, and services used by the laboratory.
- Reference materials traceable to national standards of measurement or to national standard reference materials are stored away from heavy use areas or major equipment that may effect the proper operation of the materials.
- Certificates of Traceability are available for the reference thermometer and the Class 1 weights. The reference materials are used only for calibration to maintain the validity of performance.

17 TEST METHODS AND METHOD VALIDATION

A method used under an accredited program is validated before it is put into use. All validated methods are published or documented.

Note: It is understood that some testing may be requested by clients that does not fall under an accreditation program and full validation may not be required for analysis.

Policy

The introduction of test methods developed by the laboratory for its own use is a planned activity assigned to qualified personnel equipped with adequate resources to accomplish validation. Plans are updated as necessary and communicated to all involved personnel.

17.1 Demonstration of Capability (DOC)

Demonstration of Capabilities (DOC) is documented and completed forms are kept in the training files for each analyst. All supporting data contributing to the DOC is retained and available. See SOP D1532 for more information.

A DOC is performed for each analyte whenever the method, analyst, analyte(s), or instrument type is changed. When a member of a work cell is changed, a DOC must be performed by the new member and must pass all DOC criteria before that member can work independently.

The Technical Director or the Quality Manager or his/her designee certifies that technical staff members in their area of expertise are trained and authorized to perform all tests for which we are accredited by signing the DOC form.

The process for IDOC is documented below:

a) A quality control sample is obtained from an outside source or prepared using stock standards which are independent from those used in instrument calibration.

b) The analyte(s) is prepared using a clean quality system matrix sufficient to prepare four aliquots at the concentration specified, or if unspecified, to a concentration of 1-4 times the limit of quantitation.

c) At least four aliquots are prepared and analyzed according to the test method either concurrently or over a period of days.

d) Using all of the results, calculate the mean recovery in the appropriate reporting units and the standard deviations of the population sample (in the same units) for each parameter of interest. When it is not possible to determine mean and standard deviations, such as for presence/absence and logarithmic values, the performance is assessed against established and documented criteria. Microbiology (see SOP D7114 for detailed procedure) or flashpoint IDOCs can also be established & documented by analyzing PT samples.

e) Compare the information from (d) above to the corresponding acceptance criteria for precision and accuracy in the test method (if applicable) or in laboratory-generated acceptance criteria (if there are not established mandatory criteria). If all parameters meet

the acceptance criteria, the analysis of actual samples may begin. If any one of the parameters do not meet the acceptance criteria, the performance is unacceptable for that parameter. The acceptance criteria must be defined prior to the analyst performing the method.

f) When one or more of the tested parameters fail at least one of the acceptance criteria, the analyst must proceed according to 1) or 2) below.

1. Locate and correct the source of the problem and repeat the test for all parameters of interest beginning with c) above.

2. Beginning with c) above, repeat the test for all parameters that failed to meet criteria.

Repeated failure, however, confirms a general problem with the measurement system. If this occurs, the source of the problem is located and corrected and the test repeated for all compounds of interest beginning with c).

17.2 Continuing Demonstrations of Analyst Capability

A Continuing Demonstration of Capability (CDC) after the demonstration of capability is completed; on-going proficiency is maintained and demonstrated at least annually through the analysis of either single-blind samples or performing another DOC compared to pre-determined acceptance limits for precision and accuracy. This is documented in the training file of each analyst.

17.3 Initial Test Method Evaluation

For chemical analyses, the INITIAL TEST METHOD EVALUATION involves the determination of the Limit of Detection (LOD), confirmation of the Limit of Quantitation (LOQ), an evaluation of precision and bias, and an evaluation of the selectivity of the method.

For microbiological analyses, the initial test method evaluation involves comparison with an approved method, or analyzing 10 spiked samples of a representative matrix, or by analyzing and passing one proficiency test series by an approved PT provider.

The frequency of MDL/LOD (however named) is determined based on actual analytical method(s). If the laboratory is not reporting a value below LOQ or low calibration point, a MDL/LOD study (however named) is not required.

17.3.1 Method Detection Limits (MDL)

The method detection limit (MDL) is the lowest concentration that can be measured for a given analytical method and sample matrix with 99% confidence that the analyte is present and one way to establish a detection limit not the Limit of Detection. The MDL is determined according to Appendix B of 40 CFR 136, "Guidelines Establishing Test Procedures for the Analysis of Pollutants". MDLs reflect a calculated (statistical) value determined under ideal laboratory conditions in a clean matrix, and may not be achievable in all environmental matrices. MDL studies are retained by the QA department. Detailed procedure is available in SOP D1500 (MDL, LOD & LOQ) Current Revision.

17.3.2 Limit of Detection (LOD)

Analyses where the laboratory is not reporting a value below the Limit of Quantitation, a Limit of Detection study is not required. For example, the laboratory does not report some solid matrix analyses below established LOQs/low cal points, LODs are not required to perform for these analyses.

The LOD is the smallest amount or concentration of a substance that must be present in a sample in order to be detected at a high level of confidence (99%). At the LOD, the false negative rate (Type II error) is 1%.

LODs are determined from a quality system matrix using all sample processing steps, and are recommended to verify annually, if required, or when there is a change in the test method or instrument that affects sensitivity.

The laboratory performs an MDL study for all analytes for which a spike can be created and the LOD is determined based on this study as specified in 40 CFR Part 136 Appendix B. The LOD is then set at the concentration at which it was verified and may be reported to the same significant figures as the samples using laboratory rounding rules.

Validity of the LOD is verified annually by analyzing a qualitative QC sample in each matrix at no more than 1-3 X the MDL for a single analyte test and 1-4 X for multiple analyte tests. This verification must be performed on each instrument used for sample analysis to report data.

{NOTE: When more than one instrument is used for the same test, the LODs are determined on each instrument. The highest LOD is then used for all instrumentation and the same verification concentration is used on all instruments.}

17.3.3 Limit of Quantitation (LOQ)

The minimum levels, concentrations, or quantities of a target variable (e.g., target analyte) that can be reported with a specified degree of confidence

The lowest calibration standard may be equal to or less than the LOQ, but never above the LOQ.

The LOQ will always be greater than or equal to the LOD.

The LOQ is verified annually using a quality systems matrix sample spiked at 1-2 times the determined LOQ that returns a concentration within the acceptance criteria for accuracy according to the requirements of the Laboratory Control Samples. However, annual LOQ verification is not required if the LOD is determined or verified annually on that instrument.

17.3.4 Precision

Precision is the measure of how closely multiple analyses of a particular sample agree with each other. To determine the precision of the method and/or laboratory analyst, a routine program of duplicate analyses is performed. The results of the duplicate analyses are used to calculate the relative percent difference (RPD), which is the governing quality control parameter for precision. The relative percent difference (RPD) for duplicate analyses is defined as 100 times the difference (range) of each replicate set, divided by the average value (mean) of the duplicate set.

17.3.5 Accuracy

Accuracy is the measure of the closeness of an observed value to the "true" value (theoretical or reference value or population mean). The accuracy of an analytical method and/or the laboratory analyst is based on the analysis of laboratory control standards. The results of the laboratory control standards are used to calculate the quality control parameter for accuracy evaluation, the Percent Recovery (%R). The %R is defined as 100 times the observed concentration divided by the true concentration of the spike.

The QA targets for all inorganic analyses are defined in the SOP with less than 20 RPD for precision. The organic QA targets are statutory in nature; warning and control limits for organic analyses are initially set for groups of compounds based on preliminary method validation data. When additional data is available, the QA targets may be reconsidered. All QA targets are routinely re-evaluated at least annually (and updated, if necessary) against laboratory generated data to insure targets continue to reflect realistic, methodologically achievable goals.

17.4 Uncertainty

Uncertainty can be calculated using the Quality Control based nested approach as described in SOP D1516. Uncertainty will only be calculated if requested by the client. The approach uses batch quality control over a period of time. This approach can also incorporate sample uncertainty if field quality control is available. A minimum of twenty measurements is required.

17.5 Laboratory-Developed or Non-Standard Method Validation

Laboratory developed, modified standard methods, and non-standard methods may require method validation.

Where applicable, the laboratory validates non-standard methods, laboratory-designed/developed methods, standard methods used outside their published scope, and amplifications and modifications of standard methods to confirm that the methods are fit for the intended use.

The range and accuracy of the values obtainable from validated methods (e.g. the uncertainty of the results, detection limit, selectivity of the method, linearity, limit of repeatability and/or reproducibility, robustness against external influences and/or cross-sensitivity against interference from the matrix of

the sample/test object), is assessed for the intended use and whether it is relevant to the clients' needs.

The use of non-standard methods by the laboratory is agreed upon in advance with the client.

Any updates to the method development plans are communicated to all involved personnel.

17.6 Control of Data

All calculations and all relevant data are subject to appropriate checks in a systematic manner and verified manually.
Spreadsheets provided to the laboratory for use in calculations, must be approved by management, which includes verification of cell protection and formula accuracy. The QA/QC monthly audit will also includes spot checks of random spreadsheet.

New software is tested and verified for accuracy before being implemented on the system. Documentation of software approved for use is maintained in a verification file and kept by the QA Manager. After implementation, all users are advised of the changes and requested to report any problems with the software to the LIMS administrators. When updates are received from the manufacturer, the revised name and date/time stamp provide version control.

All computer workstations are protected from outside access using Windows Active Directory. When workstations are not in use or are not monitored, they are to be locked. User Groups have been identified to provide granularity to the security policy.

Instrument logins are used at individual instrument control workstations to allow for work cell access to common data. The personnel identified as part of the work cell are provided with the instrument login account information.

Procedure

The laboratory assures that computers and software are protected, maintained, and secure through measures such as documentation, locked access, and control of the laboratory environment.

Only authorized personnel have access to the laboratory and any storage areas. All computers are password protected.

The laboratory assures that computers, user-developed comp0uter software, automated equipment, or microprocessors used for the acquisition, processing, recording, reporting, storage, or retrieval of environmental test data are:

a) documented in sufficient detail and validated as being adequate for use;

b) protected for integrity and confidentiality of data entry or collection, data storage, data transmission and data processing;

c) maintained to ensure proper functioning and are provided with the environmental and operating conditions necessary to maintain the integrity of environmental test data; and

d) held secure including the prevention of unauthorized access to, and the unauthorized amendment of, computer records.

18 EQUIPMENT

18.1 General Equipment Requirements

The purchase of analytical instrumentation is based on anticipated sample volume and the need to maintain superior quality data. Specifications are carefully examined to be sure new instrumentation meets current and anticipated needs. Warranty and service contract information is gathered at the time bids are reviewed and this information is considered in making the final selection. An extensive performance check-out before the instrument is accepted is mandatory. New equipment must undergo a rigorous method validation before being put into service. Operators of new instruments are sent to training courses if necessary. Inventory records are maintained for all major capital equipment.

Laboratory equipment and instrumentation are maintained in compliance with instrumentation manuals. All equipment is kept in working condition to allow for conformity to each approved method. A list of instrumentation and equipment is maintained by the QA/QC Department and is included in Appendix G.

18.2 Equipment Operation and Calibration

Equipment is defined as any non-disposable mechanical and/or electronic device used in the generation or measurement of data.

The calibration of instruments and support equipment is required to ensure that the analytical system is operating correctly and functioning within acceptable precision, accuracy and sensitivity limits. Calibration is defined as the systematic determination of the relationship of the response of the measurement system to a known standard. If traceable chemical standards are not available, standards are prepared according to the laboratory quality control procedures or the project's requirements. The calibration requirements for each type of equipment or instrument are defined in the standard operating procedures summarizes the calibration requirements of the lab.

{Note: The calibrations or calibration checks are performed with reference standards traceable to primary standards (e.g. NIST or other certified standards) for all DoD projects}.

It is the responsibility of the analyst to verify that the instrument configuration and operating conditions used satisfy the analytical requirements and to maintain quality control data confirming instrument performance and analytical results. The inability to achieve calibration is an indication that the equipment needs maintenance. It is not acceptable for an analyst to repeat analysis of calibration or quality control standards beyond what is allowed by the SOP until "acceptable" results are achieved.

If equipment outside the permanent control of the laboratory is used, it must meet the same criteria. The laboratory shall ensure that the function and calibration status of the equipment is checked and shown to be satisfactory before it is put into service and must meet all requirements of DoD ELAP NELAC and 17025: 2005 standards.

19 EQUIPMENT MAINTENANCE

Maintenance is defined as cleaning and/or replacing equipment components to assure that the equipment has been properly and periodically serviced and is in satisfactory condition. The equipment manual is a good guideline to determine preventive and routine maintenance schedules. These manuals also assist in identification of commonly needed replacement parts so that an inventory of these parts can be properly maintained.

A maintenance log is issued for each piece of equipment. It shall be maintained by the analyst to describe problems, the maintenance performed on the instrument and outcome. This includes routine service checks by laboratory personnel (unless described in the SOP) as well as factory service calls. This log also provides a written source for future use in preventive maintenance. The logs are periodically reviewed by QA.

In order to prevent system down time, minimize corrective maintenance cost and to help insure data validity, Air Water & Soil uses a system of preventive maintenance. All routine maintenance is performed as recommended by the manufacturer. Periodic preventive maintenance is performed in-house and immediate service for corrective actions. Manufacturer representatives are called when services cannot be performed in-house.

When a piece of equipment is deemed defective, it is taken out of service and identified with an "OUT OF SERVICE" label. For support equipment such as balances, ovens, coolers, and pipettes, the QA/QC Department is notified so that proper servicing and repair can be scheduled. The analysts perform routine and preventive maintenance for major instrumentation. Satisfactory instrument performance must be verified prior to returning to service of any repaired equipment. All equipment is calibrated or checked before being placed into use to ensure that it meets laboratory specifications and the relevant standard specifications. Additional, ongoing checks or calibrations are performed as necessary to comply with required specifications.

Each item of equipment and the software used for testing and significant to the results is uniquely identified and records of equipment and software are maintained. This information includes the following:

a) identity of the equipment and its software;
b) manufacturer's name, type identification, serial number or other unique identifier;
c) checks that equipment complies with specifications of applicable tests;
d) current location;
e) manufacturer's instructions, if available, or a reference to their location;
f) dates, results and copies of reports and certificates of all calibrations, adjustments, acceptance criteria, and the due date of next calibration;
g) maintenance plan where appropriate, and maintenance carried out to date; documentation on all routine and non-routine maintenance activities and reference material verifications;
h) any damage, malfunction, modification or repair to the equipment;
i) date received and date placed into service (if available); and
j) condition when received, if available (new, used, reconditioned).

See Appendix G for a complete list of laboratory equipment

19.1 Support Equipment

SUPPORT EQUIPMENT includes, but is not limited to: balances, ovens, refrigerators, freezers, incubators, water baths, temperature measuring devices, volumetric dispensing devices, and thermal/pressure sample preparation devices (see Table 19.1-1)

All support equipment is maintained in proper working order and records are kept of all repair and maintenance activities, including service calls.

All raw data records are retained to document equipment performance. These records include logbooks, data sheets, or equipment computer files.

All support equipment is calibrated or verified quarterly and in some cases annually, over the entire range of use using NIST traceable references where available. The results are recorded that the calibration of support equipment are within specifications or (1) the equipment is removed from service until repaired, or (2) records are maintained of correction factors to correct all measurements.

Support equipment such as balances, ovens, refrigerators, freezers, and water baths are checked with a NIST traceable reference if available, each day prior to use, to ensure they are operating within the expected range for the application for which the equipment is to be used.

Mechanical volumetric dispensing equipment, including burettes (except Class A glassware), is checked for accuracy quarterly.

Glass micro-liter syringes have a certificate attesting to the established accuracy. If the certificate of accuracy for glass micro-liter syringes is not available, the accuracy of the syringe is demonstrated upon receipt and documented.

For chemical tests that use autoclaves, the temperature, cycle time, and pressure is documented by use of chemical indicators or temperature recorders and pressure gauges.

For microbiology analyses, records for autoclaves used in the laboratory are required for the following:

- initial performance of the autoclave functional properties (supplied by the installer);
- temperature demonstration of sterilization continuous monitoring device or maximum registering temperature;
- for every cycle, record date, contents, maximum temperature reached, pressure, time in sterilization mode, total run time, and analysts initials;
- quarterly check of autoclave timing device against a stopwatch; and
- annual maintenance check to include a pressure check and calibration of temperature device.

19.2 Support Equipment Maintenance

Regular maintenance of support equipment, such as balances and fume hoods is conducted at least annually.

Maintenance on other support equipment, such as ovens, refrigerators, and thermometers is conducted on an as needed basis.

Records of maintenance to support equipment are documented on the individual instrument or the Instrument Maintenance Logs. Each piece of support equipment does not necessarily have its own logbook. Maintenance logbooks may be shared with equipment that is housed in the same laboratory area (Table 19.2-1).

Table Table19.1-1 Acceptance Criteria for Support Equipment

Equipment Identification	Type of Unit	Use	Acceptance Criteria/VERIFY
Inc01	incubator	Presence/Absence, E-coli	35°C +/- 0.5°C
Inc02	incubator	Fecal (special projects only)	44.5°C +/- 0.5°C
Inc03	incubator	BOD	20°C +/- 1°C
R01	refrigerator	Wet Chem reagents & TOX samples	0 to 6°C
R02	freezer	Ice & blue ice	< -10°C
R03	Walk in refrigerator	Miscellaneous water samples	0 to 6°C
R04	Walk in refrigerator	Miscellaneous soil samples	0 to 6°C
R09	refrigerator	SVOC instrument standards	0 to 6°C
R10	refrigerator	Extraction standards	0 to 6°C
R12	refrigerator	Wet chem	0 to 6°C
R20	refrigerator	Log-in holding	0 to 6°C
R21	refrigerator	Soil samples	0 to 6°C
R23	refrigerator	SVOC water samples	0 to 6°C
R24	freezer	VOC standards	< -10°C
R25	refrigerator	VOC water samples	0 to 6°C
R26	refrigerator	SVOC sample extracts	0 to 6°C
R27	refrigerator	SVOC water samples	0 to 6°C
R28	refrigerator	VOC soil	0 to 6°C
R29	refrigerator	Microbiology	0 to 6°C
WB 01	Waterbath	Fecals	44.5°C +/- 0.2°C
WB 02	Waterbath	Fecals	35.0°C +/- 0.5°C
WB 03	Waterbath	Microbiology - Sterikon check	60°C +/- 2°C
Oven 01	Oven	TDS/TS	180 +/- 2°C
Oven 02	Oven	TSS & %Solids	104 +/- 1°C
Oven 03	Oven	Soil drying oven	104 +/- 1°C
All	Fume Hoods	Evaporation of fumes	Avg. face velocity 100 fpm

Table 19.2-1: Support Equipment Calibration and Maintenance

Table19.2-1 Calibration And Maintenance			
Instrument	**Activity**	**Frequency**	**Acceptance Criteria**
Balances	1. Clean 2. Calibrated 3. Service Contract	1. As needed 2. Daily or before use 3. Annually	Top-loading balance: ± 2% or ± 0.02 g, whichever is greater Analytical Balance: ± 0.1% or ± 0.5 mg, whichever is greater
ASTM Class 1 Weights	1. Only use for the intended purpose 2. Use plastic forceps to handle 3. Keep in case 4. Re-calibrate	Once every 5 years	Certificate of Calibration from accredited calibration laboratory
Thermometers: 1. Glass 2. Dial thermometers	Check at the temperature used, against a reference NIST certified thermometer	Liquid in glass: Before first use and annually Electronic: Before first use and quarterly; if only a single temperature is used, at the temperature of use	Apply correction factors or replace thermometer
pH electrometers	Calibration: 1. pH buffer aliquot are used only once 2. Buffers used for calibration will bracket the pH of the media, reagent, or sample tested.	Each day of use	±0.3 pH units for each buffer
pH probe	Maintenance: Use manufacturer's specifications	As needed	
Conductivity meter	1. Verify cell constant 2. Calibrate	Annually Each day of use	5.0/cm ±4%.
Spectrophotometer	1. Keep cells clean 2. Service	1. Each use 2. As needed	
Automatic or digital type pipettes	Calibrate for accuracy and precision using reagent water and analytical balance	By lot before first use and quarterly or upon evidence of deterioration	Bias: Mean within ± 2% of nominal volume Precision: RSD ≤ 1% of nominal volume (based on 10 replicate measurements) [Note: for variable volume pipettes, the nominal volume is the largest user-selectable volume setting]
Refrigerator/Freezer temperature	Monitoring of refrigerator/ freezer temperature	Daily (i.e., 7 days per week) (MIN/MAX thermometers allowed)	Refrigerators: 1 °C to 6 °C Freezers: ≤ -10 °C
BOD Incubator temperature	1. Thermometer is immersed in liquid to the appropriate immersion line. Thermometer is graduated in increment of 1°C or less.	Daily (i.e., 7 days per week) (MIN/MAX thermometers allowed)	Incubator temperature must be 20 ± 1°C

Table19.2-1 Calibration And Maintenance

Instrument	Activity	Frequency	Acceptance Criteria
Autoclave Sterilizer	1. Use a maximum-temperature-registering thermometer or a continuous recording device. 2. Use spore strips or ampules. 3. In house maintenance of autoclave or service contract.	1. Each cycle 2. One sterilizing cycle per month. 3. As needed	
Microbiological incubators, and water baths	1. Thermometers in each unit are immersed in liquid to the appropriate immersion line 2. The thermometers will be graduated in increments of 0.5°C (0.2°C increments for tests which are incubated at 44.5°C) or less	Temperature of incubators and water baths will be recorded twice a day for each day in use with readings separated by at least four hours	
DO electrometer	Calibrate as specified in SOP	Before use	
DO probe	Maintenance as specify by manufacturer	As needed	
TCLP Rotator	Check rotation per minute	Monthly	30 ± 2rpm
Hot Block digesters	Check temperature	Verify temperature prior to use across surface. Verify Daily Prior to use.	95 ± 5°C
All Fume Hoods	Check Air Flow	Annually	Avg. face velocity 100 fpm

19.3 Analytical Equipment

19.3.1 Maintenance for Analytical Equipment

All equipment is properly maintained, inspected, and cleaned. For a list of typical equipment maintenance see Table 19.3-1.

Maintenance of analytical instruments and other equipment may include regularly scheduled preventive maintenance or maintenance on an as-needed basis due to instrument malfunction and is documented in Instrument Maintenance Logs, which become part of the laboratory's permanent records.

Table 19.3-1 Analytical Equipment Maintenance

Instrument	Procedure	Frequency
Perkin Elmer AA's (Graphite Furnace)	Clean windows	As needed
	Replace windows	As needed
	Change graphite tube/platform	As needed
	Check level of rinse solution	Daily, when used
	Check waste container level	Daily, when used
	Check sample introduction probe	After tube change & as needed
	Check gas supply	Daily, when used
	Change contact rings	Approx. every 6 mo.
(Flame)	Clean nebulizer	As needed
	Align/Clean burner head	As needed
	Check gases	Daily, when used
	Check waste level	Daily, when used
	Replace tubing	As needed
Perkin Elmer Mercury Analyzer	Check tubing for wear	Daily, when used
	Fill rinse tank with 3% HCl	Daily, when used
	Change PTFE filter	Daily, when used
	Fill reductant bottle with 10% Stannous Chloride	Daily, when used
Perkin Elmer ICP's	Check pump tubing	Daily, when used
	Check liquid argon supply	Daily, when used
	Check fluid level in waste container	Daily, when used
	Check filters	Monthly
	Clean or replace filters	As needed
	Check/align torch	Daily, when used
	Rinse sample spray chamber	Daily, when used
	Clean nebulizer	As needed
	Check entrance slit for debris	Monthly
	Replace pump tubing	Approx. every other day
UV-Vis Spectrophotometer	Clean cell	Daily, when used
	Precision check/alignment of flow cell	As needed
	Wavelength verification check	As needed
Auto Flow Analyzer	Clean sampler	Daily, when used
	Check all tubing	Daily, when used
	Clean flow cell	Daily, when used
	Clean pump well and pump rollers	Quarterly
	Check/refill wash fluid	Daily, when used
	Oil rollers/chains/side rails	As needed
	Clean optics and cells	Daily, when used
IR Spectrophotometer	Clean cell	Daily, when used
	Check/adjust cell alignment	As needed
Hewlett Packard GC/MS	Ion gauge tube degassing	As needed
	Pump oil-level check	Monthly
	Pump oil changing	Annually
	Analyzer bake-out	As needed
	Clean ion source	As needed
	Resolution adjustment	As needed
	Replace quadrapoles	As needed
	Replace gas scrubbers	Annually
	Check Helium supply	Daily, when used
Hewlett Packard Gas Chromatographs	Compare standard response to last initial calibration	Daily, when used
	Check carrier gas flow rate in column	Daily via retention time data
	Check gas pressure @ tank	Daily, when used
	Check temp. of detector, inlet, column oven	Daily, when used
	Septum replacement	As needed
	Inlet liner replacement	As needed
	Seal replacement	As needed
	Check system for gas leaks with SNOOP	W/cylinder change
	Check for loose/fray wires and insulation	Monthly
	Bake injector/column	As needed
	Change/remove sections of guard column	As needed
	Replace connectors/ferrules	As needed
	Change/replace column(s)	As needed
	Clean/change autosampler syringe	As needed

Table 19.3-1 Analytical Equipment Maintenance

Instrument	Procedure	Frequency
Electron Capture Detector (ECD)	Detector wipe test (Ni-63) Detector cleaning Change detector liners	Semi-annually As needed As needed
Flame Ionization Detector (FID)	Detector cleaning	As needed
Photoionization Detector (PID)	Change O-rings Clean lamp window	As needed As needed
Archon Purge & Trap Autosampler	Recalibrate	As needed
Tekmar Purge & Trap Sample Introduction Assembly	Change trap Change sample liner	As needed (approx. quarterly) Approx. annually
Tekmar-Dohrmann TOC Analyzer	Change Copper & Tin scrubber	Approx. monthly
Analytikjena multi X 2500	Change electrolytes Change sulfuric acid	Daily, when used Daily, when used
Balances	Class "S" traceable weight check Clean pan Field service	Daily, when used As needed Annually
Conductivity Meter	0.01 M KCl calibration Conductivity cell cleaning Check cell constant	Daily, when used As needed Annually
Turbidimeter	Check light bulb	Daily, when used
Deionized/Distilled Water	Check conductivity Check deionizer light Monitor for VOA's System cleaning Replace cartridge & large mixed bed resins	Daily, when used Daily, when used Daily, when used As required As required
Drying Ovens	Temperature monitoring Temperature adjustments	Daily, when used As required
Refrigerators/ Freezers	Temperature monitoring Temperature adjustment Defrosting/cleaning	Daily, when used As needed As needed
Vacuum Pumps/ Air Compressors	Change oil	Annually
pH/Specific Ion Meter	Calibration/check slope Clean electrode	Daily, when used As needed
BOD Incubator	Temperature monitoring Coil and incubator cleaning	7 days a week Monthly
Centrifuge	Check brushes and bearings	As needed
Water Baths	Temperature monitoring Water replaced Cleaned	Daily, when used As needed As needed
Turbovaps	Temperature Monitoring Clean	Daily, when used As needed
TCLP Rotator	Check rotation	Monthly
Autoshaker	Lubricate system	As needed
Desiccators	Check color of desiccant Bake/dry desiccant & refill Change desiccant	Daily, when used As needed Semi-annually

19.3.2 Initial Instrument Calibration

Initial instrument calibration and continuing instrument calibration verification are an important part of ensuring data of known and documented quality. If more stringent calibration requirements are included in a mandated method or by regulation, those calibration requirements override any requirements outlined here or in laboratory SOPs. Generally, instrument calibrations are provided in test methods.

All initial instrument calibrations are verified with a standard obtained from a second source traceable to a national standard when commercially available. If a second source is not available, a standard prepared from a separate lot may be used as long as the manufacturer can demonstrate the lot was prepared independently from other lots purchased.

If the reference or mandated method does not specify the number of calibration standards to use, the minimum number is three for inorganics and 5 for organics not including blanks or a zero standard, except for pH analyses.

Any samples that are analyzed after an unacceptable initial calibration are re-analyzed.

The lowest calibration standard is the lowest concentration for which quantitative results can be reported without qualification. The lowest calibration standard is equal to or less than the Limit of Quantitation and is equal to or greater than the limit of detection.

The highest calibration standard is the highest concentration for which quantitative results can be reported unless otherwise stated by the method or SOP. Data reported that are greater than the highest calibration standard without dilution are considered to be an estimate and are reported with a qualifier and explained in the case narrative.

Initial instrument calibration includes calculations, integrations, acceptance criteria, and associated statistics referenced in the method specific SOPs.

Sufficient raw data records are collected to allow reconstruction of the initial instrument calibration. These include, at a minimum, calibration date, test method, instrument, analysis date, analyte names, analysts signature or initials, concentration and response, calibration curve or response factor, or unique equation or coefficient used to reduce instrument responses to concentration.
Corrective actions are performed when the initial calibration results are outside acceptance criteria. If reanalysis of samples is not possible, data is reported with appropriate qualifiers. Calibration points are not dropped from the middle of the curve to make the data pass. If the low or high calibration point is dropped from the curve, the working curve is adjusted and sample results outside the curve are qualified.

Results that are less than the lower calibration standard are considered to have increased uncertainty, and are reported with a qualifier code and explained in the case narrative.

Results that are greater than the highest calibration standard are either diluted to within the calibration range, or considered to be an estimate; and are reported with a qualifier code and explained in the case narrative.

For instrumentation where single point calibration is recommended by manufacturer's instructions and utilized, the following apply:

a) For single point plus zero blank calibrations, the zero point and the single point standard are analyzed prior to the analysis of samples, and the linear range of the instrument established by analyzing a series of standards, one of which is at the lowest quantitation level.

b) Zero blank and single point calibration standards are analyzed with each analytical batch for methods where they are specified.

c) A standard corresponding to the limit of quantitation is analyzed with each analytical batch and must meet established acceptance criteria when using single point plus zero blank calibrations.

d) The linearity of single point plus zero blank calibrations is verified at a frequency established by the method or the manufacturer.

19.3.3 Continuing Instrument Calibration

The validity of the initial calibration and ongoing calibration is verified prior to sample analysis by use of a continuing calibration verification (CCV) standard. The source of the CCV should be the same as for the initial calibration standards, and the concentration of the CCV should be between the lowest standard and the mid concentration of the calibration range.

The baseline for evaluating the CCV is the initial calibration curve. Corrective action is initiated for continuing instrument calibration verification results that are outside of acceptance criteria.

Continuing instrument calibration verification is performed at the beginning and end of each analytical batch, except for instances when an internal standard is used. For methods employing internal standards, verification is required only at the beginning of the analytical batch.

Continuing instrument calibration verification is performed whenever it is expected that the analytical system may be out of calibration or might not meet verification acceptance criteria.

Continuing instrument calibration verification is performed when the time period for calibration or the most recent calibration verification has expired.

Continuing instrument calibration verification is performed for all analytical systems that have a calibration verification requirement.

Calibration is verified for each compound, element, or other discrete chemical species.

The calculations and associated statistics for continuing instrument calibration are included or referenced in the test method SOP.

Sufficient raw data records are retained to allow reconstruction of the continuing instrument calibration verification. Continuing instrument calibration verification records connect the continuing verification date to the initial instrument calibration.

All acceptance criteria for continuing instrument calibration verification is referenced in the individual test SOP.

19.3.4 Unacceptable Continuing Instrument Calibration Verifications

If a CCV fails, routine corrective action is taken to correct the problem and the CCV is analyzed again right away. If the CCV passes, the analysis of the next samples may continue.

{Note: For DoD work, all samples analyzed prior to the failed CCV must also be analyzed after the passing CCV.}

If routine corrective action fails to immediately produce acceptable calibration verification, a new calibration is performed or acceptable performance is demonstrated after corrective action with two consecutive calibration verifications.

Samples associated with a failed calibration verification must be qualified if reanalysis is not possible, or results may be useable under the following conditions:

a) If the acceptance criteria are exceeded high (high bias) and the associated samples are below detection, then those sample results that are non-detects may be reported as non-detects.

b) If the acceptance criteria are exceeded low (low bias) and there are samples that exceed the maximum regulatory limit, then those exceeding the regulatory limit may be reported.

20 MANUAL INTEGRATION

Modern chromatographic data systems allow analysts to review data and manipulate integration parameters (manual integration). Such manipulations may have a profound impact on data integrity. When used properly, manual integration can allow an experienced analyst to overcome limitations of an automated data system. It also has the potential for misuse. All data must be integrated consistently in standards, samples and quality control samples. Manual integration is a corrective action measure and must never be used solely to meet quality control criteria. Performing improper manual integrations, including peak shaving, peak enhancing, or baseline manipulation to meet quality control criteria or to avoid corrective action is strictly prohibited. For DoD, all samples and analytes for which manual integration occurred, including the cause and justification must be documented on the case narrative. See Manual Integration SOP D2100 for examples of acceptable manual integration procedures for Air Water & Soil.

21 MEASURMENT TRACEABILITY

Measurement quality assurance comes in part from traceability of standards to certified materials.

All equipment used that affects the quality of test results are calibrated prior to being put into service and on a continuing basis. These calibrations are traceable to national standards of measurement where available.

Measurements from laboratory equipment provide the uncertainty required by test method or client.

If traceability of measurements to SI units is not possible or not relevant, evidence for correlation of results through interlaboratory comparisons, proficiency testing, or independent analysis is provided.

All equipment that affects the quality of test results are calibrated according to the minimum frequency suggested by the manufacturer, by regulation, by method, or as needed.

21.1 Reference Standards

REFERENCE STANDARDS are standards of the highest quality available at a given location, from which measurements are derived.

Reference Standards, such as ASTM Class 1 weights or traceable thermometers, are used for calibration only and for no other purpose unless it is shown that their performance as reference standards will not be invalidated.

Reference standards are calibrated by an entity that can provide traceability to national or international standards. Reference standards shall be calibrated before and after any adjustment.
The following reference standards are to be calibrated to a national standard:

a) Reference thermometers are sent out for calibration every 1 year.
b) Class 1 weights are sent out for calibration every 5 years.

21.2 Reference Materials

REFERENCE MATERIALS are measuring devices such as pipettes and balances that are sufficiently well established to use for calibration or as a frame of reference.

Reference materials, where commercially available, are traceable to national standards of measurement, or to Certified Reference Materials, usually by a Certificate of Analysis. The laboratory shall maintain CoA from manufactures for a minimum of five years.

Internal reference materials are checked as far as technically and economically possible.

Procedure

Purchased Reference Materials require a Certificate of Analysis where available. Otherwise, purchased reference materials are verified by application to a certified reference material and/or interlaboratory comparison.

Internal Reference Materials, such as working standards and intermediate stock solutions, are checked with interlaboratory comparison studies quality control samples and proficiency tests.

a) Internal glass thermometers are checked annually and all digital thermometers are checked quarterly against the NIST certified reference thermometer.
b) Balances are checked against Class 1 weights on each day of use
c) Mechanical pipettes are verified for accuracy gravimetrically on a quarterly basis.
d) Class A Glassware is verified when there is evidence of deterioration. 10 replicates must yield mean of ± 2% and RSD of 1% or less.
e) Class B Glassware is verified before first use. 10 replicates must yield mean of ± 2% and RSD of 1% or less.

21.3 Transport and Storage of Reference Standards and Materials

The laboratory handles and transports reference standards and materials in a way that protects their integrity.

Reference standard and material integrity is protected by separation from incompatible materials and/or minimizing exposure to degrading environments or materials.

Reference standards and materials are stored according to manufacturer's recommendations and separately from working standards or samples.

21.4 Labeling of Reference Standards, Reagents, and Materials

Reference standards and materials are tracked from purchase, receipt, and storage through disposal. Once received into the laboratory, they are recorded into LIMS and assigned an ID code along with the date received and lot number.

When specified by method, only reagents of that quality will be used. If not specified, analytical reagent grade is used. Reagent quality is verified during routine blank analyses and/or prior to use.

Procedure

Records for all standards, reagents, reference materials, and media include:

1. the manufacturer/vendor name (or traceability to purchased stocks or neat compounds)
2. the manufacturer's Certificate of Analysis or purity (if supplied)
3. the date of receipt
4. reference to the method of preparation
5. date of preparation
6. an expiration date after which the material shall not be used
7. preparer's initials (if prepared)

In methods where the purity of reagents is not specified, analytical reagent grade is used. If the purity is specified, that is the minimum acceptable grade. Purity is verified and documented according to Section 7, Purchasing, Services, and Supplies.

All containers of standards, reagents, or materials, whether original or prepared, are labeled with an expiration date. Expiration dates are determined as follows:

1. Neat Standards/Reagents (not prepared in the laboratory)
    a. Manufacturer's expiration date or

   b. SOP stated expiration date
   c. 2 years from opening, but not to exceed manufacturer's expiration date
2. Stock Standards/Reagents
   a. SOP stated expiration date or
   b. Manufacturer's recommended expiration date
   c. But not to exceed 6 months from preparation
3. Working Standards/Reagents
   a. SOP stated expiration date or
   b. Manufacturer's recommended expiration date or
   c. 1-2 months if no guidelines are given

All containers of prepared standards and reference materials have a preparation date and unique identifier generated by LIMS database.

Standard preparation records are kept in the LIMS and indicate traceability to purchased stocks or neat compounds, reference to the method of preparation, date of preparation, expiration date, and preparer's initials. All consumables are traceable either at the bench level and documented in the logbooks such as TSS filters, instrument lamps, GC columns, etc, or logged in the LIMS and given an auto generated unique ID such as IDEXX bacteria bottles, certified sample containers etc.

Prepared reagents are verified to meet the requirements of the test method through internal QC measures and/or blank analysis.

22 SAMPLE MANAGEMENT

22.1 Sample Receipt

Procedure

When samples are received at the laboratory, their condition is documented, they are given unique identifiers, and they are logged into the sample tracking system.

22.2 Sample Acceptance

The laboratory maintains a Sample Acceptance Policy that is available to sample collection personnel and outlined in SOP and the Air Water and Soil Terms and Conditions (Appendix H)

The minimum conditions a sample must meet on receipt are found on the sample condition checklist which include the following items:

The use of custody seals, agreement between bottle label and chain of custody, temperature, preservation, holding time, bottle type, appropriate sample volume, and VOC headspace.

A complete Chain of Custody must accompany all samples. It must include:

Sample identification, location, date and time of collection, collector's name, preservation type, sample type, and any special remarks concerning the sample.

If these conditions are not met, the client is contacted prior to any further processing.

All documents received with the sample including transmittals, memos, and chains of custody records are retained.

The laboratory checks samples for the conditions above, where appropriate, to evaluate sample acceptance.

The following preservation checks are performed and documented upon receipt:

Thermal preservation:

a) For samples that require temperature preservation, the acceptable range is from just above freezing to 6°C (metals not applicable).

b) Samples that are delivered to the lab the same day as they are collected are likely not to have reached a fully chilled temperature. This is acceptable if there is evidence that chilling has begun, i.e. samples received on ice.

   - For W.Va projects, if the thermal preservation requirements are not met within 15mins of collection, all affected samples must be narrated as non-compliant upon receipt.

c) Record on the receipt form if ice is present and the temperature received.

Chlorine checks:

d) Microbiological samples from chlorinated water systems do not require a chlorine check as all Microbiological sample containers are pre-preserved with sufficient sodium thiosulfate (to neutralize 5mg/L chlorine for drinking water and 15 mg/L chlorine for wastewater). All aqueous Pesticide (SW846-8081 & EPA 608) and SVOC (SW-846 8270 & EPA 625) samples are checked for chlorine upon receipt.

pH checks:

e) The pH of samples requiring acid/base preservation is checked upon sample receipt or upon initiation of analysis.

The sample acceptance policy is available to sample collection personnel, and emphasizes the need for a completed chain of custody, unique sample identification(s), use of water resistant ink, use of appropriate containers, adherence to holding times, sample volume requirements, special remarks about the sample(s), and what to do with compromised samples.

If the checks performed upon sample receipt indicate the criteria are not met, then 1) the sample is rejected as agreed with the client, 2) the decision to proceed is documented and agreed upon with the client, 3) the condition is noted on the Chain of Custody form and/or lab receipt documents, and 4) the data are qualified in the report if deemed necessary.

22.3 Sample Identification

Samples including subsamples, extracts, and digestates, are uniquely identified in a permanent chronological record in the database to prevent mix-up and to document receipt of all sample containers. This ID code is placed on the sample container with a durable label. Identification is maintained throughout the life of the sample.

Procedure
Samples are assigned sequential numbers that reference more detailed information kept in the data base (LIMS).

The following information is collected in the LIMS and/or sample conditions form.

a) Client or project name
b) Date and time of sampling
c) Date and time of receipt at lab
d) Unique laboratory identification number
e) Unique field identification number linked to the laboratory identification number
f) Initials of recorder
g) Analyses requested
h) Comments regarding rejection (if any).

22.4 Sample Storage

Refrigerated storage is maintained at, or just above freezing to 6°C unless otherwise directed by state or Agency requirements. The temperature of each unit is recorded daily, readings every 15mins apart, by DocuTemp temperature monitoring system. If there is a temperature excursion that cannot be returned to an in-control status, the samples are moved to an alternative unit until the problem is corrected. Storage is designed to segregate samples in such a way as to minimize the possibility of cross-contamination D1310. This includes the storage of volatile samples separate from semi-volatiles and inorganic samples. Within each unit, samples are organized by batch number for easy retrieval. Extracts are maintained in refrigerated storage until needed for analysis. Digestates typically do not need refrigeration, and are stored in the preparation area.

Segregation of high hazard non-volatile sample storage is in the SOP D1310

Refrigerator Monitoring is recorded 24/7, readings every 15mins apart, by DocuTemp temperature monitoring system.

22.5 Sample Disposal

Wastes generated in the laboratory can be divided into three types: hazardous, non-hazardous, and mixed wastes. The EPA defines wastes as hazardous if they exhibit the characteristics of ignitability, corrosivity, reactivity, or toxicity as identified in 40 CFR 261, Subpart C, or are listed in 40CFR 261, Subpart D. For the intents and purposes of laboratory waste management procedures, substances that may be disposed of as hazardous wastes include, but are not limited to:

Environmental samples,

- (Disposed 30 days after the data report is submitted to the client unless longer specific contract/program requirements were established. Disposal may include return of the samples to the client.)
- By-products of sample preparation or analysis,
- Standards or reagent solutions,
- End products of sample preparation or analysis,
- Used chemicals, or chemicals that have exceeded their shelf life, and
- Waste products generated from spill cleanup.

Air Water & Soil maintains appropriate documentation and records demonstrating that samples have been properly disposed of, in accordance with Federal, State, and local regulations. See SOP D2150. Waste Managers are trained in accordance with 49 CFR 172.700 Subpart H. Waste haulers DOT certification will be verified prior to use.

The Laboratory is classified as a Conditionally Exempt Small Quantity Generator (CEQG). Whenever possible, all non-hazardous liquids are disposed of by use of Elementary neutralization. All other samples, digestates, leachates, and extracts are categorized into one of the following waste streams and disposed of through a licensed and bonded hazardous waste disposal firm. All records are kept in a binder and maintained by the Waste Disposal personnel.

1) Flammable liquids, toxic, n.o.s. (ether, endrin) 3 UN1992 PG III
2) waste flammable liquids, toxic, n.o.s. (dichloromethane, gasoline)3 UN1992 PG III
3) waste flammable liquids, corrosive, n.o.s. (sulfuric acid, ether))3 UN2924 PG II
4) waste mercury 8 UN2809 PG III
5) hazardous waste liquid, n.o.s. (arsenic, barium) 9 NA 3082 PG III
6) waste flammable liquids, corrosive, n.o.s. (hexane, sulfuric acid) contains < 1% PCB's
7) waste corrosive, liquids, acidic, inorganic n.o.s. (sulfuric acid, chromic acid) 8 UN3264 PG II
8) Non-hazardous, non-RCRA, Non-DOT, Soils

22.6 Sample Transport

Samples that are transported under the responsibility of the laboratory, where necessary, are done so safely and according to storage conditions. This includes moving bottles within the laboratory.

22.7 Sampling Records

The Laboratory is not involved in sampling. Sub-sampling within the laboratory is performed so that a representative portion of the sample is used. This may be accomplished by coring, mixing or shaking the sample. (SOP # D2140-Subsampling)

23 QUALITY OF TEST RESULTS

23.1 Essential Quality Control Procedures

All essential quality control elements are collected and assessed on a continuing basis and used to determine usability of the data.

The qualities of test results are recorded in the LIMS so that trends may be detectable, and where practicable, are statistically evaluated.

For test methods that do not provide acceptance criteria for an essential quality control element or where no regulatory criteria exist, acceptance criteria are developed. Control limits are developed using the mean, plus or minus 3 standard deviations. All limits can be found in the LIMS.

The quality control procedures specified in the SOPs or QAPP are followed by laboratory personnel. The most stringent of control procedures are used in cases where multiple controls are offered. If it is not clear which is the most stringent, use the one that is mandated by test method or regulation.

Procedure
To monitor the validity of environmental tests performed, review includes any one or combination of the techniques below:

a) use of certified reference materials or cultures and/or internal quality control using secondary reference materials;
b) participation in proficiency testing programs;
c) replicate testing using the same or different methods;
d) retesting of retained samples; and/or
e) correlation of results for different characteristics of a sample.

Written procedures to monitor quality controls including acceptance criteria are located in the SOPs, except where noted, and include such procedures as:

a) use of laboratory control samples and blanks to serve as positive and negative controls for chemistry methods;
b) use of laboratory control samples to evaluate the performance of the total analytical system, including all preparation and analysis steps and to monitor test variability of laboratory results;
c) use of calibrations, continuing calibrations, certified reference materials and/or PT samples to monitor accuracy of the test method;
d) measures to monitor test method capability, such as limit of detection, limit of quantitation, and/or range of test applicability, such as linearity;
e) use of regression analysis, internal/external standards, or statistical analysis to reduce raw data to final results;
f) use of reagents and standards of appropriate quality;
g) procedures to ensure the selectivity of the test method;
h) measures to assure constant and consistent test conditions, such as temperature, humidity, rotation speed, etc., when required by test method;
i) use of sterility checks for equipment, media and dilution water for microbiology; and

j) use of positive and negative culture controls for microbiology.

23.2 Internal Quality Control Practices

This section describes the types of quality control samples used in the laboratory and how they are used to assess data precision and accuracy. When the analysis of a sample set is completed, the results will be reviewed and evaluated to assess the validity of the data set. All quality control samples are processed and analyzed using the same conditions as the client samples.

A reagent and/or method blank is prepared and analyzed with each set of samples. Field blanks (if provided by the client) are analyzed to determine possible sample contamination during collection and shipment to the laboratory.

Trip blanks are applicable to volatile organics analysis (VOA) where volatile contaminants can be introduced from ambient air on site, during shipment, and in the laboratory. Storage blanks are also used in volatile refrigerators and analyzed every 2 weeks. The reagent and/or method blank results are evaluated for high readings characteristic of background contamination. If high blank values are observed, laboratory glassware and reagents shall be checked for contamination and the analysis halted until the system can be brought under control before further sample analysis proceeds. For DoD projects the concentration of an analyte in a reagent blank must be less than ½ the reporting limit or less than 5% of the analyte detected in the associated samples. Field blank results are evaluated for high readings similar to the reagent and/or method blanks described above. If high field blank readings are encountered, the procedure for sample collection, shipment, and laboratory analysis will be reviewed.
If the reagent and/or method blanks and the field blank exhibit significant background contamination, the source of contamination is probably within the laboratory. In the case of VOA's, ambient air in the laboratory and reagents shall be checked as possible sources of contamination. If method blanks are not acceptable, the associated samples must be re-prepped and analyzed

Where frequency of quality control measures is linked to an analytical batch, a batch shall be defined as samples that are analyzed together with the same method, personnel, & reagents, and not to exceed 20 samples. See Table 23.2-1 for quality control definition, Purpose, and Evaluation

The following general controls are used:

Positive and Negative Controls:

a) Blanks (negative) – Matrix similar to the associated samples known to be free of analytes
b) Laboratory control sample (positive) – Matrix similar to the associated sample with a known concentration of analyte
c) Sterility checks and control cultures (positive and negative).

Selectivity is assured through:

a) absolute and relative retention times in chromatographic analyses;
b) two-column confirmation when using non-specific detectors;
c) use of acceptance criteria for mass-spectral tuning (found in test method SOPs);
d) use of acceptance criteria per method (found in test method SOP's)

e) use of the correct method according to its scope assessed during method validation; and

f) use of reference cultures (positive and negative) from a recognized manufacturer (where applicable).

Consistency, Variability, Repeatability, and Accuracy are assured through:

a) proper installation and operation of instruments according to manufacturer's recommendations or according to the processes used during method validation;

b) monitoring and controlling environmental conditions (temperature, access, proximity to potential contaminants);

c) selection and use of reagents and standards of appropriate quality; and

d) cleaning glassware appropriate to the level required by the analysis. Normal cleaning procedures are as follows. Additional cleaning procedures, when required, are provided in individual test method SOPs.

   1. Glassware, if used for organic analyses, is rinsed with solvent prior to washing.
   2. All glassware is washed with soap and water.
   3. Glassware is washed in a dishwasher when space permits.
   4. All glassware is rinsed with DI water.
   5. After rinsing with DI water, glassware is placed in an oven and baked overnight at 500° C.

e) following SOPs and documenting any deviation, assessing for impact, and treating data appropriately;

f) testing to define the variability and/or repeatability of the laboratory results, such as replicates;

g) use of measures to assure the accuracy of the test method, including calibration and/or continuing calibrations, use of certified reference materials, proficiency test samples, or other measures;

h) use of duplicate plate counts on positive samples (microbiology only).

Acceptance or rejection criteria are created according to laboratory policy where no method or regulatory criteria exist. Acceptance criteria define the boundary for the appropriate response from laboratory personnel, such as corrective action, reporting with qualifiers, reanalysis, review, and others.

Test Method Capability is assured through:

a) establishment of the limit of detection where appropriate;

b) establishment of the limit of quantitation or reporting level; and/or

c) establishment of the range of applicability such as linearity;

Data reduction is assured to be accurate by:

a) selection of appropriate formulae to reduce raw data to final results such as regression;

b) periodic review of data reduction processes to assure applicability;

c) microbiological calculations, data reduction, and statistical interpretations specified by each test method.

The laboratory follows the even/odd rounding method per EPA guidance.

Tables 23.2-1 & 23.2-2 summarizes the key elements of a quality control system for a laboratory performing chemistry and microbiology testing.

23.3 Method Blanks

Contaminated blanks are identified according to the acceptance limits in the test method SOPs or laboratory documentation.

Samples associated with a contaminated blank are evaluated as to the appropriate corrective action for the samples (e.g. reprocessing or data qualifying codes).

Procedure

Our laboratory identifies a blank as contaminated when analyte results are equal to or greater than the Limit of Detection (if reporting to LOD), or the blank is equal to or above the reporting limit *and* if the contamination is greater than 1/10 of that found in the sample.

{Note: DoD identities a blank as contaminated when it exceeds ½ the reporting limit *and* is greater than 1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater).}

When a blank is determined to be contaminated and impacts the data, the cause must be investigated and measures taken to minimize or eliminate the problem. All corrective actions are documented.

Data that are unaffected by the blank contamination (non-detects or other analytes) are reported unqualified.

Sample data that are suspect due to the presence of a contaminated blank are reanalyzed, qualified, or deleted.

23.4 Laboratory Control Samples & Laboratory Control Sample Duplicates

LABORATORY CONTROL SAMPLES (LCS) and Laboratory Control Sample Duplicates (LCSD) are prepared from analyte free water, and spiked with verified and known amounts of analytes for the purpose of establishing precision or bias measurements.

Laboratory control samples are analyzed at a frequency mandated by method, regulation, or client request, whichever is more stringent. They are at or below the mid concentration of the calibration curve when the method or client does not specify a concentration.

The results of laboratory control samples (LCS) are calculated in percent recovery or other appropriate statistical technique that allows comparison to established acceptance criteria. The laboratory calculates LCS percent recovery as:

(LCS Spike measured concentration – Method blank measured concentration) / LCS spiked concentration x 100

The individual LCS is compared to the acceptance criteria as published in the mandated test method, or where there are no established criteria, the laboratory established limits. For DoD projects, all analyte must be spiked in LCS/LCSD.

23.5 Matrix Spikes, Matrix Spike Duplicates, and Matrix Duplicates

MATRIX SPIKES (MS) are environmental samples fortified with a known amount of analyte to help assess the accuracy of method performance.
Matrix duplicates are the analysis of replicate aliquots of a sample to evaluate the precision of the analysis. Matrix Spike Duplicates (MSD) are 2 identical samples fortified with the same known amount of analyte to help assess both accuracy and precision of the method. Either MSDs or duplicates can be used in an analysis, but both are not required.

The MS/MSD and duplicate results are used to help assess the effect of the sample matrix on method performance.

Procedure

The laboratory procedure for MS/MSD includes spiking appropriate analytes at appropriate concentrations specified by the method, the client, or by regulation, then calculating percent recoveries and evaluating and reporting the results compared with the mandated test method.

$$\% \text{ Recovery} = \frac{(\text{MS Result} - \text{Nonspiked Sample Result}) \times 100}{\text{Spike Concentration Added}}$$

For matrix duplicates and MSDs the laboratory calculates the relative percent difference (RPD) of the 2 samples and evaluates and reports the results compared with the mandated test method.

$$\% \text{ RPD} = \frac{|\text{Result 1} - \text{Result 2}| \times 100}{(\text{Result 1} + \text{Result 2})/2}$$

Where there are no established criteria, the laboratory uses static control limits established per method or control limits derived from LCS/LCSD studies, as the control limits for MS/MSD and duplicates.

For MS/MSD and duplicate results outside established criteria corrective action may be documented or the data are reported with appropriate data qualifying codes.

All analytes in a multiple analyte test are analyzed in the MS/MSD at least every 2 years. For interim analysis, the following number of analytes in the MS/MSD is followed (exception – chlordane, toxaphene, and PCBs follow method):

- 1-10 compound tests require all analytes
- 11-20 compound tests require 10 or 80% (whichever is greater)
- >20 compound tests require at least 16 analytes

23.6 Surrogate Spikes

SURROGATES are substances with chemical properties and behaviors similar to the analytes of interest used to assess method performance in individual samples.

Policy

Surrogates are added to all samples including blanks other quality control samples (in test methods where surrogate use is appropriate) prior to preparation or extraction, except where the matrix precludes its use or when not commercially available.

Procedure

Surrogate recovery results are compared to the acceptance criteria as published in the mandated test method.

Where there are no established criteria, the laboratory uses static limits listed in the method SOP or statistically derived control limits. Clients may also specify project specific acceptance criteria.

For surrogate results outside established criteria, data are evaluated to determine the impact. Corrective actions include reanalysis, qualifying the data or notations in data packages and/or certificates of analyses as appropriate.

23.7 Proficiency Testing Studies

Air Water & Soil participates in three Proficiency Test (PT) studies list below. The QA Manager orders the necessary studies at approximately six months intervals for and vendor who is ISO 17025:2005 accredited by an International Laboratory Accreditation Cooperation (ILAC)/Signatory. Once the study results are released, the QA/QC department reviews all of the analytes and any outliers are recorded. The out of control performances are documented and reviewed by both the analysts who performed the analyses, their direct management, and the QA/QC department. A corrective action report documenting why the results were outside acceptable ranges is generated. These records are kept with the QA/QC department Officer and are included with the annual internal audit and management review.

Air Water & Soil's Proficiency studies include:

Soil – semiannually

WP– semiannually

Drinking Water – semiannually

When samples are received they are logged into the LIMS, workorder etc. All PT studies are analyzed as client samples with the normal batch quality control performed. It is the policy of Air Water & Soil that PT studies are handled as client samples throughout the analytical process. It is inappropriate to analyze multiple duplicates or dilutions unless this procedure is required and described in the approved analytical method.

The QA/QC department is responsible for the final review and reporting of PT results to the PT provider. PT results and batch quality control are reviewed carefully. Also reviewed are sample prep for appropriate dilution, reported concentration, consistency across methods, logical results, and transcription errors. Batch quality control failures will require re-analysis of the PT sample, or comments in the case narrative. If, in the QA Manager's opinion, Air Water & Soil must withdraw from a PT study, and all accrediting authorities shall be informed in writing of the status.

Results are reported to the PT provider via fax and/or electronic submission. Review of Proficiency Test Studies documents any recurring trends or problems evident in PT studies and evaluates their effect on environmental data. Procedures regarding corrective action for failing PT and steps taken during analyses are detailed in PT SOP D2120 and in accordance with PJLA SOP 1.

The analysis dates of successive PT samples for the same accreditation FoPT shall be at least five (5) months apart and no longer than seven (7) months apart unless the PT sample is being used for corrective action to reestablish successful history in order to maintain continued accreditation, or is

being used to reinstate accreditation after suspension, in which case the analysis dates of successive PT samples for the same accreditation FoPT shall be at least fifteen (15) calendar days apart.

23.8 Data Review

The laboratory reviews 100% all data generated in the laboratory for compliance with method, laboratory and, where appropriate, client requirements.

All data review is documented.

Initially, the analyst reviews 100% of the data they produce for acceptability of quality control measures and accuracy of the final result(s). This review includes:

- Determination of whether the results meet the laboratory-specific quality control criteria.
- Checks to ensure that the appropriate sample preparatory and analytical SOPs and methods were followed, and that COC and holding time requirements were met.
- Checks to ensure that all calibration and quality control requirements were met.
- Checks for complete and accurate explanations of anomalous results, corrective action, and the use of data qualifiers.

After the initial review, a second review of 100% data takes place by a technically qualified person. This review includes:

- Confirmation of calculations.
- Checks to determine consistency with project-specific measurement quality objectives.
- Checks all manual transfers of data.
- Spot checks electronic transfers of data.

Once the analyst analyzes and enters the data into LIMS, Tier II (chemist/senior chemist) reviews it and changes the status to "Reviewed' in LIMS. Upon completion of the second review, the management approves the data in the LIMS and the status of the batch changed to "QC Reviewed". The technical director or designee confirms that the previous reviews were documented properly and the data package is complete. The signature on the certificate of analysis documents this confirmation.

Lastly, at least 10% of data is reviewed by the Quality Manager or designee to confirm the review process is performed correctly and for completeness and accuracy. This review is not always completed before data set is issued.

24 REPORTING OF RESULTS

The result of each test carried out is reported accurately, clearly, unambiguously, and objectively and complies with all specific instructions contained in the test method. Data are reported without qualification if they are greater than the lowest calibration standard, lower than the highest calibration standard, and without compromised sample or method integrity. All final result calculations are performed in LIMS using any dilution factors and/or sample preparations for all matrices. This includes appropriate unit designations for different matrices.

Insert Qualification Code Definitions

U – Analyte was not detected and is reported as less than the LOD or as defined by the client. The LOD has been adjusted for any dilution or concentration of the sample
J – The reported result is an estimated value (e.g., matrix interference was observed or the analyte was detected at a concentration outside the quantitation range, see Box 33).
B – Blank contamination. The recorded result is associated with a contaminated blank
N – Non-target analyte. The analyte is a tentatively identified compound using mass spectrometry.
Q – One or more quality control criteria failed (e.g., LCS recovery, surrogate spike recovery or CCV).

Only the managers are responsible for authorizing the final COAs using electronic signature. The reports are generated within LIMS using electronic signature that are associated with password of each manager. After approval of certificate of analysis, report is printed with an electronic signature and delivered to the client via e-mail. A *.pdf file of the signed report is automatically created and stored in appropriate folder with date and time of final report generation.

24.1 Test Reports

The report format has been designed to accommodate each type of test performed and to minimize the potential for misunderstanding or misuse. It includes all information requested by the client and necessary for the interpretation of the test results

Procedure

Each test report generated contains the following information (unless not required by the client):

a) the title: Certificate of Analysis
b) the name and address of the laboratory, the phone number, and name of a contact person;
c) unique identification of the test report, such as a Laboratory ID #, on each page and a pagination system that ensures that each page is recognized as part of the test report and a clear identification of the end of the report, such as 3 of 10;
d) the name and address of the client as well as the project name;
e) the identification of the test method used;
f) an unambiguous identification of the sample(s), including the client identification code;
g) the date of sample receipt, date and time of sample collection, dates and times the tests were performed. The time of sample preparation and analysis if the required holding time for either activity is less than or equal to 72 hours is presented in the Case narrative.

h) reference to the sampling plan and procedures used by the laboratory where these are relevant to the validity or application of the results. (Grab indicated by single sample date/time and composite indicated by start and finish date/time.)

i) the test results with failures identified with qualifiers, units of measurement, an indication of whether results are calculated on a dry weight or wet weight basis.

j) the name, function, and signature or an equivalent electronic identification of the person authorizing the test report, and the date of issue;

k) a statement to the effect that the results relate only to the samples;

l) total number of pages

m) at the laboratory's discretion, a statement that the report shall not be reproduced except in full without written approval of the laboratory;

n) certification that the results are in compliance with the NELAC/DOD and or ISO 17025 Standards if accredited to be in compliance or provide reasons and/or justification if they do not comply.

24.2 Supplemental Test Report Information

When necessary for interpretation of the results or when requested by the client, test reports include the following additional information:

a) deviations from, additions to, or exclusions from the test method, information on specific test conditions, such as environmental conditions, and any non-standard conditions that may have affected the quality of the results, and any information on the use and definitions of data qualifiers;

b) a statement of compliance/non-compliance when requirements of the quality systems are not met, including identification of test results that did not meet NELAC sample acceptance requirements, such as holding time, preservation, etc.;

c) where applicable and when requested by the client, a statement on the estimated uncertainty of the measurement;

d) where appropriate and needed, opinions and interpretations When opinions and interpretations are included, the basis upon which the opinions and interpretations are documented. Opinions and interpretations are clearly marked as such in the test report.

e) additional information which may be required by specific methods or client including any information supplied concerning sampling;

f) qualification of results with values outside the working range.

24.3 Environmental Testing Obtained from Subcontractors

Test results obtained from test performed by subcontractors are clearly identified on the test report by subcontractor name and/or accreditation number. The test results from subcontractors are reported in writing or electronically. A copy of the subcontractors report is made available to the client.

24.4 Electronic Transmission of Results

All test results transmitted by telephone, fax, e-mail, or other electronic means comply with the requirements of this *Quality Manual* and associated procedures to protect the confidentiality and proprietary rights of the client.

24.5 Amendments to Test Reports

Material amendments to a test report after it has been issued are made only in the form of another document or data transfer. All supplemental reports meet all the requirements for the initial report and the requirements of this *Quality Manual*.

It is Air Water and Soil's policy to re-issue a report in the event it is deemed necessary to amend the report. The amended report is identified with a notation that the report is a reissue of a previously released certificate of analysis with the date and reason for the reissue.

When it is necessary to issue a complete new report, the new report is uniquely identified and contains a reference to the original that it replaces.

24.6 GLOSSARY

The following definitions are used in the text of Quality Systems. In writing this document, the following hierarchy of definition references were used: ISO 8402, ANSI/ASQC E-4-2004, EPA's Quality Assurance Division Glossary of Terms, and finally definitions developed by NELAC. The source of each definition, unless otherwise identified, is the Quality Systems Committee.

Quality Systems Definitions: Additional terms and clarifications used in the DoD QSM but not included in the NELAC Glossary are included in gray text boxes throughout this Appendix.

Acceptance Criteria: Specified limits placed on characteristics of an item, process, or service defined in requirement documents. (ASQC)

Accreditation: The process by which an agency or organization evaluates and recognizes a laboratory as meeting certain predetermined qualifications or standards, thereby accrediting the laboratory. In the context of the National Environmental Laboratory Accreditation Program (NELAP), this process is a voluntary one. (NELAC)

Accrediting Authority: The Territorial, State, or Federal agency having responsibility and accountability for environmental laboratory accreditation and which grants accreditation. (NELAC) [1.4.2.3]

Accreditation body: Authoritative body that performs accreditation. (ANSI/ASQ E4-2004)

Accuracy: The degree of agreement between an observed value and an accepted reference value. Accuracy includes a combination of random error (precision) and systematic error (bias) components which are due to sampling and analytical operations; a data quality indicator. (QAMS)

Aliquot: A discrete, measured, representative portion of a sample taken for analysis. (DoD; EPA QAD glossary)

Analyst: 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. (NELAC)

Analyte: 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 which are analyzed together. (EPA Risk Assessment Guide for Superfund; OSHA Glossary)

Assessment: The evaluation process used to measure or establish the performance, effectiveness, and conformance of an organization and/or its systems to defined criteria (to the standards and requirements of NELAC). (NELAC)

Assessment (Clarification): The evaluation process used to measure the performance or effectiveness of a system and its elements against specific criteria.

Note: In this standard, assessment is an all-inclusive term used to denote any of the following: audit, performance evaluation, peer review, inspection, or surveillance. (ANSI/ASQ E4-2004)

Audit: A systematic evaluation to determine the conformance to quantitative and qualitative specifications of some operational function or activity. (EPA-QAD)

Batch: Environmental samples that are prepared and/or analyzed together with the same process and personnel, using the same lot(s) of reagents. A **preparation batch** is composed of one to 20 environmental samples of the same NELAC-defined 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 environmental matrices and can exceed 20 samples. (NELAC Quality Systems Committee)

Atomization: A process in which a sample is converted to free atoms.

Blank: 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.

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. (NELAC)

Calibration: 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: The graphical relationship between the known values, such as concentrations, of a series of calibration standards and their instrument response. (NELAC)

Calibration Method: A defined technical procedure for performing a calibration. (NELAC)

Calibration Range: 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: A substance or reference material used to calibrate an instrument. (QAMS)

Certified Reference Material (CRM): A reference material one or more of whose property values are certified by a technically valid procedure, accompanied by or traceable to a certificate or other documentation which is issued by a certifying body. (ISO Guide 30 - 2.2)

Chain of Custody Form: A record that documents the possession of the samples from the time of collection to receipt in the laboratory. This record generally includes: the number and types of containers; the mode of collection; collector; time of collection; preservation; and requested analyses. (NELAC)

Chain of Custody: An unbroken trail of accountability that verifies the physical security of samples, data, and records. (ANSI/ASQ E4-2004)

Client: Any individual or organization for whom items or services are furnished or work performed in response to defined requirements and expectations. (ANSI/ASQ E4-2004)

Congener: A member of a class of related chemical compounds (e.g., PCBs, PCDDs)

Confirmation: 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. (NELAC)

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. (ANSI/ ASQC E4-1994)

Consensus Standard: A standard established by a group representing a cross-section of a particular industry or trade, or a part thereof. (ANSI/ASQ ANSI/ASQ E4-2004)

CONUS: Contiguous United States.

Continuing calibration verification: The verification of the initial calibration that is required during the course of analysis at periodic intervals. Continuing calibration verification applies to both external standard and internal standard calibration techniques, as well as to linear and non-linear calibration models. (IDQTF)

Corrective Action: The action taken to eliminate the causes of an existing nonconformity, defect or other undesirable situation in order to prevent recurrence. (ISO 8402)

Data Audit: A qualitative and quantitative evaluation of the documentation and procedures associated with environmental measurements to verify that the resulting data are of acceptable quality (i.e., that they meet specified acceptance criteria). (NELAC)

Data Reduction: The process of transforming raw data by arithmetic or statistical calculations, standard curves, concentration factors, etc., and collation into a more useable form. (EPA-QAD)

Definitive Data: Analytical data of known quality, concentration, and level of uncertainty. The levels of quality and uncertainty of the analytical data are consistent with the requirements for the decision to be made. Suitable for final decision-making. (UFP-QAPP)

Demonstration of Capability: A procedure to establish the ability of the analyst to generate acceptable accuracy. (NELAC)

Detection Limit (DL): The lowest concentration or amount of the target analyte that can be identified, measured, and reported with confidence that the analyte concentration is not a false positive value. (NELAC)

Detection Limit (DL) (Clarification): The smallest analyte concentration that can be demonstrated to be different from zero or a blank concentration at the 99% level of confidence. At the DL, the false positive rate (Type I error) is 1%.

Digestion: A process in which a sample is treated (usually in conjunction with heat) to convert 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. (ASQC)

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. (EPA-QAD)

Eluent: A solvent used to carry the components of a mixture though a stationary phase. (Skoog, West, and Holler. *Fundamentals of Analytical Chemistry*. 1992)

Elute: To extract; specifically, to remove (adsorbed material) from an adsorbent by means of a solvent. (Merriam-Webster's Collegiate Dictionary, 2000)

Elution: A process in which solutes are washed though a stationary phase by the movement of a mobile phase.

Environmental Data: Any measurements or information that describe environmental processes, locations, or conditions; ecological or health effects and consequences; or the performance of environmental technology. (ANSI/ASQ E4-2004)

Environmental Monitoring: The process of measuring or collecting environmental data. (UFP-QAPP)

False Negative: An analyte incorrectly reported as absent from the sample, resulting in potential risks from their presence.

False Positive: An item incorrectly identified as present in the sample, resulting in a high reporting value for the analyte of concern.

Finding: An assessment conclusion referenced to a NELAC Standard and supported by objective evidence that identifies a deviation from a NELAC requirement.

Finding (Clarification): An assessment conclusion that identifies a condition having a significant effect on an item or activity. An assessment finding may be positive or negative and is normally accompanied by specific examples of the observed condition (ANSI/ASQ E4-2004).

Note: For DoD the finding must be linked to a specific requirement.

Holding Times (Maximum Allowable Holding Times): The maximum times that samples may be held prior to analysis and still be considered valid or not compromised. (40 CFR Part 136)

Holding Times (DoD Clarification): The time elapsed from the time of sampling to the time of extraction or analysis, or from extraction to analysis, as appropriate.

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, CH_3OH (methanol), C_2H_5OH (ethanol), C_3H_7OH (propanol), C_4H_9OH (butanol), etc., form a homologous series. (*The Condensed Chemical Dictionary* G.G. Hawley, ed. 1981)

Inspection: An activity such as measuring, examining, testing, or gauging one or more characteristics of an entity and comparing the results with specified requirements in order to establish whether conformance is achieved for each characteristic. (ANSI/ASQC E4-1994)

Interference, spectral: Occurs when particulate matter from the atomization scatters the incident radiation from the source or when the absorption or emission of an interfering species either overlaps or is so close to the analyte wavelength that resolution becomes impossible. (Skoog, West, and Holler. *Fundamentals of Analytical Chemistry*. 1992)

Interference, chemical: Results from the various chemical processes that occur during atomization and later the absorption characteristics of the analyte. (Skoog, West, and Holler. *Fundamentals of Analytical Chemistry*. 1992)

Internal Standard: 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. (NELAC)

International System of Units (SI): The coherent system of units adopted and recommended by the General Conference on Weights and Measures. (CCGPM) (VIM 1.12)

Instrument Blank: A clean sample (e.g., distilled water) processed through the instrumental steps of the measurement process; used to determine instrument contamination. (EPA-QAD)

Isomer: One of two or more compounds, radicals, or ions that contain the same number of atoms of the same elements but differ in structural arrangement and properties. For example, hexane (C_6H_{14}) could be n-hexane, 2-methylpentane, 3-methylpentane, 2,3-dimethylbutane, 2,2-dimethylbutane. (Websters)

Laboratory: A body that calibrates and/or tests. (ISO 25)

Laboratory Control Sample (however named, such as laboratory fortified blank, spiked blank, or QC check sample): A sample matrix, free from the analytes of interest, spiked with verified known amounts of analytes or a material containing known and verified amounts of analytes. It is generally used to establish intra-laboratory or analyst-specific precision and bias or to assess the performance of all or a portion of the measurement system. (NELAC).

Laboratory Duplicate: Aliquots of a sample taken from the same container under laboratory conditions and processed and analyzed independently. (NELAC)

Limit of Detection (LOD): An estimate of the minimum amount of a substance that an analytical process can reliably detect. An LOD is analyte- and matrix-specific and may be laboratory-dependent.

Limit of Detection (Clarification): The smallest amount or concentration of a substance that must be present in a sample in order to be detected at a high level of confidence (99%). At the LOD, the false negative rate (Type II error) is 1%.

Limits of Quantitation (LOQ): The minimum levels, concentrations, or quantities of a target variable (e.g., target analyte) that can be reported with a specified degree of confidence.

Limit of Quantitation (Clarification): The lowest concentration that produces a quantitative result within specified limits of precision and bias. For DoD projects, the LOQ shall be set at or above the concentration of the lowest initial calibration standard.

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. (NELAC)

Management: Those individuals directly responsible and accountable for planning, implementing, and assessing work. (ANSI/ASQ E4-2004)

Management System: System to establish policy and objectives and to achieve those objectives (ISO 9000)

Matrix: The substrate of a test sample

Field of Accreditation Matrix: These matrix definitions shall be used when accrediting a laboratory.

- Drinking Water: Any aqueous sample that has been designated a potable or potential potable water source.
- Non-Potable Water: Any aqueous sample excluded from the definition of Drinking Water matrix. Includes surface water, groundwater, effluents, water treatment chemicals, and TCLP or other extracts.
- Solid and Chemical Materials: Includes soils, sediments, sludges, products and by-products of an industrial process that results in a matrix not previously defined.
- Biological Tissue: Any sample of a biological origin such as fish tissue, shellfish, or plant material. Such samples shall be grouped according to origin.

- 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 sorbent tube, impinger solution, filter, or other device. (NELAC)

Quality System Matrix: These matrix definitions are an expansion of the field of accreditation matrices and shall be used for purposes of batch and quality control requirements (see Appendix D). These matrix distinctions shall be used:

- Aqueous: Any aqueous sample excluded from the definition of Drinking Water matrix or Saline/Estuarine source. Includes surface water, groundwater, effluents, and TCLP or other extracts.
- Drinking Water: Any aqueous sample that has been designated a potable or potential potable water source.
- Saline/Estuarine: Any aqueous sample from an ocean or estuary, or other salt water source such as the Great Salt Lake.
- Non-aqueous Liquid: Any organic liquid with <15% settleable solids.
- Biological Tissue: Any sample of a biological origin such as fish tissue, shellfish, or plant material. Such samples shall be grouped according to origin.
- Solids: Includes soils, sediments, sludges and other matrices with > 15% settleable solids.
- Chemical Waste: A product or by-product of an industrial process that results in a matrix not previously defined.
- 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 sorbent tube, impinger solution, filter or other device. (NELAC)

Matrix Spike (spiked sample or fortified sample): A sample prepared by adding a known mass of target analyte to a specified amount of matrix sample for which an independent estimate 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. (QAMS)

Matrix Spike Duplicate (spiked sample or fortified sample duplicate): A second replicate matrix spike prepared in the laboratory and analyzed to obtain a measure of the precision of the recovery for each analyte. (QAMS)

May: Denotes permitted action, but not required action. (NELAC)

Measurement Quality Objectives (MQOs): The desired sensitivity, range, precision, and bias of a measurement.

Measurement System: A test method, as implemented at a particular laboratory, and which includes the equipment used to perform the test and the operator(s).

Method: 1. See Test Method. 2. Logical sequence of operations, described generically, used in the performance of measurements. (VIM 2.4)

Method Blank: A sample of a matrix similar to the batch of associated samples (when available) that is free from the analytes of interest and is processed simultaneously with and under the same conditions as

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. (NELAC)

Method Detection Limit: One way to establish a Limit of Detection, defined as the minimum concentration of a substance (an analyte) 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 Detection Limit (MDL) (Clarification): The MDL is one way to establish a Detection Limit, not a Limit of Detection.

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. (This process is often called spiking the sample.)

National Accreditation Database: The publicly accessible database listing the accreditation status of all laboratories participating in NELAP. (NELAC)

National Environmental Laboratory Accreditation Conference (NELAC): A voluntary organization of State and Federal environmental officials and interest groups purposed primarily to establish mutually acceptable standards for accrediting environmental laboratories. A subset of NELAP. (NELAC)

National Environmental Laboratory Accreditation Program (NELAP): The overall National Environmental Laboratory Accreditation Program of which NELAC is a part. (NELAC)

Negative Control: Measures taken to ensure that a test, its components, or the environment do not cause undesired effects, or produce incorrect test results. (NELAC)

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.

OCONUS: Outside Contiguous United States.

Performance Audit: The routine comparison of independently obtained qualitative and quantitative measurement system data with routinely obtained data in order to evaluate the proficiency of an analyst or laboratory. (NELAC)

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. (NELAC)

Precision: The degree to which a set of observations or measurements of the same property, obtained under similar conditions, conform to themselves; a data quality indicator. Precision is usually expressed as standard deviation, variance or range, in either absolute or relative terms. (NELAC)

Preservation: Refrigeration and/or reagents added at the time of sample collection (or later) to maintain the chemical and/or biological integrity of the sample. (NELAC)

Proficiency Testing: A means of evaluating a laboratory's performance under controlled conditions relative to a given set of criteria through analysis of unknown samples provided by an external source. (NELAC) [2.1]

Proficiency Testing Oversight Body/Proficiency Testing Provider Accreditor (PTOB/PTPA): An organization with technical expertise, administrative capacity and financial resources sufficient to implement and operate a national program of PT provider evaluation and oversight that meets the responsibilities and requirements established by NELAC standards. (NELAC)

Proficiency Testing Program: 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. (NELAC)

Proficiency Testing Study Provider: Any person, private party, or government entity that meets stringent criteria to produce and distribute NELAC PT samples, evaluate study results against published performance criteria and report the results to the laboratories, primary accrediting authorities, PTOB/PTPA, and NELAP. (NELAC)

Proficiency Test Sample (PT): A sample, the composition of which is unknown to the analyst and is provided to test whether the analyst/laboratory can produce analytical results within specified acceptance criteria. (QAMS)

Protocol: A detailed written procedure for field and/or laboratory operation (e.g., sampling, analysis) which must be strictly followed. (EPA-QAD)

Quality Assurance: An integrated system of activities involving planning, quality control, quality assessment, reporting and quality improvement to ensure that a product or service meets defined standards of quality with a stated level of confidence.

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. (EPA-QAD)

Quality Control: The overall system of technical activities whose purpose is to measure and control the quality of a product or service so that it meets the needs of users. (QAMS)

Quality Control Sample: A sample used to assess the performance of all or a portion of the measurement system. QC samples may be Certified Reference Materials, a quality system matrix fortified by spiking, or actual samples fortified by spiking.

Quality Manual: 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. (NELAC)

Quality System: A structured and documented management system describing the policies, objectives, principles, organizational authority, responsibilities, accountability, and implementation plan of an organization for ensuring quality in its work processes, products (items), and services. The quality system provides the framework for planning, implementing, and assessing work performed by the organization and for carrying out required QA and QC. (ANSI/ASQC E-4 1994)

Quantitation Range: The range of values in a calibration curve between the LOQ and the highest successfully analyzed initial calibration standard. The quantitation range lies within the calibration range.

Raw Data: Any original factual information from a measurement activity or study recorded in a laboratory notebook, worksheets, records, memoranda, notes, or exact copies thereof that are necessary for the reconstruction and evaluation of the report of the activity or study. Raw data may include photography, microfilm or microfiche copies, computer printouts, magnetic media, including dictated observations, and recorded data from automated instruments. If exact copies of raw data have been prepared (e.g., tapes which have been transcribed verbatim, data and verified accurate by signature), the exact copy or exact transcript may be submitted. (EPA-QAD)

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. (QAMS)

Reference Material: A material or substance one or more properties of which are sufficiently well established to be used for the calibration of an apparatus, the assessment of a measurement method, or for assigning values to materials. (ISO Guide 30-2.1)

Reference Standard: A standard, generally of the highest metrological quality available at a given location, from which measurements made at that location are derived. (VIM-6.08)

Reference Toxicant: The toxicant used in performing toxicity tests to indicate the sensitivity of a test organism and to demonstrate the laboratory's ability to perform the test correctly and obtain consistent results (see Appendix D, Section 2.1.f). (NELAC)

Replicate Analyses: The measurements of the variable of interest performed identically on two or more sub-samples of the same sample within a short time interval. (NELAC)

Reporting Limit: A client-specified lowest concentration value that meets project requirements for quantitative data with known precision and bias for a specific analyte in a specific matrix.

Requirement: Denotes a mandatory specification; often designated by the term "shall". (NELAC)

Retention Time: The time between sample injection and the appearance of a solute peak at the detector.

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

Sampling and Analysis Plan (SAP): See Quality Assurance Project Plan

Second source calibration verification (ICV): A standard obtained or prepared from a source independent of the source of standards for the initial calibration. Its concentration should be at or near the middle of the calibration range. It is done after the initial calibration.

Selectivity: (Analytical chemistry) The capability of a test method or instrument to respond to a target substance or constituent in the presence of non-target substances. (EPA-QAD)

Sensitivity: The capability of a method or instrument to discriminate between measurement responses representing different levels (e.g., concentrations) of a variable of interest. (NELAC)

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 so long as the requirement is fulfilled. (ANSI)

Should: Denotes a guideline or recommendation whenever noncompliance with the specification is permissible. (ANSI)

Signal to Noise Ratio: The signal carries information about the analyte, while noise is made up of extraneous information that is unwanted because it degrades the accuracy and precision of an analysis and also places a lower limit on the amount of analyte that can be detected. In most measurements, the average strength of the noise is constant and independent of the magnitude of the signal. Thus, the effect of noise on the relative error of a measurement becomes greater and greater as the quantity being measured (producing the signal) decreases in magnitude. (Skoog, Holler, and Nieman. Principles of Instrumental Analysis. 1998)

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. (NELAC)

Standard: (Document) The document describing the elements of laboratory accreditation that has been developed and established within the consensus principles of NELAC and meets the approval requirements of NELAC procedures and policies. (ASQC)

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 the US National Institute of Standards and Technology (NIST) and characterized for absolute content, independent of analytical test method.

Standard Method: A test method issued by an organization generally recognized as competent to do so.

Standard Operating Procedure (SOP): A written document which details the method of an operation, analysis or action whose techniques and procedures are thoroughly prescribed and which is accepted as the method for performing certain routine or repetitive tasks. (QAMS)

Standardized Reference Material (SRM): A certified reference material produced by the U.S. National Institute of Standards and Technology or other equivalent organization and characterized for absolute content, independent of analytical method. (EPA-QAD)

Supervisor (however named): 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. (NELAC)

Surrogate: A substance with properties that mimic the analyte of interest. It is unlikely to be found in environment samples and is added to them for quality control purposes. (QAMS)

Target Analytes: Analytes specifically named by a client (also called project-specific analytes).

Technical Director: Individual(s) who has overall responsibility for the technical operation of the environmental testing laboratory. (NELAC)

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. (ISO/IEC Guide 2-12.1, amended)

Test Method: An adoption of a scientific technique for performing a specific measurement as documented in a laboratory SOP or as published by a recognized authority.

Testing Laboratory: Laboratory that performs tests. (ISO/ IEC Guide 2-12.4)

Test Sensitivity/Power: The minimum significant difference (MSD) between the control and test concentration that is statistically significant. It is dependent on the number of replicates per concentration, the selected significance level, and the type of statistical analysis (see Appendix D, Section 2.4.a). (NELAC)

Tolerance Chart: A chart in which the plotted quality control data is assessed via a tolerance level (e.g., +/- 10% of a mean) based on the precision level judged acceptable to meet overall quality/data use requirements instead of a statistical acceptance criteria (e.g., +/- 3 sigma) (applies to radiobioassay laboratories). (ANSI)

Traceability: The property of a result of a measurement whereby it can be related to appropriate standards, generally international or national standards, through an unbroken chain of comparisons. (VIM - 6.12)

Tuning: A check and/or adjustment of instrument performance for mass spectrometry as required by the method.

Validation: The confirmation by examination and provision of objective evidence that the particular requirements for a specific intended use are fulfilled.

Verification: Confirmation by examination and provision of evidence that specified requirements have been met. (NELAC)

Note: 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.

The result of verification leads to a decision either to restore in service, to perform adjustment, to repair, to downgrade, or to declare obsolete. In all cases, it is required that a written trace of the verification performed shall be kept on the measuring instrument's individual record.

Work Cell: A well-defined group of analysts that together perform the method analysis. The members of the group and their specific functions within the work cell must be fully documented. (NELAC)

APPENDIX-A: Scope of Testing
VELAP Certificate of Accreditation available upon request.

APPENDIX-B: MASTER SOPs LIST
AWS DOCUMENT INDEX.XLS available upon request.

APPENDIX-C: ETHICS & DATA INTEGRITY AGREEMENT
F1104 current revision available upon request.

APPENDIX-D: NEW EMPLOYEE CHECKLIST
F1112 current revision available upon request.

APPENDIX-E: DEMONSTRATION OF CAPABILITY CERTIFICATE
F1105 current revision available upon request.

APPENDIX-F: DEMONSTRATION OF CAPABILITY
F1504 current revision available upon request.

APPENDIX-G: LIST OF LABORATORY INSTRUMENTATION
AWS D1101 Current Revision available upon request

APPENDIX-H: SAMPLE ACCEPTANCE TERMS & CONDITIONS
D1300 current revision available upon request.

Table 23.2-1: Summary of Quality Control Check Definitions, Purpose and Evaluation

Summary of Quality Control Check Definitions, Purpose, and Evaluation			
QC Check	Definition	Purpose	Evaluation
Breakdown check (Endrin and DDT – Method 8081, DDT - Method 8270)	Analysis of a standard solution containing Endrin and DDT. Area counts of these compounds and their breakdown products are evaluated to assess instrument conditions.	To verify the inertness of the injection port because DDT and Endrin are easily degraded in the injection port.	If degradation of either DDT or Endrin exceeds method-specified criteria, corrective action must be taken before proceeding with calibration.
Calibration blank	Reagent water containing no analytes of interest.	To determine the zero point of the calibration curve for all initial and continuing calibrations.	This is a required QC procedure. Continuing calibration blank responses above the LOD require corrective action.
Confirmation of positive results (organics only)	Use of alternative analytical techniques (another method, dissimilar column, or different detector such as MS detector) to validate the presence of target analytes identified.	To verify the identification of an analyte.	All positive results must be confirmed.
Continuing calibration verification (CCV)	The verification of the ICAL that is required during the course of analysis at periodic intervals. Continuing calibration verification applies to both external standard and internal standard calibration techniques, as well as to linear and non-linear calibration models.	To verify that instrument response is reliable, and has not changed significantly from the current ICAL curve.	If the values for the analytes are outside the acceptance criteria, the ICAL may not be stable. Results associated with out-of-control CCV results require reanalysis or flagging.
Demonstrate acceptable analytical capability	QC samples are analyzed in series to verify ability to produce data of acceptable precision and bias.	To verify the ability to produce data of acceptable precision and bias for a specific instrument type, matrix, method, and analyst.	The average recovery of the spikes and standard deviation of the replicates must be within designated acceptance criteria. Analysis of field samples may not be conducted until this check is successful.

Summary of Quality Control Check Definitions, Purpose, and Evaluation			
QC Check	Definition	Purpose	Evaluation
Dilution test (metals only)	Analysis of a positive sample, which has been diluted to a concentration one-fifth of the original, to confirm that there is no interference in the original sample analysis.	To assess matrix interference.	Agreement within 10% between the concentration for the undiluted sample and five times the concentration for the diluted sample indicates the absence of interferences, and such samples may be analyzed without using the method of standard additions. Results outside acceptance limits indicate a possible matrix effect. For ICP, a post-digestion spike must be run; for GFAA, a recovery test must be run.
Duplicate sample (replicate)	Two identical portions of material collected for chemical analysis, and identified by unique alphanumeric codes. The duplicate may be portioned from the same sample, or may be two identical samples taken from the same site. The two portions are prepared and analyzed identically.	To provide information on the heterogeneity of the sample matrix or to determine the precision of the intralaboratory analytical process for a specific sample matrix.	A duplicate sample will provide information on the heterogeneity of the sample matrix. The greater the heterogeneity of the matrix, the greater the relative percent difference between the sample and the sample duplicate. If the sample matrix is homogeneous (such as with drinking water) and the relative percent difference is high, this could indicate a problem in the analytical system.
GC column performance check (Methods 8280)	Analysis of method-specified compounds to verify chromatographic separation of dioxin isomers.	To evaluate the performance of the analytical system and establish retention time window markers for dioxin isomers.	Sample analysis may not begin until method-specified criteria are met.
Initial calibration for all analytes (ICAL)	Analysis of analytical standards at different concentrations that are used to determine and calibrate the quantitation range of the response of the analytical detector or method.	To establish a calibration curve for the quantification of the analytes of interest.	Statistical procedures are used to determine the relationship between the signal response and the known concentration of analytes of interest. The ICAL must be successful before any samples or other QC check samples can be analyzed.
Instrument detection limit (IDL) study (Methods 6010 and 6020 only)	The process to determine the minimum concentration of a substance (analyte) that an instrument can differentiate from noise. The procedure for calculating varies by method.	To provide an evaluation of instrument sensitivity.	IDLs must be established before samples can be analyzed.
Interference check solutions (ICP and ICP/MS only)	A pair of solutions containing interfering elements that are used to verify the correction factors of analytes of concern.	To verify the established correction factors by analyzing the interference check solution at the beginning of the analytical sequence.	No samples can be run if this check does not pass acceptance criteria.
Internal standards	A substance that is introduced in known amount into each calibration	The ratio of the analyte signal to the internal standard signal is	Any samples associated with out-of-control results must be

Summary of Quality Control Check Definitions, Purpose, and Evaluation			
QC Check	Definition	Purpose	Evaluation
	standard and field and QC sample of the analyte.	then used to determine the analyte concentration.	reanalyzed.
Laboratory control sample (LCS) containing all analytes to be reported	A sample matrix, free from the analytes of interest, spiked with known amounts of analytes or a material containing known and verified amounts of analytes.	Used to evaluate the performance of the total analytical system, including all preparation and analysis steps. Assesses the ability of the laboratory/analyst to successfully recover the target analytes from a control (clean) matrix. Control limits for LCS recovery, typically expressed as percent recovery, are used for the development of statistical control limits and serve as acceptance criteria for determining whether an analytical run is in control (batch acceptance).	This is a required QC check. The inability to achieve acceptable recoveries in the LCS indicates problems with the precision and bias of the measurement system. Failure to achieve acceptable recoveries in a "clean" matrix is an indicator of possible problems achieving acceptable recoveries in field samples.
Linear dynamic range or high-level check standards (ICP and ICP/MS only)	High-level check standard periodically analyzed to verify the linearity of the calibration curve at the upper end.	To verify quantitative accuracy of data up to the high-level standard.	This QC check establishes the upper linear range of the calibration.
Low-level calibration check standard (ICP only)	A reference standard that contains a quantity of analyte equal to or less than the reporting limit.	To confirm the accuracy of measurements at or near the RL.	This QC check must be within acceptance criteria before any samples are analyzed.

Summary of Quality Control Check Definitions, Purpose, and Evaluation			
QC Check	Definition	Purpose	Evaluation
Matrix spike (MS)	A sample prepared by adding a known mass of target analyte to a specified amount of matrix sample for which an independent estimate of target analyte concentration is available.	To assess the performance of the method as applied to a particular matrix. Matrix spikes are used, for example, to determine the effect of the matrix on a method's recovery efficiency. The recovery of target analytes from the matrix spike sample is used to determine the bias of the method in the specific sample matrix.	The lack of acceptable recoveries in the matrix spike often points to problems with the sample matrix. One test of this is a comparison to the LCS recoveries. If the corresponding LCS recoveries are within acceptable limits, a matrix effect is likely. The laboratory should not correct for recovery; only report the results of the analyses and the associated matrix spike results and indicate that the results from these analyses have increased uncertainty.
Matrix spike duplicate (MSD)	A second replicate matrix spike prepared in the laboratory and analyzed to obtain a measure of the precision of recovery for each analyte.	To assess the performance of the method as applied to a particular matrix and provide information on the homogeneity of the matrix. Also used to determine the precision of the intralaboratory analytical process for a specific sample matrix.	When compared with the MS, the MSD will provide information on the heterogeneity of the sample matrix. The greater the heterogeneity of the matrix, the greater the RPD between the matrix spike and the matrix spike duplicate. If the sample matrix is homogeneous, such as with drinking water, and the RPD is high, this could indicate a problem in the analytical system.
Matrix verification sample (hexavalent chromium only)	A pH-adjusted filtrate that has been spiked with hexavalent chromium to ensure that the sample matrix does not have a reducing condition or other interferents that could affect color development.	To ensure that the sample matrix does not have a reducing condition or other interferents that affect color development.	To verify the absence of interference, the spike recovery must be between 85% and 115%. If the result of verification indicates a suppressive interference, the sample should be diluted and reanalyzed. If the interference persists after sample dilution, an alternative method (Method 7195, Coprecipitation, or Method 7197, Chelation/Extraction) should be used.
Method blank	A sample of a matrix similar to the batch of associated samples (when available) that is free from the analytes of interest and is processed simultaneously with and under the same conditions as samples through all steps of the analytical procedures, and in which no target analytes or	To assess background interference or contamination in the analytical system that might lead to high bias or false positive data. Results of method blanks provide an estimate of the within-batch variability of the blank response and an indication of	This is one of the QC samples used to measure laboratory accuracy/bias. This sample could indicate whether contamination is occurring during sample preparation and analysis. If analytes are detected > ½ RL,

Summary of Quality Control Check Definitions, Purpose, and Evaluation			
QC Check	Definition	Purpose	Evaluation
	interferences are present at concentrations that impact the analytical results for sample analyses.	bias introduced by the preparation and analytical procedure.	reanalyze or qualify (B-flag) all results for the specific analyte(s) in all samples in the associated preparatory batch, as appropriate. For common laboratory contaminants, no analytes detected > the RL.
Method of standard additions (ICP/GFAA only)	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. (This process is also called spiking the sample.)	To compensate for a sample constituent that enhances or depresses the analyte signal, thus producing a different slope from that of the calibration standards. It will not correct for additive interferences that cause a baseline shift.	This is the method used when matrix interferences are present and do not allow determination of accurate sample results.
Post digestion spike addition (ICP and ICP/MS only)	An analyte spike added to a portion of prepared sample to verify absence or presence of matrix effects.	To confirm the presence of a matrix interference. Assess matrix effects based on, (1) the occurrence of new and unusual matrices included within the batch, or (2) contingency analysis based on serial dilution or matrix spike failures.	To verify the absence of an interference, the spike recovery must be between 75% and 125%. Results outside the acceptance limits require a method of standard additions (MSA) for all samples within the batch.
Recovery test (GFAA only)	An analyte spike added to a portion of prepared sample to verify absence or presence of matrix effects.	To confirm the presence of a matrix interference. Assess matrix effects based on, (1) the occurrence of new and unusual matrices included within the batch, or (2) contingency analysis based on serial dilution or matrix spike failures.	To verify the absence of an interference, the spike recovery must be between 85% and 115%. Results outside the acceptance limits require a MSA for all samples within the batch.
Retention time window position establishment for each analyte (and surrogate) (all chromatographic methods only)	Determination of the placement of the retention time window (i.e., start/stop time) of each analyte or group of analytes as it elutes through the chromatographic column so that analyte identification can be made during sample analysis. This is done during the ICAL.	To identify analytes of interest.	Incorrect window position may result in false negatives, require additional manual integrations, or cause unnecessary reanalysis of samples when surrogates or spiked compounds are erroneously not identified.
Retention time window width calculated for each analyte (and surrogate) (non-MS chromatographic methods only)	Determination of the length of time between sample injection and the appearance of a peak at the detector. The total length of time (window) is established for each analyte or group of analytes and is set for complete elution of analyte peaks. It is based upon a series of analyses and statistical calculations that establish the measured band on the chromatogram that can be associated with a specific analyte or group of analytes.	To ensure that the chromatographic system is operating reliably and that the system conditions have been optimized for the target analytes and surrogates in the standards and sample matrix to be analyzed. It is done to minimize the occurrence of both false positive and false negative results.	Used to evaluate continued system performance. Tight retention time windows may result in false negatives or may cause unnecessary reanalysis of samples when surrogates or spiked compounds are erroneously not identified. Overly wide retention time windows may result in false positive results that cannot be confirmed upon further analysis.
Second source calibration verification (ICV)	A standard obtained or prepared from a source independent of the source of standards for the ICAL. Its concentration should be at or near the middle of the calibration range. It is done after the ICAL.	To verify the accuracy of the ICAL.	The concentration of the second-source calibration verification, determined from the analysis, is compared with the known value of the standard to determine the accuracy of the ICAL. This independent verification of the ICAL must be acceptable before sample analysis can begin.

Summary of Quality Control Check Definitions, Purpose, and Evaluation			
QC Check	Definition	Purpose	Evaluation
Surrogate spike (organic analysis only)	A substance with properties that mimic the analyte of interest. It is unlikely to be found in environment samples and is added to them for quality control purposes.	To assess the ability of the method to successfully recover specific non-target analytes from an actual matrix. Because surrogates are generally added to each sample in a batch, they can be used to monitor recovery on a sample-specific, rather than batch-specific basis.	Whereas the matrix spike is normally done on a batch-specific basis, the surrogate spike is done on a sample-specific basis. Taken with the information derived from other spikes (LCS, matrix spike), the bias in the analytical system can be determined.
Tuning (mass spectrometer methods only)	The analysis of a standard compound to verify that the mass spectrometer meets standard mass spectra abundance criteria prior to sample analysis.	To verify the proper working of the mass spectrometer.	Proper tuning of the mass spectrometer must be verified prior to sample analysis.

Table 23.2-2 Essential Quality Control Requirements -Microbiology			
Item	Frequency	Acceptance Criteria	Corrective action
Sterility blank	Each lot of media prior to first use	No growth	Investigate cause
Sterility check containers	One container (bottle) for each lot or batch sterilized (NSGM)	No growth	Investigate cause
Sterility check dilution water	One per batch of dilution water (NSGM)	No growth	Investigate cause
Positive control[1]	pure culture of target organisms/ each lot or batch of medium (prior to first use of medium)	Positive reaction	Investigate cause If necessary reject the medium
Negative control[1]	Pure culture of non-target organisms/each lot or batch of medium (prior to first use of medium)	Negative reaction	Investigate cause If necessary reject the medium
Duplicate colony counts (For numeric results only)	Monthly if sample volume permits.	Same analyst <5% difference between counts Two analysts <10% difference between counts	Investigate cause Qualify data
1) Microorganisms may be single use preparations or cultures maintained by documented procedures that demonstrate the continued purity and viability of the organism.			
Sterility blank	Each lot of media prior to first use	No growth	Investigate cause
Sterility check containers	One container (bottle) for each lot or batch sterilized (NSGM)	No growth	Investigate cause
Sterility check dilution water	One per batch of dilution water (NSGM)	No growth	Investigate cause
Positive control[1]	pure culture of target organisms/ each lot or batch of medium (prior to first use of medium)	Positive reaction	Investigate cause If necessary reject the medium
Negative control[1]	Pure culture of non-target organisms/each lot or batch of medium (prior to first use of medium)	Negative reaction	Investigate cause If necessary reject the medium

Table 23.2-2 Essential Quality Control Requirements -Microbiology			
Item	Frequency	Acceptance Criteria	Corrective action
Duplicate colony counts (For numeric results only)	Monthly if sample volume permits.	Same analyst <5% difference between counts Two analysts <10% difference between counts	Investigate cause Qualify data
1) *Microorganisms may be single use preparations or cultures maintained by documented procedures that demonstrate the continued purity and viability of the organism.*			

Table 23.2-2 Essential Quality Control Requirements Microbiology – Pour Plate Methods Only			
Item	Frequency	Acceptance Criteria	Corrective action
Sterility blank media	Each lot of media prior to first use minimum one plate per batch	Internally defined Suggest 1 col/plate	Investigate cause

Stock Cultures		
Item	Frequency	Handling
Reference cultures	Single use	Preserved and handled per mfg. specifications

REFERENCES

EPA QA/R-2, "EPA Requirements for Quality Management Plans", EPA/240/B-01/002, May 2006 and as updated (for content),

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The NELAP Institute (TNI), EL-V1-2009, "Management and Technical Requirements for Laboratories Performing Environmental Analysis", 2009, or the most recent revision.

DOD Quality Systems Manual (QSM), Rev. 4.2, October 25, 2010 and as updated.

ISO/IEC 17025:2005

D1500 Method Detection Limit, Limit of Detection & Limit of Quantitation, Standard Operating Procedure, Current Revision

Revision Number	Description of Changes	Date
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22.0	Updated Section 4.1 to indicate Full list of SOPs as available upon request. Removed example documents in Appendices A-H, and replaced with reference and statement, 'available upon request'	01-Apr-19

Quality Assurance Manual

Quality Assurance/Quality Control Policies and Procedures

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Disclaimer

This Quality Assurance Manual for ESC Lab Sciences – a subsidiary of Pace Analytical is a living document. It is reviewed at least annually and revised when needed. The information stated herein is subject to change at any time due to updates to laboratory systems, methods, operations, equipment, staff, etc.

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1.0. INTRODUCTION AND ORGANIZATIONAL STRUCTURE

"Working together to protect our environment and improve our health"
Pace Analytical Services LLC - Mission Statement

"Be the Lab of Choice for our Clients and Staff"
ESC Lab Sciences - Mission Statement

1.1. Introduction to Pace and ESC Lab Sciences

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.

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 10 of this document is a representative listing of general analytical protocol references.

1.1.3. ESC Lab Sciences is a subsidiary of Pace Analytical and is structured to provide environmental support services in compliance with numerous federal, state, and local regulations as well as to meet the analytical needs of the customer. This document defines the Quality System and Quality Assurance (QA)/Quality Control (QC) protocols for ESC.

1.1.4. The scope of ESC's management system is comprehensive and covers all technical and supporting work conducted at all facilities including the primary Lebanon Road location, the Davis, CA location, the Decatur, AL location as well as various customer support and shipping operations across the US. This includes ensuring analytical/operational activities and the quality of the data reported is appropriately recorded. ESC's senior management team ensures that the integrity of the management system is maintained when changes to the management system are planned and implemented.

1.2. Statement of Purpose and Vision

1.2.1. Statement of Purpose – Pace Analytical: To meet the business needs of our customers for high quality, cost-effective analytical measurements and services.

1.2.2. Vision Statement – ESC Lab Sciences: To lead our industry in quality, service, and productivity

1.3. Quality Policy Statement and Goals of the Quality System

1.3.1. Pace and ESC management are 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, AIHA-LAP, LLC, and applicable ISO standards) and is in accordance with any stated methods and/or 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. Management is committed to using good professional practices and demonstrates its commitment to quality by providing the personnel, equipment, and facilities necessary to ensure the laboratory gives our customers the highest possible standard of service.

1.3.3. All personnel within ESC and 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.

1.3.4. Pace and ESC management is committed to the development, implementation, and continual improvement of the laboratory's management system. Evidence of this commitment can be found in the policies and procedures that are included in this Quality Assurance Manual which includes, but is not limited to, records of management review meetings as per section 7.3 below.

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**

1.4.2. The following are the ESC Values:

- **C – Client Focused**
- **H – Honest with our Clients and Staff**
- **O – Open and Shared Financial and Operational Information**
- **I – Innovative Solutions and Systems**
- **C – Committed to Excellence in our Operation**
- **E – Environmentally Responsible**

1.5. Code of Ethics

1.5.1. Each employee is responsible for the propriety and consequences of his or her actions;

1.5.2. Each 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 and ESC does business or seeks to do business;

1.5.3. Each employee must reflect the highest standards of honesty, integrity and fairness on behalf of the Company with customers, suppliers, the public, and one another.

1.5.4. Each 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.

1.5.5. All ESC personnel, including contract and temporary, are required to sign an "Attestation of Ethics and Confidentiality" at the time of employment and during annual refresher training. Violations of this document result in serious consequences, including prosecution and termination, if

necessary. For more information see the ESC Policy Manual and SOP #010102, *Ethics, Data Integrity, and Confidentiality*.

1.5.6. Strict adherence by each employee to this Code of Ethics and to the Standards of Conduct below is essential to the continued vitality of Pace and ESC to continue the pursuit of our common mission to protect our environment and improve our health.

1.5.7. 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.

1.6. Standards of Conduct

1.6.1. **Data Integrity**

1.6.1.1. The accuracy and integrity of the analytical results and its supporting documentation produced at Pace and ESC 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.

1.6.1.2. 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.

1.6.1.3. 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.

1.6.1.4. 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.

1.6.1.5. <u>ESC's Data Integrity System</u>

ESC Lab Sciences is committed to ensuring the integrity of its data and providing valid data of known and documented quality to its customers. ESC is also committed to creating and maintaining a culture of quality throughout the organization. The elements in ESC's data integrity system include:

- A standardized data integrity training program that is given to all new employees and a yearly refresher course is also presented to all employees.
- All ESC personnel, including contract and temporary, are required to sign an "Attestation of Ethics and Confidentiality" at the time of employment and during annual refresher training.
- An in-depth periodic monitoring of data integrity which includes, but is not limited to, the following: peer data review, internal audits, QA data review of raw data, and proficiency testing studies.
- A process that allows for confidential reporting of alleged data integrity issues. Currently, an anonymous hotline is available to all employees that is managed by an outside vendor. Messages are collected, documented, reviewed, and will be followed up

on by senior management to resolve the matter. Comments made on this hotline are confidential, and callers will remain anonymous.

Anonymous Hotline Number: 1-800-398-1496

Additional information about the laboratory's data integrity system can be found in SOP #010102 *Ethics, Data Integrity, and Confidentiality*. This SOP is signed by top management and is reviewed at least annually.

1.6.2. **Confidentiality**

1.6.2.1. All employees must not use or disclose confidential or proprietary information except when in connection with their duties at Pace and/or ESC. This is effective over the course of employment and for an additional period of two years thereafter.

1.6.2.2. Confidential or proprietary information (belonging to either Pace, ESC, 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.

1.6.2.3. ESC's confidentiality policy is to not divulge or release any information to a third party without proper authorization. All information pertaining to a particular customer will remain confidential. Data will be released to outside agencies only with authorization from the customer or where federal or state law requires the laboratory to do so. Samples are generally identified with laboratory identification numbers, and access to electronic records and reports is password protected. Confidentiality statements are applied to fax and e-mail communications. All personnel, including contract and temporary, are required to sign an "Attestation of Ethics and Confidentiality" at the time of employment and during annual refresher training. Violations of this document result in serious consequences, including prosecution and termination, if necessary. For more information see the ESC Policy Manual and SOP #010102, *Ethics, Data Integrity, and Confidentiality*.

1.6.3. **Conflict of Interest**

1.6.3.1. All 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' Company 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 in a different manner than he would normally (such as bribes, gifts, kickbacks, or illegal payments).

1.6.3.2. 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.

1.6.3.3. ESC's management ensures that personnel are free from any undue pressures and influences that may adversely affect the quality of their work. ESC's organizational structure is designed to minimize the potential for conflicts or undue stresses that might influence the technical judgment of analytical personnel. Analytical personnel are generally isolated from customer contact as much as practical. In addition, the laboratory workload is continually

reviewed and managed in such a way as to reduce the potential for undue production pressure on analytical personnel.

1.7. Anonymous Compliance Alertline

1.7.1. An ethical and safe workplace is important to the long-term success of Pace, ESC, and the well-being of its employees. Pace and ESC have the 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.

1.7.2. 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.

1.7.3. Telephone: English speaking USA and Canada: (844)-970-0003.

1.7.4. Telephone: Spanish speaking North America: (800)-216-1288.

1.7.5. Website: www.lighthouse-services.com/pacelabs.

1.7.6. Email: reports@lighthouse-services.com (must include company name with report).

1.7.7. ESC provides an anonymous hotline that is available to all employees that is managed by an outside vendor. Messages are collected, documented, reviewed, and will be followed up on by senior management to resolve the matter. Comments made on this hotline are confidential, and callers will remain anonymous.

Anonymous Hotline Number: 1-800-398-1496

1.8. Laboratory Organization

1.8.1. Each Pace laboratory operates with local management, but all Pace labs share common systems and receive support from the Corporate Office. See Attachment III for the Corporate Organizational structure.

1.8.2. ESC has a defined organization and management structure. See Attachment II for ESC's organizational chart.

1.8.3. ESC's managerial and technical personnel have the authority and resources needed to carry out their duties. Management bears the specific responsibility for the implementation, maintenance, and improvement of the laboratory's management system. This includes the identification of any departures from the management system or standard operating procedures, and to initiate actions to prevent or minimize such departures.

1.8.4. ESC has specifications of the responsibility, authority, and interrelationships of all personnel who manage, perform, or verify work affecting the quality of the analytical results. Job descriptions are documented and maintained by the Human Resources department. It is the laboratory's policy that each individual understands his or her particular responsibilities and how to report problems when they occur.

1.8.5. ESC has adequate supervision provided to all analytical staff, including trainees, by persons familiar with the analytical methods and procedures.

1.8.6. ESC has technical management which has overall responsibility for the technical operations. This includes providing the resources needed to ensure the required quality of laboratory operations is met as per the policies and procedures documented in this Quality Assurance Manual. This technical management includes the Vice President of Operations, the Director of Operations, the Organics Director, the Inorganics Director, and each individual department supervisor.

1.8.7. ESC has quality management which has the responsibility and authority for ensuring that the management system related to quality is implemented and followed at all times. Currently the Quality Assurance Director, the Regulatory Affairs Director, and the Compliance Director have been appointed for this task. The Quality Assurance Director has direct access to the highest level of management at which decisions are made on laboratory policy and resources.

1.8.8. The lab is required to appoint deputies for key managerial personnel. These deputies must be documented for auditing purposes. The following table defines who assumes the responsibilities of key personnel in their absence:

PRIMARY	DEPUTY
Vice President of Operations	Director of Operations
Director of Operations	Vice President of Operations and Technical Services Manager
Organics Director	Vice President of Operations and Department Supervisors/Leads
Inorganics Director	Vice President of Operations and Department Supervisors/Leads
Radiochemistry Director	Vice President of Operations and Department Supervisors/Leads
Quality Assurance Director	Regulatory Affairs Director and Compliance Director
Information Systems Director	Ad Hoc (Applicable IT personnel as needed)
Client Operations Manager	Director of Operations and Senior Project Manager(s)
Biology Manager	Director of Operations and Department Supervisors/Leads

Note for TNI Technical Managers: A Technical Manager who is absent for a period of time exceeding 15 consecutive calendar days shall designate another full-time staff member meeting the qualifications of a TNI technical manager to temporarily perform this function. The laboratory's senior management team has the authority to make this designation in the event the existing Technical Manager is unable to do so. If this absence exceeds 35 consecutive calendar days, the primary accrediting authority shall be notified in writing.

1.8.9. The technical staff of each laboratory is generally organized into the following functional groups (as applicable for each location):

- Organic Sample Preparation
- Wet Chemistry Analysis
- Metals Analysis
- Volatiles Analysis
- Semi-volatiles Analysis

- Radiochemical Analysis
- Microbiological Analysis
- Bioassay Analysis

1.8.10. ESC has personnel that are aware of the relevance and importance of their activities and how they contribute to the achievement of the objectives of the management system. Laboratory management ensures that all personnel are aware that their job is needed, and how each role contributes to the laboratory's business goals. All personnel are required to familiarize themselves with the quality documentation relevant to their position and implement these policies and procedures in their work. All personnel must ensure that the generation and reporting of quality analytical data is a fundamental priority.

1.9. Laboratory Job Descriptions

The roles and responsibilities of some technical and quality management are defined below. Laboratory management determines the specific education and experience requirements for individual positions within the laboratory based on the specific department needs. More information can be found in the job descriptions that are maintained by the Human Resources department. All managers and supervisors are responsible to ensure that their respective departments comply with all the applicable state, federal, and industry standards.

1.9.1. Vice President of Operations

- Oversees all functions of ESC Lab Sciences
- 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 Quality Assurance Director accordingly;
- Presents the Ethics/Data Integrity training annually to all ESC employees as an instructor-led training.
- Ensures compliance with all applicable state, federal and industry standards.

1.9.2. Operations Director

- In the absence of the Vice President of Operations, performs all duties as listed above;
- Oversees the daily production and quality activities of assigned departments;
- Manages assigned departments and works with staff to ensure department objectives are met;
- Works with assigned departments to ensure capacity and customer expectations are accurately understood and met;
- Works with Vice President of Operations to prepare appropriate budget and staffing plans for applicable departments;
- Responsible for prioritizing personnel and production activities within assigned departments;
- Performs formal and informal performance reviews of applicable departmental staff.
- Ensures compliance with all applicable state, federal and industry standards.

1.9.3. Organics Director

- Monitors the standards of performance in the Volatiles and Semi-volatiles Departments;
- Monitors the validity of analyses performed and data generated in the Volatiles and Semi-volatiles Departments;

- Provides technical guidance in the review, development, and validation of new methodologies in the Volatiles and Semi-volatiles Departments;
- Oversees production and quality assurance activities in the Volatiles and Semi-volatiles Departments;
- Ensures that quality assurance and quality control criteria of analytical methods and projects are satisfied in the Volatiles and Semi-volatiles Departments;
- Assesses data quality in the Volatiles and Semi-volatiles Departments and takes corrective action when necessary;
- Approves and releases technical and data management reports;
- Ensures compliance with all applicable state, federal and industry standards.

1.9.4. Inorganics Director

- Monitors the standards of performance in the Metals and Wet Chemistry Departments;
- Monitors the validity of analyses performed and data generated in the Metals and Wet Chemistry Departments;
- Provides technical guidance in the review, development, and validation of new methodologies in the Metals and Wet Chemistry Departments;
- Oversees production and quality assurance activities in the Metals and Wet Chemistry Departments;
- Ensures that quality assurance and quality control criteria of analytical methods and projects are satisfied in the Metals and Wet Chemistry Departments;
- Assesses data quality in the Metals and Wet Chemistry Departments and takes corrective action when necessary;
- Approves and releases technical and data management reports;
- Ensures compliance with all applicable state, federal and industry standards.

1.9.5. Radiochemistry Director

- Monitors the standards of performance in the Radiochemistry Department;
- Monitors the validity of analyses performed and data generated in the Radiochemistry Department;
- Provides technical guidance in the review, development, and validation of new methodologies in the Radiochemistry Department;
- Oversees production and quality assurance activities in the Radiochemistry Department;
- Ensures that quality assurance and quality control criteria of analytical methods and projects are satisfied in the Radiochemistry Department;
- Assesses data quality in the Radiochemistry Departments and takes corrective action when necessary;
- Approves and releases technical and data management reports;
- Ensures compliance with all applicable state, federal and industry standards

1.9.6. Quality Assurance Director

- 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);
- 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;
- Reviews tenders, contracts and QAPPs to ensure the laboratory can meet the data quality objectives for any given project;
- Maintains certifications from federal and state programs;
- Ensures compliance with all applicable state, federal and industry standards;
- Maintains the laboratory training records and evaluates the effectiveness of training;
- Monitors corrective and preventive actions;
- Maintains the currency of the Quality Manual.

1.9.7. Client Operations Manager

- Oversees all the day to day activities of the Client Services Departments which includes Project Management, Sample Receiving, and Shipping;
- 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.

1.9.8. Project Manager

- Coordinates daily activities including taking orders, reporting data and analytical results;
- Serves as the primary technical and administrative liaison between customers and the laboratory;
- 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 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.

1.9.9. Department Manager/Supervisor/Lead

- 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.

1.10. Training and Orientation

1.10.1. ESC management ensures the competency of all who operate specific equipment, who perform analyses, and who evaluate results and approve data reports. Personnel performing specific tasks are qualified on the basis of appropriate education, training, experience, and/or demonstrated skills, as required.

1.10.2. ESC management ensures all personnel (including part-time, temporary, contracted, and administrative personnel) are competent, appropriately supervised, and work in accordance to the established management system. This includes training in policies, procedures, ethics, laboratory quality assurance, and safety as applicable to their role in the laboratory.

1.10.3. All personnel are trained and competent in their assigned tasks before they contribute to functions that can affect data quality. It is management's responsibility to ensure personnel are appropriately trained. All training and education requirements are outlined in SOP #030205, *Technical Training and Personnel Qualifications* and in SOP #350355, *Technical Training and Personnel Qualifications for Biology*. These procedures are reviewed/updated periodically by laboratory management.

1.10.4. ESC management authorizes specific personnel to perform particular technical duties. Records of the relevant authorization(s), education, and experience of all technical personnel are maintained by the Human Resources Department. Confirmation of competence of all technical personnel is required initially by successfully performing a demonstration of capability. All technical personnel are also required to continue to demonstrate their capability at least annually to produce reliable results through accurate analysis of certified reference materials, proficiency testing samples, and/or routine quality control samples to remain authorized to perform particular technical duties.

1.10.5. Demonstration of Capability (DOC)

Analysts complete an initial demonstration of capability (IDOC) study prior to performing a method or when there is a change in instrument type, personnel, or test method. IDOCs may also be performed when a method has not been performed by the laboratory or analyst in a 12-month period. The mean recovery and percent relative standard deviation of each analyte, taken from 4 replicates of laboratory control samples, is calculated and compared to method criteria or established laboratory criteria for evaluation of acceptance. For methods or procedures that do not lend themselves to the "4-replicate" approach, the demonstration of capability requirements will be specified in the applicable SOP. Copies of all demonstrations of capability are maintained for future reference.

Demonstrations of capability are verified on an annual basis. These are Continuing Demonstrations of Capability (CDOC). For CDOCs Performance Testing (PT) samples may be used in lieu of the 4-replicate approach listed above.

For more information see the SOP #030205, *Technical Training and Personnel Qualifications* and SOP #350355, *Technical Training and Personnel Qualifications for Biology*.

1.10.6. Training for New Staff

New staff members are given the following training, where appropriate:

- Ethics and Data Integrity
- ESC Policy Manual
- ESC Quality Assurance Manual
- Chemical Hygiene Plan (safety)
- Applicable standard operating procedures
- Basic laboratory tasks such as balance, thermometer, and pipette operations
- Use of laboratory records
- Any other specific training as appropriate to their function

Analysts must complete training satisfactory before they can work independently. When staff members undergo training, adequate and appropriate supervision by fully trained analysts is provided. Only when a new analyst has successfully passed their Initial Demonstration of Capability (IDOC) described above, may he or she conduct testing of customer samples.

For more information see the SOP #030205, *Technical Training and Personnel Qualifications* and SOP #350355, *Technical Training and Personnel Qualifications for Biology*

1.10.7. Ongoing Training

Staff members are given the following ongoing training:

- Ethics and Data Integrity Training
- Safety Training
- Routine Training – Routine training may become necessary for a person to perform a particular job effectively. This includes any changes in policies and procedures as appropriate.
- Special Training – Special training may become required as a result of new technologies, contracts, expanding markets, company-wide improvement programs, new method development, etc.

Analysts must satisfactorily perform Continuing Demonstrations of Capability (CDOC) on an annual basis.

For more information see the SOP #030205, *Technical Training and Personnel Qualifications* and SOP #350355, *Technical Training and Personnel Qualifications for Biology*.

1.10.8. Ethics and Data Integrity Training

Data integrity training is provided to all new employees (including contract and temporary), and a refresher is given at least annually for all employees. Employees are required to

understand that any infractions of the laboratory data integrity procedures shall result in a detailed investigation that could lead to very serious consequences including immediate termination, debarment, or civil/criminal prosecution. The initial data integrity training and the annual refresher training needs to have a signature attendance sheet or other form of documentation that demonstrates all staff have participated and understand their obligations related to data integrity.

All ESC personnel, including contract and temporary, are required to sign an "Attestation of Ethics and Confidentiality" at the time of employment and during annual refresher training. This document clearly identifies inappropriate and questionable behavior. Violations of this document result in serious consequences, including prosecution and termination, if necessary. The ESC Policy Manual addresses this subject in detail. Also see SOP #010102, *Ethics, Data Integrity, and Confidentiality* for more information.

Data integrity training emphasizes 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. The following topics and activities are covered:

- ESC's 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
- Record keeping
- Training, including discussion regarding all data integrity procedures
- Data integrity training documentation
- In-depth data monitoring and data integrity procedure documentation
- Specific examples of breaches of ethical behavior such as improper data manipulations, adjustments of instrument time clocks, and inappropriate changes in concentrations of standards.

1.10.9. Identification of Training Needs

In order to ensure personnel are appropriately trained, laboratory management is responsible for identifying training needs for both current and future anticipated laboratory tasks. This includes (but is not limited to) the following:

- Evaluation of routine quality control data
- Proficiency testing results
- Findings of internal and external audits
- Management reviews
- Periodic performance reviews

1.10.10. Evaluation of the Effectiveness of Training

In order to ensure personnel are appropriately trained, laboratory management is responsible for evaluating the effectiveness of the training program. This includes (but is not limited to) the following:

- Evaluations of Demonstrations of Capability (DOCs)
- Monitoring ongoing quality control data
- Proficiency testing results

1.11. Laboratory Safety and Waste

1.11.1. It is the policy of Pace and ESC 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.

1.12. Laboratory Facilities & Security

1.12.1. The design of ESC's facilities supports good laboratory practices and does not adversely affect measurement integrity. All laboratory facilities, analytical areas, energy sources, lighting, heating, and ventilation facilitate proper performance of calibrations and tests. ESC management ensures that housekeeping, electromagnetic interference, humidity, line voltage, temperature, sound and vibration levels are appropriately controlled to ensure the integrity of specific measurement results and to prevent adverse effects on accuracy or increases in the uncertainty of each measurement.

1.12.2. Environmental conditions are monitored, controlled, and recorded as required by the relevant specifications, methods, and procedures. Laboratory operations are stopped if it is discovered that the laboratory's environmental conditions jeopardize the analytical results.

1.12.3. ESC Lab Sciences maintains multiple buildings on its Mt. Juliet, TN campus. This allows for physical separation of incompatible analytical activities. For example, the analysis for volatile organic compounds is in a separate building from where samples are extracted for semi-volatile organic compounds. Each laboratory structure is specifically designed for the type of analytical activity that it contains. The air handling systems, power supplies, and gas supplies are specific for each laboratory department. The Davis laboratory occupies a single unit in a multi-business building that analyzes volatile organics only. The Decatur operation is contained in a single building facility where laboratory space is arranged to minimize cross-contamination between incompatible areas of the laboratory. The volatiles lab is isolated from other areas to prevent methylene chloride contamination and potable water bacteriological testing is performed separately from wastewater testing.

1.12.4. Laboratory security is maintained by controlled access at all three laboratories and through video surveillance at the Mt. Juliet laboratory. Entrance into any ESC-Mt. Juliet building and the Davis building requires an electronic ID badge with appropriate assigned access. Access is controlled to each area depending on the required personnel, the sensitivity of the operations performed, and possible safety concerns. For the Mt. Juliet, Davis and Decatur locations the main entrance is kept unlocked during normal business hours for visitors, and is continuously monitored by laboratory staff. All visitors must sign a visitor's log, and a staff member must accompany them during the duration of their stay.

1.12.5. ESC management ensures good housekeeping practices in all facilities to maintain a standard of cleanliness necessary for analytical integrity and personnel health and safety. Where necessary, areas are periodically monitored to detect and resolve specific contamination and/or possible safety issues.

1.13. Communications

1.13.1. ESC has established, implemented, and maintains a management system appropriate to the scope of its activities. ESC has documented its policies and procedures to the extent necessary to assure the quality of the analytical test results. The ESC management system's documentation is

communicated to, understood by, available to, and implemented by the appropriate laboratory personnel.

1.13.2. ESC management bears the responsibility of ensuring that appropriate communication processes are established within the laboratory and that communication takes place regarding the effectiveness of the management/quality system. These communication processes may include email, staff meetings, management meetings, etc.

1.13.3. ESC's management also communicates to the organization the importance of meeting customer and regulatory requirements. This is accomplished in writing through this Quality Assurance Manual, ESC's Policy Manual, and through ESC's Standard Operating Procedures. This is also accomplished verbally through staff meetings.

1.13.4. Pace 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. SERVICE TO THE CUSTOMER & SAMPLE CUSTODY

2.1. Service to the Customer

2.1.1. ESC's Customer Service Department provides specific project service through the use of Project Managers (PMs)/Technical Service Representatives (TSRs). The PM/TSR is responsible for all contract requirements and laboratory/customer communication, including information concerning schedules, delays, and major deviations in the testing process. For additional information see SOP# 020301, *Project Management.*

2.1.2. It is ESC's policy is to cooperate with its customers and to meet their expectations. The PM/TSR works closely with the customer to clarify the customer's requests and to monitor the laboratory's performance in relation to the work requested, while ensuring confidentiality to other customers.

2.1.3. ESC seeks customer feedback (both positive and negative) through various means including surveys and personal communication. This feedback is utilized to improve the management system, quality system, analytical activities, and customer services.

2.1.4. Upon customer request, ESC provides reasonable access to relevant areas of the laboratory for witnessing capability and analytical performance. Confidentiality of all customers during this process is maintained.

2.1.5. Upon request, customers are provided supplementary information and records as needed. This includes, but is not limited to, the following: sample preparation records, packaging information, verification of calibrations, and analytical reference material information.

2.1.6. ESC's PMs/TSRs are required to maintain good communication with customers. Customers are informed of any delays or major deviations in the analytical work of the laboratory.

2.2. Project Initiation

2.2.1. 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.

2.2.2. Records of these reviews (including significant changes) are maintained. Records are also maintained of pertinent discussions with the customer relating to the customer's requirements and the results of the work during the period of execution of the contract.

2.2.3. For routine/non-complex projects, a review by appropriate customer service personnel is considered adequate. Customer service confirms that the laboratory can meet the customer's data quality objectives, and the laboratory has any required certifications.

2.2.4. The reviews described above also encompass any work that will need to be subcontracted to another laboratory. See section 2.8 below for more information about subcontracting work.

2.2.5. Applicable customers are informed of any deviation from any contract. Waivers from the Department of Defense (DoD) Quality Systems Manual (QSM) requirements must be requested in writing from the appropriate DoD Chemist or Contractor Project Chemist (however named) on a project-specific basis and shall include technical justification for the waiver. Documentation of approval for the waiver must be maintained by the laboratory and readily available for review.

2.2.6. If a contract requires amendment after work has commenced, the same contract review process is repeated and any amendments are communicated to all affected parties.

2.2.7. Additional information regarding specific procedures for reviewing new work requests can be found in SOP #020303, *Contract Review* or its equivalent revision or replacement.

2.3. Sampling Materials and Support

2.3.1. Each individual Pace/ESC 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/ESC 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/ESC may provide pick-up and delivery services to their customers when needed

2.3.2. 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.

2.3.3. Laboratory Subsampling – In order for analysis results to be representative of the sample collected in the field, the laboratory has subsampling procedures. For more information see SOP #030220, *Sample Homogenization*.

2.4. Chain of Custody

2.4.1. A chain of custody (COC) provides the legal documentation of samples from time of collection to completion of analysis.

2.4.2. 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.

2.4.3. 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.

2.4.4. Additional information can be found in SOP #060105 *Sample Receiving* or its equivalent revision or replacement.

2.5. Sample Acceptance Policy

2.5.1. In accordance with regulatory guidelines, Pace and ESC comply with the following sample acceptance policy for all samples received.

2.5.2. 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 qualified on the final report.

2.5.2.1. For Ohio EPA/VAP samples, the case narrative will include a discussion of bias as appropriate when qualification of samples is required due to insufficient sample or other occurrence outside of the laboratory's control. The laboratory has the option to report the data as Not VAP-certified as an exception in the affidavit.

2.5.3. Sample Acceptance Policy requirements:

- Clearly identify the collector's name, the preservation type, and the sample type.
- Have unique client identification that are clearly marked with durable waterproof labels on the sample containers and that match the chain of custody.
- Have clear documentation on the chain of custody related to the location of the sampling site with the time and date of sample collection.
- Have all requested analyses clearly designated on the COC.
- Be in appropriate sample containers with clear documentation of the preservatives used.
- Be correctly preserved unless the method allows for laboratory preservation.
- Be received within holding time. Any samples with hold times that are exceeded will not be processed without prior customer approval.
- Have sufficient sample volume to proceed with the analytical testing. If insufficient sample volume is received, analysis will not proceed without customer approval.
- Be received within appropriate temperature ranges (not frozen but ≤6°C) unless program requirements or customer contractual obligations mandate otherwise. The cooler temperature is recorded directly on the COC. Samples that are delivered to the laboratory immediately after collection are considered acceptable if there is evidence that the chilling process has been started. For example, by the arrival of the samples on ice. If samples arrive that are not compliant with these temperature requirements, the customer will be notified. The analysis will NOT proceed unless otherwise directed by the customer. If less than 72 hours remain in the hold time for the analysis, the analysis may be started while the customer is contacted to avoid missing the hold time. Data associated with any deviations from the above sample acceptance policy requirements will be appropriately qualified.
- Samples for drinking water analysis that are improperly preserved, or are received past holding time, are rejected at the time of receipt, with the exception of VOA samples that are tested for pH at the time of analysis.

2.5.4. 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.

2.5.5. Additional information can be found in SOP #060105, *Sample Receiving* or its equivalent revision or replacement.

2.5.6. Personnel dealing with radioactive samples are trained in radioactive sample management procedures. For more information see SOP #360401, *Radioactive Sample Receiving, Handling, and Shipping* and SOP #360404, *Sample Control of Licensed Material for WET Analysis* or their equivalent revisions or replacements.

2.6. Sample Receipt Inspection and Log-in

2.6.1. All samples are verified upon receipt as meeting its description and being free from damage. In the event of a sample being lost, damaged or otherwise unsuitable for use, full details of the incident are recorded and reported to the customer by the Project Manager via a nonconformance form, prior to any analytical action being taken. Any further action taken is at the direction of the customer.

2.6.2. Login Technicians are responsible for sample login and assessing sample container integrity, documentation, and identification. Samples are inspected and noted for temperature, pH using narrow-range pH paper, headspace, proper container type, container integrity (broken or leaking), and volume levels. Samples requiring thermal preservation must arrive at the laboratory above freezing but $\leq$6°C. If the samples are not appropriately preserved, the problem is noted on a sample nonconformance form, the customer is notified, and, if the lab is instructed to proceed, proper preservation is performed. The sample nonconformance sheet becomes a permanent part of the COC.

2.6.3. Login Technicians are trained to recognize analyses with immediate, 24-hour, and 48-hour holding times. Those samples are designated as “short-holds”. When short-hold samples arrive at the laboratory, the Login procedure for those samples takes place immediately. All analysts are trained to assess incoming samples for holding time limitations.

2.6.4. If a sample has a holding time limitation, the Laboratory Information Management System (LIMS) issues a due date on the bench sheet to ensure that the extraction or analysis is completed within the time allowed. In the event that a holding time is exceeded, the Project Manager contacts the customer, informs them of the situation, and requests further direction. If instructed by the customer to proceed with the analysis, a qualifier is added to the benchsheet, which is then carried on to reporting. The final report bears the explanation in the form of a qualifier.

2.6.5. After sample inspection, all sample information on the COC is entered into the LIMS. The lab’s permanent records for samples received include the following information:

- Customer name and contact information
- The laboratory’s unique sample identification numbers
- 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
- Identification of the person making the above entries into LIMS

2.6.6. A unique sample identification number is generated for each sample submitted to the laboratory and is used throughout the analytical and disposal cycle. A record of all samples is established and maintained.

2.6.7. Each sample is assigned a unique and consecutive log number. After a sample is entered into the LIMS database it is assigned a specific log number identifier. The LIMS automatically assigns the next consecutive number any subsequent samples. Log numbers are not available for reuse and cannot be altered.

2.6.8. A durable laboratory sample label with the log number is printed from LIMS and is affixed to the sample. Each label contains a unique container ID, represents the sample ID number, and is clearly marked with preservative and requested analysis.

2.6.9. All documentation that is sent to the laboratory by the customer is retained in laboratory records.

2.6.10. Additional information for sample log-in can be found in SOP #060105 *Sample Receiving* or its equivalent revision or replacement.

2.7. Sample Storage and Protection

2.7.1. The samples are stored according to method and regulatory requirements as per the applicable analytical SOPs. While in storage, samples are stored by sample ID and analyses required. 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.

2.7.2. Refrigerated storage areas are maintained at ≤6°C (but not frozen) and freezer storage areas are maintained at ≤ -10°C (unless otherwise required per method or program). The temperature of each storage area is checked and documented at least once for each day of use. If the temperature falls outside the acceptable limits, then corrective actions are taken and appropriately documented.

2.7.3. The laboratories are operated under controlled access protocols to ensure sample and data integrity. Visitors must register at the front desk and be properly escorted at all times. Samples are taken to the appropriate storage location immediately after sample receipt and login procedures are completed. All sample storage areas have limited access. Samples are removed from storage areas by designated personnel and returned to the storage areas as soon as possible after the required sample quantity has been taken.

2.7.4. Additional information on sample storage can be found in SOP #060106, *Sample Storage and Disposal* and SOP #060112, *Cold Storage Management* or their equivalent revisions or replacements.

2.8. Subcontracting Analytical Services

2.8.1. ESC only performs analytical techniques that are within its documented capability, when this is not possible, the laboratory follows SOP #030209, *Subcontracting*. Subcontracting also occurs in the special circumstances where technical, safety, or efficiency issues dictate need. When subcontracting analytical services, whether inside or outside the Pace network, ESC assures work requiring specific accreditation is placed with an accredited laboratory or one that meets applicable statutory and regulatory requirements of the project/customer. When possible, subcontracting will be to a TNI-accredited laboratory.

2.8.2. When subcontracting analytical services, whether inside or outside the Pace network, ESC notifies the customer of the intent to subcontract the work in writing. The laboratory typically gains the approval of the customer to subcontract their work prior to implementation, preferably in writing.

2.8.3. Potential subcontract laboratories must be approved by ESC based on the criteria listed in SOP #030209, *Subcontracting* or its equivalent revision or replacement. ESC maintains a list of all approved subcontract laboratories. All analytical reports, which contain data from subcontracted laboratories, include a statement which references the subcontractor laboratory/service.

2.8.4. Any 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. ESC assumes responsibility for the qualifications of the subcontractor except when the customer or an authority specifies the subcontractor.

2.8.5. Subcontracted labs used for DoD work must be accredited by DoD or its designated representatives. Subcontracted labs must receive project specific approval from the DoD client before any samples are analyzed. These requirements also apply to the use of any laboratory under the same corporate umbrella, but at a different facility or location.

2.8.6. Additional information can be found in SOP #030209, *Subcontracting* or its equivalent revision or replacement.

2.9. Sample Retention and Disposal

2.9.1. 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.

2.9.2. The minimum sample retention time is 45 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.

2.9.3. 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 ESC to dispose of excess samples, proper arrangements will be made for disposal by an approved contractor.

2.9.4. Additional information can be found in SOP #060106, *Sample Storage and Disposal*; SOP #060112, *Cold Storage Management*; and SOP #030309, *Waste Management Plan* or their equivalent revisions or replacements.

3.0. QUALITY CONTROL PROCEDURES

3.1. Quality Control Samples

3.1.1. ESC Lab Sciences has established quality control procedures for monitoring the validity of the testing it performs. The quality control results are recorded in such a way that trends are detectable, and where practicable, are statistically evaluated. This monitoring is planned and reviewed, and includes the utilization of certified reference materials (where available), participation in proficiency testing programs, replicate or confirmation analyses, correlation of results from related analyses, comparison to historical data, etc.

3.1.2. The quality controls described below are analyzed as applicable to the analytical method used. Acceptance criteria must be established for all quality controls. When quality controls are found to be outside of the pre-defined criteria action is taken to correct the problem, samples reanalyzed, and/or final reports must be appropriately qualified.

3.1.3. Quality control samples must be processed in the same manner as associated customer samples.

3.1.4. Please reference the glossary of this document for definitions of all quality controls mentioned in this section.

3.1.5. For more information see the applicable analytical SOPs. Any deviations to the policies and procedures governing quality controls must be approved by the QA Director.

3.2. Initial Calibration Verification (ICV) or Second Source Verification (SSV)

3.2.1. It is possible for a calibration curve to meet method criteria but still not have the ability to obtain accurate results because all calibration points are from the same source. To assess the accuracy of new calibration curves relative to the purity of the standards, a single standard from a secondary source is analyzed. This secondary source must be from an alternative vendor or from a different lot if the same vendor is used for the preparation of the calibration standards. The laboratory follows specific guidelines for ICV/SSV recoveries and further information can be found in the applicable laboratory SOP. It is ESC's policy is to analyze a standard that is not the same source as the calibration standards. Some departments this second source could be the LCS or CCV when a method or regulation requires it.

3.3. Continuing Calibration Verification (CCV)

3.3.1. Analytical instrumentation is checked periodically to determine if the analytical response has changed significantly since the initial calibration was established. The values obtained from the analysis of the CCV are compared to the true values and a percent change calculated. The laboratory follows specific guidelines for CCV frequency and recoveries. Further information can be found in the applicable laboratory SOP.

3.4. Method Blank

3.4.1. 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.).

3.4.2. Please reference method-specific SOPs for acceptance criteria and associated corrective actions for method blanks.

3.4.3. For DoD samples, the method blank will be considered to be contaminated if: 1) The concentration of any target analyte in the blank exceeds 1/2 the reporting limit and is greater than 1/10 the amount measured in any sample or 1/10 the regulatory limit whichever is greater; 2) The concentration of any common laboratory contaminant in the blank exceeds the reporting limit and is greater than 1/10 the amount measured in any sample or 1/10 the regulatory limit whichever is greater or 3) The blank result otherwise affects the sample results as per the test method requirements or the project-specific objectives. If the method blank is contaminated as described above, then the laboratory shall reprocess affected samples in a subsequent preparation batch, except when sample results are below the LOD. If insufficient sample volume remains for reprocessing, the results shall be reported with appropriate data qualifiers.

3.4.4. For Ohio EPA/VAP projects, the laboratory must minimize the use of qualified data. In the case of method blank having any reportable contamination, the laboratory is required to re-prep and reanalyze the associated samples with an acceptable method blank if there is sufficient sample remaining. Acceptable method blanks are those that are free of contamination below the reporting limit. The laboratory must make every effort to take the appropriate corrective actions and resolve any anomalies regarding method blanks for Ohio EPA/VAP projects. the case narrative will include a discussion of bias as appropriate when qualification of samples is required due to insufficient sample or other occurrence outside of the laboratory's control. The laboratory has the option to report the data as Not VAP-certified as an exception in the affidavit.

3.5. Laboratory Control Sample

3.5.1. 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.

3.5.2. 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.

ESC spikes all target analytes for methods with greater than 20 compounds in the Semivolatile and Volatile Departments. ESC does use a representative standard for multi-peak analytes.

3.5.3. Please reference method-specific SOPs for acceptance criteria and associated corrective actions for LCSs.

3.5.4. 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 than 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. The use of marginal exceedances is also not allowed in the Ohio EPA/VAP.

3.5.5. For Ohio EPA/VAP projects, the laboratory must minimize the use of qualified data. In the case of LCS failures, the laboratory is required to re-prep and reanalyze the associated samples with an acceptable LCS for all target compounds if there is sufficient sample remaining. The laboratory must make every effort to take the appropriate corrective actions and resolve any anomalies regarding LCSs for Ohio EPA/VAP projects. If the LCS has a high bias and the associated samples/analytes are non-detect, the samples can be reported with appropriate qualifiers. the case narrative will include a discussion of bias as appropriate when qualification of samples is required due to insufficient sample or other occurrence outside of the laboratory's control. The laboratory has the option to report the data as Not VAP certified as an exception in the affidavit.

3.5.6. For DoD projects, the laboratory is not allowed to have any target analytes that exceed DoD LCS control limits. In the case of LCS failures, the laboratory is required to reanalyze the associated samples with an acceptable LCS for all target compounds if there is sufficient sample remaining. The laboratory must make every effort to take the appropriate corrective actions and resolve any anomalies regarding LCSs for DoD projects. All LCS failures must be accounted for in project case narratives. See applicable method SOPs for further corrective action.

3.6. Matrix Spike/Matrix Spike Duplicate (MS/MSD)

3.6.1. 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.

3.6.2. 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.

3.6.3. Please reference method-specific SOPs for acceptance criteria and associated corrective actions for MS/MSDs.

3.6.4. For Ohio EPA/VAP projects, the laboratory must minimize the use of qualified data. In the case of MS/MSD failures, the laboratory is required to reanalyze the associated samples only when the associated LCS also fails acceptance criteria and if there is sufficient sample remaining. When an LCS is acceptable and the MS results are outside of criteria, and no system anomaly is detected, the samples will be reported with appropriate data qualifiers indicating matrix interference. The laboratory must make every effort to take the appropriate corrective actions and resolve any anomalies regarding LCSs for Ohio EPA/VAP projects.

3.6.5. For DoD work, each preparation batch of samples must contain an associated MS and MSD (or sample duplicate) using the same matrix collected for the specific DoD project. If adequate sample material is not available, then the lack of MS/MSDs shall be noted in the case narrative. Additional MS/MSDs may be required on a project-specific basis. The MS/MSD must be spiked with all target analytes with the exception of PCB analysis, which is spiked per the method. The concentration of the spiked compounds shall be at or below the midpoint of the calibration range or at the appropriate concentration of concern. Multiple spiked samples may need to be prepared to avoid interferences.

3.6.6. For DoD work, the results of all MS/MSD must be evaluated using the same acceptance criteria used for the LCS.

3.7. Sample Duplicate

3.7.1. 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.

3.7.2. Please reference method-specific SOPs for acceptance criteria and associated corrective actions for sample duplicates.

3.7.3. For Ohio EPA/VAP projects, the laboratory must minimize the use of qualified data. In the case of duplicate samples exceeding the RPD criteria found in applicable analytical SOPs, the laboratory is required to reanalyze the associated sample and duplicate as long as no sampling error was detected if there is sufficient sample remaining. If the sample and duplicate still do not agree, a comment would be made stating there may be sample non-homogeneity. The laboratory must make every effort to take the appropriate corrective actions and resolve any anomalies regarding sample duplicates for Ohio EPA/VAP projects. the case narrative will include a discussion of bias as appropriate when qualification of samples is required due to insufficient sample or other occurrence outside of the laboratory's control. The laboratory has the option to report the data as Not VAP-certified as an exception in the affidavit.

3.8. Surrogates

3.8.1. Surrogates are compounds that reflect the chemistry of target analytes, are not expected to be present in environmental samples, are typically added to samples for organic analyses to measure the extraction or purge efficiency, and also serve to monitor the potential effects of the sample matrix on compound recovery.

3.8.2. Please reference method-specific SOPs for acceptance criteria and associated corrective actions for surrogates.

3.8.3. For Ohio EPA/VAP samples, the case narrative will include a discussion of bias as appropriate when qualification of samples is required due to insufficient sample or other occurrence outside of the laboratory's control. The laboratory has the option to report the data as Not VAP-certified as an exception in the affidavit.

3.9. Internal Standards

3.9.1. 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.

3.9.2. Please reference method-specific SOPs for acceptance criteria and associated corrective actions for internal standards.

3.9.3. For Ohio EPA/VAP projects, samples with internal standard that are outside of method criteria must be reanalyzed to confirm sample matrix effect. The laboratory must make every effort to take the appropriate corrective actions and resolve any anomalies regarding internal standards for Ohio EPA/VAP projects. The case narrative will include a discussion of bias as appropriate when qualification of samples is required due to insufficient sample or other occurrence outside of the laboratory's control. The laboratory has the option to report the data as Not VAP-certified as an exception in the affidavit.

3.10. Limit of Detection (LOD)

3.10.1. ESC uses 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 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.

3.10.2. For Ohio EPA/VAP projects, a valid MDL must be in place prior to sample analysis. MDLs must be spiked at or below the reporting limit and will not be accepted if it was spiked higher than the reporting limit.

3.10.3. DoD definition for LOD- The smallest amount or concentration of a substance that must be present in a sample in order to be detected at a high level of confidence (99%). At the LOD, the false negative rate is 1%.

3.10.4. Additional information can be found in SOP #030206, *Method Detection Limit (MDL), Limit of Detection (LOD), and Limit of Quantitation (LOQ)* or its equivalent revision or replacement.

3.11. Limit of Quantitation (LOQ)

3.11.1. A limit of quantitation (LOQ) for every analyte of concern must be determined. This LOQ is also 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).

3.11.2. For DoD approved methods, the LOQ and LOD shall be verified quarterly and valid LOQ must be in place prior to sample analysis.

3.11.3. Additional information can be found in SOP #030206, *Method Detection Limit (MDL), Limit of Detection (LOD), and Limit of Quantitation (LOQ)* or its equivalent revision or replacement.

3.12. Estimate of Analytical Uncertainty

3.12.1. When required, or upon customer request, ESC Lab Sciences can provide an estimate of the analytical uncertainty of test results.

3.12.2. The exact nature of some test methods may preclude rigorous, statistically valid estimation of analytical uncertainty. In these cases the laboratory attempts to identify all components of analytical uncertainty and make a reasonable estimation, and ensures that the form of data reporting does not give a wrong impression of the uncertainty. A reasonable estimation shall be based on knowledge of method performance and previous experience. When estimating the analytical

uncertainty, all uncertainty components which are of importance in the given situation shall be taken into account.

3.12.3. In those cases where a well-recognized test method specifies limits to the values of the major source of uncertainty of measurement and specifies the form of presentation of calculated results, the laboratory is considered to have satisfied the requirements on analytical uncertainty by following the test method and reporting instructions.

3.12.4. For more information about the estimation of analytical measurement uncertainty see SOP #030221, *Measurement of Uncertainty*

3.13. Proficiency Testing (PT) Studies

3.13.1. The laboratory participates in proficiency testing programs. PT samples are obtained from approved providers and analyzed and reported at a minimum of two times per year for the relevant fields of testing per matrix. PT samples are treated as typical customer samples. They are included in the laboratory's normal analytical processes and do not receive extraordinary attention due to their nature.

3.13.2. The laboratory does not share PT samples with other laboratories, does not communicate with other laboratories regarding current PT sample results, and does not attempt to obtain the assigned value of any PT sample from the PT provider.

3.13.3. The laboratory initiates an investigation and corrective action plan whenever PT results are deemed unacceptable by the PT provider. Additional PTs will be analyzed and reported as needed for certification purposes.

3.13.4. Additional information can be found in the SOP #030212, *Proficiency Testing Program*

3.14. Rounding and Significant Figures

3.14.1. In general, the laboratory reports 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.

3.14.2. ESC uses traditional/arithmetic rules for rounding data: all numbers, regardless of even or odd, is rounded up if the number ends in 5 or higher. If the number ends in less than 5, the number is rounded down. Example: When rounding to three significant figures16.15 would become 16.2 and 16.25 would become 16.3

3.14.3. Additional information can be found in the SOP #030233, *Significant Figures and Rounding of Data*

3.15. Retention Time Windows

3.15.1. 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.

3.15.2. Please reference method-specific SOPs for the proper procedure for establishing retention time windows.

3.16. Analytical Method Selection and Validation

3.16.1. ESC Lab Sciences uses appropriate methods for all analyses within its scope which meet the needs of the customer. Methods are supplemented with Standard Operating Procedures (SOPs) that list additional details to ensure consistent application. These SOPs contain information about the use and operation of all relevant equipment as well as the handling and preparation of samples for analysis. All instructions, standards, manuals and reference data relevant to the work of the laboratory are maintained current and are readily available to personnel. Deviations from methods occur only if the deviation has been documented, technically justified, authorized, and accepted by the customer.

3.16.2. The laboratory will inform customers when methods they choose are considered inappropriate and/or out of date. When a customer does not specify the method to be used, the laboratory selects appropriate and approved methods that have been designated by the project's regulatory program. The customer is informed as to the method chosen.

3.16.3. Methods utilized are preferably those published as international, regional, or national standards. The laboratory ensures that it uses the latest valid edition of a method unless it is not appropriate or possible to do so or unless regulatory requirements dictate specific revision use.

3.16.4. The laboratory validates all analytical methods used to some degree. For methods that are published and/or approved by industry standards; validation includes an evaluation of sensitivity, precision, and accuracy to ensure that it can properly operate the method before the analysis of samples.

3.16.5. Introduction of analytical methods developed by the laboratory for its own use is a planned activity and is assigned to qualified personnel equipped with adequate resources. Plans are updated as development proceeds and effective communication is maintained with all personnel involved in the development process.

3.16.6. When it is necessary to employ methods not published and/or approved by industry standards, these are subject to agreement with the customer and must include a clear specification of the customer's requirements and the purpose of the analysis. Prior to the analysis of samples, non-standard method procedures must be developed and validated appropriately. The validation is as extensive as is necessary to meet the needs in the given application. The laboratory records the results obtained, the procedure used for the validation, and a statement as to whether the non-standard method is fit for the intended use. The minimum requirements for non-standard method validation include evaluation of sensitivity, quantitation, precision, bias, and selectivity of each analyte of interest. Procedures developed for non-standard methods must contain at least the following information:

- Appropriate identification
- Scope
- Description of the type of item to be analyzed
- Parameters or quantities and ranges to be determined
- Apparatus and equipment, including technical performance requirements
- Reference standards and reference materials required
- Environmental conditions required and any stabilization period needed
- Description of the procedure, including:
  - Affixing identification marks, handling, transporting, storing and preparing of items
  - Checks to be made before the work is started

- o Verifying equipment function and, where required, calibrating and/or adjusting the equipment before each use
- o Method of recording the observations and results
- o Any safety measures to be observed

- Criteria and/or requirements for approval/rejection
- Data to be recorded and method of analysis and presentation
- Uncertainty or procedure for estimating uncertainty

3.16.7. Additional information about validation of methods can be found in the SOP #030211, *Method Validation*

4.0. DOCUMENT MANAGEMENT AND CHANGE CONTROL

4.1. Document Management

4.1.1. ESC has an established procedure for managing documents that are part of the quality system. SOP #010103, *Document Control and Distribution* ensures the following:

- Only currently approved document versions are available at points of use
- Documents are reviewed periodically and revised if necessary
- Invalid or obsolete documents are promptly removed from general use
- Obsolete documents retained for audit or knowledge preservation purposes are suitably marked and/or isolated to prevent accidental use
- Affected personnel are notified of changes to management systems documents and supporting procedures, including technical documents
- Reviews of management system documentation shall be maintained and made available for assessment
- Any documents providing instructions to laboratory personnel (e.g. operator aids) are considered part of the management system and are subject to document control procedures

4.1.2. Documents are reviewed and approved for use by authorized personnel prior to issue. Several master lists of managed documents are maintained identifying the current revision status of the controlled documents. This establishes that there are no invalid or obsolete documents in use. Copies of all quality systems documentation provided to DoD for review must be in English. The lists of managed documents may be found at:

H:\QAQC\ Public\Controlled Docs\#Controlled Docs Log.xlsx

H:\QAQC\SOPs\SOP Database.accdb

H:\QAQC\Reports\Reference\External Document List\External Document List April 2018.xlsx

4.1.3. Each managed document is uniquely identified to include the date of issue, the revision identification, page numbers, the total number of pages (or a mark to indicate the end of the document), and the electronic storage pathway.

4.1.4. **Quality Assurance Manual (QAM)**

4.1.4.1. The Quality Assurance Manual is the company-wide document that describes all aspects of the quality system for ESC. The base QAM template is distributed by the Pace Corporate Environmental Quality Department to all applicable local laboratory locations. The local management personnel modify the necessary and permissible sections of the base template and then all applicable local lab staff sign. Each local Quality Department 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. ESC's Quality Assurance Manual is based on this template and is reviewed/revised annually or whenever a change is deemed necessary by laboratory management to ensure it still reflects current practices and meets the requirements of any applicable regulations or customer specifications.

4.1.4.2. The Quality Assurance Manual may not be reproduced, in part or in full, without written consent of ESC Lab Sciences. The Quality Assurance Manual may not be altered in any way.

Whether distributed internally or as a courtesy copy to customers or regulatory agencies, this document is considered confidential and proprietary information. The Quality Assurance Manual can only be deemed official if proper signatures are present. All copies in use within ESC Lab Sciences have been reviewed, approved, and are properly controlled. Any distributed copies outside of ESC Lab Sciences are uncontrolled, unless a controlled copy is specifically requested.

4.1.5. Standard Operating Procedures (SOPs)

4.1.5.1. Standard Operating Procedures (SOPs) are written procedures that describe in detail how to accurately and consistently reproduce laboratory processes or provide additional direction for laboratory personnel. Copies of all current SOPs are accessible to all personnel. SOPs consist of three types:

- Technical SOPs pertaining to a laboratory process which have specifically required details.
- Administrative SOPs which document the more general organizational procedures.
- Quality SOPs that provide background and process for quality policy.

4.1.5.2. All SOPs are scheduled for review annually. Reviews are monitored by the QA department and draft copies of the document are issued for review/revision. If it is determined that revision is not necessary the review is documented by recording the date in the appropriate field of the Revision History Form. A note specifying that 'Reviewed with no changes' is also placed in the Description of Revisions section along with the reviewer's name(s).

4.1.5.3. For Ohio EPA/VAP certification, it is required by the Ohio Administrative Code that the laboratory must seek Ohio EPA/VAP review and approval of all SOPs and Quality Manual subsequent modifications prior to implementation.

4.1.5.4. For DoD approval, all technical SOPs are reviewed for accuracy and adequacy annually and whenever method procedures change and updated as appropriate. All such reviews are documented and made available for assessment. Non-technical SOPs that are not required elements of the quality system are considered administrative SOPs and are not required to be reviewed annually.

4.1.5.5. 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 employees use the most current version of each SOP and a historical record is maintained for each SOP.

4.1.5.6. Each SOP indicates the effective date, the revision number, and the issuing authorities. Department Director/Manager/Supervisor approval is required on technical procedures.

4.1.5.7. The laboratory has SOPs for all analytical methods within its scope of accreditation. Any deviation from a method is documented in the method modifications section of the respective SOP, including both a description of the change made and a technical justification.

4.1.5.8. Deviations from SOPs are not allowed without the permission of the QA Director, or designee. In the event that a deviation is requested, the circumstance is considered and the procedure is evaluated for necessary change and allowance.

4.1.5.9. Each determinative method SOP includes or references (as applicable) the following:

- Scope and Application
- Method Summary and Definitions
- Health and Safety

- Sample Preservation, Containers, Handling and Storage
- Interferences
- Equipment and Supplies
- Reagents and Standards
- Procedure
- Data Analysis and Calculations
- Quality Control and Method Performance
- Data Validation and Corrective Action
- Pollution Prevention and Waste Management
- Method Modifications/Clarifications
- References
- Procedure Revision/Review History

4.1.5.10. Additional sections required for SOPs used in Conjunction with DoD Projects are typically included as an SOP attachment. The DoD QSM currently requires the following additional sections in technical SOPs:

- Equipment/Instrument Maintenance
- Computer Hardware and Software
- Troubleshooting

4.1.5.11. SOPs may not be reproduced, in part or in full, without written consent of ESC Lab Sciences. SOPs may not be altered in any way. Whether distributed internally or as a courtesy copy to customers or regulatory agencies, SOPs are considered confidential and proprietary information. Any copies in use within ESC Lab Sciences have been reviewed, approved, and properly controlled. Any copies of SOPs distributed outside of ESC Lab Sciences are uncontrolled, unless a customer or regulator specifically requests a controlled copy.

4.1.5.12. Additional information about SOPs can be found in SOP #010100, *Writing, Revising, and Maintaining Standard Operating Procedures* or its equivalent revision or replacement.

4.2. Document Change Control

4.2.1. Document changes are reviewed and approved by the original approving authorities unless specifically designated otherwise. Designated authorities are required to have pertinent background information upon which to base their review and approval.

4.2.2. Where practicable, the altered text or new text in the draft is identified during the revision or review process to provide for easy identification of the modifications. Minor SOP changes that occur in the interim of each major revision of the procedure are indicated in the ESC SOP/Minor Revision Form that is attached to the SOP. All SOPs contain a revision history that provides details of changes during periodic reviews and/or major SOP revisions.

4.2.3. The document management process allows for “minor revisions” or amendments to SOPs where changes are not sufficient to cause a full procedure change. Minor revisions may take the form of handwritten or typed notes on an approved SOP Minor Revision form. Approval of these minor revisions is indicated by the initials of the approval authorities. The modified document is then distributed, and obsolete documents are removed. Minor revisions to documents are incorporated into the next full revision as soon as practical.

4.2.4. Electronic documents, such as the Quality Assurance Manual and SOPs, are maintained electronically on protected directories. All laboratory personnel have access to directories that contain the currently approved versions, but edit rights are restricted to authorized personnel only. Obsolete versions of electronic documents are maintained in directories that can only be accessed be authorized personnel.

4.2.5. Additional information can be found in SOP #010103, *Document Control and Distribution* and SOP #010100, *Writing, Revising, and Maintaining Standard Operating Procedures* or their equivalent revisions or replacements.

4.3. Policy for Use and Control of Electronic Signatures

4.3.1. Electronic signatures must be controlled by the individual as electronic files. Electronic signature files must be stored in a secure password protected environment, and are not sent to or used by other individuals. Electronic signatures carry the same weight as handwritten signatures with regards to document approval. Forging another person's signature, handwritten or electronic, will result in disciplinary action.

5.0. SUPPLIES, EQUIPMENT, AND MEASUREMENT TRACEABILITY

5.1. Purchasing Services and Supplies

5.1.1. ESC maintains SOP #030210, *Materials Procurement for Analytical Processes*, which describes the purchasing process, including vendor selection and acceptance criteria, for the purchase, storage, and evaluation of supplies and services. When relevant to the measurement integrity of analyses, ESC uses only services and supplies of adequate quality.

5.1.2. ESC maintains records of services and supplies that may affect the quality of the laboratory's analytical data. These records include the following, where applicable:

- Date of Receipt
- Expiration Date
- Source
- Lot or Serial Number
- Calibration and Verification Records
- Accreditation or Certification Scopes/Certificates

5.1.3. Department supervisors are responsible for ensuring only supplies/chemicals that meet specified requirements are ordered. Where assurance of the quality of services or supplies is unavailable, the laboratory uses these items only after they have been inspected or otherwise verified for adequate quality. Records of inspections and verifications are maintained in the laboratory.

5.1.4. Purchasing documents are maintained and they contain information that describes the services and supplies that were ordered. These purchasing documents are reviewed and approved by applicable personnel prior to release.

5.1.5. Suppliers of critical services and supplies are evaluated. An approved list of material/service suppliers is maintained where products/services purchased affect the quality of data generated by the laboratory.

5.2. Standards and Traceability

5.2.1. Each Pace facility (including ESC) retains pertinent information for standards, reagents, and chemicals to assure traceability to a national standard. This includes documentation of purchase, receipt, preparation, and use.

5.2.2. 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. For more information see SOP #030230, *Standards Logger*.

5.2.3. Reference standards and materials are used to derive the laboratory's analytical measurements; therefore, it is essential that the reference standards and materials used are of very high quality.

5.2.3.1. Reference Standards

The laboratory uses ASTM Class 1 reference weights and NIST traceable reference thermometers which are calibrated and/or verified for accuracy by an ISO 17025 (or

equivalent) accredited vendor that can provide traceability to national or international standards at a minimum frequency of every 5 years. All working thermometers are calibrated or verified at least annually using a NIST traceable thermometer.

5.2.3.2. Reference Materials

Whenever possible, reference materials must be purchased from a vendor that is accredited to ISO 17034 or Guide 34. Purchased reference materials require a Certificate of Analysis (COA) where available. If a reference material cannot be purchased with a Certificate of Analysis (COA), it must be verified by analysis and comparison to a certified reference material and/or there must be a demonstration of capability for characterization. For additional information see SOP# 030231, Standard Recertification.

5.2.4. 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 identification number. This number is used in any applicable sample preparation or analysis records so the standard can be traced back to the standard preparation record. This process ensures traceability back to the national standard.

5.2.5. Reference material standards used for instrument calibration are verified by using a second source of the material. The second source materials are from a different manufacturer or different lot from the same manufacturer. Reference material standards are checked frequently and replaced if degradation or evaporation is suspected. The laboratory also provides satisfactory evidence of correlation of results by participation in a suitable program of inter-laboratory comparisons or proficiency testing whenever possible.

5.2.6. The laboratory handles and transports reference standards and materials in a manner that protects the integrity of the materials. Reference standard and material integrity is protected by separation from incompatible materials and/or minimizing exposure to degrading environments or materials. Standards and reference materials are stored separately from samples, extracts, and digestates. All standards are stored according to the manufacturer's recommended conditions. Temperatures colder than the manufacturer's recommendation are acceptable if it does not compromise the integrity of the material (e.g. remains in liquid state and does not freeze solid). In the event a standard is made from more than a single source with different storage conditions, the standard will be stored according to the conditions specified in the analytical method. See the applicable analytical SOPs for specific reference material storage protocols.

5.2.7. Documentation and Labeling

5.2.7.1. The laboratory retains records for all standards, reagents, and reference materials. These records include the manufacturer/vendor, the manufacturer's Certificate of Analysis or purity (if available), the date of receipt, and recommended storage conditions. These records also include manufacturer lot numbers when applicable.

5.2.7.2. For the original containers, the expiration date provided by the manufacturer is recorded on the container if the expiration date is not already present. If an expiration date is not provided then no expiration date labeling is required.

5.2.7.3. All prepared standard or reagent containers include the laboratory's unique identification number, the standard or chemical name, the date of preparation, the date of expiration, and the preparer's initials. For containers that are too small to accommodate labels that list all of the above information associated with a standard, the minimum required information will be the laboratory's unique identification number, date prepared, and expiration date. The expiration date of prepared standards does not exceed the expiration date of any parent standard used.

5.2.7.4. Standards, reference materials, and reagents are not used after their expiration dates unless their reliability is thoroughly documented and verified by the laboratory. If a standard exceeds its expiration date and is not re-certified, the laboratory removes the standard and/or clearly designates it as acceptable for qualitative/troubleshooting purposes only. All prepared standards, reference materials, and reagents are verified to meet the requirements of the test method through routine analyses of quality control samples. For additional information see SOP #030231, *Standard Recertification*.

5.3. Analytical Equipment/Instrumentation

5.3.1. ESC management ensures that all laboratories are furnished with all the equipment required for the correct performance of the analytical tests they performs. Analytical equipment used that is significant to the analytical results is uniquely identified when practical. Calibration procedures are established for instruments and equipment that have a significant effect on the analytical results. 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.

5.3.2. 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.

5.3.3. For analytical instrumentation, the most appropriate curve fitting model from among the following choices must be utilized (given in the order of preference):

- Average Response Factor
- Linear – No Weighting
- Linear – 1/X Weighting
- Linear – 1/X2 Weighting
- Quadratic

5.3.4. When second order (quadratic) curves are evaluated, acceptability must include an assessment of a graphic representation of the curve to confirm that this fit type is not being used to mask detector saturation and that the curve (which defines a parabola) does not result in two concentrations for one response. When quadratic curves are used there must be a minimum of six initial calibration standards. Higher order polynomial curves (i.e., third-order and greater) are not allowed at ESC.

5.3.5. Analytical equipment is operated only by authorized personnel. Up-to-date instructions and procedures for the use and maintenance of analytical equipment are readily available for use by the appropriate laboratory personnel. This includes any relevant equipment manuals provided by the manufacturer.

5.3.6. Records are maintained for analytical equipment used that is significant to the analytical results. These records include at least the following:

- Identity of the equipment (and software if applicable)
- Manufacturer's name, type of equipment, and serial number or other unique identification
- Checks that equipment complies with specifications
- Current location, where appropriate
- Manufacturer's instructions, if available, or reference to their location
- Dates, results, and reports of all calibrations, adjustments, acceptance criteria, and the due date of next calibration where appropriate
- Maintenance carried out to date. Also, the maintenance plan where appropriate
- Any damage, malfunction, modification, or repair to the equipment
- Date placed in service
- Condition when received (e.g., new, used, reconditioned)
- Operational status
- Instrument configuration and settings

5.3.7. The laboratory has established procedures for the safe handling, transport, storage, use, and any planned maintenance of analytical equipment to ensure proper functioning and in order to prevent contamination or deterioration. These procedures include the checks necessary to ensure proper functionality when analytical equipment is returned from being used outside of the permanent control of the laboratory. For additional information see SOP #030401, *Instrument Transport*.

5.3.8. 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. For additional information see SOP #030303, *Lockout/Tagout*.

5.3.9. 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 to determine if any analytical results were affected. See section 6.1 below for the Control of Non-Conforming Data policies and procedures.

5.3.10. Whenever practicable, all laboratory equipment requiring calibration is labelled, coded, or otherwise identified to indicate the status of calibration, including the date when last calibrated and the date or expiration criteria when recalibration is due. This requirement is mostly applicable to support equipment such as balances, mechanical pipettes, and temperature reading devices which require periodic calibration. Major analytical equipment that is calibrated and/or verified at time of use does not need to be labeled with its calibration status. Calibration records described above are sufficient to indicate the calibration status.

5.3.11. When, for whatever reason, equipment goes outside the direct control of the laboratory, the laboratory ensures that the function and calibration status of the equipment are checked and shown to be

satisfactory before the equipment is returned to service. For additional information see SOP #030401, *Instrument Transport*.

5.3.12. When intermediate checks are needed to maintain confidence in the calibration status of the equipment, these checks are carried out according to a defined procedure. These intermediate checks include continuing calibration verification checks performed on major analytical equipment, and also periodic checks of support equipment such as balances and pipettes.

5.3.13. Where calibrations give rise to a set of correction factors, the laboratory has procedures to ensure that copies (e.g., in computer software) are correctly updated.

5.3.14. Analytical and supporting equipment is protected from inadvertent adjustments that could affect the integrity of the laboratory results. Instruments are located in access-protected areas. Software is tested and approved before use. Spreadsheets used in the calculation of analytical results are tested, approved, and locked before being placed into service.

5.4. Support Equipment Calibration and Verification Procedures

5.4.1. All support equipment is calibrated or verified using NIST traceable references, 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. Raw data records are retained to document equipment performance. On each day the equipment is used, balances, ovens, refrigerators, freezers and water baths are checked and recorded.

5.4.2. Analytical Balances

5.4.2.1. 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.

5.4.3. Thermometers

5.4.3.1. 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 5 years with equipment directly traceable to NIST.

5.4.3.2. 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.

5.4.3.3. Laboratory thermometer calibration data are maintained in the local Quality department.

5.4.4. pH/Electrometers

5.4.4.1. The meter is calibrated according to manufacturer's instructions before use each day, using fresh buffer solutions.

5.4.5. Spectrophotometers

5.4.5.1. During use, spectrophotometer performance is checked at established frequencies in analysis sequences against initial calibration verification (ICV) and continuing calibration verification (CCV) standards.

5.4.6. Mechanical Volumetric Dispensing Devices

5.4.6.1. 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, at a minimum, on a quarterly basis.

5.5. Instrument/Equipment Maintenance

5.5.1. The objectives of the laboratory's 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.

5.5.2. Department Managers/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.

5.5.3. To minimize downtime and interruption of analytical work, preventive 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.

5.5.4. Department Managers/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.

5.5.5. All instrument maintenance (including service calls) is documented in maintenance logbooks that are assigned to each particular instrument or system.

5.5.6. 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 reason for performing the maintenance, the initials (or other identifier) 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).

5.5.7. 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. For additional information see SOP #030303, *Lockout/Tagout*.

6.0. CONTROL OF RECORDS & DATA

ESC has established and maintains procedures for the identification, collection, indexing, access, filing, storage, maintenance and disposal of quality and technical records. Mechanisms have been established for records to remain legible, readily identifiable, and retrievable. These mechanisms also ensure that records are retained for all original observations, calculations and derived data, calibration records, and analytical reports. These observations, data, and calculations are recorded at the time they are made and are identifiable to the specific task. These records allow for the historical reconstruction of laboratory activities related to sample handling and analysis. For more information about the control of records see SOP #010103, *Document Control and Distribution Procedure*, SOP #030201, *Data Handling*, SOP #040601, *IT Processes*; and SOP #020304, *Protection and Transfer of Records*.

ESC has internal auditing procedures for the independent review of records to ensure they are legible, accurate, and complete. For more information see Section 7.1 below and SOP #010104, *Internal Audits* or its equivalent revision or replacement.

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 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.

To ensure that data is protected from inadvertent changes or unintentional destruction, the laboratory uses procedures to check calculations and data transfers. This includes (but is not limited to) the following:

- Peer data review and internal audits of raw data
- Calculations on electronic benchsheets/spreadsheets are password protected
- Where possible, version control software features are utilized to prevent electronic data from being overwritten when changes are made.
- Where possible, audit trail software features are utilized. Audit trails serve as an electronic log to record changes to electronic data including the identification of the person who made the change.
- Where possible, data is uploaded directly from the instrument
- Electronic data files are backed-up routinely. For more information see SOP #040601, *Information Technology Processes*.

6.1. Control of Non-Conforming Data

6.1.1. Identification of Non-Conforming Data

6.1.1.1. Non-conforming work is work that does not conform to customer requirements, standard specifications, or documented laboratory policies/procedures. Some examples of non-conformances are departures from SOPs/test methods or quality control results that do not meet

acceptance criteria. Identification of non-conforming work can come through various sources which include, but are not limited to; results of quality control samples and instrument calibrations, observations of laboratory personnel, data review, and internal audits.

6.1.2. Policies and Procedures for the Control of Non-Conforming Data

6.1.2.1. Many types of non-conformances are listed in the applicable SOPs along with the responsibilities and actions that are needed. Any needed corrections for these non-conformance events are taken immediately together with any decision about the acceptability of the nonconforming data.

6.1.2.2. In the event that a non-conformance is likely to reoccur or that there is doubt about the compliance of the laboratory's operations with its own policies or procedures; laboratory personnel will investigate the significance of the non-conformance and document corrective actions if applicable. When quality of the analytical data has been adversely affected, customers are notified and work is recalled as necessary. For more information see section 8 below for corrective actions and the SOP #030208, *Corrective and Preventive Action*.

6.1.2.3. Customer requests for departures must be pre-approved by appropriate laboratory personnel. These planned and pre-approved departures/non-conformances do not require reviews/investigations; however, they still must be documented. When necessary, planned and pre-approved non-conformances are noted in the final analytical report to advise the data user of any ramification to data quality.

6.1.3. Release of Nonconforming Data

6.1.3.1. The laboratory allows the release of nonconforming data only with approval on a case-by-case basis by the department supervisor, or their designee. Permitted non-conformances, such as QC failures, are fully documented and include the reason for the deviation and the impact of the departure on the data. Where necessary, customer service will notify the customer of the situation and will advise of any ramifications to data quality. Also where necessary, non-conformances are noted in the final analytical report to advise the data user of any ramification to data quality.

6.1.4. Stop Work Procedures

6.1.4.1. Personnel in the quality assurance department have the responsibility and authority to ensure the laboratory’s quality system is implemented and followed at all times. In circumstances where a laboratory is not meeting the established level of quality or not following the policies set forth in this Quality Assurance Manual, the Quality Assurance Director has the authority to halt laboratory operations should he or she deem such an action necessary. The Quality Assurance Director will immediately communicate the halting of operations to the rest of ESC’s senior management team and will keep them posted on the progress of corrective actions.

6.1.4.2. If the Quality Assurance Director and the rest of ESC’s senior management team are not in agreement with regards to the halting of operations, then Pace corporate personnel (such as the Chief Operating Officer and the Director of Environmental Quality) are called in to mediate the situation.

6.1.4.3. The department supervisors and members of senior management also have the authority to halt laboratory operations should they deem this action necessary. If this is done they will

notify personnel in the quality assurance department, and they will keep them informed about the progress of corrective actions.

6.1.4.4. All laboratory personnel have the authority to halt laboratory operations in the event that a situation impacts data validity or safety. When this action is deemed necessary, then the applicable supervisor must be notified of the situation as soon as possible. The supervisor and/or members of senior management will evaluate the severity of the situation for further decision making.

6.1.4.5. Once a stop work order has been approved and implemented, personnel in the quality assurance department have the responsibility of ensuring the effectiveness of the corrective actions taken and authorizing the resumption of work.

6.1.5. For DoD work, all affected DoD customers of potential data quality issues resulting from nonconforming work must be notified within 15 business days from discovery. Records of corrections taken or proposed corrective actions to resolve the nonconformance must be submitted to the customers within 30 business days of discovery.

6.1.6. For DoD work, instances of inappropriate and prohibited laboratory practices (as detailed in Section 5.2.7 of the DoD QSM) must be reported to the laboratory's DoD accrediting body (currently A2LA) within fifteen 15 business days of discovery. Records of corrections taken or proposed corrective actions must be submitted to the laboratory's DoD accrediting body (currently A2LA) within 30 business days of discovery.

6.2. Primary Data Review

6.2.1. Analysts performing the analysis are responsible for the initial data reduction and review, and have the primary responsibility for the quality of the data produced. The analysts initiate the data review process by reviewing and accepting/rejecting the data. This includes, but is not limited to; confirming all samples were prepared/analyzed according to the appropriate method and laboratory SOP, verifying dilutions are calculating properly, ensuring good chromatography, verifying proper spectral interpretations, evaluating quality control data, verifying that any customer/project specific requirements are met, and noting any non-conformances. The primary analyst is also responsible for compiling the initial data package for further data review.

6.2.2. The primary analyst compiles the initial data for secondary data review. This compilation must include sufficient documentation for secondary data review.

6.2.3. Additional information regarding the data reduction and review process can be found in SOP #030201, *Data Handling & Reporting* and SOP #030227, *Data Review* or their equivalent revision(s) or replacement(s).

6.3. Secondary Data Review

6.3.1. 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.

6.3.2. 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. Secondary data reviews must also verify that all manual entries of raw data are accurate and there are no transcription errors.

6.3.3. Additional information regarding the data reduction and review process can be found in SOP #030201, *Data Handling & Reporting* and SOP #030227, *Data Review* or their equivalent revision(s) or replacement(s).

6.4. Final Administrative Review

6.4.1. All final reports receive a final administrative review of some degree. Once the data have been technically reviewed and approved in the secondary data review process, authorization for release of the data from the analytical section is indicated in the LIMS. A Project Manager (PM) or Technical Service Representatives (TSR) will then perform a final administrative review of the data which includes examining the report for method appropriateness, detection limit/QC acceptability, and any other apparent errors. If no errors are found, the PM or TSR approves the report in LIMS and the customer has the reports emailed to them. If errors are noted, the data is returned to the department for correction and resubmission to the PM or TSR. In the case of DoD work, 100% of all packages must have a final administrative review to confirm that primary and secondary reviews were recorded properly and the data package is complete.

6.5. Compliance Data Review

6.5.1. Compliance data reviews are performed by the Quality Department staff and are considered to be part of the overall internal audit program of the laboratory. These reviews are typically performed after the data has been released to the customer. A list is produced weekly from LIMS showing all methods run by the laboratory and how many batches were analyzed the previous week. Some of these data packages will undergo a compliance data review as per a schedule set by this department. For DoD work, at least 10% of all data packages will reviewed for technical completeness/accuracy.

6.6. Data Reporting

6.6.1. The results of each analysis carried out by the laboratory are reported accurately, clearly, unambiguously, objectively, and in accordance with any specific instructions in regulatory requirements, analytical method(s), and/or laboratory standard operating procedures. The analytical data is reported in an analytical report that is issued to the customer. Analytical reports include all information requested by the customer, any necessary information for the interpretation of the results, and all information required by the analytical method(s) used.

6.6.2. 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. For more information see SOP #030201, *Data Handling and Reporting*.

6.6.3. Standard analytical reports contain the following information:

- A title (e.g. Analytical Report)
- ESC Lab Sciences name and address
- Telephone number and name of a laboratory contact to where questions can be referred
- A unique identification number for the report. The pages of the report are numbered and a total number of pages are indicated.
- Name and address of the customer

- Identification of the analytical methods used
- The unique laboratory's identification of the samples analyzed as well as customer's identification of the samples
- The condition of the samples received and the identification of any sample that did not meet acceptable sampling requirements such as improper sample containers, holding times missed, sample temperature, etc.
- Dates and times of sample collection, sample receipt by the laboratory, sample preparation, and sample analysis
- Reference to the sampling plan and sampling procedures used if sampling was conducted by the laboratory
- The analytical results with the units of measurement and reporting limits.
- The name, title, and signature of the person authorizing the analytical report
- A statement about the results relate only to the items tested
- Deviations from the analytical methods. These can include failed quality control parameters, deviations caused by the matrix of the sample, etc. This can be part of the case narrative or as defined footnotes to the analytical data.
- For Whole Effluent Toxicity, identification of the statistical method used to provide data
- Date report was issued
- For solid samples, identification of whether results are on a dry weight or wet weight basis
- Identification of all test results provided by a subcontracted laboratory or other outside source
- Any non-accredited tests are identified as such
- Identification and qualification of results obtained outside of quantitation levels
- Definitions of any data qualifiers used
- In conjunction with Ohio EPA/VAP projects, a signed affidavit is also required.

6.6.4. In addition to the requirements listed above, final reports also contain the following items when necessary for the interpretation of results:

- Deviations from, additions to, or exclusions from the analytical method(s) used. Also where relevant, information on specific analytical conditions such as environmental conditions
- Where relevant, a statement of compliance/non-compliance with requirements and/or specifications (e.g. TNI Standard)
- 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
- Where appropriate and needed, opinions and interpretations (see note below)
- Note: When opinions and interpretations are included in the analytical reports, the laboratory documents the basis upon which the opinions and interpretations have been made. These may include opinions on the compliance/non-compliance of the results with regulatory requirements, fulfillment of contractual requirements, and recommendations on how to use the results. Opinions and interpretations are clearly marked as such in the analytical report and are contained in the case narrative.
- Any additional information required by the customer and/or a specific analytical method.

6.6.5. When the analytical reports contain results of tests performed by subcontractors, these results are clearly identified. When analytical work has been subcontracted, the subcontracted laboratory issues analytical reports to ESC Lab Sciences in writing and/or electronically. Copies of analytical reports

from subcontracted laboratories are made available to customers. For more information see Section 2.8 above and SOP #030209, *Subcontracting.*

6.6.6. Customer data that requires transmission by electronic means undergoes appropriate steps to include all the required reporting information and to adequately maintain data integrity and confidentiality.

6.6.7. The format of the laboratory's analytical reports are designed to accommodate each type of analytical test carried out by the laboratory and to minimize the possibility of misunderstanding or misuse of analytical results.

6.6.8. 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. This process is described in SOP #030223, *Report Revision.*

6.6.9. 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 and ESC will provide electronic data deliverables (EDD) as required by contracts or upon customer request.

6.6.10. The following positions are the only approved signatories for ESC final reports:

- Vice President of Operations
- Operations Director
- Quality Assurance Director
- Client Operations Manager
- Project Manager
- Assistant Project Manager

6.7. Data Security

6.7.1. 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 laboratory.

6.7.2. When computers or automated equipment are used for the acquisition, processing, recording, reporting, storage or retrieval of data, the laboratory ensures that:

- Computer software developed by the laboratory is documented in sufficient detail and suitably validated as being adequate for use
- Procedures are established and implemented for protecting the data. Such procedures include (but are not be limited to) integrity and confidentiality of data entry or collection, data storage, data transmission, and data processing
- Computers and automated equipment are maintained to ensure proper function and are provided with the environmental and operating conditions necessary to maintain the integrity of data
- Individual user names and passwords are required for all LIMS
- Upon employment, laboratory employees are provided initial training in computer security awareness and ongoing refresher training is conducted an annual basis
- Periodic inspections of LIMS are performed to ensure the integrity of electronic data
- Customers are notified prior to changes in LIMS software or hardware configurations that will adversely affect the customer's electronic data

- Spreadsheets used for calculations are verified before initial use and after any changes to equations or formulas, including software revision upgrades. Formula cells are write-protected to minimize inadvertent changes to the formulas.
- Procedures have been established for:
  - Methods of software development that are based on the size and nature of the software being developed
  - Testing and QC methods to ensure that all software accurately performs its intended functions, including:
    - Acceptance criteria
    - Tests to be used
    - Personnel responsible for conducting the tests
    - Records of test results
    - Frequency of continuing verification of the software
    - Test review and approvals
  - Software change control methods that include instructions for requesting, authorizing, requirements to be met by the software change, testing, QC, approving, implementing changes, and establishing priority of change requests
  - Software version control methods that record the software version currently used. Data sets are recorded with the date and time of generation and/or the software version used to generate the data set;
  - Maintaining a historical file of software, software operating procedures, software changes, and software version numbers
  - Defining the acceptance criteria, testing, records, and approval required for changes to LIMS hardware and communication equipment.
- Records maintained in the laboratory to demonstrate the validity of laboratory generated software include:
  - Software description and functional requirements
  - Listing of algorithms and formulas
  - Testing and QA records
  - Installation, operation and maintenance records
- Electronic data security measures ensure the following:
  - Individual user names and passwords have been implemented
  - Operating system privileges and file access safeguards are implemented to restrict the user of the LIMS data to users with authorized access
  - All LIMS users are trained in computer awareness security on an annual basis
  - System events, such as log-on failures or break-in attempts are monitored
  - The electronic data management system is protected from the introduction of computer viruses
  - System backups occur on a regular and published schedule and can be performed by more than just one person
  - Testing of the system backups must be performed and recorded to demonstrate that the backup systems contain all required data
  - Physical access to the servers is limited by security measures
- Commercial “off the shelf” software, e.g., word processing, database and statistical programs in general use within its designed application range may be considered sufficiently validated. However, laboratory software configuration/modifications are validated as above.

6.8. Data Archiving

6.8.1. All records compiled by the laboratory 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 ten years unless superseded by federal, state, contractual, and/or accreditation requirements.

6.8.2. 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.

6.8.3. 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. Additional information can be found in SOP #020306, Business Continuity and Disaster Preparedness Plan.

6.9. Data Disposal

6.9.1. 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 are retained for a minimum of ten years unless superseded by federal, state, contractual, and/or accreditation requirements.

6.9.2. For Ohio EPA/VAP labs, all documents and data prepared or acquired in connection to VAP work must be retained for a period of 10 years after the data of reporting. After 10 years, if the laboratory wishes to dispose of the records, the laboratory must notify the VAP agency by certified mail of such intent and provide the agency an opportunity to request the materials from Pace. The documents must not be disposed of until notification has been received in response to the Pace request for disposal.

7.0. QUALITY SYSTEM AUDITS AND REVIEWS

7.1. Internal Audits

7.1.1. Responsibilities

7.1.1.1. The Quality Assurance Department 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 Quality Assurance Department evaluates audit observations and verifies the completion of corrective actions. In addition, a periodic Pace corporate audit will be conducted. The Pace 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 #010104, *Internal 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 sections:

- System and Method Audits – These are the traditional internal audit function and include analyst interviews to help determine whether laboratory practice matches method requirements and SOP language. Applicable raw analytical data and/or final report reviews are usually conducted in conjunction with these traditional internal audits. These audits are conducted according to a predetermined schedule.
- Compliance Data Reviews – These are thorough raw data and record reviews conducted by the quality assurance department that include (but are not limited to) sample receipt records, sample preparation records, analytical records, and the final analytical reports. A portion of the analytical data produced by the laboratory is randomly selected to undergo a compliance data review. These reviews are outside of the laboratory production environment which allows the data to be very closely examined without the pressure of time constraints.
- Corrective action follow-up audits are conducted on an as needed basis to ensure that documented corrective actions are implemented and to verify their effectiveness.

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. In addition to the scheduled internal audits, unscheduled internal audits are conducted whenever doubts are cast on the laboratory's compliance with regulatory requirements or its own policies and procedures. These unscheduled internal audits may be conducted at any time and may be performed without an announcement to laboratory personnel.

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. For DoD work, instances of inappropriate and prohibited laboratory practices (as detailed in Section 5.2.7 of the DoD QSM) must be reported to the laboratory's DoD accrediting body (currently A2LA) within fifteen 15 business days of discovery. Records of corrections taken or proposed corrective actions must be submitted to the laboratory's DoD accrediting body (currently A2LA).

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 quality assurance personnel will write and issue the internal audit report identifying which audit observations are deficiencies that require corrective action.

7.1.3.2. Findings from all internal audits will be routed to the applicable laboratory personnel for corrective action. The responsible party will propose a plan of correction in a timely manner to correct all of the cited deficiencies. The proposed plan should include a time frame for the completion of the corrective actions. This time frame should depend on the complexity of the deficiencies and the amount of resources needed to properly correct the deficiency. The quality department reviews the responses to the internal audit findings. If the responses are determined to be adequate, then the quality department will use the action plan with the given time frame for verifying the completion of the corrective action(s). If the responses are determined to be inadequate, then the response is returned to the responsible party for modification.

7.1.3.3. To complete the internal audit process, the quality department performs a re-examination of the areas where deficiencies were found to verify that all proposed corrective actions have been implemented. An audit deficiency is considered closed once implementation of the necessary corrective action has been audited and verified. If corrective action cannot be verified, the associated deficiency remains open until that action is completed

7.1.3.4. 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 one week, if investigations show that the laboratory results may have been affected. If the issue is complex and the full scope of affected customers is not easily determined, then additional time might be required. However, this additional timeframe for customer notification of complex issues should not exceed one month of discovery. For DoD work, all affected DoD customers must be notified within 15 business days from discovery of any investigation that casts doubt upon the validity of test results.

7.1.3.5. Additional information can be found in SOP #010104, *Internal Audits* or its equivalent revision or replacement.

7.2. External Audits

7.2.1. Pace laboratories (including ESC) are audited regularly by regulatory agencies to maintain laboratory certifications and by customers to maintain appropriate specific protocols.

7.2.2. It is the laboratory's policy to cooperate and assist with all external audits, whether performed by customers or an accrediting body. Management ensures that all areas of the laboratory are accessible to auditors as applicable and that appropriate personnel are available to assist in conducting the audit.

7.2.3. External audit teams review the laboratory to assess the effectiveness of quality systems. The quality assurance department personnel will host the external audit team and assist in facilitation of the audit process. After the audit, the external auditors will usually 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 quality assurance department. Laboratory management will ensure that the necessary resources are provided to effectively develop and implement the corrective action plans. The quality assurance department collates this information and provides a written response to the external audit team. The response contains the corrective action plan and expected completion dates for each element of the plan. The quality department is also responsible for following-up with laboratory personnel to ensure corrective actions are implemented and they are 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 #010105, *Management Review* 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 and copies of the report are distributed to appropriate laboratory staff. Results must feed into the laboratory planning system and must include goals, objectives, and action plans. Laboratory management ensures that any actions identified during the review are carried out within an appropriate and agreed upon timescale.

8.0. CORRECTIVE AND PREVENTIVE ACTION

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 laboratory's quality system 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 the laboratory's corrective action system that lists at a minimum, the deficiency by issue number, the deficiency source, responsible party, root cause, resolution, due date, and date resolved.

Additional information can be found in SOP #030208, *Corrective and Preventive Action* or its equivalent revision or replacement.

8.1. General Corrective Action Procedure

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:

8.1.1.1. Laboratory Non-Conformance Trends

Below are several types of non-conformances that may occur in the laboratory that would require some sort of a corrective action. One time instances are typically handled with a comment or qualifier. A systemic problem with any of these categories may require an official corrective action process.

- Login error
- Preparation Error
- Contamination
- Calibration Failure
- Internal Standard Failure
- LCS Failure
- Laboratory accident
- Spike Failure
- Instrument Failure
- Final Reporting error

8.1.1.2. Proficiency Testing (PT) Results

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 quality assurance department reviews and approves their findings.

Additional information can be found in SOP #030212, *Proficiency Testing Program* or its equivalent revision or replacement

8.1.1.3. Internal and External Audits

The quality assurance department 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 quality

department is also responsible for providing any back-up documentation used to demonstrate that a corrective action has been completed

8.1.1.4. Data Review

In the course of performing primary and secondary review of data or in the compliance data reviews done by the quality assurance department, 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

8.1.1.5. Customer Complaints

Sales and/or customer service personnel are responsible for initiating corrective actions, when warranted, for customer complaints. The possible causes of the problem are communicated to the appropriate laboratory personnel for investigation. After potential corrective actions have been determined, sales and/or customer service personnel review the corrective action(s) to ensure all customer needs or concerns are being adequately addressed. Records of all complaints, investigations, and corrective actions are maintained. For more information see SOP #020302, *Client Complaint Resolution*.

8.1.1.6. Holding Time Violations

In the event that a holding time has been missed, the analyst or supervisor is responsible for initiating corrective action. Appropriate laboratory management must be made aware of all holding time violations so the customer can be contacted. Laboratory personnel will work with the customer so that appropriate decisions can be made regarding the hold time excursion. The ultimate resolution is then documented and included in the customer's project file.

8.1.2. Documentation of corrective actions may be in the form of a comment or qualifier on the final report that explains the deficiency (e.g., matrix spike recoveries outside of acceptance criteria) or it may be a more formal corrective action report that is entered into the laboratory's corrective action system. 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 process. If a formal corrective action report is warranted, then the person initiating the corrective action must document the issue, the affected projects/samples, any known causes of the issue, and any corrective actions that they have taken.

8.2. Root Cause Analysis

8.2.1. It is necessary that corrective actions taken address the root cause of the issue in order to prevent reoccurrences. In some cases, an identified cause equals to the "root cause" of the issue. In other cases, an identified cause is actually the outcome or symptoms of an underlying "root cause". Root cause analysis is the key and sometimes the most difficult part in the corrective action procedure. Often the root cause is not obvious and thus a careful analysis of all potential causes of the problem is required. Potential causes could include customer requirements, the samples, sample specifications, methods and procedures, staff skills and training, consumables, or equipment and its calibration.

8.2.2. In the event that the root cause is not obvious, 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 laboratory's corrective action system.

8.2.3. 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).

8.3. Selection, Implementation, and Monitoring of Corrective Actions

8.3.1. Where uncertainty arises regarding the best corrective action approach for addressing the root cause of an issue, appropriate laboratory personnel will recommend corrective actions that are appropriate to the magnitude and risk of the problem that will most likely eliminate the problem and prevent recurrence. If needed, senior laboratory management will then decide the best course of action needed. The corrective action that is chosen will then be implemented and documented in the laboratory's corrective action system.

8.3.2. Personnel in the quality assurance department are responsible for monitoring the implementation and documentation of corrective actions to ensure that the corrective actions taken are effective. This verification of the corrective actions effectiveness is documented laboratory's corrective action system.

8.4. Additional Audits

8.4.1. When the identification of non-conformances or departures casts doubt on compliance with the laboratory's policies, procedures, or regulatory requirements; laboratory management ensures that appropriate areas of activity are audited in accordance with Section 7.1 as soon as possible. These additional audits can be short and focused to follow-up with the implementation of the corrective actions to confirm their effectiveness. Additional full-scale audits are only necessary when a serious issue or risk to the laboratory's business is identified.

8.5. Preventive Action

8.5.1. Preventive action is a pro-active process to identify opportunities for improvement rather than a reaction to the identification of problems or complaints. ESC takes advantage of several information sources to identify opportunities for improvement in all its systems including technical, managerial, and quality systems. These sources include, but are not limited to, the following:

- Identification of trends
- Staff meetings
- Customer feedback
- Managerial reviews

8.5.2. Some examples of preventive action include, but are not limited to, the following:

- Scheduled instrument maintenance (Preventive maintenance)
- Adding additional staff
- Acquisition of new equipment
- Training activities

8.5.3. All laboratory personnel have the authority to offer suggestions for improvements and to recommend preventive actions. However, it is ultimately the responsibility of laboratory management for implementing preventive action. When improvement opportunities are identified or if preventive

action is required; then action plans are developed, implemented, and monitored to reduce the likelihood of the occurrence of non-conformities and/or to take advantage of the opportunities for improvement.

8.5.4. For more information see SOP #030208, *Corrective and Preventive Action.*

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.
AIHA-LAP, LLC	American Industrial Hygiene Association, Laboratory Accreditation Program, LLC
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 Preventive 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 $(1 - \alpha)$ 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 – β, 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

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10.15. Requirements for Quality Control of Analytical Data for the Environmental Restoration Program, Martin Marietta, ES/ER/TM-16, December, 1992.

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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 template. ESC files an electronic version of a Microsoft Word document with tracked changes detailing all revisions made to this template. These documents are available upon request. All current revisions are summarized in the table below.

Document Number	Reason for Change	Date
Quality Assurance Manual 17.0	Completely reorganized and rewritten QAM. Organization structure of QAM based on the Pace template rev 19.0. Revised and added language to this template where applicable from ESC's QAM rev 16.0. Added ESC-Decatur and ESC-Davis laboratory information.	5/1/2018

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 $\overline{CF}$ or $\overline{RF}$ of the ICAL Standards)
Measured Value = Amount measured (can also be the CF or RF of the CCV)

PERCENT DRIFT

$$\%Drift = \frac{CalculatedConcentration - TheoreticalConcentration}{TheoreticalConcentrtion} * 100$$

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)

CALIBRATION FACTOR (CF)

$$CF = \frac{A_s}{C_s}$$

where:
A_s = Average Peak Area over the number of peaks used for quantitation
C_s = Concentration of the analyte in the standard

RESPONSE FACTOR (RF)

$$RF = \frac{(Conc._{IStd})(Area_{Analyte})}{(Conc._{analyte})(Area_{IStd})}$$

where:
A_s = Response for analyte to be measured
A_{is} = Response for the internal standard
C_{is} = Concentration of the internal standard
C_s = Concentration of the analyte to be measured

LINEAR CALIBRATION MODEL

$$y = mx + b$$

where:
m = Slope of the line
b = The y intercept

QUADRATIC CALIBRATION MODEL

$$y = ax^2 + bx + c$$

where:
c = The y intercept

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

ATTACHMENT I- QUALITY CONTROL CALCULATIONS (CONTINUED)

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

PERCENT ERROR

$$\%Error = \frac{x_i - x'_i}{x_i} * 100$$

where:
x'_i = Measured amount of analyte at calibration level i
x_i = True amount of analyte at calibration level i

RELATIVE STANDARD ERROR (RSE)

$$RSE = 100 \times \sqrt{\sum_{i=1}^{n} \left[\frac{x'_i - x_i}{x_i} \right]^2 \Big/ (n-p)}$$

where:
x_i = True amount of analyte at calibration level i
x'_i = Measured amount of analyte at calibration level i
p = Number of terms in fitting equation (Average = 1, Linear = 2, Quadratic = 3)
n = Number of calibration points

ATTACHMENT I- QUALITY CONTROL CALCULATIONS (CONTINUED)

MINIMUM DETECTABLE ACTIVITY (MDA)

The MDA is used for radiochemical analysis and is calculated with the following equations:

MDA with Blank Population

$$MDA = \frac{3.29 * S_b}{KT_s} + \frac{3}{KT_s}$$

Where:
K = E × V × R × Y × F × 2.22
E = efficiency
V = sample volume
R = tracer recovery
Y = gravimetric carrier recovery
F = ingrowth or decay factor
2.22 = conversion from dpm to pCi
T_s = count time of sample in minutes
S_b = standard deviation of the blank population

MDA without Blank Population

$$MDA = \frac{3.29 * \sqrt{\frac{b}{T_s} + \frac{b}{T_b}}}{K} + \frac{3}{KT_s}$$

Where:
b = background count rate in cpm
T_b = Count time of background in minutes

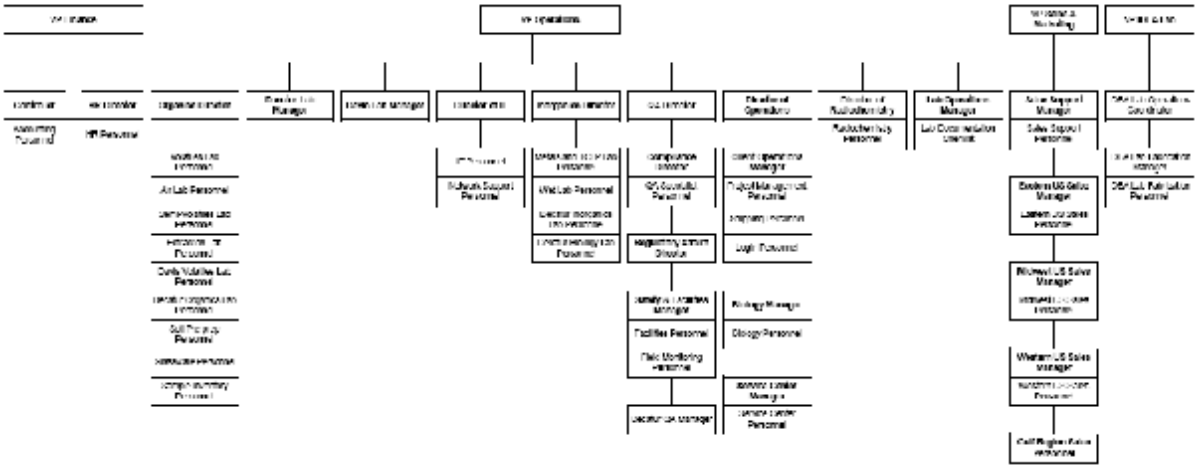
RELATIVE ERROR RATIO (RER)/NORMALIZED ABSOLUTE DIFFERENCE (NAD)/DUPLICATE ERROR RATIO (DER)

RER, NAD, and DER are used for radiochemical analysis and are calculated by the following:

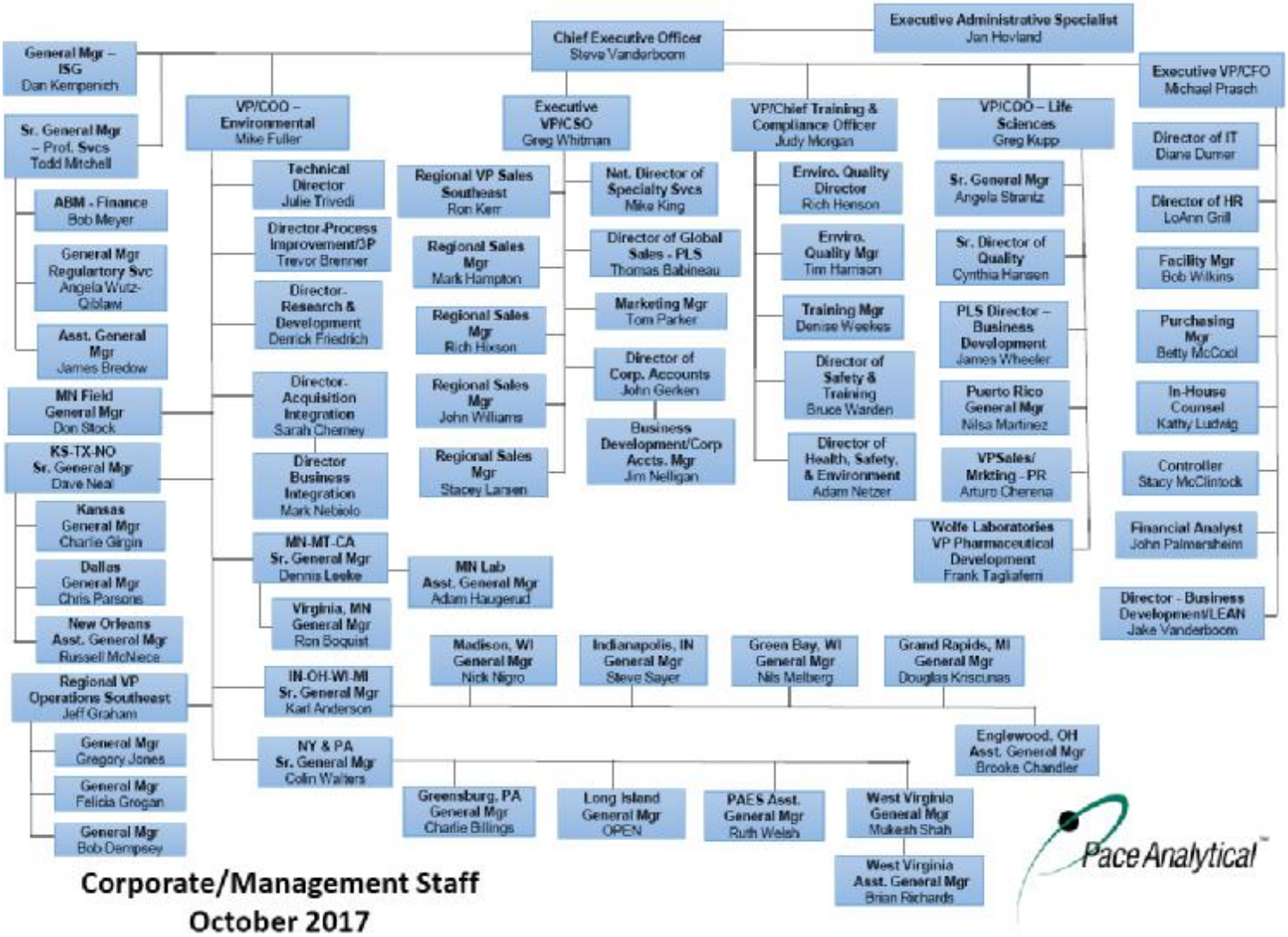
$$RER/NAD/DER = \frac{|S - R|}{\sqrt{U_S^2 + U_R^2}}$$

Where:
S = Sample Value
U_S = Sample Uncertainty (at 2 sigma)
R = Replicate Value
U_R = Replicate Uncertainty (at 2 sigma)

ATTACHMENT II- ESC LAB SCIENCES ORGANIZATIONAL CHART



ATTACHMENT III- CORPORATE ORGANIZATIONAL CHART



ATTACHMENT IV- EQUIPMENT LISTS

ESC – MT. JULIET LABORATORY EQUIPMENT LIST: MAJOR ITEMS - Air Analysis *This table is subject to revision without notice*					
Item	***Manufacturer***	***Model***	***Instrument Name***	***Serial #***	***Location***
GC/FID	Agilent	6890N	AIRGC2	US10137006	Air Lab
Headspace Autosampler	EST/PTS	LGX50	AIRGC2	2688	Air Lab
Gas Chromatograph	HP	6890N TCD	AIRGC3	US10726007	Air Lab
Headspace Autosampler	EST/PTS	LGX50	AIRGC3	2689	Air Lab
Gas Chromatograph/Mass Spectrometer	HP	6890/5973	AIRMS1	GCUS00024616 MSUS63810244	Air Lab
Thermal Desorber	Markes	TO100-XR	AIRMS1	GB00K21022-16/9	Air Lab
Gas Chromatograph/Mass Spectrometer	Agilent	6890N/5975	AIRMS2	CN10551083	Air Lab
Preconcentrator	Entech	7200	AIRMS2	2290	Air Lab
Tedlar Autosampler	Entech	7032A	AIRMS2	1017	Air Lab
Canister Autosampler	Entech	7016CA	AIRMS2	1039	Air Lab
Gas Chromatograph/Mass Spectrometer	Agilent	6890/5973	AIRMS3	US000011333 US91911078	Air Lab
Injector	Agilent	G2614A	AIRMS3	US14213143	Air Lab
Gas Chromatograph/Mass Spectrometer	Agilent	6890/5973	AIRMS4	US00024695 US82311265	Air Lab
Canister Autosampler	Entech	7016CA	AIRMS4	0203	Air Lab
Gas Chromatograph/Mass Spectrometer	Agilent	6890/5973	AIRMS5	GCUS0003961 MSUS0340681	Air Lab
Preconcentrator	Entech	7200	AIRMS5	1162	Air Lab
Canister Autosampler	Entech	7016D	AIRMS5	1422	Air Lab
Tedlar Autosampler	Entech	7032AB	AIRMS5	1044	Air Lab
Gas Chomatograph/Mass Spectrometer	Agilent	7890A/5975C	AIRMS6	GCUS10831022 MSU91732329	Air Lab
Canister Autosampler	Entech	7016D	AIRMS6	1505	Air Lab
Preconcentrator	Entech	7200	AIRMS6	1322	Air Lab
Tedlar Autosampler	Entech	7032A	AIRMS6	1044	Air Lab
Canister Autosampler	Entech	7016CA	AIRMS7	0218	Air Lab
Gas Chromatograph/Mass Spectrometer	Agilent	7890A/5975	AIRMS7	GCCN13231014 MSUS50680012	Air Lab
Thermal Desorber	Markes	Unity-XR	AIRMS7	GB00U32627-16/9	Air Lab
Dynamic Diluter	Entech	Model 4600A		1086	Air Lab
TO Canister	Restek/Entech	TO-Can/ SiloniteCan	2100 cans owned	N/A	Air Lab
Passive Sampling Kit	Restek/Entech		1578 owned	N/A	Air Lab
Field hand held PID	RAE Systems	MiniRAE3000		592-917273	Air Lab
Canister Cleaner	Entech	3100A	Oven 1	1448	Air Lab
Oven	Entech	3513ENT	Oven 1	1482060344516	Air Lab
Oven	Entech	3513ENT	Oven 1	1482060344515	Air Lab
Canister Cleaner	Entech	3100A	Oven 2	1178	Air Lab
Oven	Entech	3513ENT	Oven 2	1482060344518	Air Lab
Oven	Entech	31-350ER	Oven 2	B33ER-01180	Air Lab

ESC – MT. JULIET LABORATORY EQUIPMENT LIST: MAJOR ITEMS - Air Analysis
This table is subject to revision without notice

Item	*Manufacturer*	*Model*	*Instrument Name*	*Serial #*	*Location*
Canister Cleaner	Entech	3100A	Oven 3	1473	Air Lab
Oven	Entech	31-350	Oven 3	B33-02663	Air Lab
Oven	Entech	31-350ER	Oven 3	B33ER-01142	Air Lab
Canister Cleaner	Entech	3100D	Oven 4	1741	Air Lab
Oven	Entech	09-OV6L12	Oven 4	0144	Air Lab
Oven	Entech	09-OV6L12	Oven 4	0143	Air Lab
Canister Cleaner	Entech	3100D	Oven 5	1866	Air Lab
Oven	Entech	09-OV6L8	Oven 5	0134	Air Lab
Oven	Entech	09-OV6L8	Oven 5	0135	Air Lab

ESC MT. JULIET LABORATORY EQUIPMENT LIST: MAJOR ITEMS – Aquatic Toxicity Lab
This table is subject to revision without notice

Item	*Manufacturer*	*Model*	*Location*
Analytical Balance	Mettler	XSE 105 Dual Range	Aquatic Tox Lab
Class “I” weights (2)	Troemner	SN # 67812	Aquatic Tox Lab
Conductivity Meter	Orion	150 A+	Aquatic Tox Lab
Dissolved Oxygen Meter	YSI	Model 5000	Aquatic Tox Lab
Stereoscope	Olympus	SZX-IllK100 (ESC1709)	Aquatic Tox Lab
Oven (1)	Fisher	655F	Aquatic Tox Lab
Cold Room	Thermo-Kool	Walk-In Refrigerator	Aquatic Tox Lab
pH meter	Beckman	SN 2192	Aquatic Tox Lab
Incubator-I9	Thermo Scientific Precision	3759	Aquatic Tox Lab
Incubator I4	Thermo Scientific Precision.	3759	Aquatic Tox Lab
Incubator	VWR	2030-ZZMFG	Aquatic Tox Lab
Stereoscope	Olympus	SZX2-ILLD (ESCP0004)	Aquatic Tox Lab
pH Meter	Orion	VersaStar	Aquatic Tox Lab
Waterbath	Lindberg/Blue	WB1130A	Aquatic Tox Lab
Stereoscope	Olympus	SZH-ILLD (ESC125)	Aquatic Tox Lab
Stereoscope	Olympus	SZH-ILLD (No ESC ID)	Aquatic Tox Lab
Waterbath	Lindberg Blue M	MW-1110A-1	Aquatic Tox Lab
Refrigerator	True	T-49	Aquatic Tox Lab
Water Purifier	ELGA Pure lab	4LXXXSCM2	Aquatic Tox Lab
Mini fridge	Haier	HC27SG42RB	Aquatic Tox Lab
pH/Conductivity Benchtop meter	Thermo Scientific Orion	VSTAR 52	Aquatic Tox Lab
RDO Probe	Thermo Scientific Orion	VSTAR-RD	Aquatic Tox Lab
Oven (2)	Thermoscientific	Heratherm OGS400	Aquatic Tox Lab
Stereoscope	Olympus	SZH-ILLD (ESC005820	Aquatic Tox Lab
Freezer	Kenmore	198.8130582	Aquatic Tox Lab

Incubator	Crown Tonka	Walk-In	Aquatic Tox Lab

ESC-MT. JULIET LABORATORY EQUIPMENT LIST: MAJOR ITEMS - Metals Analysis and Preparation
This table is subject to revision without notice

Item	*Manufacturer*	*Model*	*Name*	*#*	*Serial number*	*Location*
Balance- Top Loading	Torbal	AGN100	METBAL4 Analytical	1	701001026	Metals Prep
Balance - Top Loading	Mettler Toledo	PB3002-5	METBAL2	1	1119070828	Metals Prep
Balance - Top Loading	Mettler Toledo	PB3002-5	METBAL4	1	1121462199	Metals Prep
Balance - Top Loading	Mettler Toledo	XS4002S	METBAL3	1	B712847753	Metals Prep
Hot Block	Thomas Cain/Seal Analytical	SmartBlock	MPH	1	123009	Metals Prep
Hot Block	Env. Express	SC154	MPE	1	9062CECW3953	Metals Prep
Hot Block	Env. Express	SC154	MPF	1	2015CECW4278	Metals Prep
Hot Block	Env. Express	SC154	MPG	1	2015CECW4338	Metals Prep
Prep station	Thomas Cain/Seal Analytical	Deena II	Deena1	1	020050	Metals Prep
Prep station	Thomas Cain/Seal Analytical	Deena II	Deena2	1	020093	Metals Prep
Microwave	CEM	MARS 5 Xpress	1	1	MD-7441	Metals Prep
Microwave	CEM	MARS 5 Xpress	2	1	MD-9640	Metals Prep
Microwave	CEM	MARS 5 Xpress	3	1	MD-4692	Metals Prep
Microwave	CEM	MARS 6	4	1	MJ2771	Metals Prep
Microwave	CEM	MARS 5 Xpress	5	1	MD-9972	Metals Prep
Centrifuge	Thermo	Heraeus Megaforge 40	NA	1	41123868	Metals Prep
Turbidimeter	HACH	2100N	NA	1	05090C020685	Metals Prep
Water Purification - Nanopure	Elga	Pure Lab Ultra	NA	1	ULT00002665	Metals Prep
Auto pipetters	Eppendorf, Oxford	Varies	NA		NA	Metals Prep
ICPMS with autosampler	Agilent	7700	ICPMS7	1	JP12482187	Metals Lab
ICPMS with autosampler	Agilent	7900	ICPMS8	1	JP16281469	Metals Lab
ICPMS with autosampler	Agilent	7900	ICPMS9	1	JP14400452	Metals Lab
ICPMS with autosampler	Agilent	7900	ICPMS10	1	JP14080164	Metals Lab
ICP Simultaneous with autosampler	Thermo	ICAP 7400 DUO	ICP12	1	IC74DC141801	Metals Lab
ICP Simultaneous with autosampler	Thermo	ICAP 7400 DUO	ICP13	1	IC74DC143804	Metals Lab
ICP Simultaneous with autosampler	Thermo	ICAP 7400 DUO	ICP14	1	IC74DC151103	Metals Lab
Hot Block	Env. Express	SC154	HG1	1	2122097	Mercury Lab
Hot Block	Env. Express	SC154	HG2	1	2121806	Mercury Lab
Hot Block	Env. Express	SC154	MPC	1	1120213057	Mercury Lab
Hot Block	Env. Express	SC154	MPD	1	212415	Mercury Lab

ESC-MT. JULIET LABORATORY EQUIPMENT LIST: MAJOR ITEMS - Metals Analysis and Preparation
This table is subject to revision without notice

Item	*Manufacturer*	*Model*	*Name*	*#*	*Serial number*	*Location*
Mercury Auto Analyzer	Perkin Elmer	(1) FIMS 100	III	1	110156051101	Mercury Lab
Mercury Auto Analyzer	Teledyne	QuickTrace 7600	HG6	1	US17016008	Mercury Lab
Mercury Auto Analyzer	Leeman	Hydra II AA	HG5	1	65043	Mercury Lab
Balance - Top Loading	Mettler Toledo	PB3002-5	HGBAL1	1	71242213216	Mercury Lab
TCLP Extraction Unit	Env. Express	6 Position	K	1	NA	TCLP Lab
TCLP Extraction Unit	Env. Express	12 Position	A	5	NA	TCLP Lab
TCLP Extraction Unit	Env. Express	12 Position	E	5	NA	TCLP Lab
TCLP Extraction Unit	Env. Express	12 Position	I	5	NA	TCLP Lab
TCLP Extraction Unit	Env. Express	12 Position	L	5	NA	TCLP Lab
TCLP Extraction Unit	Env. Express	12 Position	O	2	NA	TCLP Lab
TCLP Extraction Unit	Env. Express	12 Position	S	2	NA	TCLP Lab
TCLP Extraction Unit	Env. Express	12 Position	1	2	NA	TCLP Lab
TCLP Extraction Unit	Env. Express	12 Position	2	2	NA	TCLP Lab
TCLP Extraction Unit	Env. Express	10 Position	C	1	NA	TCLP Lab
TCLP Zero Headspace Extractor	Env. Express	Vessels	NA	41	NA	TCLP Lab
PH Meter	Thermo	Orion Versastar	1	1	V04967	TCLP Lab
PH Meter	Thermo	Orion VersastarPro	2	1	V11227	TCLP Lab
Balance	Mettler Toledo	MS3002S		1	B246522879	TCLP Lab
Balance	Mettler Toledo	PB3002-5		1	1128150150	TCLP Lab
Auto pipetters 1000 l to 20 l	Oxford	Varies	NA		NA	Metals Lab
MAX/MIN Thermometer	Fischer Scientific	MAX/MIN	TCLP #1		122376671	TCLP Lab
Hotplate/Stirrer	Thermo	Cimarec+	1	1	C30100131115141 15	TCLP Lab
Hotplate/Stirrer	IKA	RT15	2	1	03.492224	TCLP Lab
Hotplate/Stirrer	IKA	RT15	3	1	03.503438	TCLP Lab

ESC-MT. JULIET LABORATORY EQUIPMENT LIST: MAJOR ITEMS - Microbiological Analysis
This table is subject to revision without notice

Item	*Manufacturer*	*Model*	*Location*
Analytical Balance	Mettler Toleda	XSE1050DU	Microbiology Lab
Class “I” weights	(1 set) Troemner	000565	Microbiology Lab
Autoclave	Pelton and Crane	Validator 8	Microbiology Lab
Water Bath	Lindberg Blue	WB1130A	Microbiology Lab
Water Bath	Blue M	MW-1110A-1	Microbiology Lab
Oven	Fisher	655F	Microbiology Lab
Incubator	VWR	2030 22MFG	Microbiology Lab
Quantitray Sealer	IDEXX	2X	Microbiology Lab
Incubator	Thermo Scientific Precision	3759	Microbiology Lab
Colony Counter	Quebecor	3325	Microbiology Lab

ESC-MT. JULIET LABORATORY EQUIPMENT LIST: MAJOR ITEMS - Microbiological Analysis
This table is subject to revision without notice

Item	*Manufacturer*	*Model*	*Location*
pH Meter	Beckman	pH/Temp/mV/ISE	Microbiology Lab
Refrigerator	True	T-49	Microbiology Lab
Stereoscope (2)	Olympus	SZH-ILLD	Microbiology Lab
UV light; short and long wave	UVP		Microbiology Lab
Autoclave	SterileMax	Harvey	Microbiology Lab
Stereoscope	Olympus	SZX-ILLK100	Microbiology Lab
Water Purifier	ELGA Pure La	4LXXXSCM2	Microbiology Lab
Oven	VWR	13054U	Microbiology Lab
pH meter/Conductivity meter/LDO	Thermo Scientific Orion	VStar 02105	Aquatic Tox Lab

ESC-MT. JULIET LABORATORY EQUIPMENT LIST: MAJOR ITEMS – Mold/ BOD Analysis
This table is subject to revision without notice

Item	*Manufacturer*	*Model*	*Serial #*	*Location*
Analytical Balance	Mettler	PL602-S	1125081657	Bacteriology Lab
Autoclave	Tuttnauer	2540EK	2906170	Bacteriology Lab
Biolog MicroStation	Biolog, Inc.	Microlog 3	342689	Bacteriology Lab
BOD SP Robotic Analyzer	Skalar	SP50	8123	BOD
BOD SP Robotic Analyzer	Skalar	SP50	8124	BOD
Class I BSC	AirFiltronix	AirFiltronix HS 4500	41031	Mold Lab
Class II BSC	Labconco	Labconco 36209	3076555	Bacteriology Lab
Class II BSC	Labconco	Labconco 36213	60554894	Mold Lab
COD Reactor	HACH	45600	900903221	BOD
DO meter	YSI	5000	081C101451	BOD
DO meter	YSI	5000	081C101450	BOD
Fisher Scientific Vortexq	Fisher Scientific		80109016	
Incubator	Precision Scientific	30M		Bacteriology Lab
Incubator	Fisher	Not Visible	100212	BOD
Incubator	Thermo Scientific Precision	3271	317217-1241	BOD
Incubator	Precision	818	35AK-10	BOD
Incubator	Labtronix	BOD2100D	21000010213	Mold Lab
Incubator	Precision Scientific	30M	9303590	Bacteriology Lab
Incubator	VWR	2030	802202	BOD
Incubator	Quincy Lab	10-100	I11-2454	Mold Lab
Microscope	NIKON	LABOPHOT	242008	Mold Lab
Microscope	NIKON	LABOPHOT	235267	Mold Lab
Microscope	Olympus	CH2	900216	Mold Lab
Microscope	Olympus	BH-2	708821	Mold Lab

ESC-MT. JULIET LABORATORY EQUIPMENT LIST: MAJOR ITEMS – Mold/ BOD Analysis
This table is subject to revision without notice

Item	*Manufacturer*	*Model*	*Serial #*	*Location*
Microscope	Leitz	Laborlux	512663	Mold Lab
Microscope	VWR Scientific	VWRC1	V167173	Mold Lab
pH meter	Thermo Scientific	Orion Star A211	X38960	BOD
Plate Reader	Biotek	ELX808BLG	203222	Bacteriology Lab
Refrigerator	Frigidaire	FRT17G4BW9	BA703306	Mold Lab
Refrigerator	Whirlpool	EL88TRRWS03	442001106	Mold Lab
Refrigerator	Whirlpool	EL7ATRRMQ07	EWR4973976	Mold Lab
Refrigerator	Whirlpool			Bacteriology Lab
Spectrophotometer	Hach	DR 2700	1388224	BOD
Stereoscope	VWR Scientific	VWRS1	V168430	Mold Lab
Stir Plate	Corning	PC-420D	23507102961	Bacteriology Lab
Stir Plate	IKA	Big Squid	102	Bacteriology Lab
Stir Plate	VWR	205	7852	BOD
Stir Plate	VWR	220	5031	BOD
Turbidimeter	Biolog, Inc.	21907	6093898	Bacteriology Lab
Vortex Genie2 Mixer	VWR	G-560	2-223236	Bacteriology Lab
Waterbath	Blue M-MagniWhirlpool	MW-1110A	14991	Bacteriology Lab
Waterbath	Precision	Circulating 260	21-AJ11	BOD

ESC-MT. JULIET LABORATORY EQUIPMENT LIST: MAJOR ITEMS – Protozoan Analysis
This table is subject to revision without notice

Item	*Manufacturer*	*Model*	*Location*
Flow control valve	Plast-o-matic	FC050B	Protozoan Lab
Centrifugal pump	Jabsco	18610-0271	Protozoan Lab
Graduated container	Nalgene	20 Liter Carboy	Protozoan Lab
Laboratory shaker	Lab-Line	3587-4	Protozoan Lab
Laboratory shaker side arms	Lab-Line	3589	Protozoan Lab
1500 XG swinging bucket centrifuge	Damon/IEC Division	CRU-5000	Protozoan Lab
Sample mixer/rotator	DYNAL	Cat#: 947.01	Protozoan Lab
Magnetic Particle Concentrator	DYNAL	MPC-1	Protozoan Lab
Magnetic Particle Concentrator	DYNAL	MPC-S	Protozoan Lab
Magnetic Particle Concentrator	DYNAL	MPC-6	Protozoan Lab
Flat-sided sample tubes	DYNAL	Cat#: 740.03	Protozoan Lab
Epifluorescence/differential interference contrast microscope	Olympus	BX-40	Protozoan Lab
Excitation/band pass microscope for fluorescein isothiocyanate (FTIC)	C-Squared	UN3100	Protozoan Lab
Excitation/band pass filters for 4',6-diamidino-2-phenylindole (DAPI)	C-Squared	UN41001	Protozoan Lab
Masterflex pump	Cole Parmer	7553-50	Protozoan Lab
Balance	Denver Instrument	MXX-412	Protozoan Lab

ESC-MT. JULIET LABORATORY EQUIPMENT LIST: MAJOR ITEMS – Protozoan Analysis *This table is subject to revision without notice*			
Item	***Manufacturer***	***Model***	***Location***
Biosafety Cabinet	Labconco	Cat#: 36208043726	Protozoan Lab

ESC-MT. JULIET LABORATORY EQUIPMENT LIST: MAJOR ITEMS - Semi-Volatiles Analysis *This table is subject to revision without notice*					
Item	***Manufacturer/ Model***	***Instrument Name***	***#***	***Serial #***	***Location***
Gas Chromatograph 2	HP 6890	svcompa	2	US00004397	SVOC
Gas Chromatograph 3	Agilent 6890	svcompo	3	US00002051	SVOC
Gas Chromatograph 7	Agilent 6890	svcompe	7	US10350064	SVOC
Gas Chromatograph 8	Agilent 6890	svcompp	8	DE00022534	SVOC
Gas Chromatograph 9	HP 6890	svcompj	9	US00029095	SVOC
Gas Chromatograph 10	Agilent 6890	svcompk	10	US00039655	SVOC
Gas Chromatograph 11	Agilent 6890	svcompn	11	US00040550	SVOC
Gas Chromatograph 12	Agilent 6890	Svcompaf	12	US00034155	SVOC
Gas Chromatograph 13	HP 6890	Svcomps	13	US00010364	SVOC
Gas Chromatograph 14	HP 6890	Svcompt	14	US00020581	SVOC
Gas Chromatograph 16	Agilent 6890	Svcompv	16	US10212071	SVOC
Gas Chromatograph 17	Agilent 6890	Svcompw	17	US10344078	SVOC
Gas Chromatograph 18	Agilent 6890	Svcompd	18	US10351038	SVOC
Gas Chromatograph 19	Agilent 6890	Svcompaa	19	CN10516070	SVOC
Gas Chromatograph 20	Agilent 6890	Svcompab	20	CN10543031	SVOC
Gas Chromatograph 21	Agilent 7890	Svcompae	21	CN 10730070	SVOC
Gas Chromatograph 22	Agilent 7890	svcompad	22	CN 10730081	SVOC
Gas Chromatograph 23	Agilent 6890	svcompag	23	CN 92174366	SVOC
Gas Chromatograph 24	Agilent 6890	svcompah	24	CN 92174369	SVOC
Gas Chromatograph 25	Agilent 7890	svcompaj	25	CN 10091009	SVOC
Gas Chromatograph 26	Agilent 7890	Svcompar	26	CN11501138	SVOC
Gas Chromatograph 27	Agilent 7890	Svcompas	27	CN11501139	SVOC
Gas Chromatograph 28	Agilent 7890	Svcompat	28	US11521018	SVOC
Gas Chromatograph 29	Agilent 7890	Svcompau	29	CN11521077	SVOC
Gas Chromatograph 30	Agilent 7890	svcompav	30	US11521020	SVOC
Gas Chromatograph 31	Agilent 7890	svcompba	31	CN13503096	SVOC
Gas Chromatograph 32	Agilent 7890	svcompbc	32	CN14423060	SVOC
Gas Chromatograph 33	Agilent 7890	svcompbd	33	CN15033026	SVOC
Gas Chromatograph 34	Agilent 7890	svcompbe	34	CN15033027	SVOC
Gas Chromatograph Detectors 2	FID Detector	svcompa	2	N/A	
Gas Chromatograph Detectors 3	NPD/NPD Detectors	svcompo	3	N/A	SVOC
Gas Chromatograph Detectors 7	FID Detector	svcompe	7	N/A	SVOC

ESC-MT. JULIET LABORATORY EQUIPMENT LIST: MAJOR ITEMS - Semi-Volatiles Analysis
This table is subject to revision without notice

Item	*Manufacturer/ Model*	*Instrument Name*	*#*	*Serial #*	*Location*
Gas Chromatograph Detectors 8	FID Detector	svcompp	8	N/A	SVOC
Gas Chromatograph Detectors 9	FID Detector	svcompj	9	N/A	SVOC
Gas Chromatograph Detectors 10	FID Detector	svcompk	10	N/A	SVOC
Gas Chromatograph Detectors 11	ECD/ECD Detectors	svcompn	11	F) U11750 B) U12481	SVOC
Gas Chromatograph Detectors 12	FPD/FPD Detectors	svcompaf	12	N/A	SVOC
Gas Chromatograph Detectors 13	Detectors	svcomps	13	N/A	SVOC
Gas Chromatograph Detectors 14	ECD/ECD Detectors	svcompt	14	F) U3113 B) U2620	SVOC
Gas Chromatograph Detectors 16	FID Detector	svcompv	16	N/A	SVOC
Gas Chromatograph Detectors 17	FID Detector	svcompw	17	N/A	SVOC
Gas Chromatograph Detectors 18	ECD/ECD Detectors	svcompd	18	F) U11613 B) U13988	SVOC
Gas Chromatograph Detectors 19	ECD/ECD Detectors	svcompaa	19	F) U6632 B) U8422	SVOC
Gas Chromatograph Detectors 20	ECD/ECD Detectors	svcompab	20	F) U13989 B) U0418	SVOC
Gas Chromatograph Detectors 21	FID Detector	svcompae	21	N/A	SVOC
Gas Chromatograph Detectors 22	ECD/ECD Detectors	svcompad	22	F)U12039 B) 12038	SVOC
Gas Chromatograph Detectors 23	ECD/ECD Detectors	svcompag	23	F) U2621 B) U8104	SVOC
Gas Chromatograph Detectors 24	ECD/ECD Detectors	svcompah	24	F) U8423 B) U12482	SVOC
Gas Chromatograph Detectors 25	FID Detector	svcompaj	25	N/A	SVOC
Gas Chromatograph Detectors 26	FID Detector	svcompar	26	N/A	SVOC
Gas Chromatograph Detectors 27	FID Detector	svcompas	27	N/A	SVOC
Gas Chromatograph Detectors 28	ECD/ECD Detectors	Svcompat	28	F) U26768 B) U26237	SVOC
Gas Chromatograph Detectors 29	ECD/ECD Detectors	svcompau	29	F) U20277 B) U20299	SVOC
Gas Chromatograph Detectors 30	ECD/ECD Detectors	svcompav	30	F) U20425 B) U20424	SVOC
Gas Chromatograph Detectors 31	FID Detector	svcompba	31	N/A	SVOC
Gas Chromatograph Detectors 32	FID Detector	svcompbc	32	N/A	SVOC
Gas Chromatograph Detectors 33	FID Detector	svcompbd	33	N/A	SVOC

ESC-MT. JULIET LABORATORY EQUIPMENT LIST: MAJOR ITEMS - Semi-Volatiles Analysis
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Item	*Manufacturer/ Model*	*Instrument Name*	*#*	*Serial #*	*Location*
Gas Chromatograph Detectors 34	FID Detector	svcompbe	34	N/A	SVOC
Gas Chromatograph/Mass Spectrometer 1	Agilent 6890GC 5973MSD	svcompf	1	GC CN10335001 MS US33220022	SVOC
Gas Chromatograph/Mass Spectrometer 2	Agilent 6890GC 5973MSD	svcompc	2	GC US10409048 MS US35120400	SVOC
Gas Chromatograph/Mass Spectrometer 4	Agilent 6890GC 5973MSD	svcomph	4	GC CN10403067 MS US35120308	SVOC
Gas Chromatograph/Mass Spectrometer 7	Agilent 6890GC 5973MSD	svcompm	7	GC ---------- MS US03940745	SVOC
Gas Chromatograph/Mass Spectrometer 9	Agilent 6890GC 5973MSD	svcompx	9	GC CN10344042 MS US33220158	SVOC
Gas Chromatograph/Mass Spectrometer 10	Agilent 6890GC 5973MSD	svcompy	10	GC CN10340045 MS US33220183	SVOC
Gas Chromatograph/Mass Spectrometer 11	Agilent 6890GC 5975MSD	svcompac	11	GC CN10509031 MS US60532657	SVOC
Gas Chromatograph/Mass Spectrometer 12	Agilent 7890GC 5975MSD	svcompai	12	GC CN10728074/ MS 12-0706-1325	SVOC
Gas Chromatograph/Mass Spectrometer 13	Agilent 7890GC 5975MSD	svcompak	13	GC CN10301081/ MS US10313621	SVOC
Gas Chromatograph/Mass Spectrometer 14	Agilent 7890GC 5975MSD	Svcompal	14	GC: CN11031022 MS: US11093726	SVOC
Gas Chromatograph/Mass Spectrometer 15	Agilent 7890GC 5975MSD	Svcompam	15	GC: CN10301081 MS: US10313621	SVOC
Gas Chromatograph/Mass Spectrometer 16	Agilent 7890GC 5975MSD	Svcompan	16	GC: CN10301152 MS: US10313616	SVOC
Gas Chromatograph/Mass Spectrometer 17	Agilent 7890GC 5975MSD	Svcompao	17	GC: CN11191064 MS: US11363807	SVOC
Gas Chromatograph/Mass Spectrometer 18	Agilent 7890GC 5975MSD	Svcompap	18	GC: CN11401093 MS: US11403903	SVOC
Gas Chromatograph/Mass Spectrometer 19	Agilent 7890GC 5975MSD	Svcompaq	19	GC: CN11391051 MS: US11383838	SVOC
Gas Chromatograph/Mass Spectrometer 20	Agilent 7890GC 5975MSD	Svcompaw	20	GC: CN12031161 MS: US11503941	SVOC
Gas Chromatograph/Mass Spectrometer 21	Agilent 7890GC 5975MSD	Svcompax	21	GC: CN12031160 MS: US11513903	SVOC
Gas Chromatograph/Mass Spectrometer 22	Agilent 7890GC 5975MSD	Svcompay	22	GC: CN11521157 MS: US12023909	SVOC
Gas Chromatograph/Mass Spectrometer 23	Agilent 7890GC 5975MSD	Svcompaz	23	GC: CN12031114 MS: US11433926	SVOC
Gas Chromatograph/Mass Spectrometer 24	Agilent 7890GC 5977MSD	Svcompbb	24	GC:CN14163165 MS: US92043581	SVOC
Gas Chromatograph/Mass Spectrometer 25	Agilent 7890GC 5975MSD	Svcompbf	25	GC:CN10906031 MS: US11343905	SVOC
High Performance Liquid Chromatography (HPLC1)	Agilent 1100 Series DAD/FLD	hplc1	1	DAD de01608402 FLD de23904489	SVOC
High Performance Liquid Chromatography (HPLC2)	Agilent 1100 Series DAD/FLD	hplc2	2	DAD de30518420 FLD de92001880	SVOC
High Performance Liquid Chromatography	Agilent 1100 Series DAD	hplc3	3	DAD us64400711	SVOC
High Performance Liquid	Agilent1100 Series DAD	hplc4	4	DAD de43623013	SVOC

ESC-MT. JULIET LABORATORY EQUIPMENT LIST: MAJOR ITEMS - Semi-Volatiles Analysis
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Item	*Manufacturer/ Model*	*Instrument Name*	*#*	*Serial #*	*Location*
Chromatography					
Analytical Balance	Mettler-Toledo MS1602S			B115130112	Ext. Lab
Analytical Balance	Mettler-Toledo MS1602S			B243464732	Ext. Lab
Analytical Balance	Mettler-Toledo XS204			1122411619	Ext. Lab
Analytical Balance	Ohaus			1202120814	Ext. Lab
Analytical Balance	Ohaus			B513752880	Ext. Lab
Analytical Balance	Ohaus ARA520			1202120618	Ext. Lab
Analytical Balance	Ohaus SP602			7132101108	Ext. Lab
Automated Soxhlet	Gerhardt Soxtherm			2951	Ext. Lab
Automated Soxhlet	Gerhardt Soxtherm			2952	Ext. Lab
Automated Soxhlet	Gerhardt Soxtherm			2953	Ext. Lab
Automated Soxhlet	Gerhardt Soxtherm			2954	Ext. Lab
Centrifuge	Sorvall ST-41			2225	Ext. Lab
Centrifuge	Sorvall ST-41			2227	Ext. Lab
Concentrator	Buchi			1461	Ext. Lab
Concentrator	Buchi			1462	Ext. Lab
Concentrator	Buchi			1463	Ext. Lab
Concentrator	Buchi			1464	Ext. Lab
Concentrator	Buchi			1465	Ext. Lab
Concentrator	Buchi			1466	Ext. Lab
Concentrator	Buchi			1467	Ext. Lab
Concentrator	Buchi			1468	Ext. Lab
Concentrator	Buchi			1469	Ext. Lab
Concentrator	Buchi			2302	Ext. Lab
Concentrator	Buchi			2303	Ext. Lab
Concentrator	Buchi			2304	Ext. Lab
Microwave	CEM MARS 6			MJ2518	Ext. Lab
Microwave	CEM MARS 6			MJ6367	Ext. Lab
Microwave	CEM MARS 6			MJZ868	Ext. Lab
O&G Solvent Evaporator	Horizon Speed-Vap III			04-2020	Ext. Lab
O&G Solvent Evaporator	Horizon Speed-Vap III			03-1001	Ext. Lab
O&G Solvent Evaporator	Horizon Speed-Vap III			2186	Ext. Lab
O&G Solvent Evaporator	Horizon Speed-Vap IV			15-0055	Ext. Lab
O&G Solvent Evaporator	Horizon Speed-Vap IV			15-0056	Ext. Lab
O&G SPE Extractor	Horizon SPE-DEX 3100			15-0113	Ext. Lab
O&G SPE Extractor	Horizon SPE-DEX 3100			15-0116	Ext. Lab
O&G SPE Extractor	Horizon SPE-DEX 3100			15-0117	Ext. Lab
O&G SPE Extractor	Horizon SPE-DEX 3100			15-0118	Ext. Lab
Oven	Fisher			00700127	Ext. Lab
Oven	Fisher			1000594	Ext. Lab
Ring & Puck Mill	SPEX ShatterBox 8530			10191	Ext. Lab
Sonicator	Misonix 4000			2016080588	Ext. Lab
Sonicator	Misonix 4000			2016080589	Ext. Lab

ESC-MT. JULIET LABORATORY EQUIPMENT LIST: MAJOR ITEMS - Semi-Volatiles Analysis
This table is subject to revision without notice

Item	*Manufacturer/ Model*	*Instrument Name*	*#*	*Serial #*	*Location*
Sonicator	Misonix 4000			2016080594	Ext. Lab
Sonicator	Misonix 4000			2016080601	Ext. Lab
Sonicator	Qsonica Q700			92183M-16-16	Ext. Lab
Sonicator	Qsonica Q700			92186M-10-16	Ext. Lab
Sonicator	Qsonica Q700			92189M-10-16	Ext. Lab
Sonicator	Qsonica Q700			92193M-10-16	Ext. Lab
Water Bath	Branson			RPA040384175E	Ext. Lab
Water Bath	ThermoScientific			2033602-102	Ext. Lab

ESC-MT. JULIET LABORATORY EQUIPMENT LIST: MAJOR ITEMS - Volatiles Analysis
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Item	*Manufacturer*	*Model*	*Instrument Name*	*#*	*Serial #*	*Location*
Gas Chromatograph	Hewlett Packard	5890 Series II	VOCGC	1	3333A31215	Volatiles
Gas Chromatograph	Agilent	6890	VOCGC	2	CN10609095	Volatiles
Gas Chromatograph	Hewlett Packard	5890 Series II	VOCGC	3	2950A26786	Volatiles
Gas Chromatograph	Hewlett Packard	5890 Series II	VOCGC	4	3336A50614	Volatiles
Gas Chromatograph	Hewlett Packard	5890 Series II	VOCGC	5	3027A29678	Volatiles
Gas Chromatograph	Hewlett Packard	5890 Series II	VOCGC	6	2950A27895	Volatiles
Gas Chromatograph	Hewlett Packard	5890 Series II	VOCGC	7	3313A37610	Volatiles
Gas Chromatograph	Hewlett Packard	5890 Series II	VOCGC	13	2921A23548	Volatiles
Gas Chromatograph	Agilent	6890	VOCGC	10	US00022519	Volatiles
Gas Chromatograph	Agilent	6890	VOCGC	12	US00000410	Volatiles
Gas Chromatograph	Agilent	6890	VOCGC	14	CN10408054	Volatiles
Gas Chromatograph	Agilent	6890	VOCGC	15	US10232130	Volatiles
Gas Chromatograph/ Mass Spectrometer	Agilent	6890 GC/ 5975 MSD	VOCMS	2	GCCN10641044 MSUS63234371	Volatiles
Gas Chromatograph/ Mass Spectrometer	Agilent	6890 GC/ 5973 MSD	VOCMS	6	GCCN10343037 MSUS44647141	Volatiles
Gas Chromatograph/ Mass Spectrometer	Agilent	6890 GC/ 5973MSD	VOCMS	4	GCUS00003465 MSUS82311257	Volatiles
Gas Chromatograph/ Mass Spectrometer	Agilent	6890 GC/ 5973MSD	VOCMS	7	GCUS00040221 MS05040022	Volatiles
Gas Chromatograph/ Mass Spectrometer	Agilent	6890 GC/ 5973MSD	VOCMS	8	GCUS00040221 MS03940725	Volatiles
Gas Chromatograph/ Mass Spectrometer	Agilent	6890 GC/ 5973MSD	VOCMS	13	GCCN103390006 MSUS91911078	Volatiles
Gas Chromatograph/ Mass Spectrometer	Agilent	6890 GC/ 5973MSD	VOCMS	14	GCUS00009794 MSUS63810153	Volatiles
Gas Chromatograph/ Mass Spectrometer	Agilent	6890 GC/ 5973MSD	VOCMS	16	GCUS00006479 MSUS82321899	Volatiles
Gas Chromatograph/ Mass Spectrometer	Agilent	6890 GC/ 5973MSD	VOCMS	18	GC CN10517046 MSUS03340424	Volatiles
Gas Chromatograph/ Mass	Agilent	6890 GC/	VOCMS	19	GCCN10611062	Volatiles

ESC-MT. JULIET LABORATORY EQUIPMENT LIST: MAJOR ITEMS - Volatiles Analysis
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Item	*Manufacturer*	*Model*	*Instrument Name*	*#*	*Serial #*	*Location*
Spectrometer		5973MSD			MSUS60542638	
Gas Chromatograph/ Mass Spectrometer	Agilent	6890 GC/ 5975MSD	VOCMS	20	GCCN621S4367 MSUS469A4832	Volatiles
Gas Chromatograph/ Mass Spectrometer	Agilent	6890 GC/ 5975MSD	VOCMS	21	GCCN621S4368 MSUS469A4833	Volatiles
Gas Chromatograph/ Mass Spectrometer	Agilent	7890 GC/ 5975MSD	VOCMS	22	GCCN10728074 MSUS71236615	Volatiles
Gas Chromatograph/ Mass Spectrometer	Agilent	6890 GC/ 5975MSD	VOCMS	23	GCCN10728068 MSUS71236616	Volatiles
Gas Chromatograph/ Mass Spectrometer	Agilent	7890 GC/ 5975MSD	VOCMS	24	GCCN10151020 MSUS10223406	Volatiles
Gas Chromatograph/ Mass Spectrometer	Agilent	7890 GC/ 5975MSD	VOCMS	25	GCCN99205324 MSUS98003634	Volatiles
Gas Chromatograph/ Mass Spectrometer	Agilent	7890 GC/ 5975MSD	VOCMS	26	GCCN10301152 MSUS10313616	Volatiles
Gas Chromatograph/ Mass Spectrometer	Agilent	7890 GC/ 5975MSD	VOCMS	27	GCCN10301155 MSUS10313619	Volatiles
Gas Chromatograph/ Mass Spectrometer	Agilent	6890 GC/ 5973MSD	VOCMS	28	GCUS000034135 MSUS94240103	Volatiles
Gas Chromatograph/ Mass Spectrometer	Agilent	6890 GC/ 5973MSD	VOCMS	30	GCUS10208101 MSUS10442360	Volatiles
Gas Chromatograph/ Mass Spectrometer	Agilent	7890 GC/ 5975MSD	VOCMS	31	GCUS14453011 MSUS54441572	Volatiles
Gas Chromatograph/ Mass Spectrometer	Agilent	7890 GC/ 5975MSD	VOCMS	32	GCCN13113015 MSUS92013978	Volatiles
Gas Chromatograph/ Mass Spectrometer	Agilent	7890 GC/ 5975MSD	VOCMS	33	GCCN11351165 MSUS52440724	Volatiles
Gas Chromatograph/ Mass Spectrometer	Agilent	7890 GC/ 5975MSD	VOCMS	35	GCCN10849077 MSUS83131017	Volatiles
Gas Chromatograph/ Mass Spectrometer	Agilent	7890 GC/ 5975 MSD	VOCMS	36	GCCN11281031 MSUS50680017	Volatiles
Gas Chromatograph/ Mass Spectrometer	Agilent	7890 GC/ 5977MSD	VOCMS	37	GCCN15333012 MSUS1534M407	Volatiles
Gas Chromatograph/ Mass Spectrometer	Agilent	7890 GC/ 5975MSD	VOCMS	38	GCCN11281031 MSUS83141150	Volatiles
Gas Chromatograph/ Mass Spectrometer	Agilent	INTUVO9000 GC/5977A MS	VOCMS	39	GCCN17040005 MSUS1417L240	Volatiles
Gas Chromatograph/ Mass Spectrometer	Agilent	7890B GC/5977A MSD	VOCMS	40	GCCN 15133171 MSUS1542L427	Volatiles
Gas Chromatograph/ Mass Spectrometer	Agilent	7890B GC/5977B MS	VOCMS	41	GCCN10940090 MSUS1705M027	Volatiles
Centurion Autosampler	(15) PTS/EST	Centurion				Volatiles
Autosampler	(19) Varian	Archon				Volatiles
Autosampler	(8) OI Analytical	4100				Volatiles
Purge and Trap	(21) OI Analytical	Eclipse 4660				Volatiles

ESC-MT. JULIET LABORATORY EQUIPMENT LIST: MAJOR ITEMS - Volatiles Analysis
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Item	*Manufacturer*	*Model*	*Instrument Name*	*#*	*Serial #*	*Location*
Purge and Trap	(4) OI Analytical	Eclipse 4760				Volatiles
Purge and Trap	(12) PTS/EST	Encon				Volatiles
Purge and Trap	(9) PTS/EST	Evolution				Volatiles

ESC-MT. MULIET LABORATORY EQUIPMENT LIST: MAJOR ITEMS – Wet Lab
This table is subject to revision without notice

Item	*Manufacturer*	*Model*	*Instrument Name*	*Serial #*	*Location*
Analytical Balance	Mettler	XP205	Balance 3	1129420141	Wet Lab
Analytical Balance	Mettler Toledo	AG204	WetBal 1	1120381348	Wet Lab
Analytical Balance	Mettler Toledo	AT200	WetBal 6	L91221	Wet Lab
Analytical Balance	VWR	403B	WetBal 7	5262015102	Wet Lab
Autoanalyzer	OI Analytical	FS 3100	FS 3100-1	301831056 (NH3) 251833391 (CN)	Wet Lab
Autoanalyzer	OI Analytical	FS 3100	FS 3100-2	3168140781(NH3) 325833494 (CN)	Wet Lab
Autoanalyzer	OI Analytical	FS 3100	FS 3100-3	407831164 (NO2NO3) 403833925 (PHT)	Wet Lab
Autoanalyzer	Lachat	Quikchem 8000	Lachat 2	A83000-1027	Wet Lab
Autoanalyzer	Lachat	Quikchem 8000	Lachat 3	A83000-1638	Wet Lab
Autoanalyzer	Lachat	Quikchem 8500	Lachat 4	60900000341	Wet Lab
Autoanalyzer	Lachat	Quikchem 8500	Lachat 5	60900000342	Wet Lab
Autoanalyzer	Lachat	Quikchem 8500	Lachat 6	70500000452	Wet Lab
Autoanalyzer - digestor	Lachat	BD-46	DIG1	100700000-982	Wet Lab
Autoanalyzer - digestor	Lachat	BD-46	DIG1	1800-871	Wet Lab
Autoanalyzer - digestor	Lachat	BD-46	DIG2	1000700000-982	Wet Lab
Autoanalyzer - digestor	Lachat	BD-46	DIG2	1800-872	Wet Lab
Automated Titraor	SCP	TitrEC	SCP1	115-230V	Wet Lab
Automated titrator	Metrohm	855 titrosampler	Titrando	3256	Wet Lab
Balance	Ohaus	Scout Pro	WetBal 2	B146454764	Wet Lab
Balance	Mettler Toledo	PRB02	WetBal 4	1117223611	Wet Lab
Balance	Ohaus	Scout Pro	WetBal 5	7124350259	Wet Lab
Bomb Calorimeter	Parr	1108 Oxygen Bomb	Parr Bomb	5424	Wet Lab
Centrifuge	Thermo	ST40	Centrifuge	4119863	Wet Lab
Class “I” weights	Troemner	Serial #7944		4057	Wet Lab
COD Reactor	Environmental Express	B3000	COD Reactor	2016CODW101	Wet Lab
Conductivity Meter	ORION	MODEL 170	ATI Orion	32470051	Wet Lab

ESC-MT. MULIET LABORATORY EQUIPMENT LIST: MAJOR ITEMS – Wet Lab
This table is subject to revision without notice

Item	*Manufacturer*	*Model*	*Instrument Name*	*Serial #*	*Location*
Conductivity Meter	Thermo Fisher	Orion VersaStar	Orion VS-2	V02971	Wet Lab
Discrete Analyzer	Seal	AQ400	Seal1	141032	Wet Lab
Distillation Unit - Cyanide	Environmental Express	Distillation 1	LMD1920-106	2270	Wet Lab
Distillation Unit - Cyanide	Environmental Express	Distillation 2	LMD1920-106	2271	Wet Lab
Distillation Unit - Cyanide	Environmental Express	Distillation 3	LMD1920-106	2272	Wet Lab
Distillation Unit - Phenol	Westco Scientific	Model EASY-DIST	Dist 1	1062	Wet Lab
Distillation Unit - Phenol	Westco Scientific	Model EASY-DIST	Dist 2	1198	Wet Lab
Drying Oven	VWR	1390 FM	103-105	501202	Wet Lab
Drying Oven	Shel Lab	FX28-2	178-182	12006713	Wet Lab
Drying Oven	Shel Lab	SM028-2	178-182	8041917	Wet Lab
Flash Point Tester	LAZAR Scientific	SETA-93	Automated	1038328	Wet Lab
Flash Point Tester	Koehler	Pensky-Martens K16200	Manual	R07002693B	Wet Lab
Flash Point Tester	Koehler	Pensky-Martens K16201	Manual	R070022328D	Wet Lab
Hot Block TDS	Environmental Express	TDS024	TDS Hot Block	2017TDSW101	Wet Lab
Hot Plate	Cole Parmer	HS19 C-P	Hot Plate	50000073	Wet Lab
Hot Plate	Thermo Fisher	Type 2200	Hot Plate	C1707140516473	Wet Lab
Hot Plate	Cole Parmer	HS19 CP	Hot Plate	50002676	Wet Lab
Hot Plate	Cole Parmer	HS19 CP	Hot Plate	50002447	Wet Lab
Hot Plate	Cole Parmer	HS19 CP	Hot Plate	50002557	Wet Lab
Ion Chromatograph	Dionex	ICS-2000	IC5	6050731	Wet Lab
Ion Chromatograph	Dionex	ICS 1500	IC6	8100010	Wet Lab
Ion Chromatograph	Dionex	ICS 2000	IC8	8090820	Wet Lab
Ion Chromatograph	Dionex	ICS 2100	IC9	10060822	Wet Lab
Ion Chromatograph	Dionex	ICS 2100	IC10	10091285	Wet Lab
Ion Chromatograph	Dionex	ICS 2100	IC11	11012204	Wet Lab
Ion Chromatograph	Dionex	ICS 2100	IC12	12020460	Wet Lab
Ion Chromatograph	Thermo Fisher	ICS 1600	IC13	13031204	Wet Lab
Ion Chromatograph	Thermo Fisher	ICS-2100	IC14	15030082	Wet Lab
Ion Chromatograph	Thermo Fisher	ICS-2100	IC15	15071973	Wet Lab
Ion Chromatograph	Thermo Fisher	ICS-2100	IC16	15071973	Wet Lab
Ion Chromatograph	Thermo Fisher	ICS-1600	IC17	15110462	Wet Lab
Ion Chromatograph	Thermo Fisher	ICS-2100	IC18	15120139	Wet Lab

ESC-MT. MULIET LABORATORY EQUIPMENT LIST: MAJOR ITEMS – Wet Lab
This table is subject to revision without notice

Item	*Manufacturer*	*Model*	*Instrument Name*	*Serial #*	*Location*
Ion Chromatograph	Thermo Fisher	Integrion	IC19	16070510	Wet Lab
Ion Chromatograph	Thermo Fisher	Integrion	IC20	16090734	Wet Lab
Muffle Furnace	Thermolyne	(1) 30400	FURNACE	23231	Wet Lab
ORP Meter	YSI	ORP15	ORP	JC000114	Wet Lab
pH Meter	Fisher	AB15	AB15+	AB92329028	Wet Lab
pH Meter	Orion	410A	Orion	58074	Wet Lab
pH Meter	Thermo Fisher	Orion Versa Star	Orion VS-1	V00659	Wet Lab
pH Meter	Thermo Fisher	Orion Starfall 1	PH1	J13992	Wet Lab
Refrigerated Recirculator	Polyscience	Recirculator	Recirculator1	1282	Wet Lab
Refrigerated Recirculator	Polyscience	Recirculator	Recirculator2	1608	Wet Lab
SimpleDist	Env. Express	SC154	SimpDist1	8940CECW3871	Wet Lab
SimpleDist	Env. Express	SC155	SimpDist2	9062CECW3952	Wet Lab
SimpleDist	Env. Express	SC156	SimpDist3	9062CECW3955	Wet Lab
Spectrophotometer	Hach	DR6000	DR6000-1	1646676	Wet Lab
Spectrophotometer	Hach	DR6000	DR6000-2	1646781	Wet Lab
Spectrophotometer (UV/Vis)	Hach	DR 5000	DR5000-1	1381711	Wet Lab
TOC Analyzer	Shimadzu	Model TOC-VWS	TOC2	39830572	Wet Lab
TOC Analyzer	Shimadzu	TOC-VCPH	TOC3	H51304435	Wet Lab
TOC Analyzer	Shimadzu	TOC-L	TOC5	H54335232035	Wet Lab
TOC Analyzer	GE	Sievers M5310C	TOC7	16112058	Wet Lab
TOX Analyzer	Mitsubishi	AOX-200	AOX1	E7B00107	Wet Lab
TOX Analyzer	Mitsubishi	TOX-100	TOX2	1035	Wet Lab
TOX Analyzer	EST	TE Xplorer	TOX3	2015-184	Wet Lab
TOX Analyzer	EST	TE Xplorer	TOX4	2016202	Wet Lab
Turbidimeter	Hach	TL2300	TURB1	2017070C0008	Wet Lab
Turbidimeter	Hach	2100N	Turbidimeter1	94110000093	Wet Lab

ESC-MT. JULIET LABORATORY EQUIPMENT LIST: MAJOR ITEMS – Rad Lab
This table is subject to revision without notice

Title	*Quantity*	*Make*	*Model*	*Serial #*	*Location*
Chemchek KPA-11 Kinetic Phosphorescence Analyzer w/Gilson Sample Changer and Gilson Dilutor 401 Syringe Pump	2	Chemchek	KPA-11	1418986; 649025031; 91-5050024	Rad Lab

ESC-MT. JULIET LABORATORY EQUIPMENT LIST: MAJOR ITEMS – Rad Lab

This table is subject to revision without notice

Title	*Quantity*	*Make*	*Model*	*Serial #*	*Location*
Canberra 2404 Alpha/Beta Counter	5	Canberra	2404	1090352; 988600/787196; 488584	Rad Lab
Packard Tri-Carb 2550TR Liquid Scintillation Counter	1	Packard	2550TR	103332	Rad Lab
Packard Tri-Carb 2200CA Liquid Scintillation Counter	1	Packard	2200CA	102180	Rad Lab
Canberra LB4100 Alpha/Beta Counter	3	Canberra	LB4100U2	13000001; 13000002; 13000000; 117	Rad Lab
Canberra Genie 2000 Alpha Spectrometer System	2	Canberra	Genie 2000	See Description	Rad Lab
Canberra Genie 2000 Gamma Spectrometer System	2	Canberra	Genie 2000	See Description	Rad Lab

ESC-DECATUR LABORATORY EQUIPMENT LIST: BACTERIOLOGICAL/AQUATIC TOXICITY

This table is subject to revision without notice

Equipment Number	Description	Manufacturer	Serial Number
079	Conductivity Metter	Fisher	AB81208756
159	pH Meter Model AB15	Fisher Accumet	4117294P
0243	Dissolved Oxygen Meter, Model 5100	YSI	12B10202B
	Incubator (bacteriological samples) #2	Thermo Fisher model 51028066	41581913
	Incubator (bacteriological samples) #1	Thermo Fisher model 51028067	41583136

ESC-DECATUR LABORATORY EQUIPMENT LIST: METALS

This table is subject to revision without notice

Equipment Number	Description	Manufacturer	Serial Number
0040	Thermometer -10 - +110C	Fisher	14-983-10B
0213	Optima 7300DV ICP	Perkin-Elmer	077C0062201
0221	Turbidimeter, 2100Q	Hach	10110C006457
R-9044	Gelex Secondary Stds Hach # 02890-00	Hach	Lot A1019
0235	Mercury Analyzer Model M-6100 CVAA & ASX-520 auto-sampler	CETAC Technologies	121104QT76 analyzer, 091198A520 autosampler
0242	Hot Block, SC 100	Environmental Express	145CEC0183
0240	Hot Block, SC 191 stirrer	Environmental Express	8016CEP1163
0295	Nexion 350 D ICP-MS + Auto-sampler + Chiller + FAST system +computer	Perkin-Elmer	Nexion SN: 85DN6091401, Chiller 5U1680020, Lenovo computer SMJ04FLNU, FAST

			PC3 X4DXX-A-160622

ESC-DECATUR LABORATORY EQUIPMENT LIST: INORGANICS *This table is subject to revision without notice*			
Equipment Number	**Description**	**Manufacturer**	**Serial Number**
0023	COD heating block with timer	Hach	980500017667
0068	Spectrophotometer	Genesys 20 Model 4001/4	35GD353002
0067	BOD Auto EZ reader	Thermo	A0061
0077	pH meter model 420A & Triode probe	Orion 9107BN	30179
0095	pH/ISE Meter, Model 920A	Orion	1447
0101	Muffle Furnace	Fisher Scientific, Model 550-126	s/n 305N0030
0211	Distillation unit/auto - titrator	Buchi/Titrino	Buchi s/n 1000040018 Type-K-360, Titrino Titrator s/n 10109, part# 1.719.0010, type-719S
0216	Oven	Blue M model OV-472-2	OV3 24471 38
0226	Phosphorus digestion unit	Tecator	
0232	Genesys 10S Vis Spectrophotometer	ThermoFisher	2D9P076001
0236	Distillation unit/auto - titrator	Buchi/Titrino	Buchi s/n 1000116430 Type-K-360, Titrino Titrator s/n 17147, part# 1.719.0010, type-719S
0245	FS3100 Cyanide Analyzer (avail)	OI Analytical	149831195
0246	FS3100 Cyanide Analyzer (total)	OI Analytical	302831498
0247	BOD Incubator	Thermo Scientfic Model 3721	162118-2982
0249	TKN Digestor	Buchi Model K-439	1000150618
0250	TKN scrubber	Buchi Model B-414Bas	1000112608
0251	COD Digestor	Hanna Instruments HI839800-01	1147924
0282	DO meter	YSI model 5100-115v	14J101552
0283	Versastar meter (multi-function)	Thermo Orion	V03535
0286	Forced Air Oven	Fisher Scientific, Model 8921	s/n 610855-263
0287	BOD Incubator, model 3721	Thermo Scientfic Model 3721	111972-2468
0293	BOD 200 apparatus	SCP	BDX0115500011
0294	BOD 200 apparatus	SCP	BDX0115500012
0298	Forced Air Oven, Labstrong CT002712	North Central Laboratories	27160500002

ESC-DECATUR LABORATORY EQUIPMENT LIST: INORGANICS
This table is subject to revision without notice

Equipment Number	Description	Manufacturer	Serial Number
0300	Muffle Furnace	Fisher Scientific, Model 750-14	412N0004
089	Ion Chromatograph DX120 & Ion Chromatograph Autosampler	Dionex	1031375, 970 60607
0198	Ion Chromatograph ICS 1600 RFIC & Autosampler	Dionex	9070013
0239	TOC Analyzer TOC -L, CPH E100; auto-sampler ASI-L	Shimadzu	TOC-L H54215000551; A/S H57114900467
0284	TOC Analyzer TOC -L, CPN ; auto-sampler	Shimadzu	TOC-L H54315232013 CS; A/S H57415200591

ESC-DECATUR LABORATORY EQUIPMENT LIST: ORGANICS
This table is subject to revision without notice

Equipment Number	Description	Manufacturer	Serial Number
080	Water Bath	NESLAB	101242027
0175	Muffle Furnace	Vulcan A-550	9493306 / AKV9725-101
0195	Gas Chromatograph model 7890A (FID/NPD) model G3440A	Agilent	CN10827119
0212	Volatiles Gas Chromatograph - Mass Spectrometer 7890A/5975C	Agilent	US10143111 (MS) CN10021075 (GC)
0244	Q500 Sonicator	Qsonica	72898AD+-01-13
0254	7890A GC/ 5977 MS (semi-volatiles)	Agilent	CN13483185 (GC) US1349M227 (MS)
0281	7890A GC/ 5977 MS (volatiles)	Agilent	US1451L418; CN14513033; US14330003
0301	Q500 Sonicator	Qsonica	93364AQ-01-17

ESC-DAVIS LABORATORY EQUIPMENT LIST: VOLATILES
This table is subject to revision without notice

Equipment Number	Description	Model	Manufacturer	Serial Number
19MSV4	Autosampler	Varian	Dynatech Archon	13104
19MSV4	Concentrator	3100 P&T	Tekmar	US02150010
19MSV4	GC/MS	6890 GC/ HP5973 MS	HP	US00028923 & US91922612
19MSV6	Autosampler	Varian	Dynatech Archon	13500
19MSV6	Concentrator	3100 P&T	Tekmar	US01064003
19MSV6	GC/MS	6890 GC / HP5973 MS	HP	US00040666 & US10360129
19MSV9	Autosampler	Varian	Dynatech Archon	13499
19MSV9	Concentrator	3100 P&T	Tekmar	US02081006
19MSV9	GC/MS	6890 GC / HP5973	HP	US00042860 &

		MS		US10460538
19MSVC	Autosampler	Centurian	ENCON	CENTS365041414
19MSVC	Concentrator	ENCON EV	ENCON	EV591051214
19MSVC	GC/MS	6890 GC / HP5973 MS	HP	US10207007 & US10462118
19MSVD	Autosampler	Centurian	ENCON	CENTW544122315
19MSVD	Concentrator	ENCON EV	ENCON	EV659030515
19MSVD	GC/MS	7820A GC / 5977B MS	Agilent	CN15522023 & US1602R003
19MSVB	Autosampler	Varian	Dynatech Archon	13754
19MSVB	Concentrator	3100 P&T	Tekmar	2141003
19MSVB	GC/MS	6890 GC / HP5973 MS	HP	US10207086 & US10462107

ATTACHMENT V- LABORATORY SOP LIST

	Department	Number	Title
1.	Administrative	020301	Project Management
2.	Administrative	020302	Client Complaint Resolution Procedure
3.	Administrative	020303	Contract Review
4.	Administrative	020304	Protection and Transfer of Laboratory Records
5.	Administrative	020305	Laboratory Communications Regarding Sample Analysis
6.	Administrative	020306	Business Continuity and Disaster Preparedness Plan
7.	Administrative	020307	Pennsylvania Department of Environmental Protection (PA DEP) Drinking Water Maximum Contaminant Level (MCL) Violation Reporting
8.	Administrative	030209	Subcontracting
9.	Administrative	030210	Materials Procurement for Analytical Processes
10.	Administrative	030223	Report Revision
11.	Administrative	030224	Sample Re-Analysis
12.	Administrative	030230	Standards Logger - Tree Operation
13.	Administrative	060105	Sample Receiving
14.	Administrative	060106	Sample Storage, Disposal and Sample Control Technicians
15.	Administrative	060108	Return Sample Shipping by Common Carrier
16.	Administrative	060110	Sample Shipping
17.	Administrative	060111	Total Solids (SM 2540G)
18.	Administrative	060112	Cold Storage Management
19.	Air	330367	Measurement of Volatile Organic Compounds and Gasoline Range Components in Ambient Air by Gas Chromatography/Mass Spectrometry (EPA TO-15 and EPA Method 18-Modified)
20.	Air	330367 OH	VOCs in Ambient Air by TO15/8260B
21.	Air	330369 OH	VOCs in Air by GCMS 8260 for the Ohio VAP Program
22.	Air	330370	Method for the Determination of Methane, Ethane, Ethene, Propane, and Acetylene (Based on RSK-175)
23.	Air	330371	Canister Cleaning, Certification and Storage of Air Sampling Equipment
24.	Air	330371 OH	Cleaning, Certification and Storage of Air Sampling Equipment for Ohio EPA/VAP
25.	Air	330372	The Analysis of Fixed Gases and Helium Tracer Gas from Passivated Canisters or Pump-Assisted Bag Samples Using Gas Chromatography Thermal Conductivity Detection (ASTM D1946, ASTM D5314)
26.	Air	330373	Method for the Determination of Methanol and Ethanol - MEETAC (Based on EPA 8015C)
27.	Air	330378	Measurement of VOCs in Ambient Air by GC/MS (EPA TO-17 and Method 325b)
28.	Bioassay	340303	Biochemical Oxygen Demand (SM 5210B)
29.	Bioassay	340312	Dissolved Oxygen Membrane Electrode and Optical Based Sensing Method
30.	Bioassay	350301	Fathead Minnow, Pimephales promelas, Larval Survival and Growth Test (EPA Method 1000.0)
31.	Bioassay	350302	Cladoceran, Ceriodaphnia dubia, Chronic Survival and Reproduction Test (EPA Method 1002.0)

ATTACHMENT V- LABORATORY SOP LIST (CONTINUED)

Department	Number	Title
32. Bioassay	350303	Pimephales promelas Acute Toxicity Testing
33. Bioassay	350303 NC	North Carolina Pimephales promelas Acute Toxicity Testing
34. Bioassay	350304	Ceriodaphnia dubia Acute Toxicity Testing
35. Bioassay	350304 NC	North Carolina Ceriodaphnia dubia Acute Toxicity Testing
36. Bioassay	350305	Fecal Coliform - Membrane Filter Technique (SM 9222D)
37. Bioassay	350315	Fecal Coliform Determination in Biosolids: Membrane-Filter Technique (SM 9221B/9221F/9222D)
38. Bioassay	350315 A	Fecal Coliforms (Class A and Class B) in Sewage Sludge (Biosolids) by MPN using A-1 Medium (EPA Method 1681)
39. Bioassay	350316	Total Coliform and E. coli Membrane-Filter Technique (SM 9222B, SM9221B/F)
40. Bioassay	350317	Reference Toxicant Testing
41. Bioassay	350318 NC	North Carolina Mini Chronic Whole Effluent Toxicity Test Procedure for Ceriodaphnia dubia (EPA Method 1002.0)
42. Bioassay	350320	Acceptability Test of New Food Batches for WET Testing
43. Bioassay	350321	Pocket Colorimeter Chlorine Tester Maintenance and Calibration
44. Bioassay	350322	Dissolved Oxygen Meter Maintenance and Calibration
45. Bioassay	350323	Fluke Thermometer Operation and Maintenance
46. Bioassay	350324	Digital Light Meter Maintenance and Operation
47. Bioassay	350325	pH Meter Maintenance and Calibration
48. Bioassay	350326	Thermometer and Chart Recorder Operation, Maintenance and Verification Procedure
49. Bioassay	350327	Bottle Top Dispensor Maintenance and Method of Operation
50. Bioassay	350328	Conductivity Meter Maintenance and Calibration
51. Bioassay	350329	Taxonomic Verification/Identification of Pimephales promelas - Fathead Minnow
52. Bioassay	350330	Taxonomic Verification/Identification of Ceriodaphnia dubia
53. Bioassay	350332	Laboratory Maintenance of Bacteria Reference Cultures
54. Bioassay	350333	Quality Control and Quality Assurance of Microbiological Equipment and Testing Materials
55. Bioassay	350343	Total Coliform and E. coli Enumeration by the Enzyme Substrate Method (SM 9223B)
56. Bioassay	350345	Receipt and Maintenance of Pimephales promelas (Fathead Minnow)
57. Bioassay	350346	Ceriodaphnia dubia Culture Maintenance, Food Preparation, and Food Maintenance
58. Bioassay	350348	Enterococci Enumeration by the Defined Substrate Method Enterolert (ASTM 6503-99)
59. Bioassay	350354	Heterotrophic Plate Count - Pour Plate Method (SM 9215B)
60. Bioassay	350355	Technical Training and Personnel Qualifications for Biomonitoring - Aquatic Toxicity, Mold, and Microbiology
61. Bioassay	350356	Waterbath and Incubator Temperature Stability and Load Testing
62. Bioassay	350359	Calibration and Maintenance of Autoclaves

ATTACHMENT V- LABORATORY SOP LIST (CONTINUED)

	Department	Number	Title
63.	Bioassay	350362	Analytical Balance Operation and Verification in the Aquatic Toxicity/Microbiology Laboratory
64.	Bioassay	350364 NC	North Carolina Phase II Chronic Whole Effluent Toxicity Test Procedure for Ceriodaphnia dubia (Modified EPA Method 1002.0)
65.	Bioassay	350369	Sterilization, Sanitization and Residue Testing of Microbiological Glassware and Equipment
66.	Bioassay	350380	Class "A" MPN Fecal Coliform Analysis (SM 9221E & C)
67.	Cryptosporidium	350401	Isolation & Identification of Giardia and/or Cryptosporidium in water
68.	Cryptosporidium	350402	Method 1622/1623 Field-Filtering Sample Collection and Laboratory Delivery
69.	Cryptosporidium	350403	Method 1622/1623 Bulk Sample Collection and Laboratory Delivery
70.	Cryptosporidium	350404	Method 1622/1623 Sample Receiving
71.	Cryptosporidium	350405	Training Protocol for Method 1622/1623
72.	Cryptosporidium	350406	Data Collection and Verification for Method 1622/1623
73.	Cryptosporidium	350407	Microscope Analyst Verification
74.	Cryptosporidium	350408	Biosafety Guidelines for the Cryptosporidium Laboratory
75.	Cryptosporidium	350409	IPR, OPR and MS Spiking Procedures and Corrective Actions
76.	Cryptosporidium	350410	IEC CRU-5000 Centrifuge Operation and Maintenance
77.	Cryptosporidium	350411	Lab-Line Multi-Wrist Shaker Operation and Maintenance
78.	Cryptosporidium	350412	Cryptosporidium Laboratory Equipment Cleaning
79.	Cryptosporidium	350413	Olympus BX40 Microscope Operation and Maintenance
80.	Cryptosporidium	350414	SteamScrubber® Dishwasher Operation and Maintenance
81.	Field Sampling	060303	Wastewater Sampling
82.	Field Sampling	060304	Groundwater Sampling
83.	General	030214	Storage of Consumables/Supplies
84.	General	030220	Sample Homogenization and Sub-Sampling
85.	General	030222	Volume Verification for Volumetric Ware (ASTM E 542-01)
86.	General	030227	Data Review
87.	General	030227 OH	Data Review
88.	General	030228	General Analytical Balance Operation and Verification in the Laboratory
89.	General	030229	Verification of Automatic Temperature Compensation Probes on Laboratory pH Meters
90.	General	030234	Temperature Calibration for CEM Microwaves using Intelli-Temp Calibrator
91.	General	030401	Instrument Transport
92.	General	030701	Glassware Cleaning
93.	Information Technology	040601	Information Technology Processes
94.	Information Technology	041102	Electronic Data Deliverables
95.	Metals	340384 A	Mercury in Aqueous/Liquid Samples (Cold-Vapor Technique)(EPA Methods 7470A and 245.1)
96.	Metals	340384 A OH	Mercury IN LIQUID (Cold-Vapor Technique)

ATTACHMENT V- LABORATORY SOP LIST (CONTINUED)

	Department	Number	Title
97.	Metals	340384 B	Mercury in Solid waste (Cold-Vapor Technique)(EPA Methods 7471A & 7471B)
98.	Metals	340384 B OH	Mercury in Solid waste (Cold-Vapor Technique)
99.	Metals	340386	Determination Metals and Trace Elements in Various Matrices by ICP-AES (EPA Methods 6010B, 6010C, 6010D [ICP-OES], and 200.7) Including Hardness (EPA Methods 200.7 and 6010B/C/D and SM 2340B)
100.	Metals	340386 OH	Determination Metals by Inductively Coupled Plasma-Atomic Emission Spectrometry (ICPAES) (SW-846 6010B)
101.	Metals	340390	Determination of Metals by Inductively Coupled Plasma Mass Spectroscopy (ICP-MS) (EPA Methods 6020, 6020A, 6020B & 200.8)
102.	Metals	340390 OH	ICPMS 6020/200.8
103.	Metals	340393	Trivalent Chromium by Calculation (EPA Methods 6010B/C, 6020/A, 7196A, 7199, and 3060A, SM 3500Cr B & C)
104.	Metals Prep	340354 A	Turbidity - Metals Drinking Water Screen Only (EPA Method 180.1)
105.	Metals Prep	340358	Toxicity Characteristic Leaching Procedure (EPA Method 1311)
106.	Metals Prep	340363	Extraction Procedure Toxicity Test (EPA Method 1310B)
107.	Metals Prep	340364	Muliple Extraction Procedure
108.	Metals Prep	340380	Digestion of Metals and Trace Elements in Drinking Water and Wastes for ICP-AES and ICPMS by Microwave and Hot Block Digestion (EPA Method 200.2)
109.	Metals Prep	340388	Acid Digestion of Sediments, Sludges, Soils, and Oils (3050B, 3051, and 3051A)
110.	Metals Prep	340388 OH	Acid Digestion of Sediments, Sludges, Soils, and Oils (3050B/3051)
111.	Metals Prep	340389	Acid Digestion of Aqueous Samples and Extracts, including Total Recoverable and Dissolved Metals (EPA Methods 3005A, 3010A, 3015, & 3015A)
112.	Metals Prep	340389 OH	Acid Digestion of Aqueous Samples and Extracts, 3010A/3015
113.	Metals Prep	340392	Sodium Adsorption Ratio/Ex. Sodium Percentage
114.	Metals Prep	340704	Synthetic Precipitation Leaching Procedure (EPA Method 1312)
115.	Metals Prep	340705	California Waste Extraction Test (CAL WET)(California Code of Regulations, Title 22, Chapter 11, Appendix II)
116.	Mold	350306	Preparation, Processing, and Analysis of Spore Traps
117.	Mold	350307	Processing of Fungal Andersen Samples for Quantification
118.	Mold	350308	Fungal Quantification
119.	Mold	350309	Processing RODAC Fungal & Bacterial Plates for Quantification
120.	Mold	350310	Preparation, Processing and Analysis of Swabs and Tape Lifts for Direct Exam
121.	Mold	350311	Viable Mold Spore ID from Culture Plates
122.	Mold	350312	Mold QA/QC
123.	Mold	350313	Mold Laboratories' Safety and Housekeeping
124.	Mold	350314	Processing of Bacterial Swabs, Bulk, and Dust Samples for the Presence/Absence of Coliforms/E. coli and Enterococci using Colisure and Enterolert

ATTACHMENT V- LABORATORY SOP LIST (CONTINUED)

	Department	Number	Title
125.	Mold	350319	Processing of Bacterial Andersen Samples for Quantification
126.	Mold	350334	Microscope Usage
127.	Mold	350335	Non-viable Fungal Spore Identification
128.	Mold	350342	Processing of Water from Sprinkler Systems, Water and Petroleum Wells for Presence/Absence and Determination of Potential Iron Related Bacteria, Sulfate Reducing Bacteria, Slime Forming Bacteria, and Acid Preoducing Bacteria by BART(TM) Testing
129.	Mold	350347	Processing of Bacterial Swabs, Bulk, Dust and Water Samples for Quantification
130.	Mold	350349	Bacterial Identifiication Using Biolog
131.	Mold	350352	Anaerobic Plate Count: Pour Plate Method (SM 9215B Modified)
132.	Mold	350367	LabConco Flaskscrubber Operation and Maintenance
133.	Mold	350370	Preparation of Culture Media
134.	Mold	350371	Operation, Calibration, and Maintenance of the Autoclave in the Mold Laboratory
135.	Mold	350379	Laboratory Maintenance of Bacterial and Fungal Reference Cultures in the Mold Laboratory Maintenance
136.	Organic Extractions	330702	Separatory Funnel Liquid-Liquid Extraction (EPA Methods 3510C & 625)
137.	Organic Extractions	330702 A	Separatory Funnel Liquid-Liquid Extraction for Wisconsin/Minnesota Samples (EPA Method 3510C, SW-846 Update III, Revision 3, Dec. 1996)
138.	Organic Extractions	330702 B	Reduced Volume Separatory Funnel Liquid-Liquid Extraction (EPA Methods 3510C, 625, 608, FL PRO)
139.	Organic Extractions	330702 B OH	RV Separatory Funnel Liquid-Liquid Extraction 3510C
140.	Organic Extractions	330702 OH	Separatory Funnel Liquid-Liquid Extraction 3510C
141.	Organic Extractions	330707	Microwave Extraction (EPA Method 3546)
142.	Organic Extractions	330707 OH	Microwave Extraction (3546)
143.	Organic Extractions	330708	Buchi Syncore Concentration System
144.	Organic Extractions	330708 OH	Buchi Syncore Concentration System
145.	Organic Extractions	330709	Microextraction Procedure (3511)
146.	Organic Extractions	330709 OH	Microextraction Procedure (EPA Method 3511)
147.	Organic Extractions	330739	Silica Gel Cleanup (330739)
148.	Organic Extractions	330740	3665A Sulfuric Acid Clean Up (EPA Method 3665A)
149.	Organic Extractions	330740 OH	Sulfuric Acid Cleanup (EPA Method 3665A)
150.	Organic Extractions	330741	3660C Sulfur Clean up
151.	Organic Extractions	330741 OH	3665A Sulfur Clean up
152.	Organic Extractions	330754	Waste Dilution for Semivolatile Analysis (EPA Method 3580A)
153.	Organic Extractions	330755	PCBs in Oil for Progress Energy
154.	Organic Extractions	330770 A	TPH/O&G- Soxhlet extraction using Hexane
155.	Organic Extractions	330771	n-Hexane Oil and Grease Extraction by SPE
156.	Organic Extractions	330771 A	n-Hexane Oil and Grease Extraction by SPE for South Carolina
157.	Quality	010100	Writing, Revising, and Maintaining Standard Operating Procedures
158.	Quality	010102	Ethics, Data Integrity, and Confidentiality

ATTACHMENT V- LABORATORY SOP LIST (CONTINUED)

	Department	Number	Title
159.	Quality	010103	Document Control and Distribution
160.	Quality	010103 OH	Document Control and Distribution
161.	Quality	010104	Internal Audits
162.	Quality	010105	Management Review
163.	Quality	030201	Data Handling and Reporting
164.	Quality	030205	Technical Training and Personnel Qualifications
165.	Quality	030206	Method Detection Limits (MDL), Limits of Detection (LOD) and Limits of Quantitation (LOQ)
166.	Quality	030207	Generation of Control Limits
167.	Quality	030208	Corrective and Preventive Action
168.	Quality	030211	Method Validation
169.	Quality	030212	Proficiency Testing Program
170.	Quality	030215	Manual Integration
171.	Quality	030215 OH	Manual Integration Procedure
172.	Quality	030216	Spreadsheet Validation
173.	Quality	030221	Measurement of Uncertainty
174.	Quality	030225	Use of Accreditation Symbols
175.	Quality	030226	Requirements for Suppliers Providing Calibration Services
176.	Quality	030231	Standards Recertification
177.	Quality	030233	Significant Figures and Rounding of Data
178.	Quality	030235	Sample Dilution Policy
179.	Radioactivity	360401	Radioactive Sample Receiving, Handling, and Shipping
180.	Radioactivity	360402	Survey Meter Source Checking
181.	Radioactivity	360403	Radiation and Contamination Surveys
182.	Radioactivity	360404	Sample Control of Licensed Material for WET Analyses
183.	Radioactivity	360501	Basic Radiation Safety Training
184.	Safety	030217	Emergency Management Plan
185.	Safety	030218	Fume Hood Usage
186.	Safety	030219	Spill Prevention and Control
187.	Safety	030302	Environmental Sustainability & Pollution Prevention
188.	Safety	030303	Lockout/Tagout
189.	Safety	030305	Accident Investigation and Root Cause Analysis Plan
190.	Safety	030306	Employee Monitoring for Solvent Exposure
191.	Safety	030308	Medical Screening and Surveillance
192.	Safety	030309	Waste Management Plan
193.	Safety	030310	Safety and Health Program and Training Requirements
194.	Safety	030311	Waste Neutralization
195.	Safety	030312	ESC Contractor Safe Work Practices Agreement
196.	Safety	030314	Chemical Hygiene Plan
197.	Safety	060107	Proper Use of the ESC Motorized Utility Carts
198.	Semivolatiles	330317	Sulfolane (Modified EPA Method 8270C/D)

ATTACHMENT V- LABORATORY SOP LIST (CONTINUED)

	Department	Number	Title
199.	Semivolatiles	330318	Organonitrogen and Organophosphorus Pesticides by Gas Chromatography (EPA Methods 8141B, 614, 622, and 1657)
200.	Semivolatiles	330319	THAA's
201.	Semivolatiles	330320	Chlorinated Herbicides by Gas Chromatography (Methods 8151A, 615 & 1658)
202.	Semivolatiles	330320 OH	Chlorinated Herbicides by Gas Chromatography (Method 8151A)
203.	Semivolatiles	330322	Polynuclear Aromatic Hydrocarbons by HPLC (EPA 8310, EPA 610, SM 6440B)
204.	Semivolatiles	330323	Nitroaromatics and Nitramines by High Performance Liquid Chromatography (HPLC) - EPA Methods 8330A & 8330B
205.	Semivolatiles	330343	Polychlorinated Biphenyls (PCBS) by Gas Chromatography (Soil, Water & Oil) (EPA Methods 608, 8082, & 8082A, SM 6431B)
206.	Semivolatiles	330343 OH	8082 PCB's
207.	Semivolatiles	330344	Pesticides by Gas Chromatography (EPA Methods 608, 8081A, 8081B, SM 6630C)
208.	Semivolatiles	330344 OH	Pesticides and PCBS by Gas Chromatography (608 and 8081A)
209.	Semivolatiles	330345	Semi-volatile Organics by Gas Chromatography/Mass Spectrometry using Capillary Column (EPA Methods 8270C, EPA 8270D, EPA Method 625, SM 6410B), Including Provisions for Analysis in SIM Mode
210.	Semivolatiles	330345 OH	Semi-volatile Organics by GC/MS using Capillary Column
211.	Semivolatiles	330346	EDB and DBCP by GC/ECD (EPA Methods 504.1 & 8011)
212.	Semivolatiles	330346 OH	EDB and DBCP by GC/ECD (EPA Method 8011)for Ohio VAP
213.	Semivolatiles	330348	507 NP Pesticides in Drinking Water by GC NPD
214.	Semivolatiles	330350 A	Diesel Range Organics/Total Petroleum Hydrocarbons (C10 to C28) by Gas Chromatography With #2 Diesel Fuel (EPA Methods 8015B/C/D)
215.	Semivolatiles	330352	Method for Determination of Extractable Petroleum Hydrocarbons BY GC/FID With 1:1 Diesel/Motor Oil – Modified 8015B, 8015C & 8015D with provisions for: AZ, CA, IN (ERO), ND (TEH/TEM – client specific), OH, TN, and Waste Oil Analysis
216.	Semivolatiles	330352 OH	Extractable Petroleum Hydrocarbons - Ohio
217.	Semivolatiles	330353	Method for the Determination of Extractable Petroleum Hydrocarbons (EPH)(Based on MA EPH for NC, LA, MT, CT, NJ, and WA)
218.	Semivolatiles	330355	Analysis of Petroleum Range Organics by GC-FID (FL PRO, CT ETPH Methods)
219.	Semivolatiles	330356	Texas Natural Resource Conservation Commission - Total Petroleum Hydrocarbons (TNRCC 1005 and 1006)
220.	Semivolatiles	330358	Method for the determination if Extractable Petroleum Hydrocarbons by GC/FID (IDNR OA-2 and NWTPH-Dx, Including HCID by Modified EPA Method 8015)
221.	Semivolatiles	330359	AK102/AK103
222.	Semivolatiles	330360	Analysis of Wisconsin/Minnesota Petroleum-Range Organics by GC-FID
223.	Semivolatiles	330361	Glycols by GC/FID (EPA Method 8015B/C/D-Modified))
224.	Semivolatiles	330376	Kansas Method for Determination of MRH and HRH

ATTACHMENT V- LABORATORY SOP LIST (CONTINUED)

Department	Number	Title
225. Semivolatiles	330377	Multi-Increment Sampling
226. Volatiles	330351	BTEX (Method 8021B, 602, SM6200C 2th) and Gasoline Range Organics (Methdo 8015B, 8015C, 8015D) by GC (with provisions for Calif-Lo, NWTPH-Gx, OA1, WI GRO (synthetic), Wyoming LAUST Req., GRO Luoisiana, AK101 GRO)
227. Volatiles	330351 OH	BTEX and Gasoline Range Organics by Gas Chromatography - Oh VAP
228. Volatiles	330354	Method for the Determination of Volatile Petroleum Hydrocarbons (VPH) (Based on MA VPH for NC, LA, CT, MT, and KS)
229. Volatiles	330357	Volatile Organic Compounds (GRO by GCMS) (EPA Methods 8260B, 8015B, 8015C, 8015D)
230. Volatiles	330363	Volatile Organic Compounds by GC/MS (EPA 8260B, 8260C, 624, and SM 6200B)
231. Volatiles	330363 OH	Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry 8260A/B Ohio VAP
232. Volatiles	330364	Measurement of Purgeable Organic Compounds in Water by Capillary Column Gas Chromatography/Mass Spectrometry (EPA Method 524.2, Supplement III, Revision 4.1, Aug. 1995)
233. Volatiles	330365	Volatile Organic Compounds Screening using the RAE Systems Photoionization Gas Detector Model MiniRAE 3000
234. Volatiles	330751	Closed System Purge-and-Trap and Extraction for Volatile Organics in Soil and Waste Samples (EPA Method 5035A)
235. Volatiles	330751 OH	5035 Closed System Purge and Trap and Extraction for VOC's in Soil for Ohio VAP
236. Volatiles	330752	Purge and Trap for Aqueous Samples (EPA 5030B, SW846 Update III)
237. Volatiles	330752 OH	5030B Purge and Trap for Ohio VAP
238. Wet Chemistry	340300	Acidity (SM 2310B)
239. Wet Chemistry	340301	Total Alkalinity, Manual and Automated (Titration)(SM 2320B)
240. Wet Chemistry	340302	Alkalinity (Methyl Organge) in Surface and Waste Waters - Lachat Quick Chem 8500 (EPA Method 310.2)
241. Wet Chemistry	340305	Total (Residual) or Free Chlorine (DPD) (SM4500-Cl-G)
242. Wet Chemistry	340307 A	Cyanide- All Forms, Colorimetric, Automated UV using Lachat FIA (EPA Methods 9010C, 9012B, 9013, 9013A, 335.4 and SM 4500-CN C, E, G, I)
243. Wet Chemistry	340307 A OH	Total Cyanide, Colorimetric, Automated UV using Lachat FIA (EPA Method 9012B)
244. Wet Chemistry	340307 C	Cyanide- OI Method
245. Wet Chemistry	340309	Chemical Oxygen Demand
246. Wet Chemistry	340310	Color by Visual Comparison (SM2120B)
247. Wet Chemistry	340313	Density (Specific Gravity)
248. Wet Chemistry	340317	Total Hardness (mg/l as CaCO3) - (Titrimetric)
249. Wet Chemistry	340317 A	Total Hardness by Lachat Method 130.1
250. Wet Chemistry	340318 B	Hexavalent Chromium (Colorimetric) Water 7196A
251. Wet Chemistry	340318 B OH	Hexavalent Chromium (Colorimetric) Water 7196A

ATTACHMENT V- LABORATORY SOP LIST (CONTINUED)

Department	Number	Title
252. Wet Chemistry	340318 C	Hexavalent Chromium (Colorimetric) in Solid Materials (EPA Methods 7196A and 3060A)
253. Wet Chemistry	340319	Determination of Elements in Water and Solids by Ion Chromatography (EPA Methods 300.0, 300.1, 9056, 9056A, and SM 4110B)
254. Wet Chemistry	340319 OH	Ion Chromatography - Anions OH VAP
255. Wet Chemistry	340325	MBAS (Methylene Blue Active Substances)
256. Wet Chemistry	340327 A	Ammonia, Phenolate (Lachat)
257. Wet Chemistry	340327 B	Ammonia, Phenolate (OI)
258. Wet Chemistry	340328	Organic Nitrogen
259. Wet Chemistry	340331	Threshold Odor Test (EPA Method 140.1, Standard Methods 2150B)
260. Wet Chemistry	340333 A	Nitrate/Nitrite (OI Autoanalyzer)
261. Wet Chemistry	340334	Paint Filter Liquids Test (EPA Method 9095B)
262. Wet Chemistry	340335	pH, Manual or Automated (EPA Methods 150.1, 9040B, 9040C, 9045C and 9045D; SM 4500H+ B) Including Corrosivity for Solids and Liquids using these Methods
263. Wet Chemistry	340336 A	Total Phenol - 4AAP (Lachat) SM5530D, EPA Methods 420.1, 420.2, & 9066
264. Wet Chemistry	340336 A OH	Phenol - 4AAP (Lachat Autoanalyzer)
265. Wet Chemistry	340338 A	Total Phos.(361.2,4500P-B/F) Colorimetric
266. Wet Chemistry	340338 A OH	Total Phos.(361.2,4500P-B/F) Colorimetric
267. Wet Chemistry	340338 B	Orthophosphate (365.2,4500P-E) Colorimetric
268. Wet Chemistry	340338 C	Total Phosphorus in Groundwater/Wastewater (EPA 365.4) (Colorimetric/Block Digestor)
269. Wet Chemistry	340339	Water Reactivity (SW-846, Chapter 7, Section 7.3 & 40 CFR 261.23)
270. Wet Chemistry	340342	Specific Conductance, Manual (Conductivity) (EPA Methods 120.1 & 9050A and SM2510B)
271. Wet Chemistry	340344 A	Sulfide (Colorimetric Methylene Blue) (376.2)
272. Wet Chemistry	340344 B	Sulfide Acid-soluble,and acid-insoluble Method 9034
273. Wet Chemistry	340345	Sulfite
274. Wet Chemistry	340346	Settleable Solids
275. Wet Chemistry	340347	Total Dissolved Solids (EPA Method 160.1, SM 2540C)
276. Wet Chemistry	340348	Total Suspended Solids (SM 2540D)
277. Wet Chemistry	340349	Total Solids and/or Percent Moisture (SM 2540B & 2540G)
278. Wet Chemistry	340350	Total Volatile Solids
279. Wet Chemistry	340352 A	Total Kjeldahl Nitrogen by Flow Injection Analysis Colorimetry (EPA Method 351.2, SM4500-Norg A/C/D)
280. Wet Chemistry	340354	Turbidity
281. Wet Chemistry	340356 A	Total Organic Carbon (TOC) & Total Inorganic Carbon (TIC) Using Shimadzu 5000A (EPA Methods 415.1 & 9060A, SM 5310B) – Groundwater and Wastewater Only
282. Wet Chemistry	340356 B	TOC for Drinking Water only
283. Wet Chemistry	340356 C	Total Organic Carbon In Soils (loss of weight on ignit.

ATTACHMENT V- LABORATORY SOP LIST (CONTINUED)

	Department	Number	Title
284.	Wet Chemistry	340357	Ignitability
285.	Wet Chemistry	340359	Ultraviolet Absorbing Organic Constituents (SM 5910B)
286.	Wet Chemistry	340360	Total Organic Halides (TOX) (EPA Methods 9020B & 450.1, SM 5320B)
287.	Wet Chemistry	340361	Ferrous Iron, SM-3500-Fe-B
288.	Wet Chemistry	340362	Heat of Combustion
289.	Wet Chemistry	340365	Particles Not Otherwise Regulated, Total (PNOR) NIOSH 0500
290.	Wet Chemistry	340366	Oxidation Reduction Potential
291.	Wet Chemistry	340367	Extractable Organic Halides (EOX) (EPA Method 9023)
292.	Wet Chemistry	340368	Total Organic Carbon in Soil (Walkley-Black)
293.	Wet Chemistry	340369	Carbon Dioxide by Calculation
294.	Wet Chemistry	340370	Perchlorate in DW
295.	Wet Chemistry	340371	Chlorine in Oil (ASTM D808-00)
296.	Wet Chemistry	340372	Hexavalent Chromium in Water by IC (EPA Methods 7199, 218.6 and 218.7, SM 3500Cr C/E)
297.	Wet Chemistry	340372 A	Hexavalent Chromium in Soil by IC (EPA Methods 7199 and 3060A)
298.	Wet Chemistry	340373	Organic Matter (FOM) and Fractional Organic Carbon (FOC) (ASTM D2974-07A)
299.	Wet Chemistry	340374	Total Volatile Dissolved Solids (TVDS)
300.	Wet Chemistry	340376	Total Organic Halides in Oil (EPA 9076)
301.	Wet Chemistry	340377	Manual Nitrocellulose Analysis (US Army Bioengineering Research and Development Lab, Document #ADA0670871) - Modified
302.	Wet Chemistry	340378	Volatile Suspended Solids
303.	Wet Chemistry	340379	Guanidine Nitrate by Ion Chromatography (EPA Methods 9056, 9056A-Mod)
304.	Wet Chemistry	340381	Ash in Petroleium Products (ASTM D482-07)
305.	Wet Chemistry	340394	Salinity

ATTACHMENT VI- ESC-MT. JULIET LABORATORY CERTIFICATION LIST

SCOPE AND APPLICATION CERTIFICATES ARE MAINTAINED AND FILED IN THE LOCAL QUALITY DEPARTMENT

State/Agency	Certificate Number	Expiration Date/Status	Certified Programs	Approved Programs[6]	Cert.Type	Cert. Authority
Alabama	40660	6/30/2018	DW, DW-Rad	WW, RCRA, UST	Reciprocity	TN
Alaska	UST-080	1/11/2018	UST	UST	AK	AK
Arizona	AZ0612	6/25/2018	AIR, SDW, WW, SW, SDW-Rad, WW-Rad, SW-Rad, SDW-Crypto, SDW-Micro		Audit	AZ
Arkansas	88-0469	1/21/2018	NPW, SCM, Aquatic Toxicity		NELAP	NJ
California	2932	8/31/2018	NPW, HW		NELAP	NJ
Colorado	None	3/31/2018	DW, DW-Micro	WW, RCRA, UST	Reciprocity	TN
Connecticut	PH-0197	9/30/2019	DW, NPW, SCM(RCRA)		Reciprocity	NJ
Florida	E87487	6/30/2018	DW, Crypto, NPW, Aquatic Toxicity, SCM, Air, NPW-Micro		NELAP	NJ
Georgia DW	923	10/23/2018	DW, Crypto, Micro		Reciprocity	TN
Georgia	None	6/30/2018	NPW, SCM, Air, Aquatic Toxicity, NPW-Micro, Rad		NELAP	NJ
Idaho	TN00003	6/30/2018	DW	WW, RCRA, UST	NELAP	NJ
Illinois	200008	11/30/2017	DW, NPW, SCM		NELAP	NJ
Indiana	C-TN-01	6/16/2019	DW	WW, RCRA, UST	Reciprocity	TN
Iowa	364	5/1/2018	SDWA, WW, UST, SW/CS, SDWA-Rad, WW-Rad		Audit	IA
Kansas	E-10277	10/31/2017	DW, NPW, Aquatic Toxicity, SCM, DW-Rad, NPW-Rad, SCM-Rad		NELAP	NJ
Kentucky DW	90010	12/31/2017	DW, DW-Rad, DW-Micro, Crypto	RCRA	Reciprocity	TN
Kentucky UST	16	11/30/2017	UST		Audit	A2LA
Kentucky WW	90010	12/31/2017	WW, WW-Micro, WW-Rad		Reciprocity	NJ
Louisiana	Agency ID 30792	6/30/2018	NPW, SCM, Air, Aquatic Toxicity, NPW-Rad, SCM-Rad		NELAP	NJ
Louisiana DW	LA150002	12/31/2017	DW		NELAP	NJ
Maine	TN0002	7/5/2019	DW, NPW, Crypto, Air, SCM		Reciprocity	TN, NJ
Maryland	324	12/31/2017	DW		Reciprocity	TN
Massachusetts	M-TN003	6/30/2018	DW, NPW	RCRA, UST	Reciprocity	TN
Michigan	9958	6/16/2019	DW	WW, RCRA, UST	Reciprocity	TN
Minnesota	047-999-395	12/31/2017	NPW, SCM, Air		Audit	MN
Mississippi	None	6/16/2019	DW	WW, RCRA, UST	Reciprocity	NJ
Missouri	340	6/16/2019	DW	WW, RCRA, UST	Reciprocity	NJ
Montana	CERT0086	1/1/2018	DW	WW, RCRA, UST	Reciprocity	TN
Nebraska	NA	6/30/2018	DW	WW, RCRA, UST	Reciprocity	TN
Nevada	TN-03-2002-34	7/31/2018	WW, DW, SCM, Crypto, Aquatic Toxicity		NELAP	NJ
New Hampshire	2975	5/20/2018	DW, Air, Crypto, NPW, SCM, DW-Micro, DW-Rad, NPW-Rad		NELAP	NJ
New Jersey - NELAP	TN002	6/30/2018	DW, NPW, SCM, Air, Crypto, Aquatic Toxicity, DW-Micro, NPW-Micro, DW-Rad, NPW-Rad, SCM-Rad		NELAP	NJ
New Mexico	None	Renewal		WW, RCRA, UST	NELAP	NJ

State/Agency	Certificate Number	Expiration Date/Status	Certified Programs	Approved Programs[6]	Cert.Type	Cert. Authority
New York	11742	4/1/2018	DW, WW, SCM, Air		NELAP	NJ
North C. Aquatic Tox	41	11/1/2018	Aquatic Toxicity		Audit	NC
North Carolina DW	DW21704	7/31/2018	DW, DW-Micro, Crypto		Audit	NC
North Carolina	Env375	12/31/2017	WW, WW-Micro		Audit	NC
North Dakota	R-140	6/30/2018	DW, WW, RCRA, DW-Rad, NPW-Rad, SCM-Rad		Reciprocity	TN, WI
Ohio EPA/VAP	CL0069	6/26/2019	DW, WW, SCM		Audit	OH
Oklahoma	9915	8/31/2018	NPW, SCM, Air,DW-Rad, NPW-Rad, SCM-Rad		NELAP	NJ
Oregon	TN200002	1/15/2018	DW, WW, SCM		NELAP	NJ
Pennsylvania	68-02979	12/31/2017	DW, DW-Micro, NPW, SCM, Air, Aquatic Toxicity, Crypto, DW-Rad, NPW-Rad, SCM-Rad		NELAP	NJ
Rhode Island	221	12/30/2017	DW, Crypto, DW-Micro, NPW, SCM, Aquatic Toxicity	WW, RCRA, UST	Reciprocity	TN
South Carolina	84004	6/30/2018	DW, NPW		NELAP	NJ
South Dakota	Pending	1/0/1900	0			
Tennessee DW	2006	6/16/2019	DW, DW-Rad	WW, RCRA, UST	Audit	TN
Tennessee DW Micro	2006	10/23/2018	DW Micro		Audit	TN
Texas - Env.	T 104704245-07-TX	10/31/2018	DW, DW-Micro, NPW, NPW-Micro, SCM, Air, Aquatic Toxicity, DW-Rad, NPW-Rad, SCM-Rad		Reciprocity	NJ
Texas - Mold	LAB0152	3/10/2019	MOLD		NA	TX
Utah	6157585858	7/31/2018	Air, DW, NPW, SCM, Aquatic Toxicity, DW-Rad, NPW-Rad, SCM-Rad		NELAP	NJ
Vermont	VT2006	1/5/2018	DW	WW, RCRA, UST	Reciprocity	TN
Virginia VELAP	460132	6/14/2018	Air, DW, Crypto, DW-Micro, NPW, NPW-Micro, SCM, Aquatic Toxicity, Crypto, DW-Rad, NPW-Rad, SCM-Rad		NELAP	NJ
Washington	C1915	8/19/2018	Air, DW, NPW, SCM, Aquatic Toxicity		Audit	A2LA
West Virginia	233	2/28/2018	NPW, SCM, Aquatic Toxicity		Audit	WV
West Virginia Crypto	9966 M	12/31/2017	DW		Reciprocity	NJ
Wisconsin	998093910	8/31/2018	NPW, SCM		Audit	WI
Wyoming	A2LA	11/30/2017	WW, RCRA, UST	WW, RCRA	Audit	A2LA
A2LA[1]	1461.01	11/30/2017	DW, WW, SCM, KY-UST, WY-STR, AIR, Micro, Aquatic Toxicity, Mold, Rad		Audit	A2LA
AIHA-LAP[2]	100789	8/1/2018	EMLAP[4]		Audit	AIHA
DOD	1461.01	11/30/2017	NPW, SCM, Air, Aquatic Toxicity, Micro, Rad		Audit	A2LA
EPA[8]	TN00003	None	Cryptospiridium		Audit	EPA
EPA[8] Region 8		6/16/2019	Drinking Water		Reciprocity	TN
USDA[5]	S-67674	9/3/2018	Quarantine Permit		Audit	USDA

(1) A2LA = American Association for Laboratory Accred.
(2) AIHA-LAP = American Industrial Hygiene Association Lab Accred. Program
(3) NELAP = National Environmental Laboratory Accred. Program
(4) EMLAP = Environmental Microbiology Laboratory Accreditation Program
(5) USDA = United States Department of Agriculture
(6) Approved Programs = The state does not have a formal certification program.
(7) Pending = The state is processing our application.
(8) EPA = Environmental Protection Agency

ATTACHMENT VI- ESC-DECATUR LABORATORY CERTIFICATION LIST
SCOPE AND APPLICATION CERTIFICATES ARE MAINTAINED AND FILED IN THE LOCAL QUALITY DEPARTMENT

State/Agency	Certificate Number	Expiration Date/Status	Certified Programs	Cert.Type	Cert. Authority
Alabama	40160	2/28/2019	DW-Metals, Inorganics, Disinfection Byproducts & Bacteria	Audit	AL
Florida	E871078	6/30/2018	DW-Metals, Inorganics, Disinfection Byproducts & Bacteria	NELAP	FL
L.A.B.	L2239	2/3/2020	DW-Metals, Inorganics, Disinfection Byproducts & Bacteria	Audit	L.A.B.

ATTACHMENT VI- ESC-DAVIS LABORATORY CERTIFICATION LIST
SCOPE AND APPLICATION CERTIFICATES ARE MAINTAINED AND FILED IN THE LOCAL QUALITY DEPARTMENT

State/Agency	Certificate Number	Expiration Date/Status	Certified Programs	Cert.Type	Cert. Authority
California	2961	12/31/2018	NPW-Volatiles, HW-Volatiles	Audit	CA
Minnesota	006-999-465	12/31/2017	NPW-Volatiles, HW-Volatiles	Reciprocity	OR
North Dakota	R-214	1/29/2018	NPW-Volatiles, HW-Volatiles	Reciprocity	OR
Oregon	CA300002	1/29/2019	NPW-Volatiles, HW-Volatiles	NELAP	OR
Washington	C926	11/6/2018	NPW-Volatiles, HW-Volatiles	Reciprocity	OR

ATTACHMENT VII- METHOD HOLD TIME, CONTAINER AND PRESERVATION GUIDE

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	$\leq 6^oC$	14 Days
Acid Volatile Sulfide	Draft EPA 1629	Solid	8oz Glass	$\leq 6^oC$	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)	$\leq 6^oC$	14 Days
Alkylated PAHs		Water	1L Amber Glass	$\leq 6^oC$; pH<2 1:1 HCl (optional)	14/40 Days preserved; 7/40 Days unpreserved
Alkylated PAHs		Solid	8oz Glass	$\leq 10^oC$	1 Year/40 Days
Anions (Br, Cl, F, NO_2, NO_3, o-Phos, SO_4, bromate, chlorite, chlorate)	300.0/300.1/SM4110 B	Water	Plastic/Glass	$\leq 6^oC$; 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	$\leq 6^oC$	All analytes 28 days except: NO_2, NO_3, o-Phos (48 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	$\leq 6^oC$	48 hours
Aromatic and Halogenated Volatiles (see note 1)	8021	Solid	5035 vial kit	See note 1	14 days

Parameter	Method	Matrix	Container	Preservative	Max Hold Time
Aromatic and Halogenated Volatiles	602/8021	Water	40mL vials	pH<2 HCl; ≤ 6°C; $Na_2S_2O_3$ 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; $Na_2S_2O_3$	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; $Na_2S_2O_3$ 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	$Na_2S_2O_3$, Monochloroacetic acid pH <3; ≤ 6°C	28 Days
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

Parameter	Method	Matrix	Container	Preservative	Max Hold Time
Chlorine, Residual	SM4500Cl-D,E,G/330.5/Hach 8167	Water	Plastic/Glass	None	15 minutes
Chlorophyll	SM10200H	Water	Opaque bottle or aluminum foil	$\leq 6^oC$	48 Hours to filtration
COD	SM5220C, D/410.4/Hach 8000	Water	Plastic/Glass	pH<2 H_2SO_4; $\leq 6^oC$	28 Days
Coliform, Fecal	SM9222D	Water	100mL Plastic	$\leq 10^oC$; $Na_2S_2O_3$	8 Hours
Coliform, Fecal	SM9222D	Solid	100mL Plastic	$\leq 10^oC$; $Na_2S_2O_3$	24 Hours
Coliform, Fecal	SM9221E	Water	100mL Plastic	$\leq 10^oC$; $Na_2S_2O_3$	8 Hours
Coliform, Fecal	SM9221E	Solid	100mL Plastic	$\leq 10^oC$; $Na_2S_2O_3$	24 Hours
Coliform, Total	SM9222B	Water	100mL Plastic	$\leq 10^oC$; $Na_2S_2O_3$	8 Hours
Coliform, Total	SM9221B	Solid	100mL Plastic	$\leq 10^oC$; $Na_2S_2O_3$	8 Hours
Coliform, Total, Fecal and E. coli	Colilert/ Quanti-tray	Water	100mL Plastic	$\leq 10^oC$; $Na_2S_2O_3$	8 Hours
Coliform, Total and E. coli	SM9223B	Drinking Water	100mL Plastic	$\leq 10^oC$; $Na_2S_2O_3$	30 Hours
Color	SM2120B,E	Water	Covered Plastic/Acid Washed Amber Glass	$\leq 6^oC$	48 Hours
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$\geq$12 NaOH; $\leq 6^oC$; 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	$\leq 6^oC$	14/40 Days
Diesel Range Organics- Alaska DRO	AK102	Water	1L Glass	pH<2 HCl; $\leq 6^oC$	14/40 Days
Diesel Range Organics- TPH DRO	8015	Solid	8oz Glass Jar	$\leq 6^oC$	14/40 Days
Diesel Range Organics- TPH DRO	8015	Water	1L Amber Glass	$\leq 6^oC$; $Na_2S_2O_3$ if Cl present	7/40 Days
Diesel Range Organics- TPH DRO	8015	Tissue	1L Amber Glass	$\leq$ - 10^oC	1 Year if frozen/40 Days
Diesel Range Organics- TPH DRO	TO-17	Air	Thermal desorption tubes via SKC Pocket Pumps or equivalent	$\leq 6^oC$ but above freezing	28 Days

Parameter	Method	Matrix	Container	Preservative	Max Hold Time
Diesel Range Organics- NwTPH-Dx	Nw-TPH-Dx	Solid	8oz Glass Jar	$\leq 6^oC$	14/40 Days
Diesel Range Organics- NwTPH-Dx	Nw-TPH-Dx	Water	1L Amber Glass	pH <2 HCl; $\leq 6^oC$	14/40 Days; 7 Days from collection to extraction if unpreserved
Diesel Range Organics- Wisconsin DRO	WI MOD DRO	Solid	Tared 4oz Glass Jar	$\leq 6^oC$	10/47 Days
Diesel Range Organics- Wisconsin DRO	WI MOD DRO	Water	1L Amber Glass	$\leq 6^oC$; pH <2 HCl	14/40 Days
Dioxins and Furans	1613B	Solid	8oz Glass	$\leq 6^oC$	1 year
Dioxins and Furans	1613B	Water	1L Amber Glass	$\leq 6^oC$; $Na_2S_2O_3$ if Cl present	1 year
Dioxins and Furans	1613B	Fish/ Tissue	Aluminum foil	$\leq 6^oC$	1 year
Dioxins and Furans	8290	Water	1L Amber Glass	$\leq 6^oC$; $Na_2S_2O_3$ if Cl present	30/45 Days
Dioxins and Furans	8290	Solid	8oz Glass	$\leq 6^oC$	30/45 Days
Dioxins and Furans	8290	Fish/ Tissue	Not specified	$< -10^oC$	30/45 Days
Dioxins and Furans	TO-9	Air	PUF	None	7/40 Days
Diquat/Paraquat	549.2	Water	Amber Plastic	$\leq 6^oC$; $Na_2S_2O_3$	7/21 Days
EDB/DBCP (8011) EDB/DBCP/1,2,3-TCP (504.1)	504.1/8011	Water	40mL vials	$\leq 6^oC$; $Na_2S_2O_3$ if Cl present	14 Days
Endothall	548.1	Water	Amber Glass	$\leq 6^oC$; $Na_2S_2O_3$	7/14 Days
Enterococci	EPA 1600	Water	100mL Plastic	$\leq 10^oC$	8 Hours
Enterococci	Enterolert	Water	100mL Plastic	$\leq 10^oC$; $Na_2S_2O_3$	8 Hours
Explosives	8330/8332	Water	1L Amber Glass	$\leq 6^oC$	7/40 Days
Explosives	8330/8332	Solid	8oz Glass Jar	$\leq 6^oC$	14/40 Days
Extractable Petroleum Hydrocarbons (aliphatic and aromatic)	NJ EPH	Water	1L Amber Glass	pH < 2 HCl; $\leq 6^oC$	14/40 Days
Extractable Petroleum Hydrocarbons (aliphatic and aromatic)	NJ EPH	Solid	4oz Glass Jar	$\leq 6^oC$	14/40 Days
Extractable Petroleum Hydrocarbons (aliphatic and aromatic)	MA-EPH	Water	1L Amber Glass	pH<2 HCl; $\leq 6^oC$	14/40 Days
Extractable Petroleum Hydrocarbons (aliphatic and aromatic)	MA-EPH	Solid	4oz Glass Jar	$\leq 6^oC$	7/40 Days

Parameter	Method	Matrix	Container	Preservative	Max Hold Time
Fecal Streptococci	SM9230B	Water	100mL Plastic	$\leq 10^oC$; $Na_2S_2O_3$	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	$\leq 6^oC$; 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	$\leq 6^oC$; HCl	14 Days
Gasoline Range Organics (C3-C10)	8260B modified	Solid	4oz Glass Jar	$\leq 6^oC$	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; $\leq 6^oC$	14 Days
Gasoline Range Organics- NwTPH-Gx	Nw-TPH-Gx	Water	40mL vials	pH<2 HCl; $\leq 6^oC$	7 Days unpreserved; 14 Days preserved
Gasoline Range Organics- NwTPH-Gx	Nw-TPH-Gx	Solid	40mL vials	$\leq 6^oC$; packed jars with no headspace	14 Days
Gasoline Range Organics- Wisconsin GRO	WI MOD GRO	Water	40mL vials	pH<2 HCl; $\leq 6^oC$	14 Days
Gasoline Range Organics- Wisconsin GRO	WI MOD GRO	Solid	40mL MeOH vials	$\leq 6^oC$ in MeOH	21 Days
Glyphosate	547	Water	Glass	$\leq 6^oC$; $Na_2S_2O_3$	14 Days (18 Months frozen)
Grain Size	ASTM D422	Solid	Not specified	Ambient	N/A
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

Parameter	Method	Matrix	Container	Preservative	Max Hold Time
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 Emissions	EPA 26	Air	Solutions	None	6 Months
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	$\leq -10^oC$	1 Year if frozen
Mercury, Low-Level	1631E	Solid	Glass	None	28 Days

Parameter	Method	Matrix	Container	Preservative	Max Hold Time
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	$\leq$ - 10°C	28 Days if frozen
Mercury	7471	Solid	8oz Glass Jar	$\leq$ 6°C	28 Days
Mercury	7470/245.1/245.2	Water	Plastic/Glass	pH<2 HNO_3	28 Days
Mercury	7471/245.6	Tissue	Plastic/Glass	$\leq$ - 10°C	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	$\leq$ -10°C	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 benzalkonium chloride and $\leq$ 6°C	14 Days; 7 Days 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	$\leq$ 6°C	14 Days
Methanol, Ethanol	8015 modified	Solid	2oz Glass	$\leq$ 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	$\leq$ 0°C	28 Days; ethylated distillate 48 hours
Nitrogen, Ammonia	SM4500NH3/350.1	Water	Plastic/Glass	pH<2 H_2SO_4; $\leq$ 6°C	28 Days
Nitrogen, Total Kjeldahl (TKN)	351.2	Solid	Plastic/Glass	$\leq$ 6°C	28 Days
Nitrogen, Total Kjeldahl (TKN)	SM4500-Norg/351.2	Water	Plastic/Glass	pH<2 H_2SO_4; $\leq$ 6°C	28 Days

Parameter	Method	Matrix	Container	Preservative	Max Hold Time
Nitrogen, Nitrate	SM4500-NO3/352.1	Water	Plastic/Glass	$\leq 6^oC$	24 Hours preferred
Nitrogen, Nitrate & Nitrite combination	353.2	Solid	Plastic/Glass	$\leq 6^oC$	28 Days
Nitrogen, Nitrate & Nitrite combination	SM4500-NO3/353.2	Water	Plastic/Glass	pH<2 H_2SO_4; $\leq 6^oC$	28 Days
Nitrogen, Nitrite or Nitrate separately	SM4500-NO2/353.2	Water	Plastic/Glass	$\leq 6^oC$	48 Hours
Nitrogen, Organic	SM4500-Norg/351.2	Water	Plastic/Glass	pH<2 H_2SO_4; $\leq 6^oC$	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	$\leq 6^oC$	24 Hours
Oil and Grease/HEM	1664A/SM5520B/9070	Water	Glass	pH<2 H_2SO_4 or HCl; $\leq 6^oC$	28 Days
Oil and Grease/HEM	9071	Solid	Glass	$\leq 6^oC$	28 Days
Oil Range Organics	8015	Solid	Glass	$\leq 6^oC$	14/40 Days
Oil Range Organics	8015	Water	Glass	$\leq 6^oC$	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	$\leq 6^oC$	14 Days (7 Days from extraction)
PBDEs	1614	Water	1L Amber Glass	$\leq 6^oC$	1 Year/1 Year
PBDEs	1614	Solid	Wide Mouth Jar	$\leq 6^oC$	1 Year/1 Year
PBDEs	1614	Tissue	Aluminum Foil	$\leq -10^oC$	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	$\leq 6^oC$; $Na_2S_2O_3$ if Cl present	Pest: 7/40 Days; PCB: 1 Year/1 Year
PCBs, Pesticides (OC), Herbicides	508.1	Water	Glass	Na2SO3; pH<2 HCl; $\leq 6^oC$	14/30 Days
PCBs, total as Decachlorobiphenyl	508A	Water	1L Glass, TFE lined cap	$\leq 6^oC$	14/30 Days
Perchlorate	331	Water	Plastic/Glass	$\geq$0-6^oC, field filtered with headspace	28 Days
Permanent Gases (O2, N2, CO2)	RSK-175; PM01/AM20GAx	Water	40mL vials	benzalkonium chloride and $\leq 6^oC$	14 Days
Permanent Gases by Bubble Strip	SM9/AM20GAx	Water	20cc vapor vial with stopper septum	None	14 Days

Parameter	Method	Matrix	Container	Preservative	Max Hold Time
Permanent Gases in Vapor	AM20GAx	Vapor	20cc vapor vial with flat septum	None	14 Days
Pesticides, Organochlorine (OC)	8081	Water	1L Amber Glass	$\leq 6^oC$; $Na_2S_2O_3$ if Cl present	7/40 Days
Pesticides, Organochlorine (OC)	8081	Solid	8oz Glass Jar	$\leq 6^oC$	14/40 Days
Pesticides, Organochlorine (OC)	8081	Tissue	8oz Glass Jar	$\leq -10^oC$	1 Year if frozen/40 Days
Pesticides, Organophosphorous (OP)	8141	Solid	8oz Glass Jar	$\leq 6^oC$	14/40 Days
Pesticides, Organophosphorous (OP)	8141	Water	1L Amber Glass	pH 5-8 with NaOH or H_2SO_4; $\leq 6^oC$; $Na_2S_2O_3$ if Cl present	7/40 Days
PCBs (Aroclors)	8082	Water	1L Amber Glass	$\leq 6^oC$; $Na_2S_2O_3$ if Cl present	1 Year/1 Year
PCBs (Aroclors)	8082	Solid	8oz Glass Jar	$\leq 6^oC$	1 Year/1 Year
PCBs (Aroclors)	8082	Tissue	Plastic/Glass	$\leq -10^oC$	1 Year if frozen/1 Year
PCB Congeners	1668A	Water	1L Amber Glass	$\leq 6^oC$ but above freezing	1 Year/1 Year
PCB Congeners	1668A	Solid	4-8oz Glass Jar	$\leq 6^oC$ but above freezing	1 Year/1 Year
PCB Congeners	1668A	Tissue	4-8oz Glass Jar	$\leq -10^oC$	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; $\leq 6^oC$	28 Days
Phosphorus, Orthophosphate	SM4500P/365.1/365.3	Water	Plastic	$\leq 6^oC$	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; $\leq 6^oC$	28 Days
Phosphorus, Total	365.4	Solid	Plastic/Glass	$\leq 6^oC$	28 Days
Polynuclear Aromatic Hydrocarbons (PAH)	TO-13	Air	PUF	None	7/40 Days

Parameter	Method	Matrix	Container	Preservative	Max Hold Time
Polynuclear Aromatic Hydrocarbons (PAH)	TO-17	Air	Thermal desorption tubes via SKC Pocket Pumps or equivalent	$\leq 6^oC$ but above freezing	28 Days
Polynuclear Aromatic Hydrocarbons (PAH)	8270 SIM	Solid	8oz Glass Jar	$\leq 6^oC$	14/40 Days
Polynuclear Aromatic Hydrocarbons (PAH)	8270 SIM	Water	1L Amber Glass	$\leq 6^oC$; $Na_2S_2O_3$ if Cl present	7/40 Days
Polynuclear Aromatic Hydrocarbons (PAH)	8270 SIM	Tissue	Plastic/Glass	$\leq -10^oC$	1 Year if frozen/40 Days
Purgeable Organic Halides (POX)	9021	Water	Glass; no headspace	$\leq 6^oC$	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	$\leq 6^oC$	14/40 Days
Saturated Hydrocarbons		Water	$\leq 6^oC$; pH<2 1:1 HCl (optional)	14/40 Days preserved; 7/40 Days unpreserved	$\leq 6^oC$; pH<2 1:1 HCl (optional)
Saturated Hydrocarbons		Solid	$\leq 10^oC$	1 Year/40 Days	$\leq 10^oC$
Silica, Dissolved	SM4500Si-D	Water	Plastic	$\leq 6^oC$	28 Days
Solids, Settleable	SM2540F	Water	Glass	$\leq 6^oC$	48 Hours
Solids, Total	SM2540B	Water	Plastic/Glass	$\leq 6^oC$	7 Days
Solids, Total	SM2540G	Solid	Plastic/Glass	$\leq 6^oC$	7 Days
Solids, Total (FOC, OM, Ash)	ASTM D2974	Solid	Plastic/Glass	$\leq 6^oC$	7 Days
Solids, Total Dissolved	SM2540C	Water	Plastic/Glass	$\leq 6^oC$	7 Days
Solids, Total Suspended	SM2540D/USGS I-3765-85	Water	Plastic/Glass	$\leq 6^oC$	7 Days
Solids, Total Volatile	160.4/SM2540E	Water	Plastic/Glass	$\leq 6^oC$	7 Days
Solids, Total Volatile	160.4	Solid	Plastic/Glass	$\leq 6^oC$	7 Days
Specific Conductance	SM2510B/9050/120.1	Water	Plastic/Glass	$\leq 6^oC$	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

Parameter	Method	Matrix	Container	Preservative	Max Hold Time
Stationary Source Particulates	EPA 5	Air	Filter/Solutions	None	180 Days
Sulfate	SM4500SO4/9036/9038/375.2/ASTM D516	Water	Plastic/Glass	$\leq 6^oC$	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; $\leq 6^oC$	7 Days
Sulfite	SM4500SO3	Water	Plastic/Glass	None	15 minutes
Surfactants (MBAS)	SM5540C	Water	Plastic/Glass	$\leq 6^oC$	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	$\leq 6^oC$	14 Days
Total Organic Carbon (TOC)	SM5310B,C,D/9060	Water	Glass	pH<2 H_2SO_4 or HCl; $\leq 6^oC$	28 Days
Total Organic Carbon (TOC)	9060/Walkley Black/Lloyd Kahn	Solid	Glass	$\leq 6^oC$	14 Days
Total Organic Halogen (TOX)	SM5320/9020	Water	Glass; no headspace	$\leq 6^oC$	14 Days
Total Petroleum Hydrocarbons (aliphatic and aromatic)	TPHCWG	Water	40mL vials	pH<2 HCl, no headspace, $\leq 6^oC$	7 Days
Total Petroleum Hydrocarbons (aliphatic and aromatic)	TPHCWG	Solid	Glass	$\leq 6^oC$	14 days
Tritium	906.0	Water	Glass	None	180 days
Turbidity	SM2130B/180.1	Water	Plastic/Glass	$\leq 6^oC$	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	$\leq 6^oC$	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

Parameter	Method	Matrix	Container	Preservative	Max Hold Time
Volatile Fatty Acids	AM21G	Water	40mL clear VOA vials	$\leq 6^oC$	21 Days
Volatile Fatty Acids (low level)	AM23G	Water	40mL clear VOA vials	$\leq 6^oC$ with benzalkonium chloride	14 Days
Volatile Petroleum Hydrocarbons (aliphatic and aromatic)	MA-VPH	Water	40mL vials	pH<2 HCl; $\leq 6^oC$	14 Days preserved
Volatile Petroleum Hydrocarbons (aliphatic and aromatic)	MA-VPH	Solid	4-8oz Glass Jar	$\leq 6^oC$; 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	5 days or 72 hr depending on regulatory requirement
Volatiles	TO-17	Air	Thermal desorption tubes via SKC Pocket Pumps or equivalent	$\leq 6^oC$ 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; $\leq 6^oC$; $Na_2S_2O_3$ 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	$\leq 6^oC$	14 Days
Volatiles	624	Water	40mL vials	pH<2 HCl; $\leq 6^oC$; $Na_2S_2O_3$ 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)

Parameter	Method	Matrix	Container	Preservative	Max Hold Time
Volatiles (see note 2)	524.2	Water	40mL vials (in duplicate)	pH<2 HCl; $\leq$ 6°C; Ascorbic acid or $Na_2S_2O_3$ if Cl present[2]	14 Days
Whole Oil	ASTM D3328 (prep); ASTM D5739	Product	10mL glass vials	$\leq$ 6°C	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 4°C, **and** one vial methanol preserved at $\leq$6°C **and** one container of unpreserved sample stored at $\leq$6°C.

[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.