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April 18, 2017

Ms. Addie Walker
Bureau of Land and Waste Management
SC Department of Health and Environmental Control
2600 Bull Street
Columbia, SC 29201

RECEIVED

APR 19 2017

**SITE ASSESSMENT,
REMEDIAL ACTION
REVISIONS**

Regarding: Phase II Remedial Investigation Work Plan
Shakespeare Composite Structures Site
Newberry, South Carolina
SCDHEC VCC Number 14-6271-RP

Dear Ms. Walker:

Please find attached one hard copy and one electronic copy (on compact disc) of the Phase II Remedial Investigation Work Plan (Phase II RIWP) for the Shakespeare Composite Structures Site (the Site) located in Newberry, South Carolina. This work plan is being submitted at the request of the South Carolina Department of Health and Environmental Control (SCDHEC) as a result of the January 23, 2017 meeting regarding the status of the investigative efforts at this Site and in accordance with voluntary clean-up contract (VCC) number 14-6271-RP.

Should you have any questions regarding the work plan, please feel free to contact me at your convenience.

Sincerely,
AECOM Technical Services, Inc.

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Project Manager
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cc: Ms. Dianne Murphy – Philips Lighting North America



Technical Services, Inc.

Submitted by:
AECOM Technical Services, Inc.
Columbia, S.C
April 2017

Phase II Remedial Investigation Work Plan Shakespeare Composite Structures, LLC

Voluntary Cleanup Contract 14-6271-RP

File # 51025

19845 US Highway 76

Newberry, SC

Phase II Remedial Investigation Work Plan

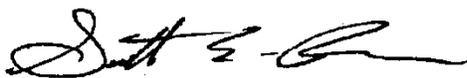
Shakespeare Composite Structures, LLC

Voluntary Cleanup Contract 14-6271-RP

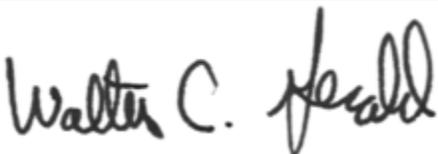
File # 51025

19845 US Highway 76

Newberry, SC



Prepared By: Scott E. Ross, P.G.
Project Manager



Reviewed by: Walter Gerald, P.G.
Sr. Program Manager

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List of Acronyms

BLS	below land surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cis-1,2 DCE	cis-1,2 - dichloroethene
CVOCs	chlorinated volatile organic compounds
DI	deionized
DO	dissolved oxygen
DOT	Department of Transportation
EPA	United States Environmental Protection Agency
ERA	Ecological Risk Assessment
FBQSTP	Field Branches Quality System and Technical Procedures
HASP	Health and Safety Plan
HHRA	Human Health Risk Assessment
HSA	hollow stem auger
IDW	investigation derived waste
MCL	maximum contaminant level
NGVD	National Geodetic Vertical Datum
NTu	Nephelometric Turbidity Units
µg/L	micrograms per liter
mg/L	milligrams per liter
ORP	oxidation-reduction potential
PCE	tetrachloroethene
PPE	personal protective equipment

List of Acronyms (continued)

QC	quality control
RECs	recognized environmental conditions
RI	remedial investigation
RSL	Regional Screening Level
SC	Specific Conductance
SESD	EPA Region IV Science and Ecosystems Support Division
SOPs	Standard Operating Procedures
SU	Standard Unit
TCE	trichloroethene
TCL	Target Compound List
USCS	Unified Soil Classification System
USEPA	United States Environmental Protection Agency
VCC	voluntary cleanup contract
VOCs	volatile organic compounds

1.0 INTRODUCTION

The Shakespeare Composite Structures, LLC (Shakespeare) facility has been designing and producing fiberglass products at their manufacturing facility located in Newberry, South Carolina (the facility) since the mid-1960s. In December 2013, Shakespeare retained AECOM Technical Services, Inc. (AECOM) to perform a Phase I Environmental Site Assessment (Phase I ESA) at their facility. The Phase I ESA was followed by a Phase II ESA, which investigated several potential area of environmental concern identified at the facility during the Phase I ESA. Results of the Phase II ESA led to several subsequent phases of investigative efforts at the Site and vicinity. These investigations have identified concentrations of chlorinated volatile organic compounds (CVOCs) in soil and groundwater beneath the facility and adjacent properties. As a result of the investigative findings, Philips Electronics North America (PENAC) and the South Carolina Department of Health and Environmental Control (SCDHEC) entered into a Responsible Party-Voluntary Cleanup Contract (VCC). The VCC includes plans to complete a Remedial Investigation (RI) and Risk Assessment (RA) at the Shakespeare site. Philips Lighting North America (PLNA), a division of PENAC has retained AECOM to assist with completion of RI and RA efforts at the Site. This document serves as the Phase II Remedial Investigation Work Plan (Phase II RIWP). The Work Plan Addendum outlines the rationale for performing additional investigative efforts and the technical approaches that will be used to collect additional data from the Shakespeare site.

1.1 Physical Setting

The Shakespeare facility is located on US Highway 76, approximately 1 mile northwest of the City of Newberry (**Figure 1-1**). The Shakespeare facility occupies 24.24-acres. The property includes the main production building and the pole winder building, totaling approximately 250,000 square-feet under roof. The property also has several smaller structures located at the west end of the property including a less than 90-day hazardous waste storage building, a residual resin curing building, along with other smaller storage buildings.

An asphaltic employee parking lot is located to the southwest of the main building, which is accessed from U.S. Highway 76 to the southwest of the subject property (**Figure 1-2**). The south end of the property contains another asphalt-paved area, which is the former employee overflow parking area where equipment and other materials currently are staged. There is a covered shed area at the southeast end of the property where finished products are packaged and staged for shipment. The area between the two buildings in the center of the property is mostly grassed and is used for equipment or material storage (i.e. forklifts, compressors, molds for poles and other products), and some grassed areas are present at the west and northwest sides of the property. Loading docks are located on the northwest and southeast corners of each building and are accessed via concrete-paved or asphalt-paved driveways from U.S. Highway 76. The northwest, northeast, and southeast perimeters of the subject property are fenced, and locking gates are present at the two driveways beyond the employee parking lot .

General land use surrounding the facility consists of agricultural, residential, undeveloped and commercial/light industrial properties. Uses of adjacent properties identified during the site visit are as follows:

North: The facility is bordered immediately to the north by a Norfolk Southern rail line and undeveloped land planted with pine trees. The property bounding the facility to the north beyond the rail line is owned by J.L. Dickert.

East: The facility is bordered immediately to the east by a residential parcel, beyond which is vacant land (pine trees) and vacant buildings formerly occupied by the Dickert Lumber Company. The property east of the private residence up to Lumber Road is also owned by J.L. Dickert.

South: The facility is bordered to the south by U.S. Highway 76 and properties owned by the Newberry County Airport and Walter Shealy. The property owned by Mr. Shealy is primarily farmland with a few small residences located sporadically across the more than 60 acres.

West: There are three residential properties located immediately to the west of the facility. The property that lies adjacent to the west of the facility is owned by Harriet Boazman. The properties to the west of the Boazman property are owned by Edna Ringer and Kimberly Chapman, respectively.

1.2 Site Operational Background

The facility is used for the design and manufacture of large fiberglass utility poles, cross arms, and other fiberglass outdoor products (such as signs and sign posts). According to information reviewed in previous documents and confirmed with Shakespeare personnel, the subject property was undeveloped, wooded land until 1965. The main building was constructed in the mid-1960s and used for fiberglass production. The pole winder building reportedly was constructed in the late 1970s. A more detailed summary of the facility's operational background and history are included in the Phase I ESA report (AECOM, 2014a).

1.3 Summary of Previous Investigative Efforts

As mentioned above, Shakespeare retained AECOM to assist with multiple ESAs to determine if the facility had any environmental issues or concerns. The ESAs were followed by multiple phases of more in-depth subsurface investigations both at the facility and on properties adjacent to the facility. The previously completed activities are briefly summarized below.

Phase I ESA. Completed in January 2014: Identified several recognized environmental conditions (RECs) at the site that led to the Phase II ESA.

Phase II ESA. Implemented in late January 2014: Included the collection of soil samples from several of the RECs identified in the Phase I ESA along with the collection of groundwater samples from beneath several portions of the facility. The Phase II ESA indicated that several chlorinated volatile organic compounds (CVOCs) including trichloroethene (TCE), and degradation compounds cis-1,2 dichloroethene (cis-1,2 DCE) and vinyl chloride (VC) are present above their respective drinking water standards (US Environmental Protection Agency [USEPA] maximum contaminant levels – MCLs) in groundwater beneath the facility. Results of the Phase II ESA are discussed in more detail in the Site Investigation Summary (AECOM, 2014b).

Site Investigation. A broader site investigation was implemented at the request of PENAC in April 2014. This work included the installation and sampling of several temporary and permanent monitoring wells as well as the collection of additional soil samples at the facility. Results further verified the presence of CVOCs in groundwater beneath the facility.

In May 2014, the investigation efforts expanded to include a more elaborate soil sampling program designed to delineate the source areas within the main and pole winder buildings, installation and sampling of additional monitoring wells, and collection of samples from several private water wells surrounding the facility. This phase of the investigation detected CVOCs in soil beneath both buildings, and indicated a more expansive area of CVOC impact in groundwater beneath the Site. Sampling of groundwater from private wells also indicated that several wells located downgradient (west and southwest of the facility) contained elevated CVOC concentrations.

Expanded Investigation. In July 2014, PENAC implemented an Expanded Investigation at the site. This included multiple phases of groundwater investigation activities on properties to the north, west, and southwest via installation of temporary wells, and installation of permanent shallow wells on these properties. This phase of investigation also included installation of several additional permanent shallow, several intermediate and bedrock monitoring wells, and collection of surface water samples (AECOM, 2014b).

The results of the Expanded Investigation efforts indicate that the lateral extent of CVOC impact to groundwater in multiple depth zones had been defined in most directions, with a limited number of data gaps that remain to be addressed.

Expanded Investigation Addendum. From December 2015 through February 2016: PENAC conducted additional groundwater investigations to fill data gaps for the shallow zone, intermediate zone, and in bedrock beneath the Site. 14 wells were installed in the shallow, nine(9) intermediate, and two (2) bedrock wells were installed during this phase of the investigation.

However, due to data gaps in not bounding the impacts, at the request of SCDHEC, a three-dimensional model was requested to be completed and submitted to SCDHEC (submitted in September 2016) to support the assessment of the locations of the next set of wells to be installed to bound the impacts in the three zones of impacted groundwater (shallow, intermediate, and bedrock).

Based upon a meeting with SCDHEC (January 2017), the locations of the next set of wells to be installed to bound the impacts in the three zones of impacted groundwater was agreed upon for next steps and that is below further discussed.

1.4 Phase II Remedial Investigation Objectives

SCDHEC has reviewed the results of the investigative efforts performed to date and has requested Shakespeare submit a plan to complete the delineation of the vertical and horizontal extent of CVOC impacts to groundwater both on- and off-Site, and to evaluate the potential risks these compounds pose to human health and the environment. The investigation and risk evaluation information will be used to determine if a remedy for the CVOC impacted groundwater is necessary.

This Phase II RIWP presents the scope of the investigative efforts and the procedures to be used during the completion of the RI. Based on the information collected to date from the Site, the objectives of the Site Investigation are as follows:

- Verify the horizontal extent of CVOCs off-Site in the shallow groundwater with the installation of one additional permanent monitoring well off-site (proposed northwest of MW12 west of the Dickert property, subject to field conditions).
- Conduct further evaluation of groundwater quality in the intermediate zone off-Site to determine the distribution of elevated CVOC concentrations at greater depths above bedrock (estimated that four intermediate wells be installed one west of MW20I; one north of MW-12, near MW-14, and one near MW-17, subject to field conditions) Conduct further evaluation of groundwater quality in the shallow bedrock on properties surrounding the former Shakespeare facility (it is proposed that one will be located southeast of water well PW-2; one will be located west of RDW-2, one will be located between MW-11 and MW-12, and one will be located southeast of MW17, subject to field conditions)
- Implementation of a semi-annual groundwater sampling program using the permanent monitoring well network to be established at the Site; and
- Provide data to be used in evaluation of the potential risks the CVOCs may pose to possible human and or ecological receptors.

The following sections of the Phase II RIWP present the rationale for the investigation and describe, in detail, the sampling methods to be used during Phase II RI field activities.

2.0 RATIONALE FOR SITE INVESTIGATION

Previous rounds of investigation have included the collection of soil and groundwater samples from numerous locations across the Site and off-Site. The results of the previous investigative efforts have indicated the presence of CVOCs TCE, cis-1,2 DCE and VC in groundwater above their respective drinking water standards in multiple groundwater samples from beneath the Site as well as locations on private property to the north and west of the Site. In accordance with the RP-VCC, PLNA has developed this work plan presenting investigative efforts to be used to determine the extent of impact to environmental media at the Site. This section discusses the rationale and objectives for the implementation of the Phase II RI.

2.1 Soil

During the Phase II ESA and initial phase of the Site Investigation, numerous surface and subsurface soil samples were collected from beneath the Shakespeare facility. The results of the soil investigation efforts to date have identified limited areas of CVOC impacts in soil. None of the reported concentrations exceeded USEPA Regional Screening Levels (RSLs) nor was an obvious source area(s) defined.

2.1.1 Soil Source Area Determination

In order to verify that definitive source areas are not present beneath the main building and pole winder building, PLNA is performing an additional soil investigation in these areas. This will include a two stage process briefly discussed below:

Sub-slab Soil Vapor Sampling

The first stage entails collection of sub-slab soil gas samples on a grid system established for each building. Soil gas samples will be collected from approximately 24 locations beneath the west end of the main building and 15 locations beneath the west end of the pole-winder building using passive soil gas sampling devices, spaced on a 20-foot grid system (**Figure 2-1**). The soil-gas sampling effort will take approximately two weeks to complete. The first portion includes installation of the passive samplers, followed by sample collection and then shipment of the samplers approximately two (2) weeks after they are installed to the laboratory for analysis. Sub-slab soil vapor samples will be submitted to Beacon Environmental Services, Inc. (Beacon) and analyzed for Target Compound List -Volatile Organic Compounds (TCL-VOCs) using SW-846 Method 8260c.

Confirmation Soil Sampling

Upon receipt of the sub-slab vapor results, PLNA and AECOM will collect confirmation soil samples from three (3) locations beneath the floor within each building for laboratory analysis. The locations of the soil borings will be determined based on the results of the soil vapor sampling effort. Soil samples designated for laboratory analysis will be collected at two foot intervals from land surface to the water table. It is estimated that eight (8) soil samples will be collected from each of the confirmatory borings

for analysis. The results of the sub-slab soil vapor and confirmatory analyses will be used to determine if CVOC hot spot areas are present in the subsurface soils beneath the plant buildings.

2.1.2 Soil Vapor Migration

AECOM is also proposing to use the passive soil-vapor samplers to determine if COVCs are present in soil vapor at property boundaries to the north and west. AECOM will install six (6) passive diffusion samplers along a transect that borders the agricultural property to the north of the plant, and six samplers along a transect that borders the property to the west of the plant. Soil vapor sampling devices collected from these areas will also be submitted to Beacon for TCL VOC analysis. The proposed soil vapor sample locations are also depicted on **Figure 2-1**. The results of this sampling effort will be used to determine if additional soil vapor sampling may be required on the private parcels.

2.2 Groundwater

Investigative efforts to date have determined that elevated concentrations of CVOCs in groundwater extend to multiple depths from beneath the facility to the north and west. The intent of the additional groundwater investigative efforts presented in this work plan is to fill-in data gaps in each groundwater zone identified by PLNA and SCDHEC. This will be accomplished using a variety of methods including the installation and sampling of permanent wells and vertical profiling of groundwater quality. This section briefly discusses the rationale for the investigative efforts in groundwater.

2.2.1 Shallow Zone

As shown on **Figure 2-2**, the lateral extent of elevated impacts to shallow groundwater has been generally delineated in all directions. However, the TCE concentration in shallow well MW-12, located on the Dickert property, has slightly higher concentrations than many of the other shallow wells in this area. As a result, based on the general north to northwest groundwater flow direction in this area, an additional well (MW26) located down gradient of MW-12 has been recommended by SCDHEC.

2.2.2 Intermediate Zone

During the previous phase of work, PLNA utilized vertical profiling of groundwater quality to determine the impact to groundwater between the shallow zone (water table) and the underlying bedrock in several portions of the Site. However, the lateral extent of impact in this depth interval has not been fully delineated to the north and west of the plant area; therefore, based on a meeting with SCDHEC in January 2017, it has been requested that additional intermediate wells be installed to more fully delineate the horizontal extent of CVOCs. As a result, PLNA and AECOM will again utilize the vertical profiling process to delineate the vertical and lateral extent of impact in the intermediate zone at a total of four locations; including one on the Chapman property to the west of the plant (MW19I), and three locations on the Dickert property (MW12I, MW14I, and MW17I) (**Figure 2-3**).

The depths at which the vertical profiling efforts will be initiated in each well boring will depend on the depth of the nearest shallow well. The anticipated depths at which the profiling will be initiated at a particular location are presented in **Table 2-1**.

Historically the profiling process utilized on-site analysis with the Color-Tec[®] screening methodology; however, due to the anticipated lower CVOC concentrations to bound the impacts this technology is not as accurate as desired. Therefore, the vertical profiling process during this phase of work will include

analysis of groundwater samples by Shealy Environmental Services, Inc. (Shealy) located in West Columbia, South Carolina. PLNA and AECOM will coordinate with Shealy regarding delivery of samples to the laboratory as soon as possible after collection with rapid reporting of analytical results. Results of the vertical profiling analyses will be used to determine the ultimate location and depth at which intermediate zone monitoring wells will be installed.

2.2.3 Bedrock Groundwater Investigation

The bedrock well installation program completed to date determined the horizontal extent of CVOCs in several directions. However, SCDHEC has requested that additional bedrock wells be installed to more fully delineate the horizontal extent of CVOCs. As a result, four additional bedrock wells will be installed at locations requested by the SCDHEC. This includes two to the north of the plant on Dickert property (MW12D and MW17D), one to the west on Chapman property (MW19D), and one to the southwest of the plant on Shealy property (SDW3).

PLNA and AECOM will also use vertical profiling to determine the vertical extent of impact in bedrock fracture zones in each new well. The intent of this effort is to locate the shallowest, productive fracture zone that is not impacted by CVOCs. An inflatable packer system will be used to isolate fracture zones and allow collection of groundwater samples from discrete intervals. Groundwater samples from the bedrock wells will also be forwarded to Shealy for rapid turnaround analysis. Each bedrock well will be screened within the fracture zone interval(that is found to not be impacted by CVOCs.

2.2.4 Monitoring Well Sampling

Groundwater from each of the existing and new monitoring wells installed during this phase of work will be sampled as part of a semi-annual site-wide sampling effort. Groundwater samples collected from each well, at a minimum, will be analyzed for TCL VOCs. Several wells will also be tested for additional parameters as discussed in Section 2.5, below. The wells to be sampled as part of this synoptic event will include the following:

- Nine (9) shallow wells(MW-1 through MW-9), six intermediate wells (MW2I, MW3I, MW5I, MW6I, MW7I), and five bedrock wells (MW2D, MW3D, MW6D, MW&D, and MW9D) on the plant site;
- Ten (10) shallow wells located within the plant buildings (TMW-21, TMW-22, TMW-23, TMW-24, TMW-25, TMW-29, TMW-30, TMW-31, TMW-32, and TMW-33);
- Nine (9) shallow wells (MW10 through MW18), one intermediate well (MW10I), and one bedrock well (MW18D) located on Dickert property;
- One shallow well (MW19) on the Chapman property;
- Two shallow wells (MW20 and MW21), and two intermediate wells (MW20I and MW21I) on the Boazman property;
- Two bedrock wells (RDW1 and RDW2) on the Ringer property;

- Three shallow wells (MW23, MW24, and MW25), one intermediate well (MW24I) and two bedrock wells (SDW1 and SDW2) on the Shealy property;
- One (1) newly proposed shallow well (MW26);
- Four (4) newly proposed intermediate wells; and
- Four (4) newly proposed bedrock wells (MW12D, MW17D, MW19D and SDW3).

Table 2-2 lists the wells to be sampled during this phase of work and the proposed analytical parameters for each well. Monitoring wells will be purged and sampled in accordance with protocols referenced in section 3.2.4 below.

2.3 Water Well Sampling

In addition to the monitoring well network, groundwater samples will also be collected from a select number of water wells located to the west of the Site. The wells to be sampled include the Boazman well and the Chapman well (PW-4). Each sample will also be analyzed for TCL VOCs. **Table 2-2** also lists the water wells to be sampled during this phase of work.

Water wells will be purged and sampled in accordance with protocols referenced in Section 3.2.4 below.

2.4 Surface Water

Based on field observations during previous phases of work at the Site, it appears that shallow groundwater may discharge to shallow creeks that bound the northern and western portions of the impacted area (**Figure 2-5**). During the previous phases of work, three surface water samples (SW-1 through SW-3) were collected from a shallow creek that bounds the northern impacts on the Dickert property.

As part of this investigative effort, Shakespeare will collect additional surface water samples from three locations on the Dickert property and from approximately two (2) locations in the creek west of the Site, on the Shealy Property. The proposed sample locations are depicted on **Figure 2-5**. Procedures to be used for surface water sample collection are discussed in Section 3.2.4.

2.5 Sample Analysis

Groundwater, soil, soil vapor and surface water samples will be collected for laboratory analysis during this investigation. Soil vapor samples will be analyzed for TCL VOCs using EPA SW-846 analytical method 8260c. Groundwater, soil, and surface water samples collected during this investigation will also be analyzed for the TCL VOC suite of parameters.

In addition groundwater samples collected from ten (10) monitoring wells will also be analyzed for a specific list of biological and additional geochemical parameters to assess for potential remedial parameters. The wells to be used for the biogeochemical analyses have been selected based on their locations within the TCE plume:

Shallow wells – MW1, MW6, MW8, MW10, MW20

Intermediate wells – MW6I, MW9I, MW10I, MW20I

Bedrock wells – MW6D

The additional parameters include the following:

- Electron acceptors - ferric iron, manganese, sulfate
- Degradation/end products - ferrous iron, dissolved manganese, sulfide, carbon dioxide, ethene, ethane, methane
- Biological Parameters – *dehalobacter*, *dehalococcoides*, and functional genes

As indicated above, **Table 2-2** lists the samples to be collected during this investigation and the parameters for which samples will be analyzed during this round of investigation.

3.0 INVESTIGATION PROCEDURES

This section of the Phase II RI Work Plan discusses the methods to be used in preparation for and when performing the investigative efforts. Procedures detailed in the USEPA Region 4 Science and Ecosystem Support Division (SESD) Field Branches Quality System and Technical Procedures (FBQSTP) will be used during the execution of the investigative efforts. Where the SESD Technical documents do not specify procedures for activities described in this work plan, AECOM Standard Operating Procedures (SOPs) or other appropriate procedures are referenced. Copies of the referenced procedures are included in Appendix A.

A site-specific Health and Safety Plan (HASP) has also been prepared by AECOM for this project and will be made available upon request, under separate cover.

3.1 Investigation Preparation Activities

Preparation for field work will include: resolution of Site access issues; selection and procurement of qualified subcontractors; procurement of necessary field and sampling equipment; designation of an investigative derived waste (IDW) storage area; and designation and construction of a temporary equipment decontamination area.

3.1.1 Resolution of Access Issues and Permits

Property access agreements for various private parcels to the north, west, and south had been negotiated and executed in 2014 and 2015. An access agreement for the property located west of the Dickert property has yet to be negotiated. Prior to any field related effort on this property, written permission for access to this property will be obtained.

Additionally, the accessibility of all proposed sampling locations will be confirmed (i.e., potential obstacles to drilling such as underground water, sewer, gas, electric and telephone lines or above-ground cables, buildings or other above-ground structures will be identified). Should the relocation of any of the proposed sampling locations be deemed necessary, minor adjustments in sampling locations of 50 feet or less will be considered to be in conformance with the work plan and will not require regulatory approval. Significant changes in sampling locations of greater than 50 feet will be proposed for the client/SCDHEC's approval during the sampling activities. Sampling relocations, regardless of their magnitude, will be documented in the field log including the reason for the change and summarized in the Phase II RI report.

In accordance with the South Carolina Well Standards [R.61-71(H)(1)(a)], a permit for well installation is required prior to initiation of drilling activities. AECOM will acquire the well permits on behalf of PLNA as part of this effort. Submittal of this Work Plan will serve as the written request for the permit to perform the drilling activities referenced herein.

3.1.2 Selection of Qualified Subcontractors

AECOM will procure qualified subcontracting firms that have experience in South Carolina with a detailed understanding of state regulations, and if possible, past experience at the project site. The contractors include an environmental drilling contractor, laboratory contractors, a waste management contractor, and an underground utility survey specialist. The drilling contractor will be selected based on proven experience, cost, and proof of appropriate OSHA related training requirements and availability.

AECOM will contract a SCDHEC-certified laboratory to perform the primary sample analysis required for this project. The laboratory will be National Environmental Laboratory Accreditation Conference (NELAC) certificated and will also be certified by the SCDHEC. As previously indicated, Shealy has been selected to perform the primary chemical analyses and a limited number of geochemical parameters. In addition, Pace Analytical Services, Inc. (PACE) will analyze a specific set of samples for dissolved gases. Microbial Insights, Inc. will perform biological analysis on a specific set of samples. The Phase II RI sample analytical program is discussed in more detail in Section 2.4, above.

3.2 Field Procedures

As discussed in Section 2, the investigative efforts will consist of an additional phase of groundwater investigation, a limited investigation of surface water quality, evaluation of soil vapor and soil quality. AECOM will utilize the USEPA Region 4 Science and Ecological Services Division (SESD) Field Branches Quality System and Technical Procedures Manual (FBQSTPM) as guidance for various investigative processes. These include several standard operating procedures (SESDPROC). These procedures are referenced throughout this portion of the work plan. Copies of the SOPs are also included in **Appendix A** of this work plan.

This section of the Work Plan details the procedures that will be used to investigate each media and other project related efforts to be performed.

3.2.1 Soil Vapor and Soil Investigation

Soil Source Area Determination

As previously indicated, the sub-slab soil vapor program will be performed in multiple stages. This effort will include collection of soil gas samples on a grid system established within each building. Soil gas samples will be collected from approximately 24 locations within the main building and 15 locations within the pole-winder building using passive soil-gas sampling devices, spaced on a 20-foot grid system. Field personnel will follow USEPA Region 4 Soil Vapor Sampling Procedure (SESDPROC-307-R3) when collecting soil vapor samples (USEPA, 2014a). Field personnel will advance small (approximately 1 inch diameter) core holes through the building floors at the locations identified on the attached map (**Figure 2-1**) using a rotary hammer drill. A shallow boring (approximately 3 feet deep) will then be advanced with the rotary drill at each core hole location. A passive soil gas sampling device provided by Beacon Environmental Services, Inc. (Beacon) will then be placed in the small diameter borehole with a cork or other device intended to seal each core hole attached to at land surface. The passive soil gas sampling devices will be left in-place for approximately two weeks. Field personnel will then retrieve the collected passive gas samples and submit them to Beacon for analysis.

Analysis of an estimated 40 soil gas samples collected from beneath the two plant buildings will allow AECOM to focus a confirmatory soil sampling program that will be performed as part of the second phase of this process.

Confirmation Soil Sampling

AECOM will select three (3) locations in each building, based on the results of the soil gas sampling, for the collection of soil samples to be submitted for laboratory analysis. Soil samples will be obtained from continuous soil cores collected at each of the three confirmatory borings using a Geoprobe™ or equivalent style drill rig. Soil samples will be collected in accordance with procedures referenced in USEPA Region 4 SESDPROC-300-R3 (USEPA, 2014a). Soil samples designated for laboratory analysis will be collected at two foot intervals from land surface to the water table. It is estimated that the depth of soil sample collection in these confirmatory borings will be approximately 16 feet below land surface.

Based on these assumptions eight (8) soil samples will be collected from each of the confirmatory borings advanced in each building. AECOM estimates that a total of 48 soil samples (24 from the main building and 24 from the pole winder building) will be collected for confirmatory analysis. Soil samples collected from the borings will be forwarded to Shealy and analyzed for TCL VOCs. Results of this sampling will be used to determine if the passive sampling efforts have identified a source area and possibly allow quantification of an impacted soil volume.

As part of this task, TCL VOC results for the soil samples will be reviewed and validated in accordance with the *USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review* (USEPA, 2008a) and the *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review* (October, 2008b) modified for method specific requirements. Results for the biogeochemical parameters will not undergo detailed validation. The results of the validation effort will be summarized in the RI Report.

Soil-Vapor Migration

Passive soil-vapor samplers will be used to determine if CVOCs are present in soil vapor at property boundaries to the north and west. AECOM will install six (6) passive diffusion samplers along transects that border the Dickert property, to the north of the plant, and the Boazman property, to the west of the plant. The proposed sample locations are also depicted on **Figure 2-1**. The results of this sampling effort will be used to determine if additional soil vapor sampling may be required on the private parcels.

3.2.2 Groundwater Investigation

As indicated in Section 2.2 above, the groundwater investigation will include the following:

- Installation of one (1) shallow permanent monitoring well;
- Vertical profiling of intermediate groundwater quality at four locations to the north and west of the plant and; Installation of four (4) intermediate monitoring wells;
- Vertical profiling of groundwater quality in bedrock fractures and installation of four additional bedrock wells;

- Development and sampling of the newly installed permanent wells; collection of groundwater elevation data from the expanded well network;
- Collection of groundwater samples from the Site monitoring well network; and
- Collection of groundwater samples from two (2) water wells (Boazman/Ringer Well and Chapman Well).

The proposed locations for the additional permanent wells are shown in **Figures 2-2 through 2-4**. The permanent wells will be installed in accordance with procedures described in the USEPA Region 4 SESD protocol (USEPA 2013a) for Design and Installation of Monitoring Wells (SESD GUID-101-R1; **(Appendix A)**) with a drill rig capable of utilizing direct push technology (DPT) and/or hollow stem augers (HSAs) as well as roto-sonic technology. Well boring advancement and well installation procedures are discussed below.

3.2.2.1 Well Boring Advancement

Shallow Wells

Soil borings advanced during this phase of work for shallow monitoring well installation will be advanced using a DPT/Geoprobe™, roto-sonic or HSA style drilling rigs. The well borings will be advanced to depths determined appropriate by information collected in the field and as determined by the AECOM field hydrogeologist.

During well boring advancement, soil cores/samples will be obtained for geologic characterization and soil classification. Soil core collection will entail the use of a variety of tools depending on the drill technology. Depending on the drilling technology that will be used, these sampling tools may include two-inch diameter by two foot stainless steel split spoons utilized during HSA drilling or a 2-1/4-inch diameter by 5 foot length Geoprobe™ soil core barrel with acetate liner. Soil cores will be collected continuously from land surface to the target depth for a boring in order to identify potential confining layers, if present, and to accurately determine the water table depth. Soil recovery and soil type will be determined and logged.

Soils collected during the well boring process will be visually classified and described on boring logs using the Unified Soil Classification System (USCS). Copies of the boring logs will be included in the Phase II RI Report to be prepared following completion of this investigation.

In the event that it becomes necessary to terminate a boring short of its intended completion depth (i.e., a boulder or other obstacle is encountered), the boring will be abandoned in accordance with the SC Well Standards [R.61-71(H)(2)(e)]. Borehole abandonment will include backfilling of the borehole with a cement and bentonite grout (at a mixture of approximately nine to one) via tremie pipe from the bottom up. A new boring will be advanced as close as possible, within 10 feet from the abandoned boring. Soil coring will be resumed below the abandoned boring termination depth.

Intermediate Wells

As indicated above, the intermediate zone vertical profiling borings will be advanced using direct push drilling technology. Proposed intermediate well locations are depicted on **Figure 2-3**. Borings advanced

as part of the intermediate zone vertical profiling will also be advanced using direct push drilling techniques. The direct push drilling techniques will also utilize a 2-1/4-inch diameter by 5 foot length Geoprobe™ soil core barrel with acetate liner. Once the core barrel is advanced its maximum length, a three (3) inch inside diameter outer casing will be advanced over the core barrel to the same depth. The core barrel is then removed from inside the casing allowing extraction of a soil core. The intermediate zone vertical profiling borings will be advanced at locations and depths specified in **Table 2-1**. The methods to be used to collect groundwater samples for screening from these borings are discussed in Section 3.2.3.1, below.

Bedrock Wells

As indicated in Section 2.2.3 above, some fracture zones within the underlying granitic bedrock contain elevated concentrations of CVOCs. The distribution of the CVOCs within fracture zones has not been fully determined; therefore, during this phase of work four (4) additional bedrock well borings are proposed to determine the lateral extent of impact to shallow fracture zones. The proposed locations for these bedrock wells are depicted on **Figure 2-4**.

The proposed bedrock well borings will be advanced using a combination of mud-rotary and wireline coring techniques. Mud-rotary drilling will be used to drill through overburden and saprolitic soils into the top of bedrock. Once bedrock is encountered, a 6-inch diameter SCH-40 PVC surface casing will be installed in the well bore. The surface casing will be grouted in place and allowed to cure for up to 48 hours before drilling into bedrock will commence.

Wire-line coring techniques will be used to advance a bedrock well bore below the surface casing. Core samples will be visually examined by an AECOM field hydrogeologist to identify separate fracture zones. Core samples will be collected continuously on five foot intervals from the top of the bedrock to a depth determined by field personnel. Bedrock well bores will be advanced until the vertical groundwater quality profiling process indicates CVOCs are not present in a fracture zone. Vertical profiling sampling procedures in bedrock are discussed in Section 3.2.3.2 below.

3.2.2.2 Permanent Monitoring Well Installation Procedures

During this phase of the RI, one shallow, four intermediate, and four bedrock zone monitoring wells will be installed at the Site to allow monitoring of groundwater elevations and water quality (**Figures 2-2 through 2-4**).

Shallow and intermediate monitoring wells will be installed in accordance with SESD GUID-101-R1 protocol and SC Well Standards and Regulations (S.C.R61-71) using HSA or mud rotary drilling techniques. Shallow and intermediate permanent monitoring wells will be constructed using two-inch diameter, flush-threaded, schedule 40 PVC casing and 10 foot long, 0.010-inch slotted PVC screens. Total well depth and placement of the screen interval will be based on location-specific data needs and local geology as determined by the field geologist.

As discussed in Section 3.2.2.1 above, soil and/or rock cores will be collected during well bore advancement to allow examination and classification of soils/location of fractures and to help determine the depths at which to install the wells. Once shallow and/or intermediate well boring advancement is completed, the well materials will be installed through the 4 1/4-inch inside diameter auger annulus or within a 6-inch diameter mud rotary borehole. Shallow and intermediate permanent monitoring wells

will be centered within a borehole while appropriately graded clean silica sand is placed in the annular space surrounding the well screen to a depth of approximately two feet above the top of the screen. The filter pack will be directly overlain by a layer of bentonite chips no less than two feet thick. The bentonite chips will be hydrated to create a seal prior to installation of a cement/bentonite grout. The grout seal, containing a mixture of approximately nine pounds of cement to one pound bentonite, will extend from the top of the bentonite seal to a depth of two to three feet below ground surface.

Each bedrock well will have a 6-inch diameter SCH-40 PVC surface casing that fully penetrates the weathered residuum and saprolite overlying the bedrock. The surface casing will be grouted in place and allowed to cure for up to 48 hours before drilling into bedrock will commence.

As indicated above, field personnel will utilize a rock coring system to obtain samples of the bedrock. Information obtained from the rock cores and vertical profiling efforts will be used to determine the depth at which the bedrock wells will be completed. Ideally, wells will be set to capture groundwater from obvious fracture zones encountered in the bedrock. Once the well boring has been sampled to a desired depth, the borehole will be flushed with fresh water to remove any drilling fluid and/or debris generated during drilling.

Bedrock well screen placement will be set across a fracture zone that is found to not contain CVOCs during the field screening. Bedrock wells will be constructed using five-foot long pre-packed, two inch diameter well screens, surrounded by additional sand filter pack, as needed to fill the annular space. A bentonite clay well seal and cement grout will be installed to ensure impacted groundwater encountered in overlying fracture zones does not migrate downward into an un-impacted fracture zone.

Each monitoring well will be completed flush with the ground surface using an 8-inch diameter cast iron bolt-down well cover set into a 2 ft x 2 ft x 6 inch concrete pad. Each permanent monitoring well will also be secured with a cap and lock.

All well construction details and/or boring information will be noted on monitoring well construction logs to be completed during the field investigation.

3.2.2.3 Well Development

Following their installation, each permanent well will be developed in accordance with the USEPA Region 4 SESD GUID-101-R1. Well development will be performed to remove fine-grained materials from the monitoring wells and to enhance the hydraulic connection between the screened interval and the surrounding aquifer. The permanent monitoring wells will be developed no sooner than 24 hours following installation, to allow the well construction materials to set. Water quality parameters will be measured using a YSI 556 water quality meter and an HF Scientific turbidity meter or equivalents. During well development the following water quality parameters will be monitored:

- pH;
- Temperature;
- Specific Conductance; and
- Turbidity.

Adequate well development is achieved when the pH, specific conductance, and temperature of the groundwater have stabilized and the turbidity has either stabilized or is below 10 Nephelometric Turbidity Units (NTUs). Stabilization shall be generally defined as pH constant within 0.2 Standard Units (SU), temperature and specific conductance constant within 10%.

A minimum of three well volumes will be removed before a well may be considered developed. If, after removal of three well volumes, the development criteria have not been achieved, the process will continue until either the criteria have been met, or ten well volumes have been removed. It is then at the discretion of the project manager to consider if a well is adequately developed or whether development activities should continue.

Water generated by well development activities will be stored in 55-gallon drums, polyethylene totes or comparable containers. The development water containers will be labeled as such with the date of generation and applicable source information. The containers will be transported to a designated on-Site storage area and characterized for off-Site disposal at the conclusion of the RI field activities.

3.2.3 Groundwater Sampling

As indicated above, groundwater sampling efforts will include collection of samples during the vertical profiling process and collection of samples from existing and newly installed permanent wells. Groundwater samples will be collected in accordance with procedures detailed in the USEPA Region IV SESD protocol for Groundwater Sampling (SESDPROC-301-R3) (USEPA, 2013b).

3.2.3.1 Intermediate Vertical Profile Borings

As indicated above, the intermediate zone vertical profiling borings will be advanced using direct-push drilling technology. Proposed intermediate well locations are depicted on **Figure 2-3**. Once a boring has been advanced to the top of a desired target depth, a 1.25 inch diameter, four-foot long, stainless steel retractable sampler will be advanced into the undisturbed subsurface. The outer casing surrounding the sampler will be back-pulled exposing a four-foot long stainless steel, 0.01 inch slot screen. A peristaltic pump will then be used to purge water from this interval for collection of a groundwater sample for confirmatory analysis. Field personnel will measure and record field parameters including pH, specific conductance, temperature, and turbidity during the purge effort. Samples for rapid laboratory analysis will be collected when the field parameters have stabilized.

This process will be repeated at two additional depth intervals, if possible depending on lithology, to allow collection of multiple groundwater samples from a boring. Field personnel will attempt to collect up to three samples from an intermediate well boring, with depths of collection varying between 5 and 10 feet below the previously sampled interval. Groundwater samples collected using this methodology will be forwarded to the laboratory the same day of collection. The laboratory will perform rush analysis for TCL VOCs on the samples, returning results within 24 hours of sample receipt, if possible.

Results of the vertical profiling efforts will be used to determine the depth at which to construct a permanent monitoring well for the intermediate depth interval.

3.2.3.2 Bedrock Vertical Profile Borings

When a separate fracture zone is encountered, field personnel will direct the purging of the fracture zone to allow collection of a groundwater sample for laboratory analysis. As the boring is advanced deeper

into the bedrock, and separate fracture zones are identified an inflatable packer system will be used to isolate the deepest fracture zone from influence of groundwater from overlying fractures. The packer system will be inflated, sealing the borehole above the deepest fracture zone. Groundwater will then be purged from an isolated fracture zone using a submersible pump.

Sampling of groundwater in the bedrock vertical profile boring will be performed using a stainless steel submersible pump. During profiling interval purging efforts, field parameters will be monitored to ensure representative groundwater is being sampled. Field personnel will measure and record field parameters including pH, specific conductance, temperature, and turbidity during the purge effort. Samples for rapid laboratory analysis will be collected when the field parameters have stabilized.

Once laboratory analyses confirm that CVOCs are not present in a fracture zone, the bedrock boring will be converted to a monitoring well in accordance with procedures discussed in Section 3.2.2.4.

3.2.3.3 Permanent Monitoring Wells

Permanent monitoring wells will be purged and sampled using the low flow-low volume sampling procedures with either a peristaltic pump or submersible pump. The primary choice of equipment for sampling a well using this method is the peristaltic pump; however, should the water column be deeper than the depth from which a peristaltic pump can lift water, a submersible pump will then be used to purge a deep well. Disposable Teflon™ lined tubing will be used with either the peristaltic pump or submersible pump during the purging and/or sampling process.

Prior to purging a well, clean polyethylene sheeting will be placed on the ground around the well to provide a clean working surface. Total depth and depth to water from the top of the PVC casing will be measured with an electronic water-level indicator and recorded in the field log and groundwater collection record. The volume of the standing water column will then be calculated in order to determine the required purge volume. The volume of the standing water column in a well is calculated using the following general equation:

$$V = 0.041(D^2)(H)$$

Where: H = length of water column in feet

D = diameter of well in inches

V = volume of water in gallons

The volume, per linear foot for a 2-inch well, equals 0.163 gallons per foot. The length of the water column (total depth minus depth to water) may be multiplied by 0.163 to obtain the volume of standing water within a 2-inch diameter well.

When purging with a peristaltic pump, a section of ¼-inch diameter, disposable Teflon™ lined polyethylene, or dedicated Teflon™ extraction tubing will be inserted into the middle portion of the water column in a well. The extraction tubing will be connected to a disposable section of 3/8-inch diameter silicon tubing that runs through the pump device. This tubing is connected to another section of ¼-inch diameter tubing that is used for discharge tubing. Purging of a well will be performed from within the screened interval.

Water quality parameters (pH, specific conductance, temperature, turbidity, dissolved oxygen (DO), and oxidation reduction potential (ORP) will be measured using a water quality meter equipped with a flow-through cell (YSI or equivalent). Turbidity may also be measured with a HF Scientific, LaMotte, or equivalent turbidity meter. The water quality meter(s) will be calibrated twice per day, prior to field use each morning and once during mid-day.

As a general rule, water quality readings will be taken periodically to determine when purging is completed. An adequate well purge is achieved when the specific conductance and temperature of the groundwater have stabilized within 10%, pH as stabilized within 0.2 SU, and the turbidity has either stabilized or is below 10 NTU. Should the low flow-low volume sampling procedure not be appropriate for sampling wells due to lack of stabilization, field personnel will utilize alternative methods specified in the USEPA Region 4 SOP SESDPROC-301-R3 (**Appendix A**). There are no criteria establishing the number of readings required to determine stability. However, if the parameters have not stabilized within five purge volumes, it is the discretion of the project manager whether to collect a sample or to continue purging.

As indicated in Section 2.4, all groundwater samples collected during this investigation will be analyzed for TCL VOCs using SW-846 Method 8260C. A subset of wells will also be sampled for a broader list of biogeochemical parameters (**Table 2-2**).

3.2.4 Surface Water Sampling

As indicated in Section 2.3, surface water samples will be collected from three locations on the Dickert Property and two locations on the Shealy Property (**Figure 2-5**).

Surface water samples will be collected in accordance with procedures described in the USEPA Region 4 SOP SESDPROC-201-R3 (USEPA, 2013c). Samples will be collected by submerging bottles directly into the water column where the water column is sufficiently deep enough to allow, without inadvertently elevating turbidity. A sample bottle will be lowered into the water column with the cap in-place and facing upstream. Once the mouth of the bottle is at the desired sampling depth, the cap will be removed allowing water to fill the container. For bottles containing preservative, the bottle will be submerged enough to allow surface water to slowly fill the bottle preventing the preservative from washing out of the sample container.

When possible, water quality parameters will also be measured in the field at the time of sample collection using a water quality meter. The field parameters measured during surface water sampling will be pH, specific conductance, temperature, DO and ORP. Field parameters will be measured by submerging the water quality instrument probe into flowing surface water. Field measurements and visual observations including color and a description of the general conditions at each surface water sampling location will be recorded on surface water sampling logs.

At each surface water body, sampling will be conducted in order from the most down-stream location to the most up-stream location to preclude disturbing sediments that could then become suspended and wash downstream potentially biasing the other samples.

3.2.5 Hydraulic Testing

Once well sampling efforts have been completed, field personnel will perform testing in 12 wells located at the Site to estimate the horizontal hydraulic conductivity (K) of the aquifer zones. Six shallow and six intermediate wells will be used for this testing.

Shallow: MW2, MW3, MW5, MW6, MW10, MW20

Intermediate: MW2I, MW3I, MW5I, MW6I, MW10I, MW20I

Rising and falling head permeability tests will be conducted to measure the aquifer response to the instantaneous addition or removal of a cylinder (or slug) of known volume. Results of the tests will be used to determine an average K for the shallow and intermediate zones. K values will be used to determine groundwater flow velocities for each zone. K and groundwater velocity values will be used during the Feasibility Study and future remediation planning efforts. This information is critical to the assessment of potential constituent migration via groundwater and preliminary evaluation of remedial alternatives.

3.2.6 Well and Sample Location and Elevation Survey

At the completion of drilling activities, all borings, new monitoring wells and surface water sample points will be located using standard global positioning system (GPS) and/or conventional survey methodology by a registered land surveyor.

Wells, borings and sample points will be surveyed for elevation referenced to the National Geodetic Vertical Datum (NGVD-88) and horizontal location referenced to the SC State Plane Coordinate System North American Datum (NAD-83) by a qualified professional land surveyor in accordance with the USEPA Region 4 protocol for Global Positioning Systems (SESDPROC-110-R4) (USEPA, 2015a). Surveying of monitoring well locations will provide horizontal control and vertical data for the ground surface, the top of the outer protective casing, and the top of the PVC well casing at each location. The top of PVC casing elevation will be surveyed at a permanently designated point marked into the top of the well casing. The designated point will be exposed only when the protective cap is removed and be the point from which all future water level measurements are taken. Vertical elevation data will be surveyed to an accuracy of 0.01 feet and horizontal position data to an accuracy of 0.1 feet.

3.2.7 Investigation-Derived Waste (IDW)

IDW generated during the field program will be managed in accordance with the USEPA Region 4 protocol for Management of Investigation Derived Waste (SESDPROC-301-R3)(USEPA, 2014).

Materials which may become IDW include: personal protective equipment (PPE), disposable equipment, soil cuttings from drilling or hand auguring, sediments, groundwater obtained through well development or well purging, and cleaning and decontamination fluids. All soil cuttings, residual sample materials, groundwater, cleaning and decontamination fluids will be containerized in Department of Transportation (DOT) approved 55-gallon drums or a roll-off container and temporarily staged at a central Site location pending results of laboratory analyses and selection of final disposal method(s). IDW materials such as non-hazardous PPE, disposable equipment, and general refuse will also be placed into a separate drum, roll-off container, or existing refuse bin, and disposed in accordance with applicable guidance.

Based on the results of previous investigative phases at the Site, it is anticipated that solid and liquid IDW will be handled and disposed of as non-hazardous waste. Final disposal options will be determined following completion of field activities and after review of validated analytical data for samples collected from the Site. Representative samples of soil IDW will be collected and analyzed for Toxicity Characteristic Leaching Procedure (TCLP) VOCs to determine if the wastes are characteristically hazardous. Analytical results for groundwater samples will be used to determine hazard classification. The TCLP results for IDW soils and groundwater quality data will be compared to the TCLP maximum concentrations listed in Table 1 of 40CFR 261.24. If groundwater sample results do not exceed the TCLP concentrations, then liquid IDW can be disposed of as non-hazardous.

3.2.8 Quality Control (QC) and Handling Procedures

The QC and handling procedures for equipment and samples collected at the site are briefly described below.

3.2.8.1 Sample Containment, Handling and Shipping

To minimize sample leakage and breakage, sample containers will be sealed and placed in shipping containers surrounded by bubble wrap or equivalent packing material. Ice will be included for those samples that require refrigeration to maintain a 4°C temperature. Chain-of-custody forms, identifying each sample contained in a shipping container, will be completed. One copy of the chain-of-custody form will be retained for the field records; the remaining copies will be placed inside a Ziploc™-type bag, and the bag sealed and taped to the inside cover of the shipping container.

Samples will be delivered daily to the Shealy Environmental Services, Inc. facility by AECOM field personnel. All samples will be handled and shipped in accordance with the procedures included in the USEPA Region 4 protocol for Packaging, Marking, Labeling and Shipping of Environmental and Waste Samples (SESDPROC-209-R3)(USEPA, 2015a).

3.2.8.2 Collection of QA/QC Samples

QA/QC samples will be collected during all sampling and will include trip blanks, equipment blanks, duplicate samples, matrix spike samples, and matrix spike duplicate samples. QA/QC sample frequency is summarized below.

- trip blank samples – 1 per shipping cooler,
- equipment blank samples 1 for every 20 environmental samples,
- duplicate samples – 1 for every 20 environmental samples,
- matrix spike – 1 for every 20 environmental samples, and
- matrix spike duplicate samples – 1 for every 20 environmental samples.

3.2.8.3 Field Equipment Calibration

Sampling activities detailed in this work plan call for the use of field equipment including a photoionization detector (PID), water quality meter, turbidity meter, electronic water level indicator, and a GPS. The water quality meter will be capable of measuring pH, specific conductance, temperature, DO, and ORP. All field equipment will be calibrated prior to each use (at the beginning of each day) and a calibration check during the middle of the day. All instruments will be calibrated, maintained, and operated in accordance of the manufacturer's specifications.

3.2.9 Field Equipment Decontamination

Reusable equipment used in the field investigations at the site will be cleaned between sample collection efforts. Cleaning of equipment is performed to prevent cross-contamination between samples and to maintain a clean working environment for all personnel. Cleaning of sampling equipment will be performed in accordance with the USEPA Region 4 protocol for Field Equipment Cleaning and Decontamination (SESDPROC-205-R3)(USEPA, 2015b).

For all sampling equipment used for the collection of samples for trace organic compounds and/or metals analyses:

- clean equipment with tap water and a laboratory grade non-phosphate detergent,
- rinse thoroughly with tap water,
- rinse thoroughly with deionized (DI) water,
- double rinse with organic free water
- wrap with aluminum foil, place in a plastic bag, and seal to prevent contamination if equipment is going to be stored or transported.

Cleaning and decontamination of all downhole drilling equipment will also be conducted in accordance with Section 3.7 of the Region 4 SESDPROC-105-R3.

Solvents, detergents, and rinse waters used to clean field equipment will not be reused during field decontamination. Procedures for handling and disposition of IDW, including used wash water, rinse water, and spent solvents will be conducted in accordance with Section 3.2.7

4.0 Remedial Investigation Report

It is anticipated that upon completion of the efforts summarized in this work plan, PLNA will move forward with preparation of the RI Report for this site. The RI Report will be a comprehensive report including data generated from the Phase II ESA through the most recent round of investigation. The report will discuss the results for soil, groundwater and surface water samples collected from the Site during this investigative process. The RI Report will include figures depicting sample locations and the distribution of any CVOC constituents of concern; data summary tables, data validation details, trend analysis figures, conclusions regarding the information collected to date and possible recommendations for future efforts. Appendices will contain all lithologic logs, individual monitoring well construction details, well development logs, groundwater sampling logs, laboratory reports (original data sheets), and laboratory validation notes.

An anticipated general outline for the report is as follows:

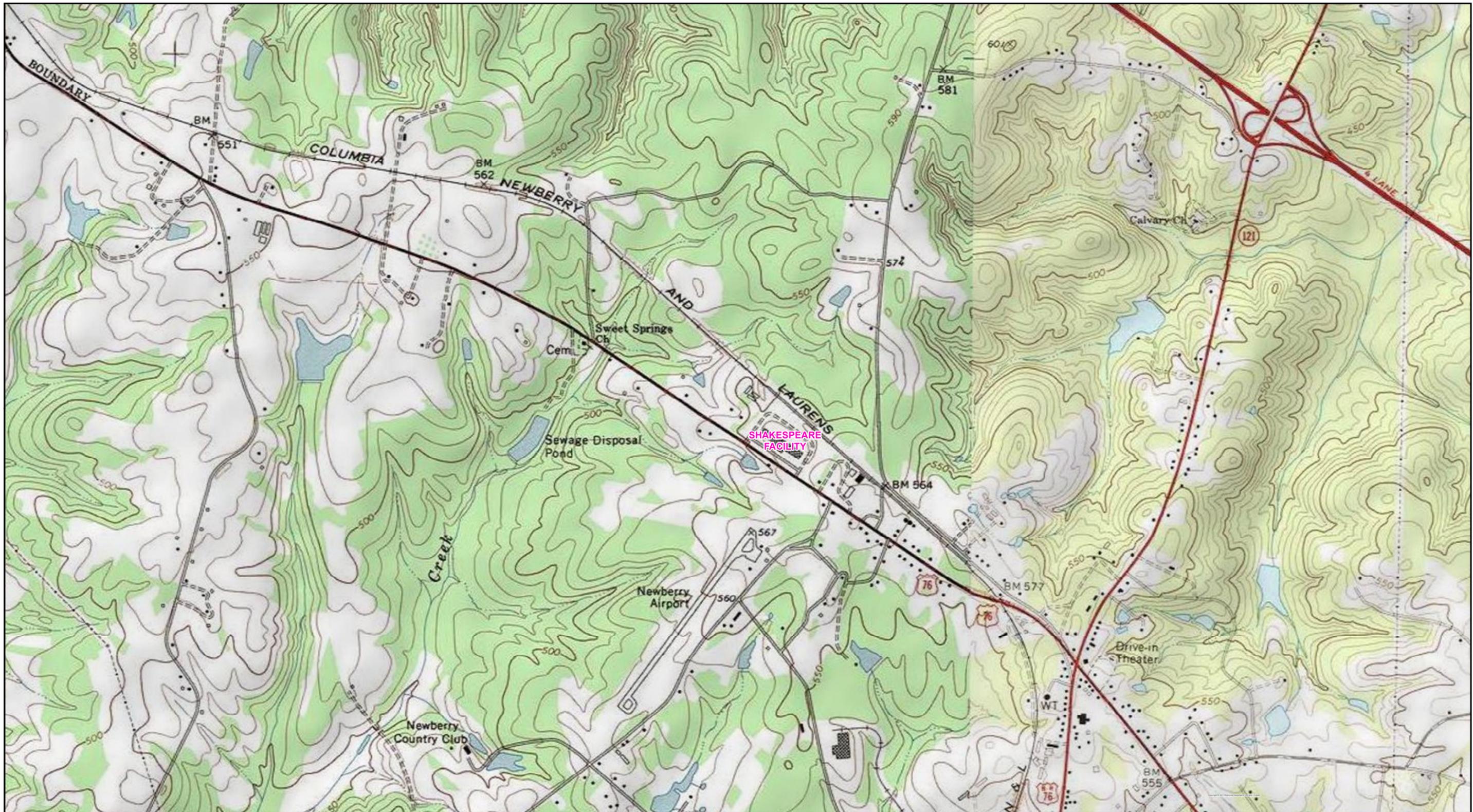
- Introduction – this section will be used to discuss site history and the purpose of the report.
- Investigation Procedures – this section will summarize the investigative history and briefly describe the investigative activities and procedures utilized during each phase of assessment.
- Physical Characteristics of the Site – this section will discuss the site setting, geology and hydrogeology of the site and surrounding area.
- Nature and Extent of Soil & Groundwater Impacts – this section will summarize compounds detected and the extent of their presence in the study area.
- Risk Assessment – this section will discuss the chemistry data from groundwater, soil, soil vapor, and surface water samples. These data will be screened in a preliminary evaluation to identify chemicals of potential concern (COPCs) to be carried through the Risk Assessment process. The Risk Assessment will consist of two components: a Human Health Risk Assessment (HHRA) and Ecological Risk Assessment (ERA);
- Conclusions – will summarize the pertinent information from each section and present general conclusions regarding a path forward for the site within the RP-VCC process.

A draft version of the RI Report will be submitted in electronic format to PLNA for review. The RI Report will be finalized for submittal to SCDHEC after receipt of comments from PLNA. A schedule for submittal of the RI Report will be developed after SCDHEC's approval of the Phase II RI Work Plan.

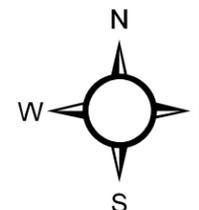
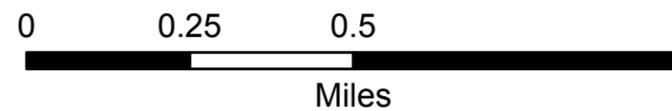
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FIGURES



Source:
Newberry West and Newberry East Quadrangles
from ArcGIS Online map service USA_Topo_Maps.



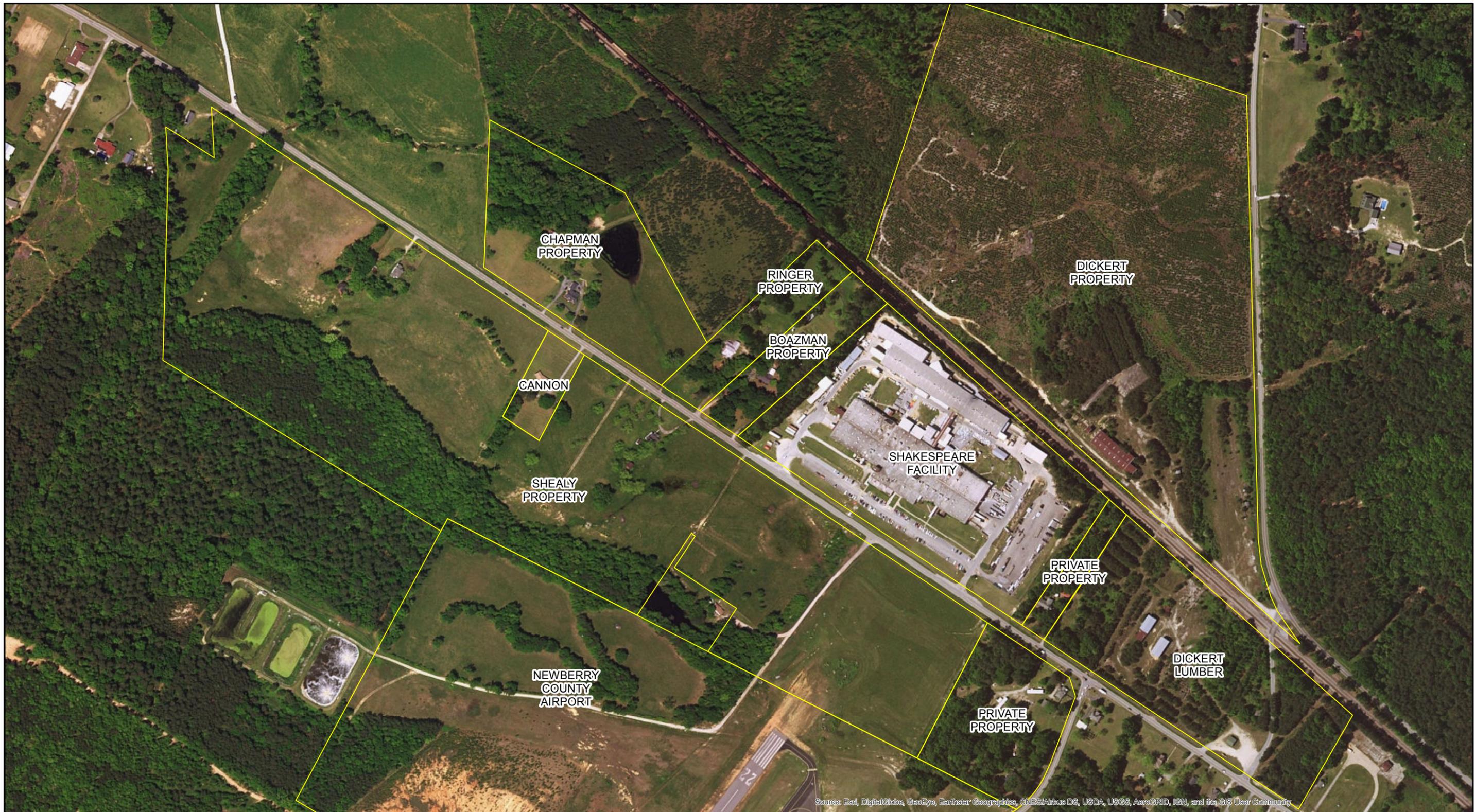
AECOM

101 Research Drive
Columbia, SC 29203-9389
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Figure 1-1: Site Location Map

Shakespeare Composition Structures
Newberry, South Carolina

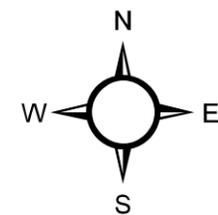
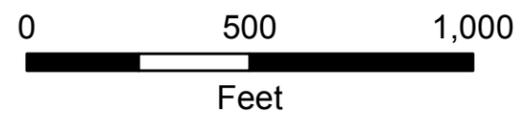
Project No.: 60534283; Prepared by: JC; Date: 4/5/2017.



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

 Property Parcels



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Figure 1-2: Site Plan

Shakespeare Composition Structures
 Newberry, South Carolina

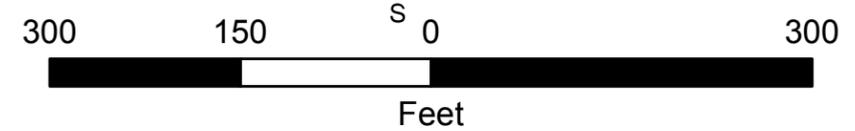
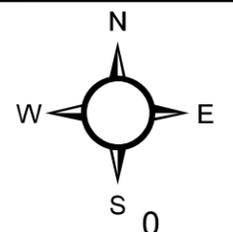
Project No.: 60534283; Prepared by: JC; Date: 4/5/2017.



Source: Esri, DigitalGlobe,

Legend

- Historical Soil Sampling Location
- Proposed Soil Vapor Sampling Location



G:\Projects\Active\60328308_Shakespeare\map\ProposedSoilVaporSamplingLocations.mxd

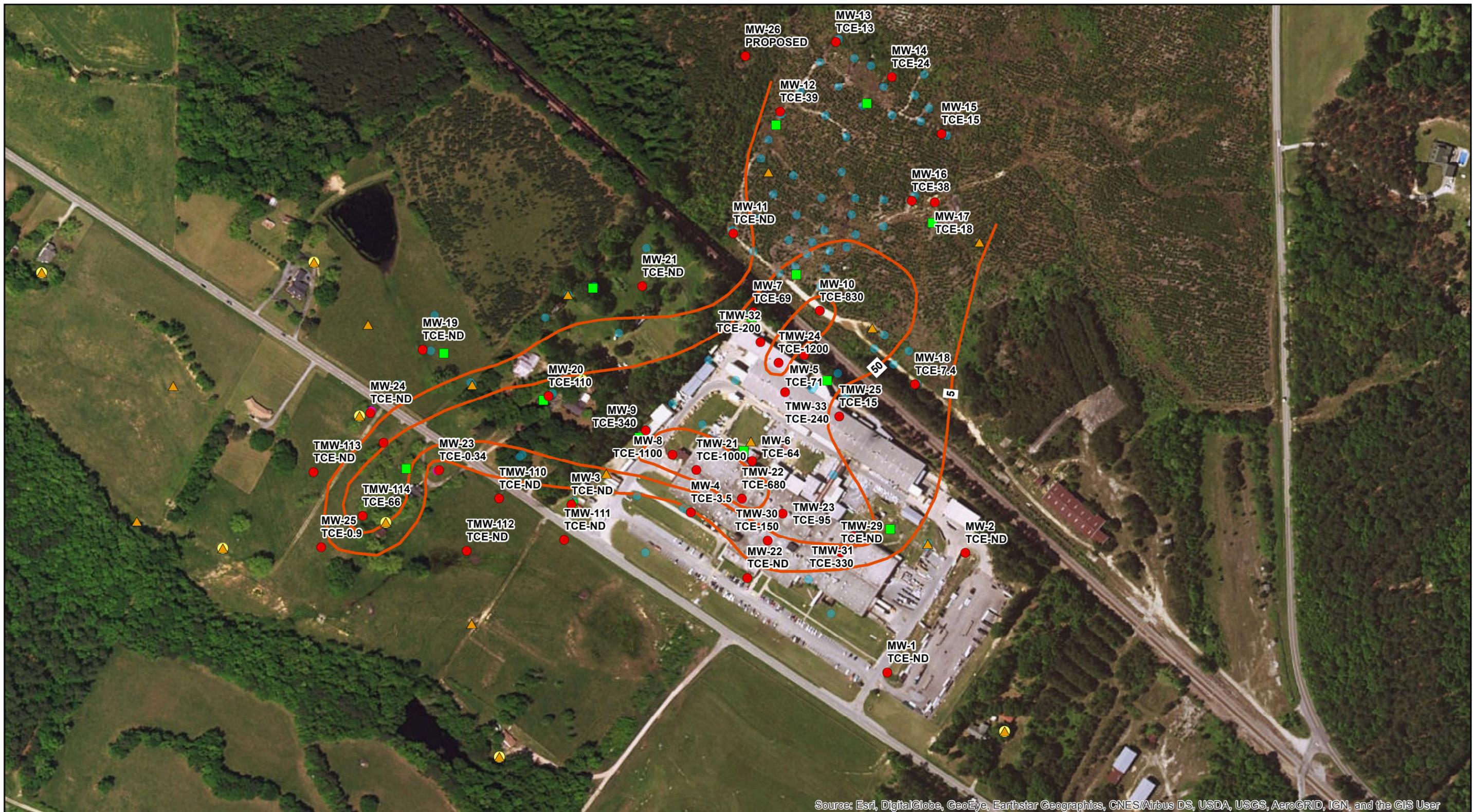


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Figure 2-1: Proposed Soil Vapor Sampling Locations

Shakespeare Composition Structures
 Newberry, South Carolina

Project No.: 60534283; Prepared by: JC; Date: 4/5/2017.



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User

Legend

- Shallow Well
- Intermediate Well
- ▲ Bedrock Well
- Water Supply Well
- Existing Shallow Zone Monitoring Well
- Abandoned Temporary Wells
- TCE Isoconcentration Contour (ug/L)

TCE-15: Trichloroethene concentration 15 ug/L.
 ND: Non detected.

0 300 600 900

Feet

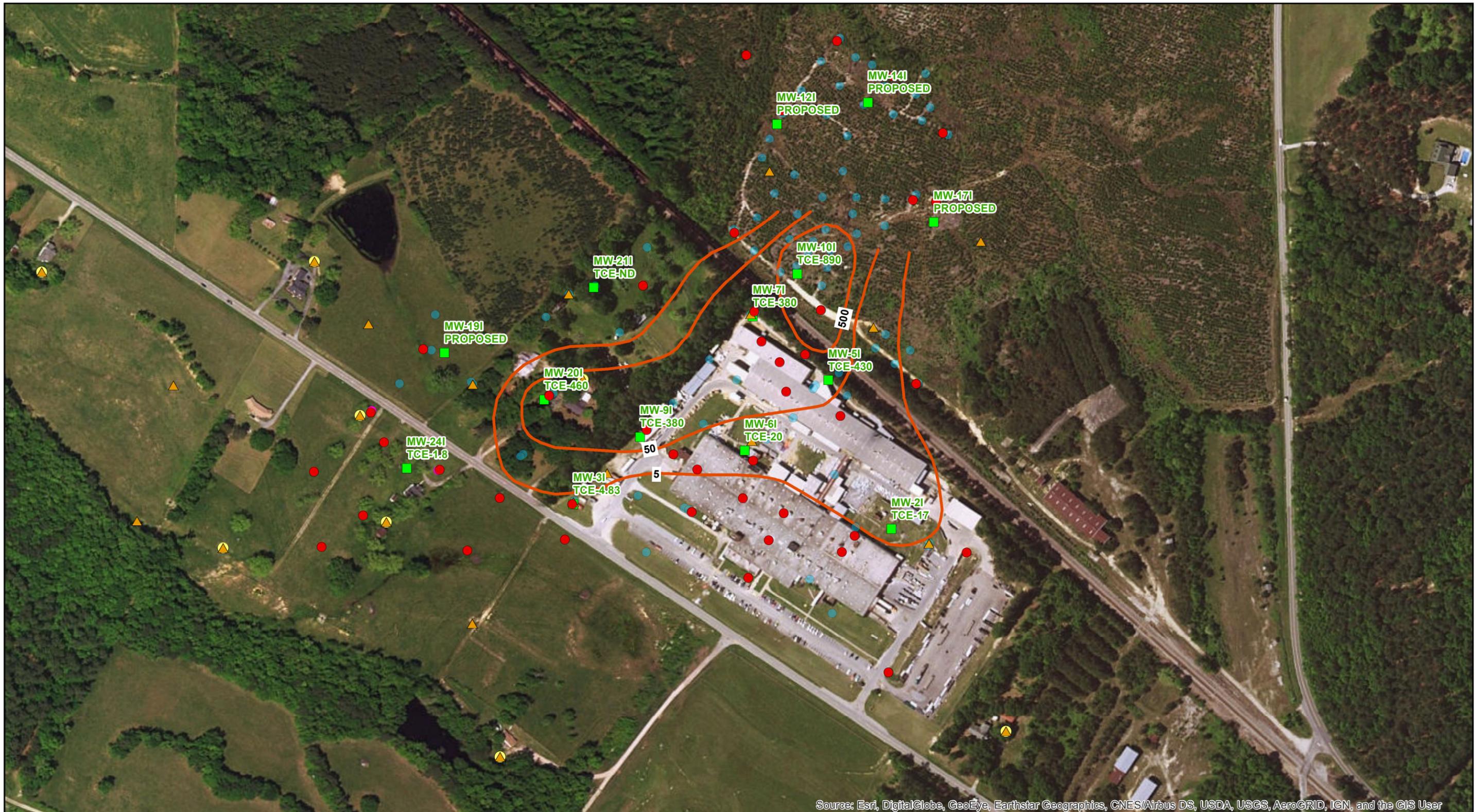
G:\Projects\Active\60328308_Shakespeare\map\Shallow_TCE.mxd

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Figure 2-2: Shallow Well Locations

Shakespeare Composition Structures
 Newberry, South Carolina

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Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User

Legend

- Shallow Well
- Intermediate Well
- ▲ Bedrock Well
- Water Supply Well
- Existing Shallow Zone Monitoring Well
- Abandoned Temporary Wells
- TCE Isoconcentration Contour (ug/L)

TCE-17: Trichloroethene concentration 17 ug/L.
 ND: Non detected.

N
 W ○ E
 S

0 300 600 900

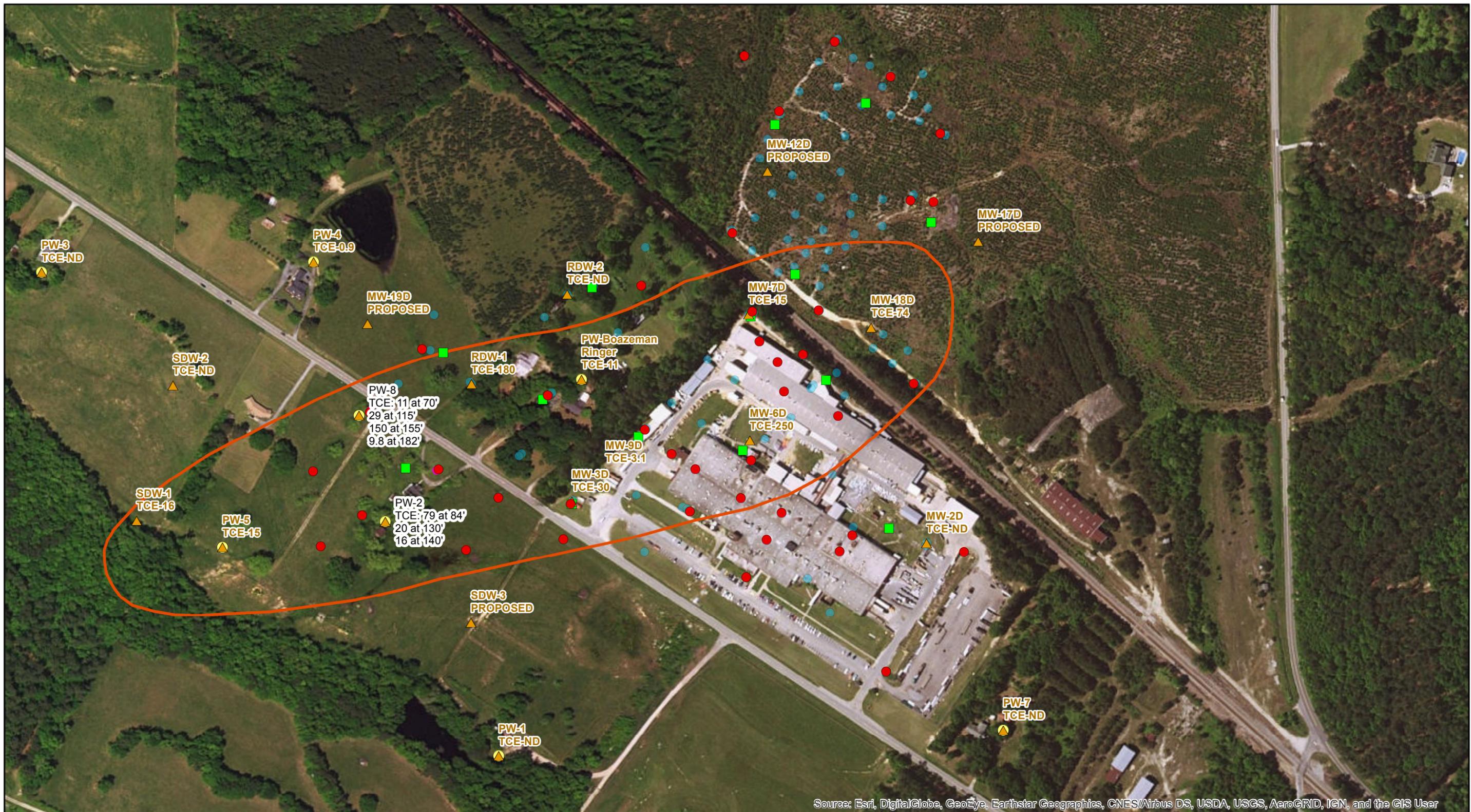
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Figure 2-3: Intermediate Well Locations
 Shakespeare Composition Structures
 Newberry, South Carolina

Project No.: 60534283; Prepared by: JC; Date: 4/5/2017.

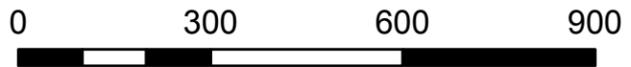
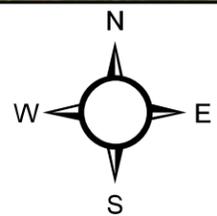


Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User

Legend

- Shallow Well
- Intermediate Well
- ▲ Bedrock Well
- Water Supply Well
- Existing Shallow Zone Monitoring Well
- Abandoned Temporary Wells
- TCE Isoconcentration contour (ug/L)

TCE-15: Trichloroethene concentration 15 ug/L.
 ND: Non detected.



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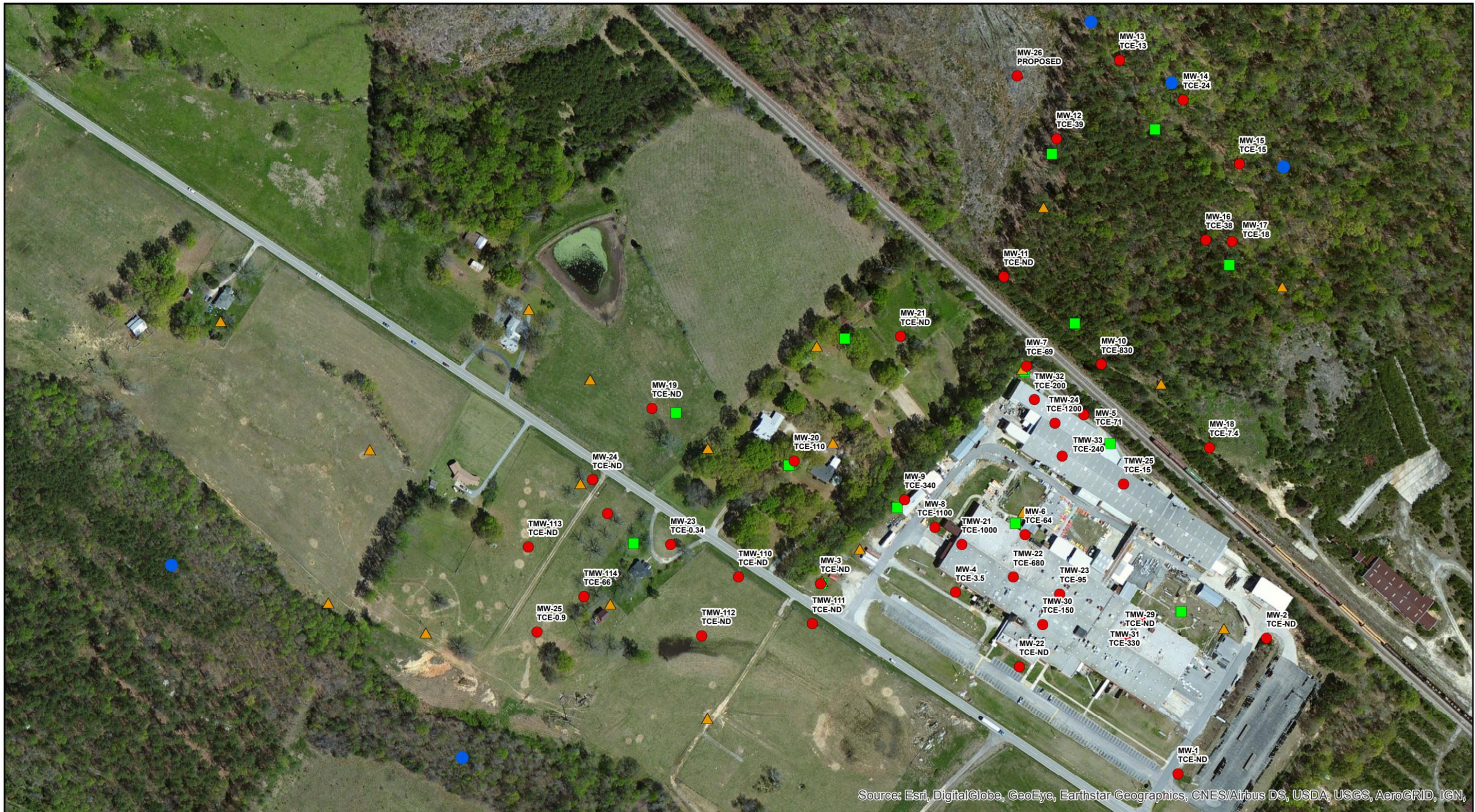


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Figure 2-4: Bedrock Well Locations

Shakespeare Composition Structures
 Newberry, South Carolina

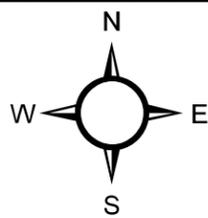
Project No.: 60534283; Prepared by: JC; Date: 4/5/2017.



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN,

Legend

- Proposed Surface Water Sampling Location
- Shallow Well
- Intermediate Well
- ▲ Bedrock Well



0 500 1,000

Feet

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Figure 2-5: Proposed Surface Water Sampling Locations

Shakespeare Composition Structures
Newberry, South Carolina

Project No.: 60534283; Prepared by: JC; Date: 4/5/2017.

TABLES

Table 2-1

**Proposed Well Locations
Phase II Remedial Investigation Work Plan
Shakespeare Composite Structures Site
Newberry, South Carolina**

Existing Well Location ID	Depth of Nearest Historic Sample	Profiling Start Depth	Proposed Depth for Permanent Well	Description of Proposed Location
Shallow Wells				
MW12	30	35	30	MW26 - Folk property, located approximately 200 feet northwest of MW12
Intermediate Wells				
MW12	31	36	TBD	MW12I - South of MW12 on Dickert property
MW19	15	20	TBD	MW19I - Adjacent to existing shallow well MW19
MW14	20	25	TBD	MW14I - South of MW14 on Dickert property
MW17	30	35	TBD	MW17I - Adjacent to MW17 on Dickert property
Bedrock Wells				
MW12	31	TBD*	TBD	MW12D - South of MW12 on Dickert Property
MW17	20	TBD*	TBD	MW17D - East of MW17 on Dickert property
MW19	15	TBD*	TBD	MW19D - West of MW19 on Chapman property
TMW112	30	TBD*	TBD	SDW3 - South of former location of TMW112 on Shealy Property

* Depth at which profiling in bedrock will be initiated will be determined once top of bedrock is encountered.

Appendix A

Standard Operating Procedures

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

OPERATING PROCEDURE

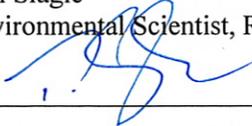
Title: Soil Gas Sampling

Effective Date: May 14, 2014

Number: SESDPROC-307-R3

Authors

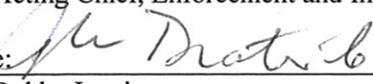
Name: Tim Slagle
Title: Environmental Scientist, Regional Expert

Signature: 

Date: 5/12/2014

Approvals

Name: John Deatruck
Title: Acting Chief, Enforcement and Investigations Branch

Signature: 

Date: 5/12/14

Name: Bobby Lewis
Title: Field Quality Manager, Science and Ecosystem Support Division

Signature: 

Date: 5/12/14

Revision History

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

History	Effective Date
<p>SESDPROC-307-R3, <i>Soil Gas Sampling</i>, replaces SESDPROC-307-R2</p> <p>General: Corrected any typographical, grammatical, and/or editorial errors. Throughout the document mention of quality system or SESD quality system was replaced with Field Branches Quality System or FBQS.</p> <p>Cover Page: Changed the Author from Tim Slagle to TBD. Changed the Enforcement and Investigations Branch Chief from Archie Lee to Acting Chief John Deatrick. Changed the FQM from Liza Montalvo to Bobby Lewis.</p> <p>Revision History: Changes were made to reflect the current practice of only including the most recent changes in the revision history.</p>	May 14, 2014
<p>SESDPROC-307-R2, <i>Soil Gas Sampling</i>, replaces SESDPROC-307-R1</p>	September 8, 2010
<p>SESDPROC-307-R1, <i>Soil Gas Sampling</i>, replaces SESDPROC-307-R0</p>	November 1, 2007
<p>SESDPROC-307-R0, <i>Soil Gas Sampling</i>, Original Issue</p>	February 05, 2007

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1 General Information

1.1 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.

1.2 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 SESD field personnel determine that any of the procedures described in this section are inappropriate, inadequate or impractical and that another procedure must be used to obtain a soil 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.

1.3 Documentation/Verification

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

1.4 References

Geoprobe® Systems Tools and Equipment Catalog, Kejr Engineering, Inc., Salinas, Kansas, 1997.

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

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

SESD Operating Procedure for Equipment Inventory and Management, SESDPROC-104, Most Recent Version

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

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

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

SESD Operating Procedure for Packaging, Marking, Labeling and Shipping of Environmental and Waste Samples, SESDPROC-209, Most Recent Version

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

The Yellow Field Book©, Kejr Engineering, Inc., Salinas, Kansas, 2000.

US EPA. 1999. Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, Second Edition, Compendium Method TO-15, Determination of Volatile Organic Compounds (VOCs) in Air Collected in Specially Prepared Canisters and Analyzed by Gas Chromatography/Mass Spectrometry (GC/MS); Center for Environmental Research Information, Office of Research and Development, Cincinnati, OH; EPA/625/R-96/010b

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

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

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

Geoprobe Systems, Direct Push Installation of Devices for Active Soil Gas Sampling & Monitoring, Technical Bulletin No. MK3098, Prepared May, 2006.

1.5 General Precautions

1.5.1 Safety

Proper safety precautions must be observed when collecting soil gas samples. Refer to the SESD Safety, Health and Environmental Management Program (SHEMP) Procedures and Policy Manual and any pertinent site-specific Health and Safety Plans (HASP) for guidelines on safety precautions. These guidelines 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.

1.5.2 Procedural Precautions

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

- Special care must be taken not to contaminate samples. This includes storing samples in a secure location to preclude conditions which could alter the properties of the sample. Samples shall be custody sealed during long-term storage or shipment.
- Collected samples are in the custody of the sampler or sample custodian until the samples are relinquished to another party.
- If samples are transported by the sampler, they will remain under his/her custody or be secured until they are relinquished.
- Shipped samples shall conform to all U.S. Department of Transportation (DOT) and/or International Air Transportation Association (IATA) hazardous materials shipping requirements.
- Documentation of field sampling is done in a bound logbook.
- Chain-of-custody documents shall be filled out and remain with the samples until custody is relinquished.
- All shipping documents, such as air bills, bills of lading, etc., shall be retained by the project leader and stored in a secure place.

2 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 soil gas sampling will be conducted to investigate the presence or extent of organic compounds, Teflon® tubing is required to ensure the integrity of the sample.

2.2 Special Precautions for Soil Gas Sampling

- A clean pair of new, non-powdered, disposable gloves will be worn each time a different location is sampled and the gloves should be donned immediately prior to sampling. The gloves should be changed any time during sample collection when their cleanliness is compromised.
- If possible, one member of the field sampling team should take all the notes and photographs, fill out tags, etc., while the other members collect the samples.
- Use O-rings on all tooling, adapters and probe rods to ensure that the entire sampling train is air-tight. This is necessary to prevent soil ingress during installation and to maintain sample integrity by ensuring that no ambient air is introduced into the sample during collection.
- When using the Post-Run Tubing (PRT) sampling system, excavate a small depression around the rods after driving the distance of the intended open interval. Fill the depression with bentonite crumbles (not pellets) and hydrate with tap water to ensure sealing at the ground surface. Special care should be taken to keep the rod string aligned with the push axis of the probe machine.

2.3 Sample Handling Requirements

1. Soil gas samples will typically be collected by directly filling evacuated, specially-prepared stainless steel canisters (SUMMA or SilcoSteel® canisters), after sample delivery line purging.
2. The canister will be labeled and identified according to SESD Operating Procedure for Packaging, Marking, Labeling and Shipping of Environmental and Waste Samples (SESDPROC-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.

- Control Sample: If applicable to the study or investigation, a control sample should be collected from a location not affected by the possible contaminants of concern and submitted with the other samples.
- Field Blank: A canister field blank, prepared prior to the investigation by ASB personnel, should also be submitted with the sample set during the investigation.
- Equipment rinsate blank: Equipment rinsate blanks should be collected if equipment, such as PRT adapters, probe rod or other sampling equipment is field cleaned and re-used to document that low-level contaminants were not introduced into the sample by the decontaminated equipment.
- Field Split: Field split samples, at a minimum frequency of one for every twenty samples, should be collected. Split samples are collected by attaching the center leg of a Swagelok® “T” to the end of the sample tubing. The remaining legs of the “T” are connected to two sample containers which are opened and filled simultaneously.

2.5 Records

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

3 Geoprobe® PRT System Installation

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, i.e., using this method, there is no leakage at probe rod joints that will compromise the integrity of the sample.

The downhole components of the PRT system include:

- Sample delivery tubing
- Probe rods
- PRT Adapter
- Expendable point holder
- Expendable point

O-ring seals are used on the PRT Adapter, the expendable point holder and at all rod joints. The O-rings prevent 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 rod. In SESD 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.

1. Place O-ring on PRT expendable point holder and attach to initial section of probe rod.
2. Place O-ring on expendable point and press into expendable point holder.
3. Add drive cap to probe rod and push PRT system into ground the distance of the intended open-interval. Take special care to assure that the rods are in line with the push axis of the probe machine. Dig a small depression around the rod string. Fill the depression with bentonite crumbles (not pellets) and hydrate with tap water.
4. At 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.
5. Using a properly decontaminated water level sounder, check, if conditions warrant, to make sure groundwater is not present prior to proceeding with Step 6.
 6. Secure the PRT adapter to a length of 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. The adapter is secured tightly to the tubing using electrical tape. This will not compromise the integrity of the sample to be collected, as the sample is pulled directly through the adapter and is never exposed to the tape.
 7. 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 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.
 8. At this point, the PRT system has been installed and is ready for sampling. If the sample can not be collected immediately, the end of the tubing should be capped with a stainless steel Swagelok® cap. Sampling is conducted using one of the procedures described in Section 5, Sampling PRT and Permanent Soil Gas Installations

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:

1. **Direct Placement of Pellets or Grout** - If the sampling depth was fairly shallow, on the order of ten feet or less, 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.

2. **Re-entry Grouting** - For locations where sampling was conducted at somewhat greater depths or where the surficial formations tend to collapse, the only viable option for grout placement may be to re-probe the entire depth with an 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 1.0-inch, 1.25-inch or 1.5-inch diameter probe rod. In SESD practice, 1.25-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 to install a permanent soil gas sampling implant using the Geoprobe®. These are the general procedures which are used with 1.25-inch diameter probe rod.

1. Attach O-ring to implant point anchor.
2. Press implant point anchor into point holder and attach to first section of probe rod.
3. Push implant point anchor to the desired depth for implant installation. Using O-rings on all rod joints will prevent soil intrusion.
4. When the desired depth has been reached, attach the implant to the sample delivery tubing. This is accomplished by loosening or removing the Swagelok® fitting and pressing the tubing into the implant. When the end of the tubing is sufficiently engaged in the end of the implant, the Swagelok® fitting is tightened to secure the tubing in the implant. The Swagelok® tightening recommendation is 1 and ¼ turns after finger-tightening. It is critical that the tubing be securely attached to the implant so that it does not pull off during subsequent steps of the installation.
5. Feed the tubing into the probe rod until the implant reaches the implant point anchor. At this point, cut the tubing to allow enough tubing to remain for sampling, usually three to four feet.

6. Rotate the tubing and implant counter-clockwise, threading the implant into the anchor. If there was any soil intrusion during the push, the implant may not dock. 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.
7. After the implant has been docked, use a pull cap and pull the probe rod approximately one foot, exposing the implant. Observe the tubing to make sure that anchor remained in place and is not being pulled with the rod.
8. 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. While pouring the beads, it is advisable to gently shake the tubing to prevent the beads from bridging inside the probe rod.
9. After placing the beads, the implant is sealed using a flowable mixture of the glass beads and fine-powdered bentonite. To accomplish this, two to three feet 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. After placement of the bead/bentonite seal, hydrate by pouring one gallon of de-ionized water above the seal.
10. After placement and hydration of the seal, the rod string is removed and the resultant annular space is grouted using one of the following procedures, which are dependent on the depth and stability of the open hole.
 - a. 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.
 - b. 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. ½-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 SESDGUID-101, Section 2.3.5.
11. 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 SESDGUID-101. The finish

should be performed after 24 hours of grout curing.

12. After installation is complete the soil gas implant is sampled using one of the methods described in Section 5, Sampling PRT and Permanent Soil Gas Installations.

5 Sampling PRT and Permanent Soil Gas Installations

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 SESD.

- **Canister Sampling for Laboratory Analysis** – After installation is complete and immediately prior to sampling, a flow-limiting device, consisting of a sintered stainless steel filter and a critical orifice, is attached at the sampling end of the tubing. After the device is connected to the Teflon® tubing, it is necessary to remove all stagnant or ambient air from the sample string. This volume, equal to approximately three times the volume of the sample string, should be estimated or calculated and attention must be given to not over-purging the estimated or calculated volume of the tubing and sample interval prior to sampling. Line purging can be accomplished using a low-flow pump, such as a personal air sampling pump, or a TVA1000.

After all stagnant/ambient air has been removed, the purging pump is removed and an evacuated canister is attached using a Swagelok® or other suitable secure connection. After connection, 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, at which time the canister valve is closed and the canister tagged with pertinent sampling information. Alternatively, in some situations a mass-flow controller will be required to collect a sample over a specified, longer period of time period. This type of sampler is typically out-fitted with a gauge that will display the canister vacuum during the sampling period. When using this type of device, it is advisable to check the canister vacuum throughout the sampling period to verify filling. Gauge pressure/vacuum reading should be recorded in the project logbook.

- **Real-time Field Analytical Methods** – Real-time analytical measurements may be obtained from PRT or soil gas implant 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.

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

GUIDANCE

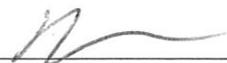
Title: Design and Installation of Monitoring Wells

Effective Date: January 29, 2013

Number: SESDGUID-101-R1

Authors

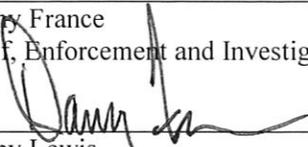
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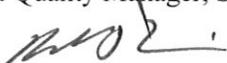
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Revision History

This table shows changes to this controlled document over time. The most recent version is presented in the top row of the table. Previous versions of the document are maintained by the SESD Document Control Coordinator.

History	Effective Date
<p>SESDGUID-101-R1, <i>Design and Installation of Monitoring Wells</i>, replaces SESDPROC-101-R0.</p> <p>General: Corrected any typographical, grammatical and/or editorial errors.</p> <p>Cover Page: The Enforcement and Investigations Branch Chief was changed from Antonio Quinones to Danny France. The FQM was changed from Laura Ackerman to Bobby Lewis.</p> <p>Section 1.2: Added the following statement: Mention of trade names or commercial products does not constitute endorsement or recommendation for use.</p> <p>Section 1.3: Omitted the reference to the H: drive of the LAN.</p> <p>Section 1.4: Replaced the “SESD Operating Procedure for Field Records and Documentation, SESDPROC-204-Most Recent Version” with its updated version, the “SESD Operating Procedure for Logbooks, SESDPROC-010, Most Recent Version.</p> <p>Section 1.5.1: Updated the SEMP Manual reference to reflect that the most recent version of the Manual will be used.</p> <p>Section 1.5.2: On the second bullet, replaced the reference with the “SESD Operating Procedure for Logbooks (SESDPROC-010).”</p>	<p>January 29, 2013</p>
<p>SESDGUID-101-R0, <i>Design and Installation of Monitoring Wells</i>, Original Issue</p>	<p>February 18, 2008</p>

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1 General Information

1.1 Purpose

This document describes general and specific procedures, methods and considerations to be used and observed when designing and installing permanent and temporary groundwater monitoring wells to be used for collection of groundwater samples.

1.2 Scope/Application

The procedures contained in this document are to be used by field personnel when designing, constructing and installing groundwater monitoring wells. On the occasion that SESD field personnel determine that any of the procedures described in this section are either inappropriate, inadequate or impractical and that another procedure must be used for any aspect of the design, construction and/or installation of a groundwater monitoring well, 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.

1.3 Documentation/Verification

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

1.4 References

USEPA Region 4 Environmental Investigations Standard Operating Procedures and Quality Assurance Manual (EISOPQAM), November 2001

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

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

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

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

SESD Operating Procedure for Groundwater Sampling, SESDPROC-301, Most Recent Version

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

EPA/540/S-95/503, *Nonaqueous Phase Liquids Compatibility with Materials Used in Well Construction, Sampling, and Remediation*

ASTM standard D5092, *Design and Installation of Ground Water Monitoring Wells in Aquifers*

1.5 General Precautions

1.5.1 Safety

Proper safety precautions must be observed when constructing and installing groundwater monitoring wells. Refer to the SESD Safety, Health and Environmental Management Program Procedures and Policy (SHEMP) Manual (Most Recent Version) and any pertinent site-specific Health and Safety Plans (HASPs) for guidelines on safety precautions. These guidelines should be used to complement the judgment of an experienced professional. When using this procedure, minimize exposure to potential health hazards through the use of protective clothing, eye wear and gloves. Address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate. Section 2.6, Safety Procedures for Drilling Activities, contains detailed and specific safety guidelines that must be followed by Branch personnel when conducting activities related to monitoring well construction and installation.

1.5.2 Procedural Precautions

The following precautions should be considered when constructing and installing groundwater monitoring wells.

- Special care must be taken to minimize or prevent inadvertent cross-contamination between borehole locations. Equipment, tools and well materials must be cleaned and/or decontaminated according to procedures found in SESD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205).
- All field activities are documented in a bound logbook according to the procedures found in SESD Operating Procedure for Logbooks (SESDPROC-010).

2 Permanent Monitoring Well Design Considerations

2.1 General

The design and installation of permanent monitoring wells involves drilling into various types of geologic formations that exhibit varying subsurface conditions. Designing and installing permanent monitoring wells in these geologic environments may require several different drilling methods and installation procedures. The selection of drilling methods and installation procedures should be based on field data collected during a hydrogeologic site investigation and/or a search of existing data. Each permanent monitoring well should be designed and installed to function properly throughout the duration of the monitoring program. When designing monitoring wells, the following should be considered:

- Short-and long-term objectives;
- Purpose of the well(s);
- Probable duration of the monitoring program;
- Contaminants likely to be monitored;
- Surface and subsurface geologic conditions;
- Properties of the aquifer(s) to be monitored;
- Well screen placement;
- General site conditions; and
- Potential site health and safety hazards.

In designing permanent monitoring wells, the most reliable, obtainable data should be utilized. Once the data have been assembled and the well design(s) completed, a drilling method(s) must be selected. The preferred drilling methods for installing monitoring wells are those that temporarily case the borehole during drilling and the construction of the well, e.g. hollow-stem augers and sonic methods. However, site conditions or project criteria may not allow using these methods. When this occurs, alternate methods should be selected that will achieve the project objectives. The following discussion of methods and procedures for designing and installing monitoring wells will cover the different aspects of selecting materials and methods, drilling boreholes, and installing monitoring devices.

2.2 Drilling Methods

The following drilling methods may be used to install environmental monitoring wells or collect samples under various subsurface conditions. In all cases the preferred methods are those that case the hole during drilling, i.e. Hollow Stem Augers (HSA) and sonic methods using an override system. Other methods may be used where specific subsurface or project criteria dictate.

2.2.1 Hollow Stem Auger (HSA)

This type of auger consists of a hollow, steel stem or shaft with a continuous, spiraled steel flight, welded onto the exterior. A hollow auger bit, generally with carbide teeth, disturbs soil material when rotated, whereupon the spiral flights transport the cuttings to the surface. This method is best suited in soils that have a tendency to collapse when disturbed. A monitoring well can be installed inside of hollow-stem augers with little or no concern for the caving potential of the soils. If caving sands exist during monitoring well installations, a drilling rig must be used that has enough power to extract the augers from the borehole without having to rotate them. A bottom plug, trap door, or pilot bit assembly can be used at the bottom of the augers to keep out most of the soils and/or water that have a tendency to enter the bottom of the augers during drilling. Potable water (analyzed for contaminants of concern) may be poured into the augers during drilling to equalize pressure so that the inflow of formation materials will be held to a minimum. Water-tight center bits are not acceptable because they create suction when extracted from the augers. This suction forces or pulls cuttings and formation materials into the augers, defeating the purpose of the center plug. Augering without a center plug or pilot bit assembly is permitted, provided that the soil plug, formed in the bottom of the augers, is removed before sampling or installing well casings. Removing the soil plug from the augers can be accomplished by drilling and washing out the plug using a rotary bit, or augering out the plug with a solid-stem auger bit sized to fit inside the hollow-stem auger. Bottom plugs can be used where no soil sampling is conducted during the drilling process. The bottom plug is wedged into the bottom of the auger bit and is knocked out at depth with drill pipe or the weight of the casing and screen assembly. The plug material should be compatible with the screen and casing materials. The use of wood bottom plugs is not acceptable. The type of bottom plug, trap door, or pilot bit assembly proposed for the drilling activity should be approved by a senior field geologist prior to drilling operations. Boreholes can be augered to depths of 150 feet or more (depending on the auger size), but generally boreholes are augered to depths less than 100 feet.

2.2.2 Solid Stem Auger

This type of auger consists of a sealed hollow or solid stem or shaft with a continuous spiraled steel flight welded on the outside of the stem. An auger bit connected to the bottom disturbs soil material when rotated and the helical flights transport cuttings to the surface. At the desired depth the entire auger string is removed to gain access to the bottom of the borehole. This auger method is used in cohesive and semi-cohesive soils that do not have a tendency to collapse when disturbed. Boreholes can be augered to depths of 200 feet or more (depending on the auger size), but generally boreholes are augered to depths less than 100 feet.

Both of the previously discussed auger methods can be used in unconsolidated soils and semi-consolidated (weathered rock) soils, but not in competent rock.

Each method can be employed without introducing foreign materials into the borehole such as water and drilling fluids, minimizing the potential for cross contamination. Minimizing the risk of cross contamination is one of the most important factors to consider when selecting the appropriate drilling method(s) for a project.

2.2.3 Sonic Methods

These methods generally alternately advance concentric hollow drill stems using rotation in conjunction with axial vibration of the drill stem. After each stage of drill stem advancement, the inner string is removed with a core of drill cuttings while the outer 'override' string remains to hold the borehole open. The cuttings can be removed nearly intact from the inner casing for examination of the stratigraphy prior to sampling or disposal. Because there are no auger flights to increase the borehole diameter, the quantity of cuttings removed from the hole is minimized as compared to hollow stem augering. With moderate rotation, smearing of the formation materials on the borehole walls is reduced as well. This drilling method is useful in a variety of materials, from flowing sands to heavily consolidated or indurated formations.

In flowing sands, the drill casings can be filled and/or pressurized with potable water to prevent excess entry of formation materials into the drill string. The same QA/QC requirements for sampling of material introduced to the borehole apply as in other drilling methods. Because the amount of water introduced into the borehole can be significant, an approximation of the water used in the drilling process should be logged for use in estimating appropriate well development withdrawal.

Sonic drilling allows a larger diameter temporary casing to be set into a confining layer while drilling proceeds into deeper aquifers. This temporary casing is then removed during the grouting operation. In many cases this will be acceptable technique. However, the level of contamination in the upper aquifer, the importance of the lower aquifers for drinking water uses, the permeability and continuity of the confining layer, and state regulations should be taken into account when specifying this practice as opposed to permanent outer casing placed into the confining unit. Note that when using the temporary casing practice, it is critical that grout be mixed and placed properly as specified elsewhere in this section.

Because the total borehole diameter in sonic drilling is only incrementally larger than the inner casing diameter, particular care should be taken that the well casing is placed in the center of the drill stem while placing the filter pack. Centralizers should be used in most cases to facilitate centering, particularly in the case of deep wells with PVC casing.

2.2.4 Rotary Methods

These methods consist of a drill pipe or drill stem coupled to a drilling bit that rotates and cuts through the soils. The cuttings produced from the rotation of the drilling bit are transported to the surface by drilling fluids which generally consist of water, drilling mud, or air. The water, drilling mud, or air are forced down through the drill pipe, and out through the bottom of the drilling bit. The cuttings are then lifted to the surface between the borehole wall and the drill pipe, (or within a concentric drill stem in reverse rotary). Except in the case of air rotary, the drilling fluid provides a hydrostatic pressure that reduces or prevents borehole collapse. When considering this method, it is important to evaluate the potential for contamination when fluids and/or air are introduced into the borehole.

Due to the introduction of the various circulating fluids, the use of rotary methods requires that the potential for contamination by these fluids be evaluated. Water and mud rotary methods present the possibility of trace contamination of halogenated compounds when municipal water supplies are used as a potable water source. Air rotary drilling can introduce contamination through the use of lubricants or entrained material in the air stream. Unless contaminated formations are cased off, the circulation of drilling fluids presents a danger of cross contamination between formations. In any of the rotary (or sonic) methods, care must be exercised in the selection and use of compounds to prevent galling of drill stem threads.

2.2.4.1 Water Rotary

When using water rotary, potable water (that has been analyzed for contaminants of concern) should be used. If potable water (or a higher-quality water) is not available on-site, then potable water will have to be transported to the site or an alternative drilling method will have to be selected. Water does not clog the formation materials, but the suspended drilling fines can be carried into the formation, resulting in a very difficult to develop well. This method is most appropriate for setting isolation casing.

2.2.4.2 Air Rotary

Air rotary drilling uses air as a drilling fluid to entrain cuttings and carry them to the surface. High air velocities, and consequently large air volumes and compressor horsepower are required. "Down-the-hole" (DTH) percussion hammers driven by the air stream can be used with this method to rapidly penetrate bedrock materials. Where a casing through unconsolidated material is required to prevent borehole collapse, it can be driven in conjunction with advancement of the drill stem.

When using air rotary drilling in any zone of potential contamination, the cuttings exiting the borehole must be controlled. This can be done using

the dual-tube reverse circulation method where cuttings are carried to the surface inside dual-wall drill pipe and separated with a cyclone separator. An air diverter with hose or pipe carrying cuttings to a waste container is also an acceptable alternative. Allowing cuttings to blow uncontrolled from the borehole is not acceptable.

When using air rotary, the issue of contaminants being introduced into the borehole by the air stream must be addressed. Screw compressor systems should have a coalescing filter system in good working order to capture excess entrained compressor oils. The lubricant to be used with DTH hammers as well as thread lubricants to be used on drill stem should be evaluated for their potential impact on analytical samples.

2.2.4.3 Mud Rotary

Mud rotary is an undesirable drilling method because contamination can be introduced into the borehole from the constituents in the drilling mud, cross contamination can occur along the borehole column, and it is difficult to remove the drilling mud from the borehole after drilling and during well development. The drilling mud can also carry contaminants from a contaminated zone to an uncontaminated zone thereby cross-contaminating the borehole. If mud rotary is selected, only potable water and pure (no additives) bentonite drilling muds should be used. All materials used should have adequate documentation as to manufacturer's recommendations and product constituents. QA/QC samples of drilling muds and potable water should be sampled at a point of discharge from the circulation system to assure that pumps and piping systems are not contributing cross-contamination from previous use.

2.2.5 Other Methods

Other methods such as the cable-tool method, jetting method, and boring (bucket auger) method are available. If these and/or other methods are selected for monitoring well installations, they should be approved by a senior field geologist before field work is initiated.

2.3 Borehole Construction

2.3.1 Annular Space

The borehole or hollow stem auger should be of sufficient diameter so that well construction can proceed without major difficulties. For open boreholes, the annular space should be approximately 2" to allow the uniform deposition of well materials around the screen and riser, and to allow the passage of tremie pipes and well materials without unduly disturbing the borehole wall. For example, a 2" nominal diameter (nom.) casing would require a 6" inside diameter (ID) borehole.

In hollow stem augers and sonic method drill casing, the ID should be of sufficient size to allow the passage of the tremie pipe to be used for well grout placement, as well as free passage of filter sands or bentonite pellets dropped through the auger or casing. In general, 4-1/4" ID should be the minimum size used for placement of 2" nom. casing and 8-1/4" ID for 4" nom. casing. Larger augers should be used where installation difficulties due to geologic conditions or greater depths are anticipated, e.g. larger augers might be required to place a bentonite pellet seal through a long water column.

2.3.2 Over-drilling the Borehole

Sometimes it is necessary to over-drill the borehole in anticipation of material entering the augers during center bit removal or knocking out of the bottom plug. Normally, 3 to 5 feet is sufficient for over-drilling. The borehole can also be over-drilled to allow for an extra space or a "sump" area below the well screen. This "sump" area provides a space to attach a 5 or 10 foot section of well casing to the bottom of the well screen. The extra space or "sump" below the well screen serves as a catch basin or storage area for sediment that flows into the well and drops out of suspension. These "sumps" are added to the well screens when the wells are screened in aquifers that are naturally turbid and will not yield clear formation water (free of visible sediment) even after extensive development. The sediment can then be periodically pumped out of the "sump" preventing the well screen from clogging or "silting up". If the borehole is inadvertently drilled deeper than desired, it can be backfilled to the design depth with bentonite pellets, chips, or the filter sand that is to be used for the filter pack.

2.3.3 Filter Pack Placement

When placing the filter pack into the borehole, a minimum of 6-inches of the filter pack material should be placed under the bottom of the well screen to provide a firm base. Also, the filter pack should extend a minimum of 2-feet above the top of the well screen to allow for settling and to isolate the screened interval from the grouting material. In open boreholes, the filter pack should be placed by the tremie or positive displacement method. Placing the filter pack by pouring the sand into an open drill stem is acceptable with the use hollow stem augers, and other methods where the borehole is temporarily cased down to the filter pack.

2.3.4 Filter Pack Seal – Bentonite Pellet Seal (Plug)

Bentonite pellets consist of ground, dried bentonite compacted into pellets available in several sizes. Bentonite pellets are compressed to a bulk density of 70-80 lbs/ft³ and hydrate to a 30% min. solids material. Where neat cement grouts are to be used, the placement of a bentonite pellet seal above the filter pack is mandatory to prevent the possibility of grout infiltration into the screened interval prior to setting. Bentonite chips or other sealing products should not be

substituted in this application. Where bentonite grouts are to be used, the placement of a bentonite pellet seal is optional, but desirable.

Since bentonite pellets begin hydrating rapidly, they can be very difficult to place properly. They are generally placed by pouring slowly into open boreholes, hollow stem augers or sonic drill pipe. In some cases, pellets are placed by tremie pipe and flushed into place with potable water. A tamper can be used to ensure that the material is being placed properly and to rapidly break up any pellet bridging that occurs.

Pellet seals should be designed for a two-foot thickness of dry pellets above the filter pack. Hydration may extend the height of the seal. Where neat cement grouts are to be used, the pellets should be hydrated for eight hours, or the manufacturer's recommended hydration time, whichever is greater. Where the water table is temporarily below the pellet seal, potable (or higher quality) water should be added repeatedly to hydrate the pellets prior to grouting.

2.3.5 Grouting the Annular Space

The annular space between the casing and the borehole wall should be filled with either a 30% solids bentonite grout, a neat cement grout, or a cement/bentonite grout. Each type of grout selected should be evaluated as to its intended use and integrity. Bentonite grouts are preferred unless the application dictates the use of another material.

Bentonite grout shall be a 30% solids pure bentonite grout. Drilling muds are not acceptable for grouting. The grout should be placed into the borehole, by the tremie method, from the top of the bentonite seal to within 2-feet of the ground surface or below the frost line, whichever is the greater depth. The bentonite pellet seal or filter pack should not be disturbed during grout placement, either by the use of a side discharge port on the tremie tube, or by maintaining clearance between the bottom of the tremie tube and the bentonite seal or filter pack. The grout should be allowed to cure for a minimum of 24 hours before the concrete surface pad is installed. The preferred method of achieving proper solids content is by measurement of ingredients per the manufacturer's specifications during mixing with a final check by grout balance after mixing. Bentonite grouts should have a minimum density of 10 lbs/gal to ensure proper gelling and low permeability. The density of the first batch of grout should be measured while mixing to verify proper measurement of ingredients. In addition, the grouting operation should not cease until the bentonite grout flowing out of the borehole has a minimum density of 10 lbs/gal. Estimating the grout density is not acceptable.

Cement grouts are generally dictated where a high level of dissolved solids or a particular dissolved constituent would prevent proper gelling of a bentonite grout. Neat cement grouts (cement without additives) should be mixed using 6 gallons of

water per 94-lb bag of Type 1 Portland cement to a density of 15lbs/gal. The addition of bentonite (5 to 10 percent) to the cement grout can be used to delay the "setting" time and may not be needed in all applications. The specific mixtures and other types of cement and/or grout proposed should be evaluated on a case by case basis by a senior field geologist.

2.3.6 Above Ground Riser Pipe and Outer Casing

The well casing, when installed and grouted, should extend above the ground surface a minimum of 2.5 feet. A vent hole should be drilled into the top of the well casing cap to permit pressure equalization, if applicable. An outer protective casing should be installed into the borehole after the annular grout has cured for at least 24 hours. The outer protective casing should be of steel construction with a hinged, locking cap. Generally, outer protective casings used over 2-inch well casings are 4 inches square by 5 feet long. Similarly, protective casings used over 4-inch well casings are 6 inches square and 5 feet long. Other types of protective casing including those constructed of pipe are also acceptable. All protective casings should have sufficient clearance around the inner well casings, so that the outer protective casings will not come into contact with the inner well casings after installation. The protective casings should have a weep hole to allow drainage of accumulated rain or spilled purge water. The weep hole should be approximately 1/4-inch in diameter and drilled into the protective casings just above the top of the concrete surface pad to prevent water from standing inside of the protective casings. Protective casings made of aluminum or other soft metals are normally not acceptable because they are not strong enough to resist tampering. Aluminum protective casing may be used in very corrosive environments such as coastal areas.

Prior to installing the protective casing, the bentonite grout in the borehole annulus is excavated to a depth of approximately two feet. The protective casing is installed by pouring concrete into the borehole on top of the grout. The protective casing is then pushed into the wet concrete and borehole a minimum of 2 feet. Extra concrete may be needed to fill the inside of the protective casing so that the level of the concrete inside of the protective casing is at or above the level of the surface pad. In areas where frost heave of the surface pad is possible, the protective casing should first be pressed into the top surface of the bentonite grout seal and concrete poured around the protective casing. A granular material such as sand or gravel can then be used to fill the space between the riser and protective casing. The use of granular material instead of concrete between the protective casing and riser will also facilitate the future conversion of the well to a flush-mount finish, if required. The protective casing should extend above the ground surface to a height so that the top of the inner well casing is exposed when the protective casing is opened. At each site, all locks on the outer protective casings should be keyed alike.

2.3.7 Concrete Surface Pad

A concrete surface pad should be installed around each well at the same time as the outer protective casing is being installed. The surface pad should be formed around the well casing. Concrete should be placed into the pad forms and into the borehole (on top of the grout) in one operation making a contiguous unit. The size of the concrete surface pad is dependent on the well casing size. If the well casing is 2 inches in diameter, the pad should be 3 feet x 3 feet x 4 inches. If the well casing is 4 inches in diameter, the pad should be 4 feet x 4 feet x 6 inches. Round concrete surface pads are also acceptable. The finished pad should be slightly sloped so that drainage will flow away from the protective casing and off of the pad. A minimum of one inch of the finished pad should be below grade to prevent washing and undermining by soil erosion.

2.3.8 Surface Protection – Bumper Guards

If the monitoring wells are located in a high traffic area, a minimum of three bumper guards consisting of steel pipes 3 to 4 inches in diameter and a minimum 5-foot length should be installed. These bumper guards should be installed to a minimum depth of 2 feet below the ground surface in a concrete footing and extend a minimum of 3 feet above ground surface. Concrete should also be placed into the steel pipe to provide additional strength. Substantial steel rails and/or other steel materials can be used in place of steel pipe. Welding bars between the bumper posts can provide additional strength and protection in high traffic areas, but the protective bumpers should not be connected to the protective casing.

2.4 Construction Techniques

2.4.1 Well Installation

The borehole should be bored, drilled, or augered as close to vertical as possible, and checked with a plumb bob or level. Deviation from plumb should be within 1° per 50ft of depth. Slanted boreholes are undesirable and should be noted in the boring logs and final construction logs. The depth and volume of the borehole, including the over-drilling if applicable, should have been calculated and the appropriate materials procured prior to drilling activities.

The well casings should be secured to the well screen by flush-jointed threads and placed into the borehole and plumbed by the use of centralizers and/or a plumb bob and level. Another method of placing the well screen and casings into the borehole and plumbing them at the same time is to suspend the string of well screen and casings in the borehole by means of a hoist on the drill rig. This wireline method is especially useful if the borehole is deep and a long string of well screen and casings have to be set and plumbed.

No lubricating oils or grease should be used on casing threads. No glue of any type should be used to secure casing joints. Teflon "O" rings can also be used to insure a tight fit and minimize leakage; however, "O" rings made of other materials are not acceptable if the well is going to be sampled for organic compound analyses.

Before the well screen and casings are placed on the bottom of the borehole, at least 6 inches of filter material should be placed at the bottom of the borehole to serve as a firm footing. The string of well screen and casings should then be placed into the borehole and plumbed. Centralizers can be used to plumb a well, but centralizers should be placed so that the placement of the filter pack, bentonite pellet seal, and annular grout will not be hindered. Centralizers placed in the wrong locations can cause bridging during material placement. Monitoring wells less than 50 feet deep generally do not need centralizers. If centralizers are used they should be placed below the well screen and above the bentonite pellet seal. The specific placement intervals should be decided based on site conditions.

When installing the well screen and casings through hollow-stem augers, the augers should be slowly extracted as the filter pack, bentonite pellet seal, and grout are tremied and/or poured into place. The gradual extraction of the augers will allow the materials being placed in the augers to flow out of the bottom of the augers into the borehole. If the augers are not gradually extracted, the materials (sand, pellets, etc.) will accumulate at the bottom of the augers causing potential bridging problems.

After the string of well screen and casing is plumb, the filter pack material should then be placed around the well screen to the designated depth. With cased drilling methods, the sand should be poured into the casing or augers until the lower portion is filled. The casing or augers are then withdrawn, allowing the sand to flow into the evacuated space. With hollow stem augers, sand should always fill the augers 6-12 inches, maintained by pouring the sand while checking the level with a weighted tag line. The filter pack sand in open boreholes should be installed by tremie methods, using water to wash the sand through the pipe to the point of placement.

After the filter pack has been installed, the bentonite pellet seal (if used) should be placed directly on top of the filter pack to an unhydrated thickness of two feet. When installing the seal for use with cement grouts, the bentonite pellet seal should be allowed to hydrate a minimum of eight hours or the manufacturer's recommended hydration time, whichever is longer.

After the pellet seal has hydrated for the specified time, the grout should then be pumped by the tremie method into the annular space around the casings. The grout should be allowed to set for a minimum of 24 hours before the surface pad and protective casing are installed.

After the surface pad and protective casing are installed, bumper guards should be installed (if needed). The bumper guards should be placed around the concrete surface pad in a configuration that provides maximum protection to the well. Each piece of steel pipe or approved material should be installed into an 8-to 10-inch diameter hole, to a minimum depth of 2 feet below ground surface, and filled with concrete. As previously stated, the bumper guard should extend above the ground surface a minimum of 3 feet. The total length of each bumper guard should be a minimum of 5 feet.

After the wells have been installed, the outer protective casing should be painted with a highly visible paint. The wells should be permanently marked with the well number, date installed, site name, elevation, etc., either on the cover or an appropriate place that will not be easily damaged and/or vandalized.

If the monitoring wells are installed in a high traffic area such as a parking lot, in a residential yard, or along the side of a road it may be desirable to finish the wells to the ground surface and install water-tight flush mounted traffic and/or man-hole covers. Flush mounted traffic and man-hole covers are designed to extend from the ground surface down into the concrete plug around the well casing. Although flush mounted covers may vary in design, they should have seals that make the unit water-tight when closed and secured. The flush mounted covers should be installed slightly above grade to minimize standing water and promote runoff. Permanent identification markings should be placed on the covers or in the concrete plug around the cover. Expansive sealing plugs should be used to cap the well riser to prevent infiltration of any water that might enter the flush cover.

2.4.2 Double-Cased Wells

Double-cased wells should be constructed when there is reason to believe that interconnection of two aquifers by well construction may cause cross-contamination or when flowing sands make it impossible to install a monitoring well using conventional methods. A highly contaminated surface soil zone may also be cased off so that drilling may continue below the casing with reduced danger of cross contamination. A pilot borehole should be bored through the overburden and/or the contaminated zone into the clay confining layer or bedrock. An outer casing (sometimes called surface or pilot casings) should then be placed into the borehole and sealed with grout. The borehole and outer casing should extend into tight clay a minimum of two feet and into competent bedrock a minimum of 1 foot. The total depths into the clay or bedrock will vary, depending on the plasticity of the clay and the extent of weathering and/or fracturing of the bedrock. The final depths should be approved by a senior field geologist. The size of the outer casing should be of sufficient inside diameter to contain the inner casing, and the 2-inch minimum annular space. In addition, the borehole should be of sufficient size to contain the outer casing and the 2-inch minimum outer annular space, if applicable.

The outer casing should be grouted by the tremie, displacement, grout shoe, or Halliburton method from the bottom to the ground surface. The grout should be pumped into the annular space between the outer casing and the borehole wall. A minimum of 24 hours should be allowed for the grout plug (seal) to cure before attempting to drill through it. The grout mixture used to seal the outer annular space should be either a neat cement, cement/bentonite, cement/sand, or a 30% solids bentonite grout. However, the seal or plug at the bottom of the borehole and outer casing should consist of a Type I portland cement/bentonite or cement/sand mixture. The use of a pure bentonite grout for a bottom plug or seal is not acceptable, because the bentonite grout cures to a gel-like material, and is not rigid enough to withstand the stresses of drilling. When drilling through the seal, care should be taken to avoid cracking, shattering, or washing out the seal. If caving conditions exist so that the outer casing cannot be sufficiently sealed by grouting, the outer casing should be driven into place and a grout seal placed in the bottom of the casing.

2.4.2.1 Bedrock Wells

The installation of monitoring wells into bedrock can be accomplished in two ways:

1. The first method is to drill or bore a pilot borehole through the soil overburden into the bedrock. An outer casing is then installed into the borehole by setting it into the bedrock, and grouting it into place as described in the previous section. After the grout has set, the borehole can then be advanced through the grout seal into the bedrock. The preferred method of advancing the borehole into the bedrock is rock coring. Rock coring makes a smooth, round hole through the seal and into the bedrock without cracking and/or shattering the seal. Roller cone bits are used in soft bedrock, but extreme caution should be taken when using a roller cone bit to advance through the grout seal in the bottom of the borehole because excessive water and "down" pressure can cause cracking, eroding (washing), and/or shattering of the seal. Low volume air hammers may be used to advance the borehole, but they have a tendency to shatter the seal because of the hammering action. If the structural integrity of the grout seal is in question, a pressure test can be utilized to check for leaks. A visual test can also be made by examining the cement/concrete core that is collected when the seal is cored with a diamond coring bit. If the seal leaks (detected by pressure testing) and/ or the core is cracked or shattered, or if no core is recovered because of washing, excessive down pressure, etc., the seal is not acceptable. The concern over the structural integrity of the grout seal applies to all double cased wells. Any proposed method of double casing and/or seal testing will be evaluated on its own merits, and will have to be approved by a senior field geologist before and during drilling activities, if

applicable. When the drilling is complete, the finished well will consist of an open borehole from the ground surface to the bottom of the well. There is no inner casing, and the outer surface casing, installed down into bedrock, extends above the ground surface, and also serves as the outer protective casing. If the protective casing becomes cracked or is sheared off at the ground surface, the well is open to direct contamination from the ground surface and will have to be repaired immediately or abandoned. Another limitation to the open rock well is that the entire bedrock interval serves as the monitoring zone. In this situation, it is very difficult or even impossible to monitor a specific zone, because the contaminants being monitored could be diluted to the extent of being non-detectable. The installation of open bedrock wells is generally not acceptable in the Superfund and RCRA programs, because of the uncontrolled monitoring intervals. However, some site conditions might exist, especially in cavernous limestone areas (karst topography) or in areas of highly fractured bedrock, where the installation of the filter pack and its structural integrity are questionable. Under these conditions the design of an open bedrock well may be warranted.

2. The second method of installing a monitoring well into bedrock is to install the outer surface casing and drill the borehole (by an approved method) into bedrock, and then install an inner casing and well screen with the filter pack, bentonite seal, and annular grout. The well is completed with a surface protective casing and concrete pad. This well installation method gives the flexibility of isolating the monitoring zone(s) and minimizing inter-aquifer flow. In addition, it gives structural integrity to the well, especially in unstable areas (steeply dipping shales, etc.) where the bedrock has a tendency to shift or move when disturbed. Omitting the filter pack around the well screen is a general practice in some open rock borehole installations, especially in drinking water and irrigation wells. However, without the filter pack to protect the screened interval, sediment particles from the well installation and/or from the monitoring zone could clog the well screen and/or fill the screened portion of the well rendering it inoperable. Also, the filter pack serves as a barrier between the bentonite seal and the screened interval. Rubber inflatable packers have been used to place the bentonite seal when the filter pack is omitted, but the packers have to remain in the well permanently and, over a period of time, will decompose and possibly contribute contaminants to the monitoring zone.

2.5 Well Construction Materials

2.5.1 Introduction

Well construction materials are chosen based on the goals and objectives of the proposed monitoring program and the geologic conditions at the site(s). In this section, the different types of available materials will be discussed.

2.5.2 Well Screen and Casing Materials

When selecting the materials for well construction, the prime concern should be to select materials that will not contribute foreign constituents, or remove contaminants of concern from the ground water. If the monitoring program is designed to analyze for organic compounds, stainless steel materials are the preferred choice. If the monitoring program calls for the analyses of only inorganic compounds or the contaminants or formation are highly corrosive, then rigid PVC materials meeting National Sanitary Foundation (NSF) Standard 14 type WC (Well Casing) are acceptable. PVC materials may be acceptable for monitoring identified organic compounds in a soluble aqueous phase where incompatibilities are known to not exist. EPA document EPA/540/S-95/503, *Nonaqueous Phase Liquids Compatibility with Materials Used in Well Construction, Sampling, and Remediation* (<http://www.epa.gov/ada/download/issue/napl.pdf>) should be used for guidance in this area and in the use of PVC with non-aqueous phase liquids (NAPLs). Another concern is to select materials that will be rugged enough to endure the entire monitoring period. Site conditions will generally dictate the type of materials that can be used. A preliminary field investigation should be conducted to determine the geologic conditions, so that the most suitable materials can be selected. The best grade or highest quality material for that particular application should be selected. Each manufacturer can supply the qualitative data for each grade of material that is being considered. All materials selected for monitoring well installation should be evaluated and approved by a senior field geologist prior to field activities.

Well screen and casing materials generally used in monitoring well construction on RCRA and Superfund sites are listed in order of preference:

1. Stainless Steel (304 or 316)
2. Rigid PVC meeting NSF Standard 14 (type WC)
3. Other (where applicable)

There are other materials used for well screens and casings such as black iron, carbon steel, galvanized steel, and fiberglass, but these materials are not recommended for use in long term monitoring programs at hazardous waste sites, because of their low resistance to chemical attack and potential constituent contribution to the ground water. In cases where a driven casing is used, or a high strength outer casing is needed, carbon steel may be acceptable in non-corrosive aquifers. This outer casing should have threaded connections. Welding casing is

not an acceptable practice unless all relevant safety issues have been adequately addressed.

The minimum nominal casing size for most permanent monitoring wells will be 2". Where a complete program of installation, monitoring, and abandonment is being designed, smaller wells may be installed if suitable purging and sampling equipment for the smaller diameter wells can be specified and obtained. The length of well screens in permanent monitoring wells should be long enough to effectively monitor the interval or zone of interest. However, well screens designed for long term monitoring purposes should normally not be less than 5 feet in length. Well screens less than 5 feet long are generally only used in temporary monitoring wells where ground water samples are collected for screening purposes.

2.5.3 Filter Pack Materials

The filter pack materials should consist of clean, rounded to well-rounded, hard, insoluble particles of siliceous composition. The required grain-size distribution or particle sizes of the filter pack materials should be selected based upon a sieve analysis conducted on the soil samples collected from the aquifer materials and/or the formation(s) to be monitored. Filter pack materials should not be accepted unless proper documentation can be furnished as to the composition, grain-size distribution, cleaning procedure, and chemical analysis. If a data search reveals that there is enough existing data to adequately design the well screen and filter pack, then it may not be necessary to conduct a sieve analysis on the formation materials to be monitored. However, all data and design proposals will be evaluated and approved by a senior staff geologist before field activities begin.

2.5.4 Filter Pack and Well Screen Design

The majority of monitoring wells are installed in shallow ground water aquifers that consist of silts, clays, and sands in various combinations. These shallow aquifers are not generally characteristic of aquifers used for drinking water. Therefore, modifications to the procedures used for the design of water well filter packs may be required. In cases where insufficient experience exists with local or similar materials, the filter pack and well screen design should be based on the results of a sieve analysis conducted on soil samples collected from the aquifer or the formation(s) that will be monitored.

In formations consisting primarily of fines (silts and clays), the procedures for water well screen design may result in requirements for filter packs and screen slot sizes that are not available. In those cases the selection of 0.010" screen slots with a 20-40 sand filter pack, or 0.005" screen slots with 100 sand filter pack for very fine formations, will be acceptable practice. Table 6.6.1 provides size specifications for the selection of sand packs for fine formation materials. ASTM standard D5092, *Design and Installation of Ground Water Monitoring Wells in*

Aquifers, may be consulted for further guidance on specifications for sand appropriate for these applications.

**Table 6.6.1
Sand Pack Specifications**

Screen Opening (in)	Sand Pack Mesh Name	1% Passing Size (d-1) (in)	10% Passing Size (d-10) (in)	30% Passing Size (d-30) (in)	Derived 60% Passing Size (d-60) (in)	Range for Uniformity Coefficient
0.005-0.006	100	.0035 - .0047	.0055 - .0067	.0067 - .0083	.0085 - .0134	1.3 - 2.0
0.010"	20-40	.0098 - .0138	.0157 - .0197	.0197 -.0236	.020 - .0315	1.1 - 1.6

The following procedure should be used in coarser grained formations:

The data from the sieve analysis are plotted on a grain-size distribution graph, and a grain-size distribution curve is generated. From this grain-size distribution curve, the uniformity coefficient (Cu) of the aquifer material is determined. The Cu is the ratio of the 60 percent finer material (d60) to the 10 percent finer material (d10)

$$Cu = (d60/d10)$$

The Cu ratio is a way of grading or rating the uniformity of grain size. For example, a Cu of unity means that the individual grain sizes of the material are nearly all the same, while a Cu with a large number indicates a large range of particle sizes. As a general rule, a Cu of 2.5 or less should be used in designing the filter pack and well screen.

Before designing the filter pack and well screen, the following factors should be considered:

1. Select the well screen slot openings that will retain 90 percent of the filter pack material.
2. The filter pack material should be of the size that minimizes head losses through the pack and also prevents excessive sediment (sand, silt, clay) movement into the well.

3. A filter material of varying grain sizes is not acceptable because the smaller particles fill the spaces between the larger particles thereby reducing the void spaces and increasing resistance to flow. Therefore, filter material of the same grain size and well rounded is preferred.
4. The filter pack design is based on the gradation of the finest aquifer materials being analyzed.

Steps to design a filter pack in aquifers:

1. Construct a grain-size distribution curve, on a grain-size distribution graph, from the sieve analysis of the aquifer materials. The filter pack design (as stated above) is based on the gradation of the finest aquifer materials.
2. Multiply the d₃₀ size from the grain-size distribution graph by a factor of four to nine (Pack-Aquifer ratio). A factor of four is used if the formation is fine-grained and uniform (C_u is less than 3), six if it is coarse-grained and non-uniform, and up to nine if it is highly non-uniform and contains silt. Head losses through filter packs increase as the Pack-Aquifer (P-A) ratios decrease. In order to design a fairly stable filter pack with a minimum head loss, the d₃₀ size should be multiplied by a factor of four.
3. Plot the point from step 2 on the d₃₀ abscissa of a grain-size distribution graph and draw a smooth curve with a uniformity coefficient of approximately 2.5.
4. A curve for the permissible limits of the filter pack is drawn plus or minus 8 per cent of the desired curve with the C_u of 2.5.
5. Select the slot openings for the well screen that will retain 90 per cent or more of the filter pack material.

The specific steps and procedures for sieve analysis and filter pack design can be found in soil mechanics, ground water, and water well design books. The staff geologists and/or engineers should be responsible for the correct design of the monitoring wells and should be able to perform the design procedures.

2.6 Safety Procedures for Drilling Activities

A site health and safety plan should be developed and approved by the Branch Safety Officer or designee prior to any drilling activities, and should be followed during all drilling activities. The driller or designated safety person should be responsible for the safety of the drilling team performing the drilling activities. All personnel conducting drilling activities should be qualified in proper drilling and safety procedures. Before any drilling activity is initiated, utilities should be marked or cleared by the appropriate state or municipal utility protection organization. In developed areas, additional measures

should be taken to locate utilities not covered by the utility protection program. Before operating the drill rig, a pilot hole should be dug (with hand equipment) to a depth of three feet to check for undetected utilities or buried objects. Proceed with caution until a safe depth is reached where utilities normally would not be buried. The following safety requirements should be adhered to while performing drilling activities:

1. All drilling personnel should wear safety hats, safety glasses, and steel toed boots. Ear plugs are required and will be provided by the safety officer or driller.
2. Work gloves (cotton, leather, etc.) should be worn when working around or while handling drilling equipment.
3. All personnel directly involved with the drilling rig(s) should know where the kill switch(s) is located in case of emergencies.
4. All personnel should stay clear of the drill rods or augers while in motion, and should not grab or attempt to attach a tool to the drill rods or augers until they have completely stopped rotating. Rod wipers, rather than gloves or bare hands should be used to remove mud, or other material, from drill stem as it is withdrawn from the borehole.
5. Do not hold drill rods or any part of the safety hammer assembly while taking standard penetration tests or while the hammer is being operated.
6. Do not lean against the drill rig or place hands on or near moving parts at the rear of the rig while it is operating.
7. Keep the drilling area clear of any excess debris, tools, or drilling equipment.
8. The driller will direct all drilling activities. No work on the rig or work on the drill site will be conducted outside of the driller's direction. Overall drill site activities will be in consultation with the site geologist or engineer, if present.
9. Each drill rig will have a first-aid kit and a fire extinguisher located on the rig in a location quickly accessible for emergencies. All drilling personnel will be familiarized with their location.
10. Work clothes will be firm fitting, but comfortable and free of straps, loose ends, strings etc., that might catch on some moving part of the drill rig.
11. Rings, watches, or other jewelry will not be worn while working around the drill rig.
12. The drill rig should not be operated within a minimum distance of 20 feet of overhead electrical power lines and/or buried utilities that might cause a safety hazard. In addition, the drill rig should not be operated while there is lightening in the area of the drilling site. If an electrical storm moves in during drilling activities, the area will be vacated until it is safe to return.

2.7 Well Development

A newly completed monitoring well should not be developed for at least 24 hours after the surface pad and outer protective casing are installed. This will allow sufficient time for the well materials to cure before development procedures are initiated. The main purpose of developing new monitoring wells is to remove the residual materials remaining in the wells after installation has been completed, and to try to re-establish the natural hydraulic flow conditions of the formations which may have been disturbed by well construction, around the immediate vicinity of each well. A new monitoring well should be developed until the column of water in the well is free of visible sediment, and the pH, temperature, turbidity, and specific conductivity have stabilized. In most cases the above requirements can be satisfied; however, in some cases the pH, temperature, and specific conductivity may stabilize but the water remains turbid. In this case the well may still contain well construction materials, such as drilling mud in the form of a mud cake and/or formation soils that have not been washed out of the borehole. Excessive or thick drilling mud cannot be flushed out of a borehole with one or two well volumes of flushing. Continuous flushing over a period of several days may be necessary to complete the well development. If the well is pumped to dryness or near dryness, the water table should be allowed to sufficiently recover (to the static water level) before the next development period is initiated. Caution should be taken when using high rate pumps and/or large volume air compressors during well development because excessive high rate pumping and high air pressures can damage or destroy the well screen and filter pack. The onsite geologist should make the decision as to the development completion of each well. All field decisions should be documented in the field log book.

The following development procedures, listed in approximate increasing order of the energy applied to the formation materials, are generally used to develop wells:

1. Bailing
2. Pumping/overpumping
3. Surging
4. Backwashing ("rawhiding")
5. Jetting
6. Compressed air (with appropriate filtering): airlift pumping and air surging

These development procedures can be used, individually or in combination, in order to achieve the most effective well development. In most cases, over-pumping and surging will adequately develop the well without imparting undue forces on the formation or well materials. Except when compressed air is being used for well development, sampling can be initiated as soon as the ground water has re-equilibrated, is free of visible sediment, and the water quality parameters have stabilized. Since site conditions vary, even between wells, a general rule-of-thumb is to wait 24 hours after development to sample a new monitoring well. Wells developed with stressful measures may require as long as a 7-day interval before sampling. In particular, air surge developed wells require 48 hours or longer after development so that the formation can dispel the compressed air and re-stabilize to pre-well construction conditions. Because of the danger of introducing

contaminants with the airstream, the possibility of entraining air in the aquifer, and the violent forces imparted to the formation, air surging is the least desired method of development and should only be used where there is a specific need for the procedure. Air-lift pumping is permissible where an eductor pipe is used and several well volumes of water are removed from the well by other by pumping means after air-lift pumping. The selected development method(s) should be approved by a senior field geologist before any well installation activities are initiated.

2.8 Well Decommissioning (Abandonment)

When a decision is made to decommission (abandon) a monitoring well, the borehole should be sealed in such a manner that the well cannot act as a conduit for migration of contaminants from the ground surface to the water table or between aquifers. To properly decommission a well, the preferred method is to completely remove the well casing and screen from the borehole, clean out the borehole, and backfill with a cement or bentonite grout, neat cement, or concrete. In order to comply with state well decommissioning requirements, the appropriate state agency should be notified (if applicable) of monitoring well decommissioning. However, some state requirements are not explicit, so a technically sound well abandonment method should be designed based on the site geology, well casing materials, and general condition of the well(s).

2.8.1 Decommissioning Procedures

As previously stated the preferred method should be to completely remove the well casing and screen from the borehole. This may be accomplished by augering with a hollow-stem auger over the well casing down to the bottom of the borehole, thereby removing the grout and filter pack materials from the hole. The well casing should then be removed from the hole with the drill rig. The clean borehole can then be backfilled with the appropriate grout material. The backfill material should be placed into the borehole from the bottom to the top by pressure grouting with the positive displacement method (tremie method). This abandonment method can be accomplished on small diameter (1-inch to 4-inch) wells without too much difficulty. With wells having 6-inch or larger diameters, the use of hollow-stem augers for casing removal is very difficult or almost impossible. Instead of trying to ream the borehole with a hollow-stem auger, it is more practical to force a drill stem with a tapered wedge assembly or a solid-stem auger into the well casing and extract it out of the borehole. Wells with little or no grouted annular space and/or sound well casings can be removed in this manner. However, old wells with badly corroded casings and/or thickly grouted annular space have a tendency to twist and/or break-off in the borehole. When this occurs, the well will have to be grouted with the remaining casing left in the borehole. The preferred method in this case should be to pressure grout the borehole by placing the tremie tube to the bottom of the well casing, which will be the well screen or the bottom sump area below the well screen. The pressurized grout will be forced out through the well screen into the filter material and up the inside of the well casing sealing holes and breaks that are present.

A PVC well casing may be more difficult to remove from the borehole than a metal casing, because of its brittleness. If the PVC well casing breaks during removal, the borehole should be cleaned out by using a drag bit or roller cone bit with the wet rotary method to grind the casing into small cuttings that will be flushed out of the borehole by water or drilling mud. Another method is to use a solid-stem auger with a carbide tooth pilot bit to grind the PVC casing into small cuttings that will be brought to the surface on the rotating flights. After the casing materials have been removed from the borehole, the borehole should be cleaned out and pressure grouted with the approved grouting materials.

Where state regulations and conditions permit, it may be permissible to grout the casing in place. This decision should be based on confidence in the original well construction practice, protection of drinking water aquifers, and anticipated future property uses. The pad should be demolished and the area around the casing excavated. The casing should be sawn off at a depth of three feet below ground surface. The screen and riser should be tremie grouted with a 30% solids bentonite grout in the saturated zone. The remaining riser may be grouted with a cement grout for long term resistance to desiccation.

3 Temporary Monitoring Well Installation

3.1 Introduction

Five types of temporary monitoring well installation techniques have been demonstrated as acceptable. The type selected for a particular site is dependent upon site conditions. The project leader and site geologist should be prepared to test temporary well installations on site and select the best solution. Temporary wells are cost effective, may be installed quickly, and provide a synoptic picture of ground water quality.

Temporary monitoring well locations are not permanently marked, nor are their elevations normally determined. Sand pack materials may or may not be used, but typically there is no bentonite seal, grout, surface completion, or extensive development (as it normally applies to permanent monitoring wells). Temporary wells are generally installed, purged, sampled, removed, and backfilled in a matter of hours.

Due to the nature of construction, turbidity levels may initially be high. However, these levels may be reduced by low flow purging and sampling techniques as described in Section 7.2.4.

Temporary wells may be left overnight, for sampling the following day, but the well must be secured, both against tampering and against the fall hazard of the open annulus. If the well is not sampled immediately after construction, the well should be purged prior to sampling as specified in SESD Operating Procedure for Groundwater Sampling, SESDPROC-301.

3.2 Data Limitation

Temporary wells described in this section are best used for delineation of contaminant plumes at a point in time, and for some site screening purposes. They are not intended to replace permanent monitoring wells. Temporary wells can be used in conjunction with a mobile laboratory, where quick analytical results can be used to delineate contaminant plumes.

3.3 Temporary Well Materials

Materials used in construction of temporary monitoring wells are the same standard materials used in the construction of permanent monitoring wells. Sand used for the filter pack (if any) should be as specified in Section 2.5.3, Filter Pack Materials. The well screen and casing should be stainless steel for ruggedness and suitability for steam cleaning and solvent rinsing. Other materials may be acceptable, on a case by case basis. Some commercially available temporary well materials, pre-packed riser, screen and filter pack assemblies are available commercially; however, these pre-assembled materials cannot be cleaned. Appropriate QA/QC must be performed to assure there will be no introduction of contamination.

3.4 Temporary Monitoring Well Borehole Construction

Borehole construction for temporary wells is as specified in Section 2.3, using a drill rig. Alternatively, boreholes may be constructed using hand augers or portable powered augers (generally limited to depths of ten feet or less). If a drill rig is used to advance the borehole, the augers must be pulled back the length of the well screen (or removed completely) prior to sampling. When hand augers are used, the borehole is advanced to the desired depth (or to the point where borehole collapse occurs). In situations where borehole collapse occurs, the auger bucket is typically left in the hole at the point of collapse while the temporary well is assembled. When the well is completely assembled, a final auger bucket of material is quickly removed and the well is immediately inserted into the borehole, pushing, as needed, to achieve maximum penetration into the saturated materials.

3.5 Temporary Monitoring Well Types

Five types of monitoring wells which have been shown to be acceptable are presented in the order of increasing difficulty to install and increasing cost:

3.5.1 No Filter Pack

This is the most common temporary well and is very effective in many situations. After the borehole is completed, the casing and screen are simply inserted. This is the least expensive and fastest well to install. This type of well is extremely sensitive to turbidity fluctuations because there is no filter pack. Care should be taken to not disturb the casing during purging and sampling.

3.5.2 Inner Filter Pack

This type differs from the "No Filter Pack" well in that a filter pack is placed inside the screen to a level approximately 6 inches above the well screen. This ensures that all water within the casing has passed through the filter pack. For this type well to function properly, the static water level must be at least 6-12 inches above the filter pack. The screen slots may plug in some clayey environments with this construction method and others that use sand only inside the well screen.

3.5.3 Traditional Filter Pack

For this type of well, the screen and casing are inserted into the borehole, and the sand is poured into the annular space surrounding the screen and casing. Occasionally, it may be difficult to effectively place a filter pack around shallow open boreholes, due to collapse. This method requires more sand than the "inner filter pack" well, increasing material costs. As the filter pack is placed, it mixes with the muddy water in the borehole, which may increase the amount of time needed to purge the well to an acceptable level of turbidity.

3.5.4 Double Filter Pack

The borehole is advanced to the desired depth. As with the "inner filter pack" the well screen is filled with filter pack material and the well screen and casing inserted until the top of the filter pack is at least 6 inches below the water table. Filter pack material is poured into the annular space around the well screen. This type temporary well construction can be effective in aquifers where fine silts or clays predominate. This construction technique takes longer to implement and uses more filter pack material than others previously discussed.

3.5.5 Well-in-a-Well

The borehole is advanced to the desired depth. At this point, a 1-inch well screen and sufficient riser is inserted into a 2-inch well screen with sufficient riser, and centered. Filter pack material is then placed into the annular space surrounding the 1-inch well screen, to approximately 6 inches above the screen. The well is then inserted into the borehole.

This system requires twice as much well screen and riser, with attendant increases in assembly and installation time. The increased amount of well construction materials results in a corresponding increase in decontamination time and costs. The use of pre-packed well screens in this application will require rinse blanks of each batch of screens. Pre-pack Screen assemblies cannot be decontaminated for reuse.

3.6 Decommissioning

Temporary well boreholes must be decommissioned after sampling and removal of the screen and riser. Backfilling the holes with cuttings may be acceptable practice for shallow holes in uniform materials with expected low contamination levels. Use of cuttings would not be an acceptable practice if waste materials were encountered or a confining layer was breached. Likewise, where the borehole is adjacent to, or downgradient of contaminated areas, the loose backfilled material could create a highly permeable conduit for contaminant migration. If the borehole will not be backfilled with the soil cuttings for this or other reasons, then SESD Operating Procedure for Management of Investigation Derived Waste, SESDPROC-202, should be referenced regarding disposal of the cuttings as IDW.

4 Temporary Monitoring Well Installation Using the Geoprobe® Screen Point 15/16 Groundwater Sampler

4.1 Introduction

The Geoprobe® Screen Point 15/16 Groundwater Sampler is a discrete interval ground water sampling device that can be pushed to pre-selected sampling depths in saturated, unconsolidated materials. Once the target depth has been reached, the screen is opened and groundwater can be sampled as a temporary monitoring well, which yields a representative, uncompromised sample from that depth. Using knock-out plugs, this method also allows for grouting of the push hole during sample tool retrieval.

The Screen Point® 15 sampler consist of four parts (drive point, screen, sampler sheath and drive head), with an assembled length of 52 inches (1321 mm) and a maximum OD of 1.5 inches (38 mm). When opened, it has an exposed screen length of 41 inches (1041 mm). It is typically pushed using 1.25-inch probe rod. The Screen Point® 16 consists of the same parts and works in the same fashion, the only differences being larger diameter and its use with 1.5” rods.

4.1.1 Assembly of Screen Point® 15/16 Groundwater Sampler

1. Install O-ring on expendable point and firmly seat in the angled end of the sampler sheath.
2. Place a grout plug in the lower end of the screen section. Grout plug material should be chosen with consideration for site specific Data Quality Objectives (DQOs).
3. When using stainless steel screen, place another O-ring* in the groove on the upper end of the screen and slide it into the sampler sheath.
4. Place an O-ring* on the bottom of the drive head and thread into the top of the sampler sheath.
5. The Screen Point® 15/16 Groundwater Sampler is now assembled and ready to push for sample collection.

* It should be noted that O-ring use in steps 3 and 4 are optional.

4.1.2 Installation of Screen Point® 15/16 Groundwater Sampler

1. Attach drive cap to top of sampler and slowly drive it into the ground. Raise the hammer assembly, remove the drive cap and place an O-ring* in the top groove of the drive head. Add a probe rod and continue to push the rod string.

2. Continue to add probe rods until the desired sampling depth is reached.
3. When the desired sampling depth is reached, re-position the probe derrick and position either the casing puller assembly or the rod grip puller over the top of the top probe rod.
4. Thread a screen push adapter on an extension rod and attach sufficient additional extension rods to reach the top of the Screen Point® 15/16 sampler. Add an extension handle to the top of the string of extension rods and run this into the probe rod, resting the screen push adapter on top of the sampler.
5. To expose the screened portion of the sampler, exert downward pressure on the sampler, using the extension rod and push adapter, while pulling the probe rod upward. To expose the entire open portion of the screen, pull the probe rod upward approximately 41 inches.
6. At this point, the Screen Point® 15/16 Groundwater Sampler has been installed as a temporary well and may be sampled using appropriate ground water sampling methodology. If water levels are less than approximately 25 feet, EIB personnel typically use a peristaltic pump, utilizing low-flow methods, to collect ground water samples from these installations. If water levels are greater than 25 feet, a manual bladder pump, a micro bailer, or other method may have to be utilized to collect the sample (SESD Operating Procedure for Groundwater Sampling, SESDPROC-301-R0) provides detailed descriptions of these techniques and methods).

4.1.3 Special Considerations for Screen Point® 15/16 Installations

Decommissioning (Abandonment)

In many applications, it may be appropriate to grout the abandoned probe hole where a Screen Point® 15/16 sampler was installed. This probe hole decommissioning can be accomplished through two methods which are determined by location and contamination risk. In certain non-critical areas, boreholes may be decommissioned by filling the saturated zone with bentonite pellets and grouting the vadose zone with neat cement poured from the surface or Bentonite pellets properly hydrated in place. Probe holes in areas where poor borehole sealing could present a risk of contaminant migration should be decommissioned by pressure grouting through the probe rod during sampler retrieval. To accomplish this, the grout plug is knocked out of the bottom of the screen using a grout plug push adapter and a grout nozzle is fed through the probe rod, extending just below the bottom of the screen. As the probe rod and sampler

are pulled, grout is injected in the open hole below the screen at a rate that just fills the open hole created by the pull. Alternatively, the screen can generally be pulled and the hole re-probed with a tool string to be used for through-the-rod grouting.

Screen Material Selection

Screen selection is also a consideration in sampling with the Screen Point® 15/16 sampler. The screens are available in two materials, stainless steel and PVC. Because of stainless steel's durability, ability to be cleaned and re-used, and overall inertness and compatibility with most contaminants, it is the material typically used during EIB investigations.

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

OPERATING PROCEDURE

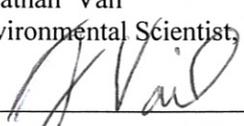
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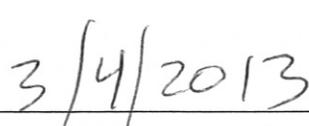
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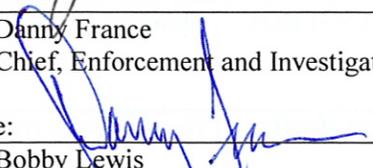
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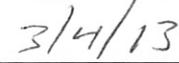
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Revision History

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

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1 General Information

1.1 Purpose

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

1.2 Scope/Application

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

1.3 Documentation/Verification

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

1.4 References

Columbia Analytical Services, Lab Science News, Passive Diffusion Devices & Polyethylene Diffusion Bag (PDB) Samplers.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

1.5 General Precautions

1.5.1 Safety

Proper safety precautions must be observed when collecting groundwater samples. Refer to the SESD Safety, Health and Environmental Management Program (SHEMP) Procedures and Policy Manual and any pertinent site-specific Health and Safety Plans (HASPs) 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.

1.5.2 Procedural Precautions

The following precautions should be considered when collecting groundwater samples.

- Special care must be taken not to contaminate samples. This includes storing samples in a secure location to preclude conditions which could alter the properties of the sample. Samples shall be custody sealed during long-term storage or shipment.
- Always sample from the anticipated cleanest, i.e., least contaminated location, to the most contaminated location. This minimizes the opportunity for cross-contamination to occur during sampling.
- Collected samples must remain in the custody of the sampler or sample custodian until the samples are relinquished to another party.

- If samples are transported by the sampler, they will remain under his/her custody or be secured until they are relinquished.
- Shipped samples shall conform to all U.S. Department of Transportation (DOT) rules of shipment found in Title 49 of the Code of Federal Regulations (49 CFR parts 171 to 179), and/or International Air Transportation Association (IATA) hazardous materials shipping requirements found in the current edition of IATA's Dangerous Goods Regulations.
- Documentation of field sampling is done in a bound logbook.
- Chain-of-custody documents shall be filled out and remain with the samples until custody is relinquished.
- All shipping documents, such as air bills, bills of lading, etc., shall be retained by the project leader and placed in the project files.

2 Special Sampling Considerations

2.1 Volatile Organic Compounds (VOC) Analysis

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

The samples should be collected with as little agitation or disturbance as possible. The vial should be filled so that there is a meniscus at the top of the vial and absolutely no bubbles or headspace should be present in the vial after it is capped. After the cap is securely tightened, the vial should be inverted and tapped on the palm of one hand to see if any undetected bubbles are dislodged. If a bubble or bubbles are present, the vial should be topped off using a minimal amount of sample to re-establish the meniscus. Care should be taken not to flush any preservative out of the vial during topping off. If, after topping off and capping the vial, bubbles are still present, a new vial should be obtained and the sample re-collected.

Samples for VOC analysis must be collected using either stainless steel or Teflon® equipment, such as:

- Bailers must be constructed of stainless steel or Teflon®
- RediFlo2® submersible pumps used for sampling should be equipped with Teflon® sample delivery tubing
- Peristaltic pump/vacuum jug assemblies should be outfitted with Teflon® tubing from the water column to the transfer cap, which should also be constructed of Teflon®

2.2 Special Precautions for Trace Contaminant Groundwater Sampling

- A clean pair of new, non-powdered, disposable gloves will be worn each time a different location is sampled and the gloves should be donned immediately prior to sampling. The gloves should not come in contact with the media being sampled and should be changed any time during sample collection when their cleanliness is compromised.
- Sample containers for samples suspected of containing high concentrations of contaminants shall be stored separately.

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

2.3 Sample Handling and Preservation Requirements

1. Groundwater samples will typically be collected from the discharge line of a pump or from a bailer, either from the pour stream of an up-turned bailer or from the stream from a bottom-emptying device. Efforts should be made to reduce the flow from either the pump discharge line or the bailer during sample collection to minimize sample agitation.
2. During sample collection, make sure that the pump discharge line or the bailer does not contact the sample container.
3. Place the sample into appropriate, labeled containers. Samples collected for VOC, acidity and alkalinity analysis must not have any headspace. All other sample containers must be filled with an allowance for ullage.
4. All samples requiring preservation must be preserved as soon as practically possible, ideally immediately at the time of sample collection. If preserved VOC vials are used, these will be preserved with concentrated hydrochloric acid by ASB personnel prior to departure for the field investigation. For all other chemical preservatives, SESD will use the appropriate chemical preservative generally stored in an individual single-use vial as described in the SESD Operating Procedure for Field Sampling Quality Control (SESDPROC-011). The adequacy of sample preservation will be checked after the addition of the preservative for all samples except for the samples collected for VOC analysis. If additional preservative is needed, it should be added to achieve adequate preservation. Preservation requirements for groundwater samples are found in the USEPA Region 4 Analytical Support Branch Laboratory Operations and Quality Assurance Manual (ASBLOQAM).

2.4 Quality Control

If possible, a control sample should be collected from a location not affected by the possible contaminants of concern and submitted with the other samples. This control sample should be collected as close to the sampled area as possible and from the same water-bearing formation. Equipment blanks should be collected if equipment is field cleaned and re-used on-site or if necessary to document that low-level contaminants were not introduced by pumps, bailers or other sampling equipment.

2.5 Records

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

3 Groundwater Sampling Methods – Purging

3.1 General

Purging is the process of removing stagnant water from a well, immediately prior to sampling, causing its replacement by groundwater from the adjacent formation that is representative of actual aquifer conditions. In order to determine when a well has been adequately purged, field investigators should monitor, at a minimum, the pH, specific conductance and turbidity of the groundwater removed during purging and, in the case of permanent monitoring wells, observe and record the volume of water removed.

There are several purging strategies that may be used, depending on specific conditions encountered for given well sampling situations. When a specific well is characterized, based on the field investigators experience and knowledge, as having fairly typical water levels, depths and purge volumes, as determined according to the procedures in Section 3.2.1, below, SESD will normally use the multiple volume purging procedures and equipment described in Sections 3.2.1 and 3.3 of this procedure for purging the well.

When the traditional multiple volume purge method is considered and it is determined that excessive quantities of IDW would be generated using this method, it may be appropriate, under very limited and specific circumstances, to use an alternate method that reduces the time and amount of purge water to be removed prior to sampling the well. The field project leader will select the alternate method only after careful consideration of the conditions presented by the well and the impact these conditions have on all aspects of the sampling event (time required to sample, quantities of IDW requiring management, etc.).

The alternate purge procedures or sampling strategies available are the “Tubing-in-Screened Interval” method and the MicroPurge or No-Purge methods. These are described and discussed in Sections 3.2.2 and 4.5 of this operating procedure, respectively.

3.2 Purging Methods and Strategies

3.2.1 Traditional Multiple Volume Purge

3.2.1.1 Purging and Purge Adequacy

3.2.1.1.1 Purge Volume Determination

Prior to initiating the purge, the amount of water standing in the water column (water inside the well riser and screen) should be determined, if possible. To do this, the diameter of the well should be determined and the water level and total depth of the well should be measured and recorded. Specific methodology for obtaining these measurements is found in SESD Operating Procedure for Groundwater Level and Well Depth Measurement (SESDPROC-105).

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

$$V = 0.041 d^2h$$

Where: h = depth of water in feet

d = diameter of well in inches

V = volume of water in gallons

Alternatively, the volume of standing water in the well and the volume of three water columns may be determined using a casing volume per foot factor for the appropriate diameter well, similar to that in Table 3.2.1. The water level is subtracted from the total depth, providing the length of the water column. This length is multiplied by the appropriate factor in the Table 3.2.1, corresponding to either the single well volume or the triple well volume, to determine both the single well volume and triple well volumes, in gallons, for the well in question. Other acceptable methods include the use of nomographs or other equations or formulae.

TABLE 3.2.1: WELL CASING DIAMETER VOLUME FACTORS

Casing Diameter (inches)	Gallons/ft, One Water Column	Gallons/ft, Three Water Columns
1	0.04	0.12
2	0.16	0.48
3	0.37	1.11
4	0.65	1.98
5	1.02	3.06
6	1.47	4.41
7	1.99	5.97
8	2.61	7.83
9	3.30	9.90
10	4.08	12.24
11	4.93	14.79
12	5.87	17.61

With respect to volume, an adequate purge is normally achieved when three to five well volumes have been removed. The field notes should reflect the single well volume calculations or determinations, according to one of the above methods, and a reference to the appropriate

multiplication of that volume, i.e., a minimum three well volumes, clearly identified as a purge volume goal.

3.2.1.1.2 Chemical Parameter Stabilization Criteria

With respect to the ground water chemistry, an adequate purge is achieved when the pH and specific conductance of the ground water have stabilized and the turbidity has either stabilized or is below 10 Nephelometric Turbidity Units (NTUs) (twice the Primary Drinking Water Standard of 5 NTUs). Although 10 NTUs is normally considered the minimum goal for most ground water sampling objectives, lower turbidity has been shown to be easily achievable in most situations and reasonable attempts should be made to achieve these lower levels. (Note: Because groundwater temperature is subject to rapid changes when collected for parameter measurement, its usefulness is subject to question for the purpose of determining parameter stability. As such, it has been removed from the list of parameters used for stability determination. Even though temperature is not used to determine stability during well purging, it is still advisable to record the sample temperature, along with the other groundwater chemistry parameters during well purging, as it may be needed to interpret other chemical parameter results in some situations.)

Stabilization occurs when, for at least three consecutive measurements, the pH remains constant within 0.1 Standard Unit (SU) and specific conductance varies no more than approximately 5 percent. Other parameters, such as dissolved oxygen (DO), may also be used as a purge adequacy parameter. Normal goals for DO are 0.2 mg/L or 10% saturation, whichever is greater. DO measurements must be conducted using either a flow-through cell or an over-topping cell to minimize or reduce any oxygenation of the sample during measurement. Oxidation Reduction Potential (ORP) should not be used as a purge stabilization parameter but may be measured during purging to obtain the measurement of record for ORP for the sampling event.

There are no set criteria for establishing how many total sets of measurements are adequate to document stability of parameters. If the calculated purge volume is small, the measurements should be taken frequently enough to provide a sufficient number of measurements to evaluate stability. If the purge volume is large, measurements taken every 15 minutes, for example, may be sufficient. See the SESD Operating Procedures for Field pH Measurement (SESDPROC-100), Field Specific Conductance Measurement (SESDPROC-101), Field Temperature Measurement (SESDPROC-102), Field Turbidity Measurement (SESDPROC-103), Field Measurement of Dissolved Oxygen (SESDPROC-106) and Field Measurement of Oxidation-Reduction Potential (SESDPROC-113) for procedures for conducting these measurements.

If, after three well volumes have been removed, the chemical parameters have not stabilized according to the above criteria, additional well volumes (up to five well volumes), should be removed. If the parameters have not stabilized within five volumes, it is at the discretion of the project leader whether or not to collect a sample or to continue purging. If, after five well volumes, pH and conductivity have stabilized and the turbidity is still decreasing and approaching an acceptable level, additional purging should be considered to obtain the best sample possible, with respect to turbidity. The conditions of sampling should be noted in the field log.

3.2.1.1.3 Purge Adequacy Considerations

In some situations, even with slow purge rates, a well may be pumped or bailed dry (evacuated). In these situations, this generally constitutes an adequate purge and the well can be sampled following sufficient recovery (enough volume to allow filling of all sample containers). ***It is not necessary that the well be evacuated three times before it is sampled.*** The pH, specific conductance, temperature, and turbidity should be measured and recorded, during collection of the sample from the recovered volume, as the measurements of record for the sampling event.

For wells with slow recovery, attempts should be made to avoid purging them to dryness. This can be accomplished, for example, by slowing the purge rate. As water enters a well that has been purged to dryness, it may cascade down the sand pack and/or the well screen, stripping volatile organic constituents that may be present and/or introducing soil fines into the water column.

It is particularly important that wells be sampled as soon as possible after purging. If adequate volume is available immediately upon completion of purging, the well must be sampled immediately. If not, sampling should occur as soon as adequate volume has recovered. If possible, sampling of wells which have a slow recovery should be scheduled so that they can be purged and sampled in the same day, after adequate volume has recovered. Wells of this type should, unless it is unavoidable, not be purged at the end of one day and sampled the following day.

3.2.2 “Tubing-in-Screened-Interval” Method

The “Tubing-in-Screen” method, sometimes referred to as the “Low Flow” method, is used primarily when calculated purge volumes for the traditional purging method are excessive and present issues related to timely completion of the project and/or management of investigation derived waste.

3.2.2.1 Purge Criteria

3.2.2.1.1 Placement of Pump Tubing or Intake

The peristaltic pump tubing or intake point of the submersible pump is placed in the approximate mid-portion of the screened interval of the well. By definition, this method cannot be applied for purging with a bailer.

3.2.2.1.2 Conditions of Pumping

Prior to initiation of pumping, a properly decontaminated well sounder should be lowered into the well being sampled to monitor the static water level prior to and during the purging process. Ideally, there should be only a slight and stable drawdown of the water column after pumping begins. If this condition cannot be met, then one of the other methods should be employed.

3.2.2.1.3 Stability of Chemical Parameters

As with the traditional purging method described in Section 3.2.1, it is important that all chemical parameters be stable as defined in Section 3.2.1.1 prior to sampling.

3.3 Equipment Considerations for Purging

Monitoring well purging is accomplished by using in-place plumbing and dedicated pumps or by using portable pumps/equipment when dedicated systems are not present. The equipment utilized by Branch personnel will usually consist of peristaltic pumps and variable speed electric submersible pumps, but may also include bladder pumps or inertial pumps. The pump of choice is usually a function of the well diameter, the depth to water, the depth of the well and the amount of water that is to be removed during purging. Whenever the head difference between the sampling location and the water level is less than the limit of suction and the volume to be removed is reasonably small, a peristaltic pump should be used for purging. For wells where the water level is below the limit of suction (approximately 25' to 30', and/or where there is a large volume of water to be purged), the variable speed electric submersible pump would be the pump of choice. SESD Operating Procedure for Pump Operation (SESDPROC-203) contains the use and operating instructions for all pumps commonly used during SESD ground water investigations.

Bailers may also be used for purging in appropriate situations, however, their use is discouraged. Bailers tend to disturb any sediment that may be present in the well, creating or increasing sample turbidity. Bailers, if improperly used, may also strip volatile organic compounds from the water column being sampled. If a bailer is used, it should be a closed-top Teflon® bailer.

3.3.1 Wells Without Plumbing or In-Place Pumps

For permanent monitoring wells, the depth to water (water level) and depth of the well (total depth) should be determined before purging. Caution should be exercised during this procedure to prevent cross-contamination between wells. This is a critical concern when samples for trace organic compounds or metals analyses are collected. See SESD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205) for cleaning procedures for well sounders. After cleaning, the well sounding device should be protected to keep it clean until its next use.

3.3.1.1 Purging with Pumps

3.3.1.1.1 Peristaltic Pumps

The following step-by-step procedures describe the process of purging with a peristaltic pump:

1. Cut a length of standard-cleaned (SESD Operating Procedure for Field Equipment Cleaning and Decontamination at the FEC (SESDPROC-206)) Teflon® tubing, equal to the well depth plus an additional five to ten feet. Enough tubing is needed to run from the ground surface up to the top of the well casing and back down to the bottom of the well. This will allow for operation of the pump at all possible water level conditions in the well.
2. Place one end of the tubing into the vacuum side of the peristaltic pump head. Proper sizing of the Teflon® and Silastic® or Tygon® tubing should allow for a snug fit of the Teflon® tubing inside the flexible tubing mounted in the pump head.
3. Run a short section of tubing (does not have to be Teflon®) from the discharge side of the pump head to a graduated bucket.
4. Place the free end of the Teflon® tubing into the well until the end of the tubing is just below the surface of the water column.
5. Secure the Teflon® tubing to the well casing or other secure object using electrician's tape or other suitable means. This will prevent the tubing from being lost in the well should the tubing detach from the pump head.
6. Turn on the pump to produce a vacuum on the well side of the pump head and begin the purge. Observe pump direction to ensure that a vacuum is being applied to the purge line. If the purge line is being pressurized, either switch the tubing at the pump head or reverse the polarity of the cables on the pump or on the battery.

7. If the pumping rate exceeds the recovery rate of the well, continue to lower the tubing into the well, as needed, until the drawdown stabilizes or the well is evacuated to dryness. If the pump is a variable speed peristaltic pump, and the water level in the well is being drawn down, reduce the speed of the pump in an attempt to stabilize the drawdown. If the well can be purged without evacuating the well to dryness, a sample with greater integrity can be obtained.
8. For wells which are not evacuated to dryness, particularly those with recovery rates equal to or very nearly equal to the purge rate, there may not be a complete exchange and removal of stagnant water in that portion of the water column above the tubing intake. For this reason, it is important that the tubing intake be placed in the very uppermost portion of the water column while purging. Standard field measurements should frequently be taken during this process to verify adequacy of the purge and readiness for sampling, as described in Section 3.

3.3.1.1.2 Submersible Pumps

When a submersible pump is used for well purging, the pump itself is lowered into the water column. The pump must be cleaned as specified in SESD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205).

The pump/hose assembly used in purging should be lowered into the top of the standing water column and not deep into the column. This is done so that the purging will "pull" water from the formation into the screened area of the well and up through the casing so that the entire static volume can be removed. If the pump is placed deep into the water column, the water above the pump may not be removed, and the subsequent samples, particularly if collected with a bailer, may not be representative of the aquifer conditions. It is recommended that the pump not be lowered more than three to five feet into the water column. If the recovery rate of the well is faster than the pump rate and no observable draw down occurs, the pump should be raised until the intake is within one foot of the top of the water column for the duration of purging. If the pump rate exceeds the recovery rate of the well, the pump will have to be lowered, as needed, to accommodate the drawdown. After the pump is removed from the well, the hose and the pump should be cleaned as outlined in SESD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205).

3.3.1.2 Purging with Bailers

Standard-cleaned (SESD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205) or SESD Operating Procedure for Field Equipment Cleaning and Decontamination at the FEC (SESDPROC-206)), closed top Teflon® bailers with Teflon® coated stainless steel leaders and new nylon rope are lowered into the top of the water column, allowed to fill, and removed. It is critical that bailers be slowly and gently immersed into the top of the water column, particularly during final stages of purging, to minimize turbidity and disturbance of volatile organic constituents. The use of bailers for purging and sampling is discouraged because the correct technique is highly operator dependent and improper use may result in an unrepresentative sample.

3.3.2 Wells With In-Place Plumbing

Wells with in-place plumbing are commonly found at municipal water treatment plants, industrial water supplies, private residences, etc. Many permanent monitoring wells at active facilities are also equipped with dedicated, in-place pumps. The objective of purging wells with in-place pumps is the same as with monitoring wells without in-place pumps, i.e., to ultimately collect a ground water sample representative of aquifer conditions. Among the types of wells identified in this section, two different approaches are necessary.

A permanent monitoring well with an in-place pump should, in all respects, be treated like a monitoring well without a pump. One limitation is that in most cases the in-place pump is “hard” mounted, that is, the pump is suspended in the well at a pre-selected depth and cannot be moved up or down during purging and sampling. In these cases, well volumes are calculated, parameters are measured and the well is sampled from the pump discharge, after volume removal and parameter conditions have been met.

In the case of the other types of wells, i.e., municipal, industrial and residential supply wells, however, not enough is generally known about the construction aspects of the wells to apply the same criteria as used for monitoring wells, i.e., 3 to 5 well volumes. The volume to be purged in these situations, therefore, depends on several factors: whether the pumps are running continuously or intermittently and whether or not any storage/pressure tanks are located between the sampling point and the pump. The following considerations and procedures should be followed when purging wells with in-place plumbing under the conditions described.

3.3.2.1 Continuously Running Pumps

If the pump runs more or less continuously, no purge (other than opening a valve and allowing it to flush for a few minutes) is necessary. If a storage tank is present, a spigot, valve or other sampling point should be located between the

pump and the storage tank. If not, locate the valve closest to the tank. Measurements of pH, specific conductance, temperature, and turbidity are recorded at the time of sampling.

3.3.2.2 Intermittently or Infrequently Running Pumps

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

3.3.3 Temporary Monitoring Wells

3.3.3.1 General Considerations

Procedures used to purge temporary ground water monitoring wells differ from permanent wells because temporary wells are installed for immediate sample acquisition. Wells of this type may include standard well screen and riser placed in boreholes created by hand augering, power augering, or by drilling. They may also consist of a rigid rod and screen that is pushed, driven, or hammered into place to the desired sampling interval, such as a direct push Wellpoint®, a Geoprobe® Screen Point 15/16 sampler or a Hydropunch® sampler. As such, the efforts to remove several volumes of water to replace stagnant water do not necessarily apply because stagnant water is not present. It is important to note, however, that the longer a temporary well is in place and not sampled, the more stagnant the water column becomes and the more appropriate it becomes to apply, to the extent possible, standard permanent monitoring well purging criteria to it to re-achieve aquifer conditions.

In cases where the temporary well is to be sampled immediately after installation, purging is conducted primarily to mitigate the impacts of installation. In most cases, temporary well installation procedures disturb the existing aquifer conditions, resulting primarily in increased turbidity. Therefore, the goal of purging is to reduce the turbidity and remove the volume of water in the area directly impacted by the installation procedure. Low turbidity conditions in these types of wells that are completed within the limit of suction are typically and routinely achieved by the use of low-flow/low stress purging techniques using variable speed peristaltic pumps.

3.3.3.2 Purging When Water Level Is Within Limit of Suction

In situations where the elevation of the top of the water column is within the limit of suction (no greater than about 25 feet head difference between the pump and the water level), a variable speed peristaltic pump may be used to purge

temporary wells. Enough tubing is deployed to reach the bottom of the temporary well screen. At the onset of purging, the tubing is slowly lowered to the bottom of the screen and is used to remove any formation material which may have entered the well screen during installation. This is critical to ensuring rapid achievement of low turbidity conditions. After the formation material is removed from the bottom of the screen, the tubing is slowly raised through the water column to near the top of the column. The tubing can be held at this level to determine if the pump rate is drawing down the water level in the well. If the water level remains the same, secure the tubing at the surface to maintain this pumping level.

If drawdown is observed on initiation of pumping, reduce the pump speed and attempt to match the drawdown of the well. Sustained pumping at these slow rates will usually result in a relatively clear, low turbidity sample. If the drawdown stabilizes, maintain that level, however, if it continues to lower, "chase" the water column until the well is evacuated. In this case, the recovered water column may be relatively free of turbidity and can be sampled. It may take several episodes of recovery to provide enough volume for a complete sample.

3.3.3.3 Purging When Water Level Is Greater Than Limit of Suction

In situations where the elevation of the water table is greater than the limit of suction, peristaltic pumps cannot be used to purge temporary wells. If the temporary well is a ScreenPoint15® sampler with small diameter probe rod riser, the only practical choices for water removal are a small diameter bailer, a small diameter bladder pump or an inertial pump. If the well is to be used strictly for VOC screening, it may be acceptable to use the bailer to bail as much sediment from the well as possible prior to sampling. If metals are the analytes of concern, the bladder pump is the best choice for lowering the turbidity of the water column prior to sampling, followed next by the inertial pump. For larger diameter temporary wells, two-inch diameter or greater, bailers and the Grundfos® RediFlo2 may be used although excessive silt or other "fines" may present problems with the operation of the pump.

3.3.3.4 Considerations for Direct Push Groundwater Sampling

With many of the direct push sampling techniques, purging is either not practical or possible, therefore, no purging is conducted. The sampling device is simply pushed or driven to the desired depth and opened and the sample is collected and retrieved. As a result, some samples collected in this way may not be satisfactory or acceptable for certain analyses, i.e., the subject procedure may yield a turbid sample that is not appropriate for metals analyses.

3.4 Field Care of Purging Equipment

New plastic sheeting should be placed on the ground surface around the well casing to prevent contamination of the pumps, hoses, ropes, etc., in the event they accidentally

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

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

3.5 Investigation Derived Waste

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

4 Groundwater Sampling Methods – Sampling

4.1 General

Sampling is the process of obtaining, containerizing, and preserving (if required) a ground water sample after the purging process is complete. Non-dedicated pumps for sample collection generally should not be used. Many pumps are made of materials such as brass, plastic, rubber, or other elastomeric products which may cause chemical interferences with the sample. Their principle of operation may also render them unacceptable as a sample collection device. It is recognized that there are situations, such as industrial or municipal supply wells or private residential wells, where a well may be equipped with a dedicated pump from which a sample would not normally be collected. Discretion should always be used in obtaining a sample.

4.2 Sampling Wells With In-Place Plumbing

Samples should be collected following purging from a valve or cold water tap as near to the well as possible, preferably prior to any storage/pressure tanks or physical/chemical treatment system that might be present. Remove any hose that may be present before sample collection and reduce the flow to a low level to minimize sample disturbance, particularly with respect to volatile organic constituents. Samples should be collected directly into the appropriate containers as specified in the ASBLOQAM. It may be necessary to use a secondary container, such as a clean 8 oz. or similar size sample jar or a stainless steel scoop, to obtain and transfer samples from spigots with low ground clearance. Also, refer to the discussion in the SESD Operating Procedure for Potable Water Supply Sampling (SESDPROC-305), Sec. 4.2, Potable Water Samples Collected from Wells with In-Place Plumbing. Potable well measurements for pH, specific conductance and turbidity and possibly temperature, if warranted, should be recorded at the time of sample collection.

4.3 Sampling Wells Without Plumbing, Within the Limit of Suction

4.3.1 Equipment Available

The pump of choice for sampling ground water within the limit of suction is the variable-speed peristaltic pump. Its use is described in the following sections. Other acceptable alternatives that may be used under these conditions are the RediFlo2® electric submersible pump (with Teflon® tubing) and a closed-top Teflon® bailer.

4.3.1.1 Peristaltic Pump, Direct from Pump Head Tubing

Samples for some constituents, primarily inorganic analytes such as metals and cyanide, may be collected directly from the pump head tubing. This method is acceptable under the following conditions:

- The pump head tubing must be changed between sampling locations;

- The pump head tubing must be either be certified clean according to SESD's internal quality control program described in Section 3.2 of the SESD Operating Procedure for Field Sampling Quality Control (SESDPROC-011) or
- An equipment rinsate blank is collected by pumping de-ionized water through a piece of the tubing.

4.3.1.2 Peristaltic Pump/Vacuum jug

It is not acceptable to collect samples for organic compound analyses through the flexible tubing used in the pump head. When collecting samples for organic compound analyses it is necessary to use a vacuum container, placed between the pump and the well for sample collection. The following step-by-step procedures describe the process of sampling with a peristaltic pump and vacuum jug (see note following these procedures for collection of VOC samples):

1. Disconnect the purge tubing from the pump. Make sure the tubing is securely attached to the protective casing or other secure object.
2. Insert the tubing into one of the ferrule nut fittings of a Teflon® vacuum container transfer cap assembly.
3. Place a suitable length of Teflon® tubing between the remaining transfer cap assembly ferrule nut fitting and the vacuum side of the flexible tubing in the peristaltic pump head. Securely hand-tighten both fittings.
4. Turn the pump on. Water should begin to collect in the transfer container (typically a 1-liter sample container) within a few minutes. If water does not begin to flow into the container within several minutes, check the transfer cap fittings and make sure the assembly is tightly attached to the container. It may be necessary to tighten the ferrule nuts with a wrench or pliers to achieve a vacuum in the system, particularly when approaching the maximum head difference between the pump and water table (limit of suction).
5. When the transfer container is nearly full, turn off the pump, remove the transfer cap assembly, and pour the sample into the appropriate containers. Because the 1-liter containers used by the Branch are rinsed with nitric acid during cleaning, they cannot be used for collecting samples to be analyzed for nitrogen sensitive parameters.
6. If additional sample volume is needed, replace the transfer cap assembly, turn the pump on, and collect additional volume. The use of Teflon® valves or ball check devices to retain the water column in the sample delivery tubing during the transfer phase, when large volumes of sample are required, is acceptable. These devices, however, must be constructed so that they may be completely disassembled and cleaned according to the procedures in SESD

Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205).

7. When sampling is completed, all Teflon® tubing should be discarded.

NOTE: Samples for volatile organic compound analyses cannot be collected using this method. If samples for VOC analyses are required, they must be collected with a Teflon® or stainless steel bailer or by other approved methods, such as the “soda straw” method. The “soda straw” method involves allowing the tubing to fill, by either lowering it into the water column (A) or by filling it via suction applied by the pump head (B). If method (A) is used, the tubing is removed from the well after filling and the captured sample is allowed to drain into the sample vial. If method (B) is used, after running the pump and filling the tubing with sample, the pump speed is reduced and the direction reversed to push the sample out of the tubing into the vials. Avoid completely emptying the tubing when filling the sample vials when using method (B) to prevent introducing water that was in contact with the flexible pump head tubing. Either method is repeated, as necessary, until all vials are filled.

4.3.1.3 RediFlo2® Electric Submersible Pump (with Teflon® Tubing)

After purging has been accomplished with RediFlo2® electric submersible pump, the sample may be obtained directly from the pump discharge, provided that Teflon® tubing was used for the sample delivery line. The discharge rate of the pump should be reduced during volatile organic compound sample collection to minimize sample disturbance. Note, if the RediFlo2® electric submersible pump is used for sampling, the pump must undergo a full external and internal cleaning. In addition, pump rinsate blanks must be collected, at the appropriate frequency, to demonstrate that the pump has been adequately cleaned between wells.

4.3.1.4 Bailers

New bailer rope should be attached to the bailer via a Teflon® coated stainless steel wire. (If a bailer was used to purge the well, it may also be used to sample the well and new bailer rope is not required between purging and sampling). The bailer should be gently immersed in the top of the water column until just filled. At this point, the bailer should be slowly removed and the contents emptied into the appropriate sample containers.

4.4 Sampling Wells without Plumbing, Exceeding the Limit of Suction

All methods described previously in Section 4.3.2.1.3, RediFlo2® Electric Submersible Pumps, and Section 4.3.2.1.4, Bailers, are suitable sample methods where the water table is too deep to consider the use of a peristaltic pump for sampling.

4.5 Micro-Purge or No Purge Sampling Procedures

The Micro-Purge or No Purge sampling procedures are usually employed when it necessary to keep purge volumes to an absolute minimum. Among the Micro-Purge or No Purge procedures that might be employed are:

- Low pump rate sampling with peristaltic or submersible pumps (typical Micro-Purge sampling),
- HydraSleeve™ or
- Passive diffusion bag (PDB) sampling

The use of these procedures is acceptable only when the site hydrogeology is well understood, with respect to the hydraulic conductivity of geologic materials within the well screen interval. The underlying assumption, when employing these procedures, is that the formation in which the well is screened has a high hydraulic conductivity ($K > 10^{-5}$ cm/sec, for example), resulting in a state of equilibrium existing between the water standing in the screened interval and the formation water in which the well is screened. In this situation, the well is considered to be in a perpetually “purged” state and purging is not required.

These procedures are generally impractical for SESD to implement because of the general lack of hydrogeologic information for the sampled wells and the real necessity, in some cases, that the pumps be pre-deployed to overcome issues related to turbidity resulting from pump placement prior to sampling.

4.5.1 Sampling with Pumps

The peristaltic pump tubing or intake point of the submersible pump is placed in the approximate mid-portion of the screened interval of the well or other interval selected by the field team leader. If turbidity and its impact on metals analyses are a concern, a period of time sufficient should be allowed to mitigate effects of pump or tubing placement. After it has been determined that sampling may proceed, the pump is turned on and operated at a rate that does not cause significant drawdown of the water column, as measured using a water level sounder. During sampling, sufficient water to supply enough volume for the analytes of concern and the purge parameters is pumped. Purging should continue until purge parameters stabilize, generally three consecutive stable sets of readings, before samples are collected.

4.5.2 HydraSleeves™

HydraSleeves™ are grab sampling devices that are deployed in a closed configuration then opened in the desired interval for sample collection. The following is a summary of its operation:

1. Sampler placement - Reusable weight is attached and the HydraSleeve™ is lowered and placed at the desired position in the well screen. In-situ water pressure keeps the reed valve closed, preventing water from entering the sampler. Well is allowed to return to equilibrium.

2. Sample collection - The reed valve opens to allow filling when the sampler is moved upward faster than 1 foot per second, either in one continuous upward pull or by cycling the sampler up and down to sample a shorter interval. There is no change in water level, and only minimal agitation during collection.
3. Sample retrieval - When the flexible sleeve is full, the reed valve closes and the sampler can be recovered without entry of extraneous overlying fluids. Samples are removed by puncturing the sleeve with the pointed discharge tube and draining the contents into containers for sampling or field measurement.

4.5.3 Passive Diffusion Bags

Passive diffusion bag (PDB) samplers are bags comprised of low-density polyethylene (LDPE) plastic and containing analyte-free water, preferably with no headspace. The bags are deployed, with stainless steel weights, to the desired sample interval and are allowed to equilibrate with the water at the point of deployment in the well. A deployment period of a minimum of 14 days is recommended to ensure equilibration prior to removal.

After 14 days, the bags are opened with a puncture device or other cutting implement and the contents transferred to containers for sampling or field measurement.

4.5.4 General Considerations for Micro-Purge or No-Purge Sampling

When using the Micro-Purge method, it may be advisable to deploy the tubing or pump in advance of sample collection. Introducing the tubing or pump into the screened interval is likely to dislodge sediment and other fines that have settled or bridged on the well screen material and the gravel pack media behind the screen. If sampling is conducted immediately, turbidity issues may render this method impractical from a parameter stability standpoint.

HydraSleeves™ and PDBs must be evaluated for appropriateness for analytes of concern.

4.6 Sample Preservation

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

4.7 Special Sample Collection Procedures

4.7.1 Trace Organic Compounds and Metals

Special sample handling procedures should be instituted when trace contaminant samples are being collected. All sampling equipment, including pumps, bailers, water level measurement equipment, etc., which comes into contact with the water in the well must be cleaned in accordance with the cleaning procedures described in the SESD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205) or SESD Operating Procedure for Field Equipment Cleaning and Decontamination at the FEC (SESDPROC-206). Pumps should not be used for sampling unless the interior and exterior portions of the pump and the discharge hoses are thoroughly cleaned. Blank samples should be collected to determine the adequacy of cleaning prior to collection of any sample using a pump other than a peristaltic pump.

4.7.2 Order of Sampling with Respect to Analytes

In many situations when sampling permanent or temporary monitoring wells, an adequate purge, with respect to turbidity, is often difficult to achieve. Removal and insertion of equipment after the purge and prior to actual sampling may negate the low turbidities achieved during purging and elevate turbidity back to unacceptable levels. For this reason, it is important that special efforts be used to minimize any disturbance of the water column after purging and to collect the aliquot for metals first. Therefore, the preferred order of sampling is metals first, followed by other inorganic analytes, extractable organic compounds and volatile organic compounds.

4.7.3 Filtering

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

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

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

2. The ground water samples were collected using sampling techniques in accordance with this section, and the ground water samples were analyzed in accordance with USEPA approved methods.
3. Efforts have been undertaken to minimize any persistent sample turbidity problems. These efforts may consist of the following:
 - Redevelopment or re-installation of permanent ground water monitoring wells.
 - Implementation of low flow/low stress purging and sampling techniques.
4. Turbidity measurements should be taken during purging and sampling to demonstrate stabilization or lack thereof. These measurements should be documented in the field notes. If the ground water sample appears to have either a chemically-induced elevated turbidity, such as would occur with precipitate formation, or a naturally elevated colloid or fine, particulate-related turbidity, filtration will not be allowed.

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

1. Accomplish in-line filtration through the use of disposable, high capacity filter cartridges (barrel-type) or membrane filters in an in-line filter apparatus. The high capacity, barrel-type filter is preferred due to the higher surface area associated with this configuration. If a membrane filter is utilized, a minimum diameter of 142 mm is suggested.
2. Use a 5 μm pore-size filter for the purpose of determining the colloidal constituent concentrations. A 0.1 μm pore-size filter should be used to remove most non-dissolved particles.
3. Rinse the cartridge or barrel-type filter with 500 milliliters of the solute (groundwater to be sampled) prior to collection of sample. If a membrane filter is used, rinse with 100 milliliters of solute prior to sample collection.

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

Bacterial Sampling

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

4.8 Specific Sampling Equipment Quality Assurance Techniques

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

4.9 Auxiliary Data Collection

During ground water sample collection, it is important to record a variety of ground water related data. Included in the category of auxiliary data are water levels measured according to the SESD Operating Procedure for Groundwater Level and Well Depth Measurement (SESDPROC-105), well volume determinations (Section 3.1.1, Purging and Purge Adequacy), pumping rates during purging (see below), and occasionally, drillers or boring logs. This information should be documented in the field records.

4.9.1 Well Pumping Rate – Bucket/Stop Watch Method

The pumping rate for a pump can be determined by collecting the discharge from the pump in a bucket of known volume and timing how long it takes to fill the bucket. The pumping rate should be in gallons per minute. This method shall be used primarily with pumps with a constant pump rate, such as gasoline-powered or electric submersible pumps. Care should be taken when using this method with some battery-powered pumps. As the batteries' charge decreases, the pump rate also decreases so that pumping rate calculations using initial, high pump rates may be erroneously high. If this method is used with battery-powered pumps, the rate should be re-checked frequently to ensure accuracy of the pumping rate calculations.

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

OPERATING PROCEDURE

Title: **Soil Sampling**

Effective Date: August 21, 2014

Number: SESDPROC-300-R3

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1 General Information

1.1 Purpose

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

1.2 Scope/Application

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

1.3 Documentation/Verification

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

1.4 References

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

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

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

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

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

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

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

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

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

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

1.5 General Precautions

1.5.1 Safety

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

1.5.2 Procedural Precautions

The following precautions should be considered when collecting soil samples:

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

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

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

2 Special Sampling Considerations

2.1 Special Precautions for Trace Contaminant Soil Sampling

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

2.2 Sample Homogenization

1. If sub-sampling of the primary sample is to be performed in the laboratory, transfer the entire primary sample directly into an appropriate, labeled sample container(s). Proceed to step 4.
2. If sub-sampling the primary sample in the field or compositing multiple primary samples in the field, place the sample into a glass or stainless steel homogenization container and mix thoroughly. Each aliquot of a composite sample should be of the same approximate volume.
3. All soil samples must be thoroughly mixed to ensure that the sample is as representative as possible of the sample media. ***Samples for VOC analysis are not homogenized.*** The most common method of mixing is referred to as quartering. The quartering procedure should be performed as follows:

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

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

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

2.3 Dressing Soil Surfaces

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

2.4 Quality Control

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

2.5 Records

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

3 Method 5035

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

3.1 Soil Samples for Volatile Organic Compounds (VOC) Analysis

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

3.2 Soil Sampling (Method 5035)

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

3.2.1 Equipment

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

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

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

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

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

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

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

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

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

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

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

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

3.2.4 *Special Techniques and Considerations for Method 5035*

Effervescence

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

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

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

Sample Size

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

Holding Times

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

Percent Solids

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

Safety

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

Shipping

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

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

Table 1: Method 5035 Summary

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

4 Manual Soil Sampling Methods

4.1 General

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

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

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

4.2 Spoons

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

4.2.1 Special Considerations When Using Spoons

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

4.3 Hand Augers

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

4.3.1 Surface Soil Sampling

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

4.3.2 Subsurface Soil Sampling

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

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

4.3.3 Special Considerations for Soil Sampling with the Hand Auger

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

5 Direct Push Soil Sampling Methods

5.1 General

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

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

5.2 Large Bore® Soil Sampler

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

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

5.3 Macro-Core® Soil Sampler

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

in either an open-tube or closed-point configuration. Although the MC® sampler can be used as an open-barrel sampler, in SESD usage, the piston point is always used to prevent the collection of slough from the borehole sides.

5.4 Dual Tube Soil Sampling System

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

5.5 Special Considerations When Using Direct Push Sampling Methods

- *Liner Use and Material Selection* – Direct Push Soil Samples are collected within a liner to facilitate removal of sample material from the sample barrel. The liners may only be available in a limited number of materials for a given sample tool, although overall, liners are available in brass, stainless steel, cellulose acetate butyrate (CAB), polyethylene terephthalate glycol (PETG), polyvinyl chloride (PVC) and Teflon®. For most SESD investigations, the standard polymer liner material for a sampling tool will be acceptable. When the study objectives require very low reporting levels or unusual contaminants of concern, the use of more inert liner materials such as Teflon® or stainless steel may be necessary.
- *Sample Orientation* – When the liners and associated sample are removed from the sample tubes, it is important to maintain the proper orientation of the sample. This is particularly important when multiple sample depths are collected from the same push. It is also important to maintain proper orientation to define precisely the depth at which an aliquot was collected. Maintaining proper orientation is typically accomplished using vinyl end caps. Convention is to place red caps on the top of the liner and black caps on the bottom to maintain proper sample orientation. Orientation can also be indicated by marking on the exterior of the liner with a permanent marker.
- *Core Catchers* – Occasionally the material being sampled lacks cohesiveness and is subject to crumbling and falling out of the sample liner. In cases such as these, the use of core catchers on the leading end of the sampler may help

retain the sample until it is retrieved to the surface. Core catchers may only be available in specific materials and should be evaluated for suitability. However, given the limited sample contact that core-catchers have with the sample material, most standard core-catchers available for a tool system will be acceptable.

- *Decontamination* – The cutting shoe and piston rod point are to be decontaminated between each sample, using the procedures specified for the collection of trace organic and inorganic compounds found in Field Equipment and Decontamination – SESDPROC-205, most recent version. Within a borehole, the sample barrel, rods, and drive head may be subjected to an abbreviated cleaning to remove obvious and loose material, but must be cleaned between boreholes using the procedures specified for downhole drilling equipment in Field Equipment and Decontamination – SESDPROC-205, most recent version.
- *Decommissioning* – Boreholes must be decommissioned after the completion of sampling. Boreholes less than 10 feet deep that remain open and do not approach the water table may be decommissioned by pouring 30% solids bentonite grout from the surface or pouring bentonite pellets from the surface, hydrating the pellets in lifts. Boreholes deeper than 10 feet, or any borehole that intercepts groundwater, must be decommissioned by pressure grouting with 30% solids bentonite grout, either through a re-entry tool string or through tremie pipe introduced to within several feet of the borehole bottom.
- *VOC Sample Collection* – Observe precautions for volatile organic compound sample collection found in Section 3 of this procedure.

6 Split Spoon/Drill Rig Methods

6.1 General

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

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

6.2 Standard Split Spoon

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

6.3 Continuous Split Spoon

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

6.4 Special Considerations When Using Split Spoon Sampling Methods

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

7 Shelby Tube/Thin-Walled Sampling Methods

7.1 General

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

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

7.2 Shelby Tube Sampling Method

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

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

7.3 Special Considerations When Using Split Spoon Sampling Methods

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

8 Backhoe Sampling Method

8.1 General

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

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

8.2 Scoop-and-Bracket Method

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

8.3 Direct-from-Bucket Method

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

8.4 Special Considerations When Sampling with a Backhoe

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

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

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

OPERATING PROCEDURE

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1 General Information

1.1 Purpose

This document describes general and specific procedures, methods and considerations to be used and observed when cleaning and decontaminating sampling equipment during the course of field investigations.

1.2 Scope/Application

The procedures contained in this document are to be followed when field cleaning sampling equipment, for both re-use in the field, as well as used equipment being returned to the Field Equipment Center (FEC). On the occasion that SESD field investigators determine that any of the procedures described in this section are either inappropriate, inadequate or impractical and that other procedures must be used to clean or decontaminate sampling equipment at a particular site, the variant procedure will be documented in the field logbook, along with a description of the circumstances requiring its use. Mention of trade names or commercial products in this operating procedure does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

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

1.4 Definitions

- Decontamination: The process of cleaning dirty sampling equipment to the degree to which it can be re-used, with appropriate QA/QC, in the field.
- Deionized water: Tap water that has been treated by passing through a standard deionizing resin column. At a minimum, the finished water should contain no detectable heavy metals or other inorganic compounds (i.e., at or above analytical detection limits) as defined by a standard inductively coupled Argon Plasma Spectrophotometer (ICP) (or equivalent) scan. Deionized water obtained by other methods is acceptable, as long as it meets the above analytical criteria. Organic-free water may be substituted for deionized water.
- Detergent shall be a standard brand of phosphate-free laboratory detergent such as Liquinox® or Luminox®. Liquinox® is a traditional anionic laboratory detergent and is used for general cleaning and where there is

concern for the stability of the cleaned items in harsher cleaners. Luminox® is a specialized detergent with the capability of removing oils and organic contamination. It is used in lieu of a solvent rinse step in cleaning of equipment for trace contaminant sampling. Where not specified in these procedures, either detergent is acceptable.

- Drilling Equipment: All power equipment used to collect surface and sub-surface soil samples or install wells. For purposes of this procedure, direct push is also included in this definition.
- Field Cleaning: The process of cleaning dirty sampling equipment such that it can be returned to the FEC in a condition that will minimize the risk of transfer of contaminants from a site.
- Organic-free water: Tap water that has been treated with activated carbon and deionizing units. At a minimum, the finished water must meet the analytical criteria of deionized water and it should contain no detectable pesticides, herbicides, or extractable organic compounds, and no volatile organic compounds above minimum detectable levels as determined by the Region 4 laboratory for a given set of analyses. Organic-free water obtained by other methods is acceptable, as long as it meets the above analytical criteria.
- Tap water: Water from any potable water supply. Deionized water or organic-free water may be substituted for tap water.

1.5 References

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

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

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

1.6 General Precautions

1.6.1 Safety

Proper safety precautions must be observed when field cleaning or decontaminating dirty sampling equipment. Refer to the SESD Safety, Health and Environmental Management Program (SHEMP) Procedures and Policy Manual and any pertinent site-specific Health and Safety Plans (HASPs) for guidelines on safety precautions. These guidelines, however, should only be used to complement the judgment of an experienced professional. Address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate. At a minimum, the following precautions should be taken in the field during these cleaning operations:

- When conducting field cleaning or decontamination using laboratory detergent, safety glasses with splash shields or goggles, and latex gloves will be worn.
- No eating, smoking, drinking, chewing, or any hand to mouth contact should be permitted during cleaning operations.

1.6.2 Procedural Precaution

Prior to mobilization to a site, the expected types of contamination should be evaluated to determine if the field cleaning and decontamination activities will generate rinsates and other waste waters that might be considered RCRA hazardous waste or may require special handling.

2 Introduction to Field Equipment Cleaning and Decontamination

2.1 General

The procedures outlined in this document are intended for use by field investigators for cleaning and decontaminating sampling and other equipment in the field. These procedures should be followed in order that equipment is returned to the FEC in a condition that will minimize the risk of transfer of contaminants from a site.

Sampling and field equipment cleaned in accordance with these procedures must meet the minimum requirements for the Data Quality Objectives (DQOs) of the study or investigation. If deviations from these procedures need to be made during the course of the field investigation, they will be documented in the field logbook along with a description of the circumstances requiring the use of the variant procedure.

Cleaning procedures for use at the Field Equipment Center (FEC) are found in SESD Operating Procedure for Equipment Cleaning and Decontamination at the FEC (SESDPROC-206).

2.2 Handling Practices and Containers for Cleaning Solutions

Improperly handled cleaning solutions may easily become contaminated. Storage and application containers must be constructed of the proper materials to ensure their integrity. Following are acceptable materials used for containing the specified cleaning solutions:

- Detergent must be kept in clean plastic, metal, or glass containers until used. It should be poured directly from the container during use.
- Tap water may be kept in tanks, hand pressure sprayers, squeeze bottles, or applied directly from a hose.
- Deionized water must be stored in clean, glass or plastic containers that can be closed prior to use. It can be applied from plastic squeeze bottles.
- Organic-free water must be stored in clean glass or Teflon® containers prior to use. It may be applied using Teflon® squeeze bottles, or with the portable system.

2.3 Disposal of Cleaning Solutions

Procedures for the safe handling and disposition of investigation derived waste (IDW); including used wash water and rinse water are in SESD Operating Procedure for Management of Investigation Derived Waste (SESDPROC-202).

2.4 Sample Collection Equipment Contaminated with Concentrated Materials

Equipment used to collect samples of concentrated materials from investigation sites must be field cleaned before returning from the study. At a minimum, this should consist of washing with detergent and rinsing with tap water. When the above procedure cannot be followed, the following options are acceptable:

1. Leave with facility for proper disposal;
2. If possible, containerize, seal, and secure the equipment and leave on-site for later disposal;
3. Containerize, bag or seal the equipment so that no odor is detected and return to the SESD.

It is the project leader's responsibility to evaluate the nature of the sampled material and determine the most appropriate cleaning procedures for the equipment used to sample that material.

2.5 Sample Collection Equipment Contaminated with Environmental Media

Equipment used to collect samples of environmental media from investigation sites should be field cleaned before returning from the study. Based on the condition of the sampling equipment, one or more of the following options must be used for field cleaning:

1. Wipe the equipment clean;
2. Water-rinse the equipment;
3. Wash the equipment in detergent and water followed by a tap water rinse.
4. For grossly contaminated equipment, the procedures set forth in Section 2.4 must be followed.

Under extenuating circumstances such as facility limitations, regulatory limitations, or during residential sampling investigations where field cleaning operations are not feasible, equipment can be containerized, bagged or sealed so that no odor is detected and returned to the FEC without being field cleaned. If possible, FEC personnel should be notified that equipment will be returned without being field cleaned. It is the project leader's

responsibility to evaluate the nature of the sampled material and determine the most appropriate cleaning procedures for the equipment used to sample that material.

2.6 Handling of Decontaminated Equipment

After decontamination, equipment should be handled only by personnel wearing clean gloves to prevent re-contamination. In addition, the equipment should be moved away (preferably upwind) from the decontamination area to prevent re-contamination. If the equipment is not to be immediately re-used it should be covered with plastic sheeting or wrapped in aluminum foil to prevent re-contamination. The area where the equipment is kept prior to re-use must be free of contaminants.

3 Field Equipment Decontamination Procedures

3.1 General

Sufficient equipment should be transported to the field so that an entire study can be conducted without the need for decontamination. When equipment must be decontaminated in the field, the following procedures are to be utilized.

3.2 Specifications for Decontamination Pads

Decontamination pads constructed for field cleaning of sampling and drilling equipment should meet the following minimum specifications:

- The pad should be constructed in an area known or believed to be free of surface contamination.
- The pad should not leak.
- If possible, the pad should be constructed on a level, paved surface and should facilitate the removal of wastewater. This may be accomplished by either constructing the pad with one corner lower than the rest, or by creating a sump or pit in one corner or along one side. Any sump or pit should also be lined.
- Sawhorses or racks constructed to hold equipment while being cleaned should be high enough above ground to prevent equipment from being splashed.
- Water should be removed from the decontamination pad frequently.
- A temporary pad should be lined with a water impermeable material with no seams within the pad. This material should be either easily replaced (disposable) or repairable.

At the completion of site activities, the decontamination pad should be deactivated. The pit or sump should be backfilled with the appropriate material designated by the site project leader, but only after all waste/rinse water has been pumped into containers for disposal. See SESD Operating Procedure for Management of Investigation Derived Waste (SESDPROC-202) for proper handling and disposal of these materials. If the decontamination pad has leaked excessively, soil sampling may be required.

3.3 "Classical Parameter" Sampling Equipment

"Classical Parameters" are analyses such as oxygen demand, nutrients, certain inorganic compounds, sulfide, flow measurements, etc. For routine operations involving classical parameter analyses, water quality sampling equipment such as Kemmerers, buckets, dissolved oxygen dunkers, dredges, etc., may be cleaned with the sample water or tap water between sampling locations as appropriate.

Flow measuring equipment such as weirs, staff gages, velocity meters, and other stream gauging equipment may be cleaned with tap water between measuring locations, if necessary.

Note: The procedures described in Section 3.3 are not to be used for cleaning field equipment to be used for the collection of samples undergoing trace organic or inorganic constituent analyses.

3.4 Sampling Equipment used for the Collection of Trace Organic and Inorganic Compounds

For samples undergoing trace organic or inorganic constituent analyses, the following procedures are to be used for all sampling equipment or components of equipment that come in contact with the sample:

3.4.1 Standard SESD Method

1. An optional Liquinox® detergent wash step may be useful to remove gross dirt and soil.
2. Clean with tap water and Luminox® detergent using a brush, if necessary, to remove particulate matter and surface films.
3. Rinse thoroughly with tap water.
4. Rinse thoroughly with organic-free water and place on a clean foil-wrapped surface to air-dry.
5. Wrap the dry equipment with aluminum foil or bag in clean plastic. If the equipment is to be stored overnight before it is wrapped in foil, it should be covered and secured with clean, unused plastic sheeting.

3.4.2 Alternative Solvent Rinse Method

The historical solvent rinse method of cleaning equipment for trace contaminant sampling remains an acceptable method.

1. Clean with tap water and Liquinox® detergent using a brush, if necessary, to remove particulate matter and surface films. Equipment may be steam cleaned (Liquinox® detergent and high pressure hot water) as an alternative to

brushing. Sampling equipment that is steam cleaned should be placed on racks or saw horses at least two feet above the floor of the decontamination pad. PVC or plastic items should not be steam cleaned.

2. . Rinse thoroughly with tap water.
3. Rinse thoroughly with deionized water.
4. Rinse with an appropriate solvent (generally isopropanol).
5. Rinse with organic-free water and place on a clean foil-wrapped surface to air-dry.
4. Wrap the dry equipment with aluminum foil. If the equipment is to be stored overnight before it is wrapped in foil, it should be covered and secured with clean, unused.

3.5 Well Sounders or Tapes

The following procedures are recommended for decontaminating well sounders (water level indicators) and tapes. Unless conditions warrant, it is only necessary to decontaminate the wetted portion of the sounder or tape.

1. Wash with Liquinox® detergent and tap water.
2. Rinse with tap water.
3. Rinse with deionized water.

3.6 Redi-Flo2® Pump

CAUTION – Do not wet the controller. Always disconnect power from the pump when handling the pump body.

The Redi-Flo2® pump and any associated connected hardware (e.g., check valve) should be decontaminated between each monitoring well. The following procedures are required, depending on whether the pump is used solely for purging or used for purging and sampling.

3.6.1 Purge Only (Pump and Wetted Portion of Tubing or Hose)

1. Disconnect power and wash exterior of pump and wetted portion of the power lead and tubing or hose with Liquinox® detergent and water solution.

2. Rinse with tap water.
3. Final rinse with deionized water.
4. Place pump and reel in a clean plastic bag and keep tubing or hose contained in clean plastic or galvanized tub between uses.

3.6.2 Purge And Sample

Grundfos Redi-Flo2® pumps are extensively decontaminated and tested at the FEC to prevent contamination from being transmitted between sites. The relevant sections of SESDPROC-206, *Field Equipment Cleaning and Decontamination at the FEC*, should be implemented in the field where a high risk of cross-contamination exists, such as where NAPL or high-concentration contaminants occur. In most cases, the abbreviated cleaning procedure described below will suffice, provided that sampling proceeds from least to most contaminated areas.

1. Disconnect and discard the previously used sample tubing from the pump. Remove the check valve and tubing adapters and clean separately (See Section 3.6.3 for check valve). Wash the pump exterior with detergent and water.
2. Prepare and fill three containers with decontamination solutions, consisting of Container #1, a tap water/detergent washing solution. Luminox® is commonly used. An additional pre-wash container of Liquinox® may be used; Container #2, a tap water rinsing solution; and Container #3, a deionized or organic-free water final rinsing solution. Choice of detergent and final rinsing solution for all steps in this procedure is dependent upon project objectives (analytes and compounds of interest). The containers should be large enough to hold the pump and one to two liters of solution. An array of 2' long 2" PVC pipes with bottom caps is a common arrangement. The solutions should be changed at least daily.
3. Place the pump in Container #1. Turn the pump on and circulate the detergent and water solution through the pump and then turn the pump off.
4. Place the pump in Container #2. Turn the pump on and circulate the tap water through the pump and then turn the pump off.
5. Place the pump in Container #3. Turn the pump on and circulate deionized or organic-free water through the pump and then turn the pump off.

6. Disconnect power and remove pump from Container #3. Rinse exterior and interior of pump with fresh deionized or organic-free water.
7. Decontaminate the power lead by washing with detergent and water, followed by tap water and deionized water rinses. This step may be performed before washing the pump if desired.
8. Reassemble check valve and tubing adapters to pump. ALWAYS use Teflon® tape to prevent galling of threads. Firm hand-tightening of fittings or light wrench torque is generally adequate.
9. Place the pump and reel in a clean plastic bag.

3.6.3 Redi-Flo2® Ball Check Valve

1. Remove the ball check valve from the pump head. Check for wear and/or corrosion, and replace as needed. During decontamination check for free-flow in forward direction and blocking of flow in reverse direction.
2. Using a brush, scrub all components with detergent and tap water.
3. Rinse with deionized water.
4. Rethread the ball check valve to the Redi-Flo2® pump head.

3.7 Mega-Monsoon® and GeoSub® Electric Submersible Pump

As these pumps have lower velocities in the turbine section and are easier to disassemble in the field than Grundfos pumps, the outer pump housing should be removed to expose the impeller for cleaning prior to use and between each use when used as a sampling pump for trace contaminant sampling.

1. Remove check valves and adapter fittings and clean separately.
2. Remove the outer motor housing by holding the top of the pump head and unscrewing the outer housing from its O-ring sealed seat.
3. Clean all pump components per the provisions of section 3.4. Use a small bottle brush for the pump head passages
4. Wet the O-ring(s) on the pump head with organic-free water. Reassemble the outer pump housing to the pump head.
5. Clean cable and reel per Section 3.4.
6. Conduct final rinse of pump with organic-free water over pump and through pump turbine.

3.8 Bladder Pumps

Bladder pumps are presumed to be intended for use as purge-and-sample pumps. The Geotech® bladder pump and Geoprobe Systems® mechanical bladder pump can be cleaned similarly.

1. Discard any tubing returned with the pump.
2. Completely disassemble the pump, being careful to note the initial position of and retain any springs and loose ball checks.
3. Discard pump bladder.
4. Clean all parts as per the standard cleaning procedure in Section 3.4.
5. Install a new Teflon® bladder and reassemble pump.

3.9 Downhole Drilling Equipment

These procedures are to be used for drilling activities involving the collection of soil samples for trace organic and inorganic constituent analyses and for the construction of monitoring wells to be used for the collection of groundwater samples for trace organic and inorganic constituent analyses.

3.9.1 Introduction

Cleaning and decontamination of all equipment should occur at a designated area (decontamination pad) on the site. The decontamination pad should meet the specifications of Section 3.2 of this procedure.

Tap water brought on the site for drilling and cleaning purposes should be contained in a pre-cleaned tank.

A steam cleaner and/or high pressure hot water washer capable of generating a pressure of at least 2500 PSI and producing hot water and/or steam, with a detergent compartment, should be obtained.

3.9.2 Preliminary Cleaning and Inspection

Drilling equipment should be clean of any contaminants that may have been transported from off-site to minimize the potential for cross-contamination. The drilling equipment should not serve as a source of contaminants. Associated drilling and decontamination equipment, well construction materials, and equipment handling procedures should meet these minimum specified criteria:

- All downhole augering, drilling, and sampling equipment should be sandblasted before use if painted, and/or there is a buildup of rust, hard or caked matter, etc., that cannot be removed by steam cleaning (detergent and high pressure hot water), or wire brushing. Sandblasting should be performed prior to arrival on site, or well away from the decontamination pad and areas to be sampled.
- Any portion of the drilling equipment that is over the borehole (kelly bar or mast, backhoe buckets, drilling platform, hoist or chain pulldowns, spindles, cathead, etc.) should be steam cleaned (detergent and high pressure hot water) and wire brushed (as needed) to remove all rust, soil, and other material which may have come from other sites before being brought on site.
- Printing and/or writing on well casing, tremie tubing, etc., should be removed before use. Emery cloth or sand paper can be used to remove the printing and/or writing. Most well material suppliers can provide materials without the printing and/or writing if specified when ordered. Items that cannot be cleaned are not acceptable and should be discarded.
- Equipment associated with the drilling and sampling activities should be inspected to insure that all oils, greases, hydraulic fluids, etc., have been removed, and all seals and gaskets are intact with no fluid leaks.

3.9.3 Drill Rig Field Cleaning Procedure

Any portion of the drill rig, backhoe, etc., that is over the borehole (kelly bar or mast, backhoe buckets, drilling platform, hoist or chain pulldowns, spindles, cathead, etc.) should be steam cleaned (detergent and high pressure hot water) between boreholes.

3.9.4 Field Decontamination Procedure for Drilling Equipment

The following is the standard procedure for field cleaning augers, drill stems, rods, tools, and associated equipment. This procedure does not apply to well casings, well screens, or split-spoon samplers used to obtain samples for chemical analyses, which should be decontaminated as outlined in Section 3.4 of this procedure.

1. Wash with tap water and detergent, using a brush if necessary, to remove particulate matter and surface films. Steam cleaning (high pressure hot water with detergent) may be necessary to remove matter that is difficult to remove with the brush. Drilling equipment that is steam cleaned should be placed on racks or saw horses at least two feet above the floor of the decontamination pad. Hollow-stem augers, drill

rods, etc., that are hollow or have holes that transmit water or drilling fluids, should be cleaned on the inside with vigorous brushing.

2. Rinse thoroughly with tap water.
3. Remove from the decontamination pad and cover with clean, unused plastic. If stored overnight, the plastic should be secured to ensure that it stays in place.

3.9.5 *Field Decontamination Procedure for Direct Push Technology (DPT) Equipment*

1. Certain specific procedures for the decontamination of DPT tools are described in the various sampling procedures, but the following general guidelines apply:
2. Prior to return to the Field Equipment Center, all threaded tool joints should be broken apart and the equipment cleaned per the provisions of *Section 2.5, Sample Collection Equipment Contaminated with Environmental Media* of this procedure.
3. Equipment that contacts the sample media and is cleaned in the field for reuse should be cleaned per the provisions of *Section 3.4, Sampling Equipment used for the Collection of Trace Organic and Inorganic Compounds* of this procedure. This would include piston sampler points and shoes, screen point sampler screens and sheaths, and the drive rods when used for groundwater sampling.
4. Equipment that does not directly contact the sample media and is cleaned in the field for reuse can generally be cleaned per the provisions of *Section 3.7.4, Field Decontamination Procedure for Drilling Equipment* of this procedure.
5. Stainless steel SP15/16 well screens require special care as the narrow slots are difficult to clean under even controlled circumstances and galvanic corrosion can release chrome from the screen surface. As soon as possible after retrieval, the screen slots should be sprayed from the outside to break loose as much material as possible before it can dry in place. To prevent galvanic corrosion, the screens must be segregated from the sampler sheaths, drive rods, and other carbon steel during return transport from the field.

3.10 Rental Pumps

Completing a groundwater sampling project may require the use of rental pumps. Rental pumps are acceptable where they are of suitable stainless steel and Teflon® construction. These pumps should be cleaned prior to use using the procedures specified herein and a rinse-blank collected prior to use.

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

OPERATING PROCEDURE

Title: Management of Investigation Derived Waste

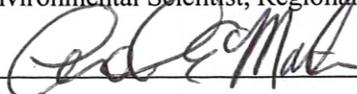
Effective Date: July 3, 2014

Number: SESDPROC-202-R3

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7/2/14

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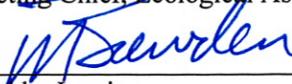


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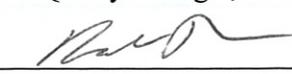


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Revision History

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History	Effective Date
<p>SESDPROC-202-R3, <i>Management of Investigation Derived Waste</i>, replaces SESDPROC-202-R2.</p> <p>General: Corrected typographical, grammatical and/or editorial errors.</p> <p>Cover Page: The Enforcement and Investigations Branch Chief was changed from Archie Lee to Acting Chief John Deatruck. The Ecological Assessment Branch Chief was changed from Bill Cosgrove to Acting Chief Mike Bowden. The FQM was changed from Liza Montalvo to Bobby Lewis.</p> <p>Revision History: Changes were made to reflect the current practice of only including the most recent changes in the revision history.</p>	July 3, 2014
<p>SESDPROC-202-R2, <i>Management of Investigation Derived Waste</i>, replaces SESDPROC-202-R1.</p>	October 15, 2010
<p>SESDPROC-202-R1, <i>Management of Investigation Derived Waste</i>, replaces SESDPROC-202-R0.</p>	November 1, 2007
<p>SESDPROC-202-R0, <i>Management of Investigation Derived Waste</i>, Original Issue</p>	February 05, 2007

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Contents

1 General Information

1.1 Purpose

This document describes general and specific procedures and considerations to be used and observed when managing investigation derived waste (IDW) generated during the course of hazardous waste site investigations.

1.2 Scope/Application

The procedures and management options for the different categories of IDW described in this document are to be used by SESD field personnel to manage IDW generated during site investigations. On the occasion that SESD field personnel determine that any of the procedures described in this section are inappropriate, inadequate or impractical and that another procedure must be used to manage IDW generated at a particular site, the variant procedure will be documented in the field logbook, along with a description of the circumstances requiring its use. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

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

1.4 References

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

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

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

1.5 General Precautions

1.5.1 Safety

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

1.5.2 Procedural Precautions

The following precautions should be considered when managing IDW:

- Due to time limitations and restrictions posed by RCRA regulations on storage of hazardous waste, accumulation start dates should be identified on all drums, buckets or other containers used to hold IDW so that it can be managed in a timely manner.
- During generation of both non-hazardous and hazardous IDW, keep hazardous IDW segregated from non-hazardous IDW to minimize the volume of hazardous IDW that must be properly managed.

2 Types of Investigation Derived Waste

Materials which may become IDW include, but are not limited to:

- Personal protective equipment (PPE) - This includes disposable coveralls, gloves, booties, respirator canisters, splash suits, etc.
- Disposable equipment and items - This includes plastic ground and equipment covers, aluminum foil, conduit pipe, composite liquid waste samplers (COLIWASAs), Teflon® tubing, broken or unused sample containers, sample container boxes, tape, etc.
- Soil cuttings from drilling or hand augering.
- Drilling mud or water used for mud or water rotary drilling.
- Groundwater obtained through well development or well purging.
- Cleaning fluids such as spent solvents and wash water.
- Packing and shipping materials.

Table 1, found at the end of this procedure, lists the types of IDW commonly generated during field investigations and the current disposal practices for these materials.

For the purpose of determining the ultimate disposition of IDW, it is typically distinguished as being either hazardous or non-hazardous. This determination is based on either clear regulatory guidance or by subsequent analysis. This determination and subsequent management is the responsibility of the program site manager.

3 Management of Non-Hazardous IDW

Disposal of non-hazardous IDW should be addressed in the study plan or QAPP for the investigation. To reduce the volume of any IDW transported back to the Field Equipment Center (FEC), it may be necessary to compact the waste into a reusable container, such as a 55-gallon drum.

If the waste is from an active facility, permission should be sought from the operator of the facility to place the non-hazardous PPE, disposable equipment, and/or paper/cardboard into the facility's dumpsters. If necessary, these materials may be placed into municipal dumpsters, with the permission of the owner. These materials may also be taken to a nearby permitted landfill. On larger studies, waste hauling services may be obtained and a dumpster located at the study site.

Disposal of non-hazardous IDW such as drill cuttings, drilling mud, purge or development water, decontamination wash water, etc., should be specified in the approved study plan or QAPP. It is recommended that these materials be placed into a unit with an environmental permit, such as a landfill or sanitary sewer. These materials must not be placed into dumpsters. If the facility at which the study is being conducted is active, permission should be sought to place these types of IDW into the facility's treatment system. It may be feasible to spread drill cuttings around the borehole, or, if the well is temporary, to place the cuttings back into the borehole. Non-hazardous monitoring well purge or development water may also be poured onto the ground down gradient of the monitoring well when site conditions permit. Purge water from private potable wells which are in service may be discharged directly onto the ground surface.

The minimum requirements for this subsection are:

- Non-hazardous liquid and soil/sediment IDW may be placed on the ground or returned to the source if doing so does not endanger human health or the environment or violate federal or state regulations. Under no circumstances, however, should monitoring well purge water be placed back into the well from which it came.
- Soap and water decontamination fluids and rinsates of such cannot be placed in any water bodies and must be collected and returned to the FEC for disposition.
- The collection, handling and proposed disposal method must be specified in the approved study plan or QAPP.

4 Management of Hazardous IDW

Disposal of hazardous or suspected hazardous IDW must be specified in the approved study plan or QAPP for the study or investigation. Hazardous IDW must be disposed as specified in USEPA regulations. If appropriate, these wastes may be placed back in an active facility waste treatment system. These wastes may also be disposed in the source area from which they originated if doing so does not endanger human health or the environment.

If on-site disposal is not feasible, and if the wastes are suspected to be hazardous, appropriate tests must be conducted to make that determination. If they are determined to be hazardous wastes, they must be properly contained and labeled. They may be stored on the site for a maximum of 90 days before they must be manifested and shipped to a permitted treatment or disposal facility. Generation of hazardous IDW must be anticipated, if possible, to allow arrangements for proper containerization, labeling, transportation and disposal/treatment in accordance with USEPA regulations.

The generation of hazardous IDW should be minimized to conserve Division resources. Most routine studies should not produce any hazardous IDW, with the possible exception of spent solvents and, possibly, purged groundwater. The use of solvents during field cleaning of equipment should be minimized by using solvent-free cleaning procedures for routine cleaning and decontamination (see SESD Operating Procedure for Field Equipment Cleaning and Decontamination, SESDPROC-205). If solvents are needed, the volume should be minimized by using only the amount necessary and by capturing the residual solvent separately from the aqueous decontamination fluids (detergent/wash water mixes and water rinses).

At a minimum, the requirements of the management of hazardous IDW are as follows:

- Spent solvents must be left on-site with the permission of site operator and proper disposal arranged.
- All hazardous IDW must be containerized. Proper handling and disposal should be arranged prior to commencement of field activities.

Table 1: Disposal of IDW

TYPE	HAZARDOUS	NON - HAZARDOUS
PPE-Disposable	Containerize in plastic 5-gallon bucket with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise return to FEC for proper disposal.	Place waste in trash bag. Place in dumpster with permission of site operator, otherwise return to FEC for disposal in dumpster.
PPE-Reusable	Decontaminate as per SESD Operating Procedure for Field Equipment Cleaning and Decontamination, SESDPROC-205, if possible. If the equipment cannot be decontaminated, containerize in plastic 5-gallon bucket with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise return to FEC for proper disposal.	Decontaminate as per SESDPROC-205, and return to FEC.
Spent Solvents	Containerize in original containers. Clearly identify contents. Leave on-site with permission of site operator and arrange for proper disposal.	N/A
Soil Cuttings	Containerize in DOT-approved container with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with program site manager for testing and disposal.	Containerize in a 55-gallon steel drum with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with program site manager for testing and disposal. **
Groundwater	Containerize in DOT-approved container with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with program site manager for testing and disposal.	Containerize in an appropriate container with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with program site manager for testing and disposal. **
Decontamination Water	Containerize in DOT-approved container with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with program site manager for testing and disposal.	Containerize in an appropriate container with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with program site manager for testing and disposal. Decontamination water may also be disposed in a sanitary sewer system, with permission from the wastewater treatment plant representative, and if doing so does not endanger human health or the environment, or violate federal or state regulations.
Disposable Equipment	Containerize in DOT-approved container or 5-gallon plastic bucket with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with program site manager for testing and disposal.	Containerize in an appropriate container with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with program site manager for testing and disposal. If unfeasible, return to FEC for disposal in dumpster.
Trash	N/A	Place waste in trash bag. Place in dumpster with permission of site operator, otherwise return to FEC for disposal in dumpster.

**** These materials may be placed on the ground if doing so does not endanger human health or the environment or violate federal or state regulations.**

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

OPERATING PROCEDURE

Title: **Packing, Marking, Labeling and Shipping of Environmental and Waste Samples**

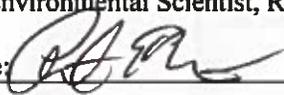
Effective Date: February 4, 2015

Number: SESDPROC-209-R3

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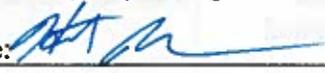
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Revision History

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SESDPROC-209-R3, <i>Packing, Marking, Labeling and Shipping of Environmental and Waste Samples</i> , replaces SESDPROC-209-R2. Cover Page: Changes made to reflect reorganization of SESD from two field branches to one: John Deatrick listed as the Chief, Field Services Branch. The FQM was changed from Liza Montalvo to Hunter Johnson. Revision History: Changes were made to reflect the current practice of only including the most recent changes in the revision history.	February 4, 2015
SESDPROC-209-R2, <i>Packing, Marking, Labeling and Shipping of Environmental and Waste Samples</i> , replaces SESDPROC-209-R1.	April 20, 2011
SESDPROC-209-R1, <i>Packing, Marking, Labeling and Shipping of Environmental and Waste Samples</i> , replaces SESDPROC-209-R0.	November 1, 2007
SESDPROC-209-R0, <i>Packing, Marking, Labeling and Shipping of Environmental and Waste Samples</i> , Original Issue	February 05, 2007

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1 General Information

1.1 Purpose

Regulations for packing, marking, labeling, and shipping of dangerous goods by air transport are promulgated by Department of Transportation under 49 CFR, Subchapter C, Hazardous Materials Regulations, and the International Air Transport Authority (IATA), which is equivalent to United Nations International Civil Aviation Organization (UN/ICAO). Transportation of hazardous materials (dangerous goods) by EPA personnel is covered by EPA Order 1000. This document describes general and specific procedures, methods and considerations to be used and observed by SESD field investigators when packing, marking, labeling and shipping environmental and waste samples to ensure that all shipments are in compliance with the above regulations and guidance.

1.2 Scope/Application

The procedures contained in this document are to be used by field personnel when packing, marking, labeling, and shipping environmental samples and dangerous goods by air transport. Samples collected during field investigations or in response to a hazardous materials incident must be classified prior to shipment, as either environmental or hazardous materials (dangerous goods) samples.

In general, environmental samples include drinking water, most groundwater and ambient surface water, soil, sediment, treated municipal and industrial wastewater effluent, biological specimens, or any samples not expected to be contaminated with high levels of hazardous materials. Samples collected from process wastewater streams, drums, bulk storage tanks, soil, sediment, or water samples from areas suspected of being highly contaminated may require shipment as dangerous goods.

Government employees transporting samples or hazardous materials (i.e., preservatives or waste samples) in government vehicles are not subject to the requirements of this section in accordance with 49 CFR 171.1(d)(5). EPA contractors, however, are not covered by this exemption and may not transport these materials without full compliance with 49 CFR.

Mention of trade names or commercial products in this operating procedure does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

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

1.4 References

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

Title 40 Code of Federal Regulations (CFR), Pt. 136.3, Identification of Test Procedures, July 1, 2001. See Table II, Footnote 3.

Title 49 CFR, Pt. 171.1(d)(5), Applicability of Hazardous Materials Regulations (HMR) to Persons and Functions.

United States Department of Transportation (US DOT). 2003. Letter from Edward T. Mazzullo, Director, Office of Hazardous Materials Standards, to Henry L. Longest II, Acting Assistant Administrator, USEPA, Ref No. 02-0093, February 13, 2003.

US Environmental Protection Agency (US EPA) Order 1000.18, February 16, 1979.

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

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

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

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

1.5 General Precautions

1.5.1 Safety

Proper safety precautions must be observed when packing, marking, labeling, and shipping environmental or waste samples. Refer to the SESD Safety, Health and Environmental Management Program (SHEMP) Procedures and Policy Manual and any pertinent site-specific Health and Safety Plans (HASPs) for guidelines on safety precautions. These guidelines, however, should only be used to complement the judgment of an experienced professional.

2 Shipment of Dangerous Goods

The project leader is responsible for determining if samples collected during a specific field investigation meet the definitions for dangerous goods. If a sample is collected of a material that is listed in the Dangerous Goods List, Section 4.2, IATA, then that sample must be identified, packaged, marked, labeled, and shipped according to the instructions given for that material. If the composition of the collected sample(s) is unknown, and the project leader knows or suspects that it is a regulated material (dangerous goods), the sample may not be offered for air transport. If the composition and properties of the waste sample or highly contaminated soil, sediment, or water sample are unknown, or only partially known, the sample may not be offered for air transport.

In addition, the shipment of pre-preserved sample containers or bottles of preservatives (e.g., NaOH pellets, HCL, etc.) which are designated as dangerous goods by IATA is regulated. Shipment of nitric acid is strictly regulated. Consult the IATA Dangerous Goods Regulations for guidance. ***Dangerous goods must not be offered for air transport by any personnel except SESD's dangerous goods shipment designee or other personnel trained and certified by IATA in dangerous goods shipment.***

3 Shipment of Environmental Samples

Guidance for the shipment of environmental laboratory samples by personnel is provided in a memorandum dated March 6, 1981, subject "Final National Guidance Package for Compliance with Department of Transportation Regulations in the Shipment of Laboratory Samples". By this memorandum, the shipment of the following unpreserved samples is not regulated:

- Drinking water
- Treated effluent
- Biological specimens
- Sediment
- Water treatment plant sludge
- POTW sludge

In addition, the shipment of the following preserved samples is not regulated, provided the amount of preservative used does not exceed the amounts found in 40 CFR 136.3 or the USEPA Region 4 Analytical Support Branch Laboratory Operations and Quality Assurance Manual (ASBLOQAM), Most Recent Version. This provision is also discussed in correspondence between DOT and EPA (Department of Transportation, Letter from Edward T. Mazzullo, Director, Office of Hazardous Materials Standards, to Henry L. Longest II, Acting Assistant Administrator, USEPA, Ref No.: 02-0093, February 13, 2003). It is the shippers' (individual signing the air waybill) responsibility to ensure that proper amounts of preservative are used:

- Drinking water
- Ambient water
- Treated effluent
- Biological specimens
- Sediment
- Wastewater treatment plant sludge
- Water treatment plant sludge

Samples determined by the project leader to be in these categories are to be shipped using the following protocol, developed jointly between USEPA, OSHA, and DOT. This procedure is documented in the "Final National Guidance Package for Compliance with Department of Transportation Regulations in the Shipment of Environmental Laboratory Samples."

Untreated wastewater and sludge from Publicly Owned Treatment Works (POTWs) are considered to be "diagnostic specimens" (not environmental laboratory samples). However, because they are not considered to be etiologic agents (infectious) they are not restricted and may be shipped using the procedures outlined below.

Environmental samples should be packed prior to shipment by air using the following procedures:

1. Allow sufficient headspace (ullage) in all bottles (except VOA containers with a septum seal) to compensate for any pressure and temperature changes (approximately 10 percent of the volume of the container).
2. Ensure that the lids on all bottles are tight (will not leak).
3. Place bottles in separate and appropriately sized polyethylene bags and seal the bags. If available, the use of Whirl-Pak bags is preferable, if unavailable seal regular bags with tape (plastic electrical tape).
4. Select a sturdy cooler in good repair. Secure and tape the drain plug with fiber or duct tape inside and outside. Line the cooler with a large heavy duty plastic bag.
5. Place cushioning/absorbent material in the bottom of the cooler and then place the containers in the cooler with sufficient space to allow for the addition of cushioning between the containers.
6. Put "blue ice" (or ice that has been "double bagged" in heavy duty polyethylene bags and properly sealed) on top of and/or between the containers. Fill all remaining space between the containers with absorbent material.
7. Securely fasten the top of the large garbage bag with tape (preferably plastic electrical tape).
8. Place the Chain-of-Custody Record or the CLP Traffic Report Form (if applicable) into a plastic bag, and tape the bag to the inner side of the cooler lid.
9. Close the cooler and securely tape (preferably with fiber tape) the top of the cooler shut. Chain-of-custody seals should be affixed to the top and sides of the cooler within the securing tape so that the cooler cannot be opened without breaking the seal.

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

OPERATING PROCEDURE

Title: Global Positioning System

Effective Date: June 23, 2015

Number: SESDPROC-110-R4

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SESDPROC-110-R3, <i>Global Positioning System</i> , replaces SESDPROC-110-R2	April 20, 2011
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1 General Information

1.1 Purpose

This document describes the Global Positioning System (GPS) and procedures, methods and considerations to be used and observed when using GPS to record location data in the field. Guidance is provided on accuracy requirements for various uses of location data and potential means to obtain the requisite accuracy. This document contains direction developed solely to provide internal guidance to SESD employees.

1.2 Scope/Application

The procedures contained in this document are to be used by SESD field investigators when using the Global Positioning System to obtain the geographical coordinates of sampling locations and/or measurements during field investigations. In SESD investigations, GPS is the preferred means of collecting horizontal location information. In most cases the accuracy of GPS is unsuitable for collection of elevation data.

On the occasion that SESD field personnel determine that any of the procedures described in this section cannot be used to obtain the required coordinate information and alternate procedures are employed, the alternate procedure will be documented in the field log book, along with a description of the circumstances requiring its use. GPS users must be currently qualified as proficient in the operation of the specific GPS equipment to be used. The manufacturer's operation manuals should be used for detailed information on the use of specific GPS equipment. Mention of trade names or commercial products in this operating procedure does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

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

1.4 References

Rand Corporation, The Global Positioning System, Assessing National Policies, Appendix B, GPS History, Chronology, and Budgets, 1995.

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

Trimble® Navigation Limited, Mapping Systems General Reference, Revision B, 1996.

USEPA, Global Position Systems – Technical Implementation Guidance, Office of Environmental Information (EPA/250/R-03/001), 2003.

USEPA, GIS Technical Memorandum 3. Global Positioning Systems – Technology and It's Application in Environmental Programs, Research and Development (PM-225). EPA/600/R-92/036, 1992.

USEPA, Locational Data Policy, Office of Information Resources Management, IRM Policy Manual 2100 Chapter 13, 1991.

2 Methodology

2.1 General

2.1.1 GPS Description

The Navigation Satellite Time and Ranging (NAVSTAR) Global Positioning System (GPS) is a worldwide radio-navigation system created by the U. S. Department of Defense (DOD) to provide navigation, location, and timing information for military operations. System testing using a limited number of satellites began in 1978 with the system being declared fully operational in 1995. The system was declared available for civilian uses in the 1980s and has seen burgeoning civilian application for navigation and mapping. GPS is the U.S. implementation of a Global Navigation Satellite System (GNSS). Increasingly, GPS receivers have the capability to utilize signals from other GNSS such as the Russian GLONASS or European Galileo systems. SESD has no limitations on the use of signals from other GNSS.

The GPS system consists of three basic elements: the space segment, control segment, and user segment. The space segment consists of the constellation of up to 24 active NAVSTAR satellites in six orbital tracks. The satellites are not in geo-synchronous orbit and are in constant motion relative to a ground user. The control segment consists of several ground stations that serve as uplinks to the satellites and that make adjustments to satellite orbits and clocks when necessary. The user segment consists of the GPS receiver which will typically consist of an antenna, multi-channel receiver, and processing unit.

For the purposes of this document, the user segment GPS receivers may be loosely grouped into Recreational and Navigational receivers (henceforth referred to as General-Use receivers), Mapping Grade receivers, and Survey Grade receivers.

- Most General-Use grade receivers are available on the retail market to consumers for a variety of applications including boating, hiking, and automotive navigation. They display an instantaneous reading of position and are generally not optimized for data collection. Waypoints containing instantaneous position fixes can often be stored and downloaded. The accuracy of these receivers is adequate for many environmental applications.
- Mapping Grade receivers are used for applications such as resource management and Geographical Information System (GIS) feature collection. The receivers are capable of averaging multiple position fixes for greater accuracy and then data-logging the results with sufficient information to post-correct the positions as described below. The accuracy that can be achieved may be better than one meter.

- Survey Grade receivers can provide accuracy at the centimeter level by using long occupation times and special techniques for receiver use and data processing. Survey Grade receivers are not currently used by SESD in field investigations.

GPS receivers derive positions by simultaneously measuring the distance (range) to several satellites in precisely known orbits, and using trilateration of the ranges to calculate a unique position for the receiver. The range to each satellite is determined by precisely measuring the transit time of radio signals broadcast from the satellites.

2.1.2 GPS Accuracy Factors

The accuracy of the basic GPS system is approximately 15m. GPS accuracy can be affected by a number of factors including the Selective Availability feature, atmospheric delays, satellite clock and orbit errors, multipath signals, signal strength, and satellite geometry relative to the user.

In the early GPS implementation, the DOD used a feature known as Selective Availability (SA) to degrade the quality and subsequent accuracy of the GPS signals to non-DOD users. With Selective Availability enabled, accuracy of position fixes could be as poor as 100m without the use of differential correction techniques described below. Currently there is no SA limitation in accuracy in place with a stated Executive Branch intention to not return to the use of the SA signal degradation.

As satellites move in their orbits and some signals are blocked by obstructions, the geometry of the available satellite signals relative to the user will constantly change. When the satellites with available signals are clustered closely together in the sky, small errors in range will result in large errors in reported position. Conversely, when the satellites are distributed more broadly across the sky, the resultant position errors will be at their minimum. The general measure of this phenomenon is Dilution of Precision (DOP), which may be represented as Position Dilution of Precision (PDOP), or more specifically for geographical coordinate collection, Horizontal Dilution of Precision (HDOP). Mapping and Survey Grade receivers generally can calculate and display DOP and allow the user to limit logging to times when the higher potential accuracy conditions of low DOP prevail. General-Use receivers may display DOP and use DOP with other factors to estimate a general accuracy figure. DOP may range from approximately 2 to 50, with high quality work usually requiring a HDOP of less than 4-6.

Signal strength and multipath signals relate to the strength and quality of the signal reaching the receiver antenna. Signal attenuation by the atmosphere, buildings, and tree cover limit the accuracy of the ranges obtained. The measure of signal strength is Signal to Noise Ratio (SNR), generally measured in decibels (db). Most receivers of any grade will display the SNR of the satellite signals in a bar graph or table. Mapping Grade

Receivers generally allow the user to specify a minimum signal strength for the use of a satellite signal (commonly 2-15db). Poor signal strength can be resolved by waiting for satellite locations to change or moving the receiver location. Multipath signals result from portions of the satellite signal bouncing off terrain, structures, or atmospheric disturbances, resulting in a degraded total signal. Higher quality Mapping Grade receivers may be capable of rejecting the stray multipath signals, such as Trimble® receivers using Everest™ technology.

2.1.3 Differential GPS

Selective Availability, clock errors, and orbital errors affect all GPS users, and atmospheric delays affect all users over a relatively wide region. A second GPS receiver in the same general area as the user will experience the same errors from these sources as the user's receiver. Consequently, correction factors from a remote station at a known location can be applied to the user's receiver in a process known as Differential GPS (DGPS). DGPS can be applied in real-time using additional radio signals, or after the collection event by a method called post-correction.

Real-time DGPS uses established networks of base stations at precisely surveyed locations. The US Coast Guard operates a system of 80 base stations which became fully operational in 1999. The range corrections are broadcast on marine radiobeacon frequencies, with redundant coverage of most of the US coastline and the Mississippi River. There is near complete single beacon coverage of most of the internal US, but there are known gaps in coverage in both EPA Region 4 and the US as a whole. The system is sometimes referred to using the more general term DGPS or in nomenclature referring to the beacon-based nature of the system. Beacon-based DGPS is implemented primarily in Navigational and Mapping Grade receivers. Use of beacon based DGPS at SESD has become increasingly rare in favor of use of the Wide Area Augmentation System

Real-time DGPS can also be implemented with a Space Based Augmentation System (SBAS). The most common SBAS used in the United States is the Wide Area Augmentation System (WAAS), developed by the Federal Aviation Administration to meet the additional demands on GPS for aircraft navigation. The WAAS network of base stations collects information on satellite clock errors, orbital errors, and atmospheric conditions. The error information is transferred to satellites in geo-synchronous orbits and subsequently broadcast to suitably equipped GPS receivers on frequencies compatible with the GPS range signals. While the beacon-based DGPS passes specific satellite range corrections to the receivers, WAAS communicates a model for the errors which is usable over large areas. Current Mapping Grade receivers will likely use WAAS with or without the option of beacon-based DGPS. Modern General-Use receivers are generally equipped with WAAS differential correction capability.

Post-Corrected DGPS is accomplished by downloading the receiver survey files to a desktop or laptop computer and then retrieving correction files for the same time period

(generally via the internet) from an established base station in the area of the survey. Post-processed accuracy improves with proximity of the base station to the surveyed locations and base station data should be used from a station within 300km of the site surveyed. The survey positions are processed by application software and a new set of positions is generated using the correction data. The capability for post-processed differential correction is limited to Mapping Grade and Survey Grade receivers.

Various factors limit GPS accuracy in the vertical plane to approximately half of that obtainable in the horizontal plane, i.e., if a location fix is accurate to 3 m in the horizontal plane, it may only be accurate to 6 m in the vertical plane. Since relatively high accuracy is usually required for the uses of elevation data, GPS is rarely used to obtain and report elevations.

2.2 Requirements for Locational Information

2.2.1 Data Uses

Locational information can serve many purposes in an environmental investigation, a few of which are listed below:

1. Providing an unambiguous means to identify facilities or sampling plats.
2. Providing locational information to key analytical data in a GIS based data archiving system to the original sampling locations.
3. Differentiating watersheds.
4. Providing information to calculate extents and volumes of contamination.
5. Providing a means to relocate the media represented by samples for removal or treatment.
6. Providing information to prepare presentation graphics of sampling locations.

Depending on the specific uses for the data and the type of work being performed, there will be different needs for the accuracy of the locational data. Studies where a sample represents a large area of relatively homogeneous material would not require the same accuracy as the location of a permanent monitoring well. Below are broad guidelines for the accuracy that might be required for different applications.

Desired Accuracy	Application
100 m	Open ocean work where sample is presumed to be representative of a large area
20 m	Open water work (lakes or estuaries) where sample is presumed to be representative of a large area
10 m	Stream and river work where samples are presumed to be broadly representative of a reach
5-3 m	Stream work where samples are representative of a specific narrowly defined section
10 m	Air Monitoring Stations
10 - 3 m	Microscale air monitoring
3 - 1 m	Permanent monitoring wells
1 m	Locations of 'Hot Spots' destined for removal of limited areal extent
3 - 1 m	Locations of Temporary groundwater wells in plumes requiring narrow delineation
3 m	Locations of Temporary groundwater wells in broad plumes
3 m	Locations of environmental samples with sample spacing >20 m
5 m	Locations of environmental samples with sample spacing >60 m
200 - 20 m	Coordinates describing a facility where mobile waste units are sampled
30 - 3 m	Locations of industrial process areas or NPDES permitted facilities where the sampling locations are described in field notes relative to the process or site features

Specific demands of a study may drive increased or decreased requirements for accuracy. The preferred means of locational data collection for most studies will be GPS, although alternate means are permissible if they meet accuracy requirements. The following table indicates the accuracy that may be expected from various means of establishing coordinates.

Accuracy	Description
200 - 50 m	Map Derived, coarse work
40 - 20 m	Map Derived, fine work or using GIS with digital imagery
15 m	General-Use General-Use Grade GPS, w/o WAAS
5 m	General-Use Grade GPS, w/ WAAS or beacon corrections
10 m	Mapping Grade GPS, no corrections, averaged readings,
3 m	Mapping Grade GPS w/ differential correction, averaged readings
1 m	Mapping Grade GPS w/ differential correction, controlled DOP and SNR, averaged readings
<10 cm	Surveying Grade GPS or optical surveying (dependent on baseline length)

Accuracy is a term used to describe the degree of conformity of a measurement. In GPS, accuracy is usually specified as an estimate of the radius from the measured coordinates that is likely to include the actual coordinates. The estimate will be based on a percentage likelihood or a certain number of standard deviations that the accuracy estimate is met. As such, it is recognized that some measurements will fall outside of the specified accuracy. For the purposes of SESD GPS work, the nominal accuracy figures derived from manufacturer's literature for specific operating conditions, displayed by the receiver at the time of feature collection, or output from processing software will be taken at face value.

2.2.2 *Datums and Data formats*

In general, a datum is a reference from which other measurements are taken. In the development of surveying systems by civil entities, different datums were used as base references that will result in differing coordinates for the same location. A GPS receiver will generally display coordinates in a number of different user-selected datums. **Unless there are specific requirements on a project, all SESD work should be conducted using the WGS84 datum.** Alternatively, the nearly equivalent NAD83 datum may be used if WGS84 is unavailable as a receiver option. If an alternate coordinate system is used where coordinates are obtained and recorded in field logbooks, the use of the alternate coordinate system should also be noted in the logbook.

The Region 4 Equis database requires that coordinates for sample locations be entered in the WGS84 datum and dd.ddddd format. Unless specific project requirements dictate otherwise, all coordinates explicitly stated in reports will be in WGS84 format and in all cases the datum used will be specified.

There is no SESD policy on significant digits for GPS information, and accuracy should not be implied from the presence of significant digits in reported coordinates. However, good scientific practice should be followed in the presentation of locational information in order that useful information not be truncated or a higher degree of accuracy implied. The following table shows the incremental distance in latitude represented by the least significant digit for various coordinate formats:

dd.ddddd°	Approximately 4" or 10 cm
dd.ddddd°	Approximately 44" or 1.1 m
dd.dddd°	Approximately 36' or 11 m
dd°mm'ss"	Approximately 100' or 30 m
dd°mm'ss.x"	Approximately 10' or 3 m
dd°mm'ss.xx"	Approximately 1' or 30 cm
dd°mm.xxxx'	Approximately 7" or 18 cm
dd°mm.xxx'	Approximately 6' or 1.8 m
dd°mm.xx'	Approximately 60' or 18 m

2.3 Quality Control Procedures

By nature of its origin in the DOD and recent application to aircraft navigation, the GPS is designed for high reliability. GPS failures resulting in an incorrect reading beyond the bounds of known errors are so rare that the possibility can be ignored for most SESD studies. If a study requires the verification of receiver function, this can be accomplished by verifying that a receiver displays the correct position while occupying a known benchmark.

2.4 Special Considerations

The data quality objectives for the application, availability of receivers, and other factors will dictate the type of receiver used. There are several specific considerations for the use of the various GPS receivers available at SESD.

2.4.1 Special considerations for the use of Trimble® Geo7X Mapping Grade Receivers

Several important settings can be adjusted or checked under the 'Setup' toolbar.

Suggested settings for Trimble® Geo7X receivers are:

1. Settings>Coordinate System:
 - System = Latitude/Longitude
 - Datum = WGS 1984
 - Altitude Reference = MSL
 - Altitude Units – Feet

These settings would rarely need to be changed, but should be checked prior to collecting data.

2. Settings>Real-time Settings
 - Set to:
 - Choice 1 = Integrated SBAS
 - Choice 2 = Wait for Real-time

When ‘Choice 2’ is set to ‘Wait for Real-time’, the receiver will not log positions if a WAAS signal cannot be received. When this occurs, ‘Choice 2’ may need to be changed temporarily to ‘Use uncorrected GNSS’. The location would then be logged with the reduced accuracy of uncorrected GPS, which should be noted in field logbooks. The accuracy of the position can be improved later by post-processing.

3. Settings>Logging Settings

At the top of the logging settings dialog is the ‘Accuracy Settings’ label. Tap the ‘wrench’ box to the right of the first field to open the Accuracy Settings dialog box.

Set the first box under ‘Accuracy Value for Display/Logging’ to ‘Horizontal’

The box below the Horizontal/Vertical selection chooses whether positions will be corrected in real time or by post-processing. Choose ‘In the field’ if Real-time WAAS corrections will be used, or ‘Postprocessed’ if positions will be post-corrected. This selection will affect the accuracy estimates displayed. If Real-time correction is used when this setting is set to ‘Postprocessed’, the estimated error reported will be erroneously low.

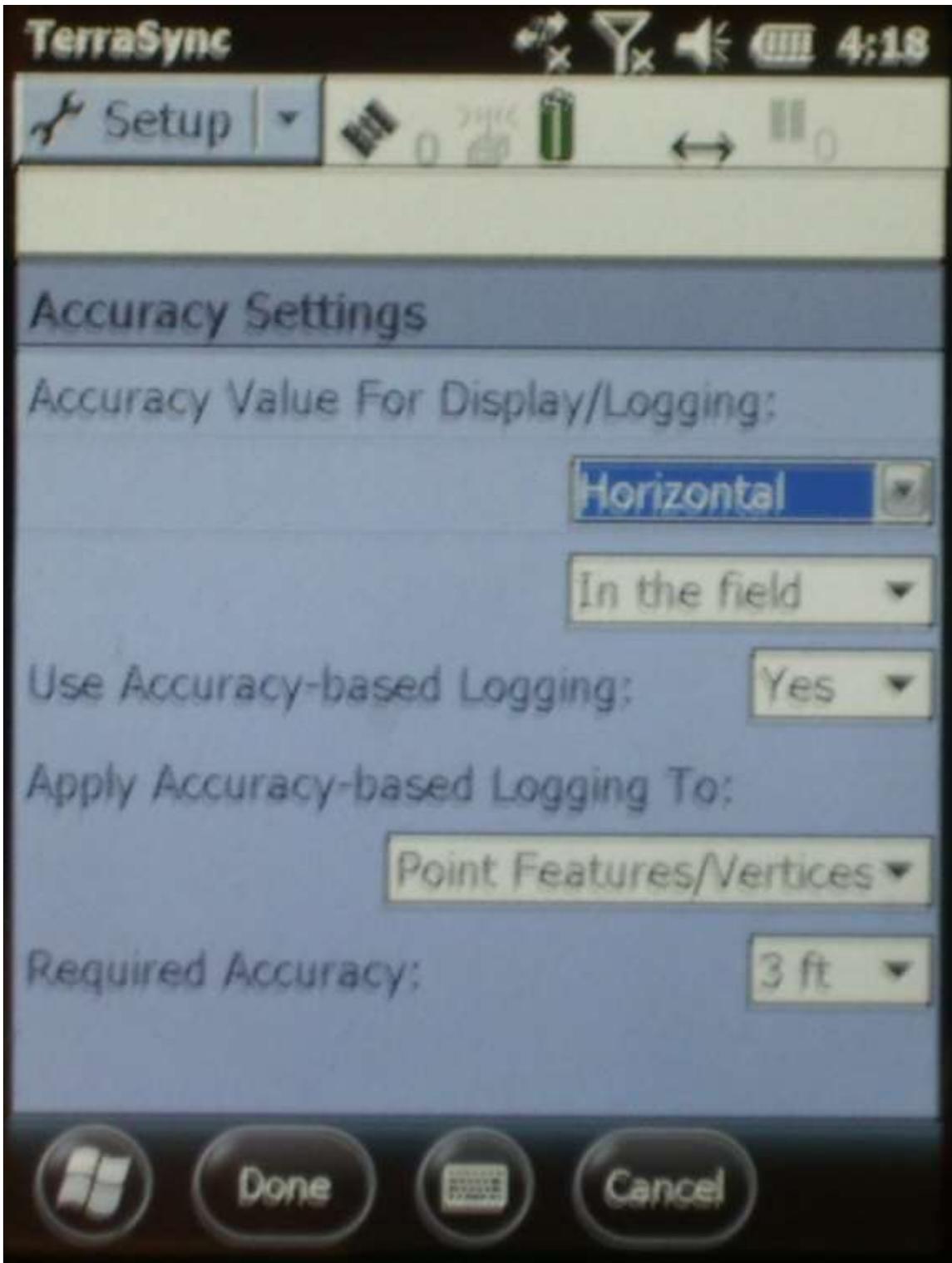
Select 'Yes' or 'No' for accuracy based logging. Selecting 'Yes' will prevent the receiver from logging until the desired accuracy can be achieved. This setting is recommended when a specific accuracy for locational data is required. Selecting 'Yes' enables the following choices:

The next box, 'Apply Accuracy-based Logging to:' can be set to point features or 'All Features'. Set appropriately.

The 'Required Accuracy' field selects the accuracy threshold that will allow logging. If a position cannot be logged because the threshold cannot be met, several options are available:

1. Set the accuracy threshold to a higher but still acceptable value.
2. Plan to post-correct the coordinates and change the settings in this dialogs accordingly. Post-correction will generally allow more accurate correction than WAAS.
3. Return to the point at a later time when propagation or satellite geometry is more suitable.
4. Use the 'Offset' feature (see below) to log the positions from a more suitable location (e.g. less tree cover).

The screen shot below shows the Accuracy Settings Dialog Box:



If the point to be logged cannot be occupied, or signals cannot be received at the location, the 'Offset' feature of the receiver can be used. The SESD Geo7X receivers can employ a laser rangefinder and internal compass to calculate the offsets. To use the 'Offset' feature:

1. Begin logging from the offset location.
2. Pull down the 'Options' menu and select 'Offset', then 'Distance – Bearing'
3. The Offset dialog will open where distances and bearings could be manually entered.
4. To use the laser rangefinder and compass to populate the dialog fields, press the physical \oplus button located on the receiver below the screen.
5. The laser rangefinder application will start and a red sighting laser will turn on. Point the laser at the desired point to survey and sight the object in the crosshairs on the screen. When sighted on the survey object, tap on the \oplus icon on the screen to lock in the distance and bearing at the bottom of the screen. Press the \oplus icon again to update the readings, or press the \checkmark icon to transfer the bearing and distance to the Offset dialog box.
6. If the numbers transferred to the Offset dialog box are appropriate, tap 'Done' to return to the feature logging screen.

There is no quality system calibration performed on the electronic compass and rangefinder. It is the responsibility of the user to assure that the bearings and ranges returned by the laser rangefinder system will result in accuracy consistent with the overall GPS work. A quick check for reasonableness can be performed by comparing the logged position on the Map screen with the current position shown.

Photos can also be taken with the unit and associated with the logged features. The user is referred to vendor documentation for instruction in the use of this feature.

Trimble® receivers at SESD contain a data dictionary that can facilitate the management of GIS data. If the COC_GIS dictionary is selected at the time of file creation, SESD standard media codes can be assigned to features at the time of logging that will accompany the data through the download process. The use of the COC_GIS data dictionary can simplify the management of the data when processed in a GIS system or when submitted to the Equis data archiving system.

The logging interval of the Trimble® Geo 7X receivers can be set to a 1 or 5 second interval as an option during feature collection. The setting may be set to 1 second to expedite feature collection. A point feature should have a minimum of 36 positions logged to obtain the additional accuracy afforded by the averaging of

positions. After a minimum of 36 positions are logged and the feature is closed, the averaged coordinates for the location can be obtained by selecting the feature on the 'Map' screen. The averaged position should always be the one entered into field notebooks.

2.4.2 Special considerations for the use of Garmin® and other General-Use Grade Receivers

Several types of General-Use grade of receivers are in use at SESD, most from the Garmin® product line. Most of the Garmin® receivers operate with a similar interface to facilitate use of the various devices. The nautical receivers/depth sounders are suitable for recording location data within the limitations described for the General-Use grade receivers.

Some receivers will allow averaging of positions to improve accuracy. Use of this feature is recommended when possible.

Anecdotal experience at SESD suggests that GPS designed primarily for automobile navigation is unsuitable for obtaining locational data.

The older Garmin receivers would display on the status screen whether differential correction was in use by displaying small 'D' characters at the base of the signal strength bars. Newer receivers do not display this information directly and correction status can only be ascertained by the accuracy estimates or monitoring the status screen for acquisition of signals from the WAAS satellites.

2.4.3 Coordinate Conversion

Coordinates may be displayed in different formats on the various receivers, or coordinates obtained from outside SESD may be presented in a format other than that required. If the coordinates are in the correct datum, but recorded in the dd°mm'ss.sss" format they can be arithmetically converted to dd.dddddd format. Convert to decimal degrees as follows:

Converting to decimal degrees (dd.dddddd) from degrees°minutes'seconds" (dd°mm'ss.sss"):

$$dd.dddddd = dd + (mm/60) + (ss.sss/3600)$$

Example: Convert 33°28'45.241" to decimal degrees

$$33 + (28/60) + (45.241/3600) = 33.479236$$

The reverse conversion is accomplished as follows:

Converting to degrees°minutes'seconds'' from decimal degrees

Starting with dd.dddddd

Multiply .dddddd by 60 to obtain mm.mmmm

Multiply .mmmm by 60 to obtain ss.sss

Then dd°mm'ss.sss'' = dd & mm & ss.sss

Example: Convert 33.479236 to dd°mm'ss.sss'' format

Multiply .479236 by 60 to obtain 28.7540 (mm.mmmm)

Multiply .7540 by 60 to obtain 45.241 (ss.sss)

Dd°mm'ss.sss'' = 33° & 28' & 45.241'' = 33°28'45.241''

The standard format for navigational purposes is decimal minutes (dd°mm.mmm'). This format is utilized due to the fact that nautical navigation charts are set up in this format. However, location information must be converted to a decimal degree (dd.ddddd°) format in order for GIS software to properly interpret the information and for submission to the Region 4 Equis database. Assuming the coordinates have been recorded in the proper datum, the conversion can be accomplished by dividing the minutes portion of the coordinates by 60.

Converting to decimal degrees from decimal minutes:

$$dd.ddddd^{\circ} = dd + (mm.mmm/60)$$

Example: Convert 81°49.386' to decimal degrees

$$81 + (49.386/60) = 81.8231 \text{ degrees}$$

The reverse conversion is accomplished as follows:

$$dd^{\circ}mm.mmm' = dd \& (.dddd*60)$$

Example: Convert 81.8231 degrees to decimal minutes (dd°mm.mmm')

Multiply .8231 by 60 to obtain 49.386 (mm.mmm)

$81^\circ \& 49.386' = 81^\circ 49.386'$

GPS users need to familiarize themselves with the differences between the formats, as they can appear similar. Spreadsheets can automate the conversion process.

2.5 Records

The GPS coordinates and the SESD equipment identification number of the GPS receiver should be recorded in field logbooks at the time of GPS coordinate collection. The data logging capability of receivers may be used in lieu of the requirement to record the coordinates in logbooks when the following conditions can be met:

1. The location can easily be found later if it needs to be resurveyed prior to demobilization. A permanent monitoring well can easily be resurveyed, while most open-water work would not afford this opportunity.
2. The data is downloaded and ascertained to meet the accuracy requirements for the project prior to demobilization from the site.
3. The data is stored in at least two separate locations for transport, such as a laptop hard drive and a flash drive or compact disc.

In all cases where positions are electronically recorded, the provisions of the Electronic Records section of the SESD Operating Procedure for Control of Records (SESDPROC-002) should be followed.

Where locational data is collected and processed electronically, but not reported explicitly in the final report, a copy of the coordinates in text format should be output and entered into the project file in paper or electronic form. The output should include:

1. Latitude, generally in dd.dddddd format.
2. Longitude, generally in dd.dddddd format.
3. Date of collection.

4. A note on the differential correction process used where it supports the accuracy requirements.
5. The datum used for the export.

Trimble® Pathfinder Office can create files with this information when exporting coordinates to a text file. The information will be contained in the .pos and .inf files.