Illinois Environmental Protection Agency

Bureau of Land • 1021 North Grand Avenue East • P.O. Box 19276 • Springfield • Illinois • 62794-9276

ILLINOIS EPA RCRA CORRECTIVE ACTION CERTIFICATION

This certification must accompany any document submitted to Illinois EPA in accordance with the corrective action requirements set forth in a facility's RCRA permit. The original and two copies of all documents submitted must be provided.

1.0 Facility Identification

Name: Equilon Enterprises LLC d/b/a/ Shell
County: Madison
Street Address: 900 South Central Ave
Site No. (IEPA): 1191150002
City: Roxana
Site No. (USEPA): ILD080 012 305

2.0 Owner Information

Name: Not Applicable
Mail Address:
City:
State: Zip Code:
Contact Name:
Contact Title:
Phone:

3.0 Operator Information

Name: Equilon Enterprises LLC d/b/a/ Shell
Mail Address: 128 East Center Street
City: Nazareth
State: PA Zip Code: 18064
Contact Name: Leroy Bealer
Contact Title: Senior Program Manager
Phone: 484-632-7955

4.0 Type of Submission (check applicable item and provide requested information, as applicable)

- ☐ RFI Phase I Workplan/Report
- ☐ RFI Phase II Workplan/Report
- ☐ CMP Report;
- ☒ Other (describe): Standard Operating Procedure Update

IEPA Permit Log No. B-43R
Date of Last IEPA Letter on Project: October 31, 2022
Log No. of Last IEPA Letter on Project: see section 6.0 below
Does this submittal include groundwater information: ☒ Yes ☐ No

Date of Submittal: 11/30/2022

5.0 Description of Submittal: (briefly describe what is being submitted and its purpose)

Routine Updates to Drilling-Related Standard Operating Procedures - 2022

6.0 Documents Submitted (identify all documents in submittal, including cover letter; give dates of all documents)

RCRA Corrective Action Form, Cover Letter, Revised SOPs

Log No. of Last IEPA Letter on Project: B-43R-M-2, B-43R-M-3, B-43R-M-5, B-43R-CA-49, B-43R-M-16 B-43R-M-31, B-43R-M-31, B-43R-M-33, B-43R-M-37, B-43R-M-40, B-43R-M-43, B-43R-M-45, and B-43R-M-49

7.0 Certification Statement

(This statement is part of the overall certification being provided by the owner/operator, professional and laboratory in Items 7.1, 7.2 and 7.3 below). The activities described in the subject submittals have been carried out in accordance with procedures approved by Illinois EPA. I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

For: Routine Updates to SOPs

Date of Submission: 11/30/2022

7.1 Owner/Operator Certification

(Must be completed for all submittals. Certification and signature requirements are set forth in 35 IAC 702.126.) All submittals pertaining to the corrective action requirements set forth in a RCRA Permit must be signed by the person designated below (or by a duly authorized representative of that person):

1. For a Corporation, by a principal executive officer of at least the level of vice president.
2. For a Partnership or Sole Proprietorship, by a general partner or the proprietor, respectively.
3. For a Governmental Entity, by either a principal executive officer or a ranking elected official.

A person is a duly authorized representative only if:

1. the authorization is made in writing by a person described above; and
2. the written authorization is provided with this submittal (a copy of a previously submitted authorization can be used).

Owner Signature: Not Applicable Date: ____________

Title: ____________

Operator Signature: [signature] Date: 11/18/2022

Title: **Senior Program Manager**

For: Routine Updates to SOPs

Date of Submission: 11/30/2022

7.2 Professional Certification (if necessary)

Work carried out in this submittal or the regulations may also be subject to other laws governing professional services, such as the Illinois Professional Land Surveyor Act of 1989, the Professional Engineering Practice Act of 1989, the Professional Geologist Licensing Act, and the Structural Engineering Licensing Act of 1989. No one is relieved from compliance with these laws and the regulations adopted pursuant to these laws. All work that falls within the scope and definitions of these laws must be performed in compliance with them. The Illinois EPA may refer any discovered violation of these laws to the appropriate regulating authority.

Any person who knowingly makes a false, fictitious, or fraudulent material statement, orally or in writing, to the Illinois EPA commits a Class 4 felony. A second or subsequent offense after conviction is a Class 3 felony. (415 ILCS 5/44 (h))

Professional's Signature: Wendy M Pennington

Date: 11/18/22

Professional's Name: Wendy M. Pennington

Address: 100 N. Broadway, 20th Floor

City: St. Louis

State: MO

Zip Code: 63102

Phone: 314-429-0100

Professional's Seal:

LICENSED PROFESSIONAL ENGINEER
WENDY M. PENNINGTON
062.064098
expires 11/2023
STATE OF ILLINOIS

7.3 Laboratory Certification (if necessary)

The sample collection, handling, preservation, preparation and analysis efforts for which this laboratory was responsible were carried out in accordance with procedures approved by Illinois EPA.

Name of Laboratory Not Applicable

_______________________ Date: ____________

Signature of Laboratory Responsible Officer

Mailing Address of Laboratory

Address ____________________

City ____________________

State ______ Zip Code ____________

____

Name and Title of Laboratory Responsible Officer

AECOM

AECOM
100 North Broadway
20th Floor
St. Louis, MO 63110
USA
aecom.com

November 30, 2022

Mr. Kenneth E. Smith, PE
Manager, Permit Section
Illinois Environmental Protection Agency
Division of Land Pollution Control
Bureau of Land
1021 North Grand Avenue East
Springfield, Illinois 62794

Routine Updates to Drilling-Related Standard Operating Procedures - 2022
Equilon Enterprises LLC dba Shell Oil Products US
Roxana, Illinois
1191150002 - Madison County
ILD080012305
Log B-43R

Dear Mr. Smith:

As part of AECOM Technical Services, Inc.'s (AECOM's) quality improvement process, we recently performed a review of Standard Operating Procedures (SOPs) used by field staff performing activities at the Investigation Site in Roxana, Illinois. Previously revised SOPs have been submitted to the Illinois Environmental Protection Agency (IEPA), most recently on March 22, 2021. These SOPs were originally submitted, as requested by IEPA, within various reports and work plans related to the Investigation Site in Roxana, Illinois. We are submitting the enclosed updated SOPs for your reference and in accordance with revisions to Sections C.7.5 and C.8.4 of the RCRA Post-Closure Permit Application[1] for the Equilon Enterprises LLC d/b/a Shell Oil Products US (Shell) facility at the WRB Refining LP Wood River Refinery.

The SOPs included with this submittal and corresponding revisions are listed below.

SOP No	SOP Title	Purpose of Revision
4	Decontamination	Editorial and formatting related to decontamination equipment used.
5	Utility Clearance Procedures	Editorial and formatting; update equipment used.
12	Grouting Procedures	Editorial and formatting.
14	Headspace Soil Screening	Editorial and formatting.
17	Logging	Editorial and formatting; update equipment used.
21	Monitoring Well Installation	Editorial and formatting; update equipment used.

[1] Class 1* Permit Modification – Section C Revision for SOP Reference (Log No. B-43R-CA-82, CA-88, CA-94 and CA-97) was submitted to IEPA on January 29, 2018. This modification was approved by an IEPA letter with modified Permit dated December 20, 2019.

SOP No	SOP Title	Purpose of Revision
29	Soil Probe Operation	Editorial and formatting; update equipment used.
42	Groundwater Profiling	Editorial and formatting; update equipment used.

As previously requested by IEPA, below is an SOP summary table, which indicates the most recent revision date for each SOP for your reference.

SOP No.	SOP Title	Last Updated
3	Calibration & Maintenance of Field Instruments	3/12/2021
4	Decontamination	11/3/2022
5	Utility Clearance Procedures	11/3/2022
8	Field Reporting and Documentation	3/12/2021
10	Well Gauging Measurements	3/12/2021
11	Groundwater Sampling & Well Wizard Operation	3/12/2021
12	Grouting Procedures	11/3/2022
14	Headspace Soil Screening	11/3/2022
17	Logging	11/3/2022
18	Low Flow Groundwater Purging & Sampling	3/12/2021
20	Well Development	3/12/2021
21	Monitoring Well Installation	11/3/2022
23	Quality Assurance Samples	3/12/2021
24	Soil and Groundwater Sample Identification, Packaging & Shipping	3/12/2021
25	Sample Containers, Preservation & Holding Times	3/12/2021
26	Sample Control & Custody Procedures	3/12/2021
28	Soil Sampling	12/9/2019
29	Soil Probe Operation	11/3/2022
42	Groundwater Profiling	11/3/2022
44R	Soil Vapor Purging & Sampling	3/12/2021
46	Indoor Air Sampling with Canisters	7/23/2015
47	Sub-slab Soil Gas Installation & Sampling with Canisters	4/4/2017
48	SVE Well Data Collection and Sampling	3/12/2021
49	SVE Effectiveness Monitoring at VMPs	3/12/2021
51	Vapor Sample Classification, Packaging & Shipping	3/12/2021
52	Soil Vapor Field Laboratory Screening	3/12/2021
53	Dwyer Digital Manometer	3/12/2021
56	LNAPL Recovery	3/12/2021

AECOM

Copies of this submittal are being electronically sent separately directly to Amy Butler (IEPA, Springfield) and Ali Al-Janabi (IEPA, Collinsville).

If you have any questions, please contact Wendy Pennington at wendy.pennington@aecom.com (314-452-8929).

Sincerely,

Wendy Pennington, PE
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encl: Revised SOPs 4, 5, 12, 14, 17, 21, 29, 42
RCRA Corrective Action Certification Form

cc: Amy Butler (IEPA - Springfield, IL)
Ali Al-Janabi (IEPA - Collinsville, IL)
Leroy Bealer (Shell)
Greg Mollett (Greensfelder)
Project File
Repositories (Roxana Public L brary, website)

1. Objective

The purpose of this Standard Operating Procedure (SOP) is to define the standard procedures for decontamination of field equipment and personnel for Shell projects in Hartford and Roxana, Illinois. This SOP serves as a supplement to information which might be in a project Work Plan or scope of work and is intended to be used together with other SOPs.

The overall objective of multimedia sampling programs is to obtain samples that accurately depict the chemical, physical, and/or biological conditions at the sampling site. Extraneous contaminants can be brought onto the sampling location and/or introduced into the medium of interest during the sampling program (e.g. using sampling equipment that is not properly or fully decontaminated). Trace quantities of contaminants can consequently be captured in a sample and lead to a false positive analytical result and an incorrect assessment of the contaminant conditions associated with the site. Decontamination of drilling, sampling, and other equipment (e.g., all non-disposable equipment that will come in direct contact with samples) is required prior to, between, and after uses to ensure that sampling cross-contamination is prevented, and that on-site contaminants are not carried off-site.

2. Other SOPs referenced in this SOP:

- SOP No. 8 - Field Reporting and Documentation

3. Equipment

The following is a list of equipment that may be needed to perform decontamination:

- Brushes
- Wash tubs
- Buckets
- Scrapers, flat bladed
- Hot or cold water - high-pressure sprayer
- Sponges or paper towels
- Liquinox detergent (or equivalent)
- Isopropyl alcohol
- Potable water
- Deionized or distilled water

- Garden-type water sprayers
- Plastic sheeting or trash bags
- GAST® high-flow pump (or equivalent)
- Appropriate PPE (i.e., Tyvek, face shield, goggles, safety glasses, nitrile gloves, etc.)
- Landtec GEM-2000 landfill gas analyzer (or similar)
- TVA-2020 FID (flame ionization detector)

4. Groundwater Equipment Decontamination Procedures

Proper mixing instructions for Liquinox detergent: use 2.5 tablespoons Liquinox detergent per gallon of water. If another detergent is being used, verify the proper mixing instructions prior to use.

New 5-gallon buckets will be used for detergent and rinse water at the start of each quarterly groundwater task. Detergent water and rinse water shall be mixed fresh each morning and shall be replaced with new solutions at least at mid-day. More frequent replacement of solutions may be necessary if gross contamination (i.e., light non-aqueous phase liquid [LNAPL], sheen, or suspended particles) is observed.

4.1 Personnel

Personnel shall be provided space to wash and rinse gloves, and any other non-disposable personal protective equipment (PPE). A container shall be available to dispose of used disposable items such as gloves, or Tyvek (if used).

The decontamination procedure for field personnel shall include:

1. Glove wash in a Liquinox (or similar) solution
2. Glove rinse in distilled water
3. Outer glove removal, if present
4. Coverall removal, if present
5. Inner glove removal

Refer to the project Health and Safety Plan (HASP) for additional information. If conditions change and/or upgrade of PPE is required, refer to the task or project specific HASP for more specific information.

4.2 Groundwater Parameter Equipment (e.g., YSI ProDSS or similar)

Equipment used to measure groundwater parameters, which does not come into contact with the analytical sample, may be decontaminated between wells if necessary (i.e., gross contamination observed on the sonde probes, history of elevated benzene results at a particular well[1], etc.) (Steps 1 through 6 below). This equipment will, at a minimum, be decontaminated at the end of each sampling day (Step 7 below). The following steps shall be used when decontaminating groundwater parameter measuring equipment at the end of each sampling day:

1. Personnel shall dress in appropriate PPE to reduce the potential of personal exposure as required by the HASP and THA.
2. Spray or wash sensors with a soap and water solution (Liquinox or similar and potable or distilled water).
3. Spray or rinse sensors with distilled water.
4. Spray or wash sensors with a distilled vinegar (or similar).
   a. Soak the optical dissolved oxygen (DO) cap in distilled white vinegar for 10 to 15 minutes.
5. Spray or rinse sensors with distilled water.
   a. Rinse the optical DO cap in distilled water.
6. Wash flow cell in a wash tub or bucket containing soap and water solution (Liquinox or similar along with potable or distilled water) and scrubbed with a bristle brush or similar utensil.
7. Rinse flow cell with distilled water in a second tub or bucket.

If flow cell is still odorous, soak in a wash tub or bucket containing soap and water solution (Liquinox or similar along with potable or distilled water) for 10 to 15 minutes. Also consider performing decontamination activities more often during the next sampling day/event.

Following decontamination, equipment shall be placed in a clean area (i.e., in the truck, in a dedicated container, etc.) or on clean plastic sheeting in the work zone to prevent contact with contaminated media. If the equipment is not used immediately after decontamination, the equipment shall be stored in a manner which minimizes potential contact with contaminants. Overnight, the equipment will be stored with the sonde sensors submerged in potable water.

[1] Elevated levels of benzene may cause accelerated deterioration of the optical dissolved oxygen lens, which in turn will require more frequent lens replacement.

4.3 Groundwater Sampling Pumps

Submersible, non-dedicated, reusable groundwater sampling pumps shall be decontaminated between each sampling location. The following steps shall be used to decontaminate groundwater sampling pumps:

1. Personnel shall dress in appropriate PPE to reduce the potential of personal exposure as required by the HASP.
2. Exterior of the sampling pump, including the electrical cord, shall be sprayed and/or wiped off with isopropyl alcohol if gross contamination (i.e. LNAPL or water with high dissolved benzene content). The outer sampling pump casing may be removed, if necessary, to remove gross contamination on sampling pump motor module.
3. Sampling pump, including electrical cord, shall be placed in a wash tub or bucket containing a soap and water solution (Liquinox or similar along with potable or distilled water). Sampling pump shall be turned on to circulate the soapy water for a minimum of 5 minutes.
    a. Sampling pump may be scrubbed with a bristle brush, sponge, or similar utensil.
    b. If the electrical cord will not fit into the wash tub or bucket, it can be wiped down with a paper towel saturated with a detergent water solution.
4. Sampling pump, including electrical cord, shall be placed in a second tub or bucket containing distilled water. Sampling pump shall be turned on to circulate rinse water for a minimum of 5 minutes and until water coming out of the pump no longer contains soapy solution.
    a. If the electrical cord will not fit into the tub or bucket, it can be wiped down with a paper towel saturated with distilled water.
5. New 5-gallon buckets will be used for detergent and rinse water at the start of each quarterly task. Detergent water and rinse water shall be mixed fresh each morning and shall be replaced with new solutions at least at mid-day. More frequent replacement of solutions may be necessary if gross contamination (i.e., LNAPL, sheen, or suspended particles) is observed.

Following decontamination, equipment shall be placed in a clean area (i.e., in the truck, in a dedicated container, etc.) or on clean plastic sheeting in the work zone to prevent potential contact with contaminants. If the equipment is not used immediately after decontamination, the equipment shall be stored in a manner which minimizes potential contact with contaminants.

4.4 Water Level / Interface Probes

The following steps shall be used to decontaminate water level meters and oil/water interface probes:

1. Personnel shall dress in appropriate PPE to reduce the potential of personal exposure as required by the HASP and THA.
2. If gross contamination is present (i.e. LNAPL or water with high dissolved benzene content) a paper towel or other disposable media shall be saturated with isopropyl alcohol.
3. A portion of a second paper towel or other disposable media shall be saturated with a detergent water solution and the remaining portion of the same paper towel or other disposable media shall be saturated with distilled water.
4. The measuring tape shall be wiped clean as it is removed from the monitoring well by passing through the saturated disposable media. The tape must pass through the isopropyl alcohol first (if using isopropyl alcohol), the detergent water solution second, and the distilled water last. Isopropyl alcohol can be used on the probe tape, but not on the probe tip as is can damage the sensors.
5. Care shall be taken to replace saturated paper towels if gross contamination is observed or to replace paper towels which become dry during the process.
6. Probe tip shall also be sprayed off with Liquinox (or similar) detergent water solution and distilled water after wiping.
   a. Solinst and Heron brand probe tips will NOT be cleaned with isopropyl alcohol.
   b. If another brand interface probe is being used, check the equipment manual to verify proper decontamination procedures and solutions.

Following decontamination, equipment shall be placed in a clean area (i.e., in the truck, in a dedicated container, etc.) or on clean plastic sheeting in the work zone to prevent potential contact with contaminants. If the equipment is not used immediately after decontamination, the equipment shall be stored in a manner which minimizes potential contact with contaminants.

4.5 OTHER SAMPLING EQUIPMENT

The following steps shall be used to decontaminate other sampling equipment:

1. Personnel shall dress in appropriate PPE to reduce the potential of personal exposure as required by the HASP.
2. Gross contamination on equipment shall be scraped/wiped off at the sampling or construction site.
3. Equipment shall be sprayed and/or wiped off with distilled water.
4. Equipment that cannot be damaged by liquid or water shall be placed in a wash tub or bucket containing soap and water solution (Liquinox or similar along with potable or distilled water) and scrubbed with a bristle brush or similar utensil.
5. Equipment that cannot be damaged by liquid or water shall then be rinsed with distilled water in a second tub or bucket.
6. New 5-gallon buckets will be used for detergent and rinse water at the start of each quarterly task. Detergent water and rinse water shall be mixed fresh each morning and shall be replaced with new solutions at least at mid-day. More frequent replacement of solutions may be necessary if gross contamination (i.e., LNAPL, sheen, or suspended particles) is observed.

Following decontamination, equipment shall be placed in a clean area (i.e., in the truck, in a dedicated container, etc.) or on clean plastic sheeting in the work zone to prevent contact with contaminated media. If the equipment is not used immediately after decontamination, the equipment shall be stored in a manner which minimizes potential contact with contaminants.

5. Drilling and Heavy Equipment

Drilling rigs and other equipment shall be decontaminated at a decontamination station located near a central staging area. The decontamination station may consist of a temporary or permanent structure capable of collecting all decontamination fluids. Mobile decontamination trailers may be used to decontaminate heavy equipment at each site. The following steps shall be used to decontaminate drilling and heavy equipment:

1. Review THA for drilling and heavy equipment decontamination.
2. Personnel shall dress in appropriate PPE to reduce personal exposure as required by the HASP and THA.
3. Equipment showing gross contamination or having caked-on drill cuttings shall be scraped with a flat-bladed scraper at the sampling or construction site.
4. Equipment that cannot be damaged by water, such as drill rigs, augers, drill bits, and shovels, shall be washed with a high-pressure water sprayer then rinsed with potable

water. Care shall be taken to adequately clean the insides of the hollow-stem augers, backhoe buckets, etc.[2]

Following decontamination, drilling equipment shall be placed on the clean drill rig and moved to a clean area. If the equipment is not used immediately, it shall be stored in a designated clean area.

5.1 Equipment Leaving the Site

Vehicles used for site activities shall be cleaned on an as-needed basis, as determined by the Site Safety Officer, using soap and water on the outside and vacuuming the inside. On-site cleaning shall be required for dirty vehicles (i.e., muddy tires) leaving the site. Construction equipment, such as hollow stem augers, other drilling equipment, etc., shall be pressure washed before the equipment is removed from the site to limit exposure of off-site personnel to potential contaminants.

Heavy-use long-term sites/facilities with excessive mud or debris that can become attached to tires will utilize track pads in and out of entrances/exits.

5.2 Wastewater

Liquid wastewater from decontamination activities shall be containerized and left at the site where it originated, unless otherwise specified. Check with the Project IDW Coordinator for additional information/guidance.

6. Tedlar® Bags

The following steps shall be used to decontaminate used Tedlar® bags for reuse:

1. Personnel shall dress in appropriate PPE to reduce the potential of personal exposure as required by the HASP and THA
2. Tedlar® bags shall be pre-sorted into the following purge categories based on the concentrations of the most recent sample[3] in the Tedlar® bag:

[2] Use of hot water and/or steam cleaning during decontamination warrants a Hot Work Permit, which must be evaluated and approved prior to use.
[3] Oxygen in Tedlar® bag will be measured using Landtec GEM-2000; THC will be measured using TVA-2020 FID.

Oxygen (%)	Minimum Number of Purges Required
10-20.9	none
0 – 10	1

Total Hydrocarbon Concentration (ppmv)	Minimum Number of Purges Required
0.0	none
0.1 - 10	1
10 - 50	2
50 – 100	3
100 – 1,000	4
1,000 – 10,000	5
>10,000	6

If the oxygen and total hydrocarbon concentration (THC) values in the previous Tedlar® bag concentration do not line up on the table above, the more conservative approach (i.e., the greatest number of purges) shall be chosen.

3. In a well-ventilated area, begin the purge process by introducing ambient air into the Tedlar® bag through a GAST® sampling pump (or equivalent). Fill the Tedlar® bag approximately 80% full and then expel the ambient air from the Tedlar® bag using the intake hose on the GAST® sampling pump (or equivalent). Repeat until the required number of purges outlined in Step 2 above has been performed, or until ambient conditions are present in the Tedlar® bag.
4. After the final purge is complete, introduce ambient air into the Tedlar® bag through the pump and screen the Tedlar® bag to ensure that Oxygen is 20.9% and THC is 0.0 ppm (ambient conditions). If ambient conditions are not present in the Tedlar® bag after purging is complete, continue purging and screening the Tedlar® bag. If ambient conditions are not present after 10 purges, discard the Tedlar® bag.
5. Once ambient conditions are verified and the Tedlar® bag is examined to ensure that it is structurally intact, expel the remaining air and affix a new sampling label. Place the Tedlar® bag in the designated storage location for future use.

7. Documentation

Sampling personnel shall be responsible for documenting the decontamination of sampling equipment, drilling equipment and/or personnel. The documentation shall be recorded with waterproof ink in the sampler's field logbook with consecutively numbered pages. The information entered in the field book concerning decontamination shall include the following:

- Decontamination personnel
- Date and start/end times
- Decontamination observations
- Weather conditions

Refer to SOP No. 8 Field Reporting and Documentation for further information regarding logbook entries and logbook management.

8. Quality Assurance Requirements

Equipment rinsate samples of the decontaminated sampling equipment may be taken to verify the effectiveness of the decontamination procedures. The rinsate sampling procedure shall include passing distilled water through or over a decontaminated sampling tool (such as a split spoon) and collecting the rinsate water into the appropriate sample bottles. The rinsate sampling procedure, including the sample number, shall be recorded in the field notebook.

1. Objective

The purpose of this Standard Operating Procedure (SOP) is to define the standard procedures for subsurface utility clearance that will allow staff to work safely and prevent damage to utility systems. This procedure provides descriptions of equipment and procedures necessary to properly clear utilities prior to beginning subsurface field activities for Shell projects in Hartford and Roxana, Illinois.

This document also defines the procedure for contacting the applicable "one-call" service for locating underground utilities. One-call, Joint Utility Locating Information for Excavators (JULIE), is a public service provided by individual states as a single point of contact for requesting a utility locate from a majority of underground utilities. This service is primarily for locating utilities on public properties and right-of ways.

Utility clearances should be completed prior to the start of any work in the area that could feasibly result in contact with or damage to that utility. Additional information and a checklist can be found in AECOM Procedure No. S3AM-331-PR1 Underground Utilities. Please use S3AM-331-PR1 in conjunction with this SOP.

Utility clearances are supposed to be completed/submitted by the company doing the drilling/excavating but they will likely require information from us. We should also confirm, in the field, that utilities have been marked. We should also get locate ticket number and information from subcontractor once it's available.

2. Other SOPs Referenced in this SOP

- SOP No. 8 – Field Reporting and Documentation

3. Equipment

Equipment typically used during utility clearance procedures:

- Project map
- Known utility map
- Marking paint
- Stakes or flags
- Permanent marker
- Coloring pencils or permanent marker in different colors

- Measuring tape and/or wheel
- Other related field paperwork, as needed.
- Camera
- Surveyors, as needed
- Appropriate PPE (hard hat, safety glasses, steel toe boots, gloves, etc.)

4. Location Marking

Prior to utility clearance, locations to be drilled or excavated should be marked by the task manager, field personnel scheduled to complete the work, or a knowledgeable assigned designee. Per one-call guidelines excavation areas should be marked either a) with stakes or flags with the necessary radius to be cleared marked on the stake or flag or b) with white marking paint (black paint may be substituted when necessary). When using paint, the extent of the area to be cleared should be marked, if possible.

As a note, fluorescent paint should not be used when DyeLIF technology is to be used.

When marking locations, initial adjustments to locations should be made based on visible utilities such as overhead power lines, sewers and other utility corridors. As a general rule drill rig masts and excavating equipment must stay at least 50 horizontal feet away from overhead utilities unless/until the voltage and height of the system has been determined. Depending on the voltage of the overhead lines or site/client requirements, a lesser distance may be used. The table below summarizes the typical minimum distances from overhead power lines. Additional information can be found in AECOM Procedure No. S3AM-302-PR1 Electrical Safety. Please use S3AM-302-PR1 in conjunction with this SOP.

Minimum Distances from Power Lines	
Nominal System (kV)	**Minimum Required Distance (feet)**
0-50	10
51-100	12
101-200	15
201-300	20
301-500	25
501-750	35
751-1,000	45

Operations adjacent to overhead power lines are prohibited unless the power has been shut off (such as lockout/tagout), the minimum distance above has been observed, or the power lines have been isolated (such as using insulating blankets) by the owner of the lines.

5. One-Call

The purpose of the one-call system is to alert member utility companies to a planned drilling or excavating project. The one-call system will inform the person making the utility call which member companies will be notified. Additional contacts may be necessary if suspected utility providers in the area of the proposed work are not members of the public one-call system. Illinois has their own one-call number Illinois: 1-800-892-0123. Illinois requires the subcontractor actually performing the drilling or excavating to make the initial call (e.g., Illinois), and each drilling subcontractor needs to have their own locating (in this case JULIE) ticket number.

Once a one-call notification has been placed the utility companies typically have 48-hours (2 business days) to respond. The time does not include weekends or observed holidays. Once a one-call has been placed work should be ready to start within 10 working days. Once work has begun, renewal of utility locates is determined by an individual state's regulations. If the markings of utility locations are destroyed or removed before excavation/drilling commences or is completed, the one-call ticket must be renewed.

A joint meet may also be requested if the area of the proposed work is large and/or complicated. Member utilities must be given 48-hours prior to the joint meet to schedule a representative to attend. Following the joint meet, an additional 48 hours must be allowed for the utility companies to mark their utilities.

The following information should be provided when making a one-call:

- Identification of who is conducting the work as well as any subcontractor such as a drilling or excavating firm. The contact information for the person responsible along with a phone number where they can be easily reached is a minimum.
- Type of work being conducted (e.g. drilling or excavating).
- Location of work being conducted described as best as possible. Addresses in conjunction with relation to buildings or other property features when possible should be used. Other forms of locating include distances and directions from intersections.
- Whether or not a joint meet is required.
- The time frame expected for work to begin.

The following information should be recorded and kept available after the one-call has been made:

- Ticket serial number
- Utilities one-call will notify
- Time and location of joint meet (if applicable)
- Time and date by which utilities are to be cleared
- Log of utilities which have been cleared, either from markings on ground at the location or locator calling to confirm.
- Re-notification date when activities extend beyond 28 days.

Industrial facilities often are responsible for utility locates on their own property and will not be covered by a one-call. Field personnel should coordinate with their contact at such a facility in order to check for known utilities under control of the facility and for any additional clearance efforts which may be required.

When possible, identify the size of underground utilities being marked. The general rule is that the accuracy of marking, from the center of the utility, is the width of the utility plus 1.5-feet. Certain utility companies may require a greater distance from their lines.

The following are the colors from the uniform color code and marking guidelines:

- White (or Black) – Proposed excavations
- Pink – Temporary survey markings
- Red – Electric power lines, cables, conduit and lighting cables
- Yellow – Gas, oil, steam, petroleum or gaseous materials
- Orange – Communication, alarm or signal lines, cables or conduit
- Blue – Potable water
- Purple – Reclaimed water, irrigation and slurry lines
- Green – Sewers and drain lines

These colors shall be used by both the company requesting the utility locate and the member companies marking underground utilities.

6. Private Utility Clearance

Private utility clearance involves using ground penetrating radar (GPR) and/or electromagnetic (EM) technologies to check for utilities prior to beginning secondary utility clearance and excavation or drilling activities. GPR and EM should be performed by a trained and qualified subcontractor.

7. Secondary Utility Clearance

Secondary utility clearance involves using an air knife, a hand auger, a post-hole digger and/or a shovel to check for utilities prior to beginning the excavation or boring.

Air Knife/Vacuum Excavation

Air Knife/Vacuum Excavation operations involve air/water jetting combined with a high suction vacuum to create a boring or trench of specified dimensions. Single point borings need to have the hole cleared to below the depth of known utilities in the area and to a diameter 3 inches greater than the diameter of the tools penetrating the ground surface (per Shell guidelines). If the depth of utilities in the area is not known, a minimum depth of 5 to 10 feet can be used, depending on client/property owner requirements.

As an alternative, a "V-trench" or a triangle configuration of air-knife holes can also be used to clear a location. If the air-knife is to be completed in a triangle formation, the air knife holes should be completed in sets of three in as tight a triangle as the boring size will allow, with the center of the boring to be completed at the center of the triangle. Whichever method is selected, the air knife boring(s) must be located so that the absence of underground utilities can be confirmed. Once the location is confirmed as being clear, the air knife hole(s) or trench should be backfilled with air knife spoils or an inert material, such as silica sand or flowable fills, unless drilling is to commence right away. Refer to the scope of work or other project documentation for other backfill options.

Hand Auger

Due to access, availability or other reasons, air knifing/vacuum excavation may not be an option. If this is the case, hand augers may be used to clear a location. Due to the size of the hand auger bucket, multiple hand auger holes may be necessary to clear a location for a single boring. If multiple hand augers are necessary, the best option is to complete hand auger holes in sets of three in as tight a triangle as the boring size will allow, with the center of the boring to be completed at the center of the triangle. The same depth requirement for clearance applies to hand auger holes as it does for air knifing/vacuum excavation. Once the location is confirmed as being clear, the hand auger hole(s) should be backfilled with hand auger spoils or an inert material, as described for air knifing/vacuum excavation holes.

Post-hole digger / Hand Shovel

As a last choice, conventional means such as a post-hole digger or hand shovel may be used to clear a location. This option is generally best only when any known utilities are very shallow, or the surface material is extremely coarse (large gravels and rocks). Hand shovels and post-hole diggers have a higher chance of damaging weaker utilities, so caution should be taken when used. If deeper clearance than a foot or two is necessary, either an air knife or hand auger should be used for utility clearance. Other procedures/protocols mentioned above still apply.

8. Final Boring Placement

To the extent possible, excavation or drilling work should not be performed within 5 feet of a confirmed or suspected utility or other subsurface structure. The minimum distance to perform work from any utility may vary and should be confirmed with the utility company. If drilling will be performed within 5 feet of a confirmed or suspected utility, contact the utility company/companies to discuss any potential precautions that should be taken. Shell projects require the secondary utility clearance hole be cased if within 10 feet of a gas line. Casing may also be used if the sidewall caves in or water fills in the secondary utility clearance hole. If an unmarked utility is encountered during secondary utility clearance, contact the project/task manager and/or site contact/property owner for further guidance and information.

9. Documentation

Once private utility locating personnel and one-call personnel have marked any utility lines in the vicinity of the work to be performed, document the markings for the project file. Documentation can include, but is not limited to:

- Photographs showing the markings and surrounding area,
- Field sketch of the vicinity including work locations and utility lines marked,
- Updating the area basemap (AutoCAD) with utility information, if necessary/possible,
- Private utility clearance report from the trained and licensed subcontractor,
- One-call ticket printout documenting the utilities contacted, etc.
- Shell Borehole Clearance form
- AECOM Procedure S3AM-331-PR1 Underground Utilities Checklist
- AECOM Procedure S3AM-302-PR1 Electrical Safety Checklist

Refer to SOP No. 8 Field Reporting and Documentation for further guidance. Documentation should be kept with the project file for future reference.

1. Objective

The purpose of this Standard Operating Procedure (SOP) is to define the procedures and equipment for the grouting of borings following their completion for Shell projects in Hartford and Roxana, Illinois. If a monitoring well or piezometer is to be installed in the boring refer to the procedure outlined in SOP No. 21 Monitoring Well Installation. If a soil vapor monitoring point is to be installed in the boring, refer to the procedure outlined in SOP No. 57 Soil Vapor Monitoring Point Installation.

2. Other SOPs Referenced in this SOP

- SOP No. 8 – Field Reporting and Documentation
- SOP No. 21 – Monitoring Well Installation
- SOP No. 57 – Soil Vapor Monitoring Point Installation

3. Equipment

The following is the typical equipment for grouting a borehole:

- Portland Type I or II Cement
- Powdered bentonite
- Potable water
- Appropriate health and safety equipment as specified in the project/task Health and Safety Plan (HASP)
- Field book and/or boring log sheets
- Drums or other suitable container for mixing of grout

4. Procedures

A standard mixture of cement-bentonite grout will consist of the following ratio:

- 1 (94 lb) sack of Portland cement,
- Powdered bentonite (as permitted by state regulations), and
- 7 to 15 gallons of potable water.

A standard mixture of high-solids bentonite grout will consist of the following:

- Powdered bentonite (as permitted by state regulations), and
- 7 to 15 gallons of potable water.

The allowable grouting compound should be confirmed with the regulatory agency or permit, if applicable.

The grouting procedures for either type of grout consist of the following:

1. Mix the bentonite and water first to a creamy consistency.
2. Slowly add the Portland Cement (if used). The amount of bentonite or water can be varied to control the consistency and pumpability of the mix.
3. Pump the mixture through tremie pipe or drill rods placed down the boring to displace any water or drilling fluids.
4. Withdraw rods or piping when grout has reached surface.
5. Repeat steps 1 – 4 as augers/drill pipe are removed.
6. Grout the remaining open boring to the surface after the augers are removed. The grout will be tremied into the borehole until it is completely filled.
7. After the grout sets for 24 hours it will be checked for settlement. If necessary, additional grout will be added to top off. Hydrated bentonite chips, or similar, may also be used to top off.
8. Add surface seal (asphalt or concrete) as necessary.

5. Documentation

Documentation will be written in the field book according to SOP No. 8 Field Reporting and Documentation and may include, but is not limited to, the following:

- Date
- Time
- Personnel
- Weather
- Subcontractors
- Health and Safety monitoring equipment and readings
- Portland and bentonite bag counts
- The quantity and composition of the grout
- Start and completion dates and times

- Discussion of all procedures and any problems encountered during drilling/grouting.

1. Objective

The purpose of this Standard Operating Procedure (SOP) is to define the standard procedure for performing field headspace screenings. Volatile Organic Compound (VOC) field headspace screenings will be performed on selected soil samples to obtain preliminary estimates of VOC concentrations. This qualitative data will be used as criteria in selecting soil samples from locations where collection depths have not been predetermined. This document defines the standard procedure for headspace soil screening for Shell projects in Hartford and Roxana, Illinois.

2. Other SOPs Referenced within this SOP

None.

3. Equipment

The following equipment is typically required.

- Resealable zipper bag, or glass jars with plastic lids.
- Photoionization detector (PID)
- Permanent Marker
- Watch (or similar to keep time)

4. Procedure

The following general procedure is to be followed:

1. Obtain approximately 1/2 qt of soil and place in clean resealable zipper bag or glass jar with plastic lid. Immediately seal the zipper bag or jar. Record the boring location and sample depth on the bag or jar. **Note:** The selected drilling technology and/or defined sampling plan may limit volume of soil available for field headspace screening.
2. Break soil into about 1 in. sized particles by squeezing the bag/shaking the jar, taking care not to compromise the seal.
3. Place sample in a location where it can be left undisturbed for a minimum of 5 minutes. If the temperature is less than 35°F, place the sample in a heated vehicle or other location for a minimum of 5 minutes.
4. Measure ambient air background VOC concentrations.

5. After at least 5 minutes has elapsed, obtain PID reading from bag or jar headspace by opening a space in the seal just large enough to allow the PID probe to enter unobstructed. Continue monitoring until PID readings drop to background concentrations or stabilize. **Note:** Soil with high water content or significant contamination may require frequent replacement of moisture/dust trap on PID or use of other types of filters for PID readings.
6. Record highest PID reading measured on the field boring log and/or in the field book.
7. Archive or dispose of soil per site field sampling plan, work plan or outlined scope of work.

1. Objective

The purpose of this Standard Operating Procedure (SOP) is to define the standard procedure for logging of soil and rock samples both for environmental and geotechnical characterization purposes for Shell projects in Hartford and Roxana, Illinois. This procedure provides descriptions of equipment and field procedures necessary to log soil and rock samples.

2. Other SOPs Referenced within this SOP

- SOP No. 8 – Field Reporting and Documentation

3. Equipment

The following equipment is typically used during soil and rock sample logging:

1. Unified Soil Classification System (USCS) Chart
2. Boring logs
3. Tape measure
4. Pocket Penetrometer, if available
5. Field data sheets
6. Field book
7. Waterproof pen and/or permanent marker
8. Munsell Soil-Color Chart
9. Water and clean VOA, HCL VOA
10. Nitrile and puncture proof Gloves
11. Clean, small putty knife for soil splitting
12. Shop towels
13. Ziplock bags
14. Photo Ionization Detector (PID)
15. Sieve(s) (if applicable)

4. Sample Descriptions

This section provides an approach for describing (logging) soil samples in the field. General observations made before, during, and after field activities should be recorded in a field book in accordance with the procedures defined in SOP No. 8 Field Reporting and Documentation:

Soil

The soil's description should include as a minimum:

1. Apparent strength (for fine-grained soils) or density (for coarse-grained soil) adjective
2. Water content condition adjective (dry, moist, wet)
3. Color description (using Munsell soil chart when available)
4. Descriptive adjective for main soil type
    - Particle-size distribution adjective for gravel and sand
    - Plasticity adjective and soil texture (silty or clayey) for inorganic and organic silts or clays
5. Minor soil type name with "y" added (if ≥ 30 percent)
6. Main soil type's name (all capital letters)
7. Geologic name, if known (in parentheses or in notes column)
8. Descriptive adjective, some or trace, for minor soil type if ≤ 30 percent. See **Minor Soil Types** description below (page 9) for more information on when to use, "some", "trace", or "with".
9. Minor soil type(s)
10. Inclusions
11. The USCS Group Name and Symbol appropriate for the soil type in accordance with ASTM D 2487, with few exceptions, and (symbol in parenthesis)

The various elements of the soil's description should be stated in the order listed above.

Examples:

Fine-grained soils:	Soft, wet, gray, high plasticity CLAY, trace f. sand – Fat CLAY (CH); (Alluvium)
Coarse-grained soils:	Dense, moist, brown, medium to fine grained silty SAND, trace fine gravel to coarse sand – Silty SAND (SM); (Alluvium)

When changes occur within the same soil layer, such as change in apparent density, then this change must be indicated ("Becomes XYZ"). Note that only those aspects of the soil description that are different from the description of the overlying soil are mentioned. Note also the depth at which some characteristic is no longer present must be noted ("XYZ grades out").

Apparent Strength and Density

Strength and density descriptive terms are related to blow count resistance using a 2-inch OD, 24-inch-long split barrel sampler and standard penetration tests (a 140-pound hammer dropped 30-inches) (ASTM D 1586-84). Strength can also be related to pocket penetrometer resistance. Use the values and descriptions in the table presented below to determine the strength or density.

Strength & Density

Cohesive Clays (clays & silts)			Non-cohesive Granular Soils (sands & gravels)	
Blow Count	**Pocket Penetrometer (tsf)**	**Strength**	**Blow Count**	**Density**
0-2	<0.25	Very soft	0-4	Very loose
3-4	0.25-0.50	Soft	4-10	Loose
5-8	0.50-1.0	Medium stiff	11-30	Medium dense
9-15	1.0-2.0	Stiff	31-50	Dense
16-30	2.0-4.0	Very stiff	>50	Very dense
>30	>4.0	Hard		

A blow count of >50 for a 12-inch interval[1] constitutes spoon refusal and the sample should be terminated at that time.

The strength of the soil can be determined without blow counts using the following guide:

H Hard Soil – Brittle or tough, may be broken in the hand with difficulty. Can be peeled with a pocketknife.

VST Very Stiff – Soil can barely be imprinted by pressure from the fingers or indented by thumbnail.

ST Stiff – Soil can be imprinted with considerable pressure from fingers or indented by thumbnail.

M Medium Stiff – Soil can be imprinted easily with fingers; remolded by strong finger pressure.

[1] Blow counts are recorded for four separate 6-inch sections when driving a 2-foot long split spoon sampler. The blow counts for the second and third 6-inch section should be used to assist with the strength/density determination. The blow counts for the first section should NOT be used due to possible disturbed soil from the augers. The blow counts for the fourth section should NOT be used due to potential compaction from the split spoon.

So Soft – Soil can be pinched in two between the thumb and forefinger; remolded by light finger pressure.

Vso Very Soft – Soil exudes between fingers when squeezed; specimen (height = 2 x diameter) sags under its own weight.

Water Content

The amount of water present in the soil sample or its water content adjective should be described as dry, moist, or wet as follows:

Descriptors for Water Content (moisture)

Description	Condition
Dry	No sign of water and soil is dry to the touch
Moist	Signs of water and soil is relatively dry to the touch
Wet	Signs of water and the soil definitely wet to the touch; granular soil exhibits some free water when densified

The descriptor "damp" should not be used (use "moist"). The descriptor "saturated" should not be used (use "wet").

Color

The colors should be assigned consistent with a Munsell Color Chart and should be described when the sample is first retrieved at the soil's as-sampled water content (the color will change with water content). A Munsell Color Chart is provided as Appendix A. When the soil is marked with spots of color, the term mottled can be applied with the following descriptors:

Descriptors for Mottling

Abundance	Size	Contract
f: few (<2%)	fine (<5 mm)	faint
c: common (2%-20%)	medium (5-15 mm)	distinct
m: many (>20%)	coarse (>15 mm)	prominent

Soils with a homogeneous texture but having color patterns, which change and are not considered mottled, can be described as streaked.

Soil Types

The constituent parts of a given soil type are defined on the basis of texture in accordance with particle-size designators separating the soil into coarse-grained, fine-grained, and highly organic designations.

Coarse-grained (gravel and sand)

Soils with more than 50% of the particles larger than No. 200 sieve (0.074 mm). The soil components are described on the basis of particle size as follows:

Grade Limits and Grade Standards

Grade Names	
Name	**Grain Size**
Sand	
Fine	#200 to #40 sieve
Medium	#40 to #10 sieve
Coarse	#10 to #4 sieve
Gravel	
Fine	#4 sieve to ¾-inch
Coarse	¾-inch to 3-inches
Cobbles	3-inches to 12-inches
Boulders	>12-inches

The particle-size distribution is identified as well graded or poorly graded. Well-graded coarse-grained soil contains a good representation of all particle sizes from largest to smallest, with ≤12 percent fines. Poorly graded coarse-grained soil is uniformly graded with most particles about the same size or lacking one or more intermediate sizes, with ≤12 percent fines. A table of USC symbols and names for coarse-grained soils is presented below.

USCS Symbols and Names for Coarse-grained Soils

USCS Symbol	**Typical Names**
GW	Well graded gravels, gravel-sand mixtures, little or no fines
GP	Poorly graded gravels, gravel-sand mixtures, little or no fines
GM	Silty gravels, gravel-sand-silt mixtures
GC	Clayey gravels, gravel-sand-clay mixtures
SW	Well graded sands, gravelly sands, little or no fines
SP	Poorly graded sands, gravelly sands, little or no fines
SM	Silty sand, sand-silt mixtures
SC	Clayey sands, sand-clay mixtures

The following field identification tests can be used to estimate the grain size distribution of coarse-grained soils:

Feel and Smear Tests – A pinch of soil is handled lightly between the thumb and fingers to obtain an impression of the grittiness or of the softness of the constituent particles. Thereafter, a pinch of soil is smeared with considerable pressure between the thumb and forefinger to determine the degrees of roughness and grittiness, or the softness and smoothness of the soil.

Coarse- to medium-grained sand:	Typically exhibits a very harsh and gritty feel and smear.
Coarse- to fine-grained sand:	Has a less harsh feel, but exhibits a very gritty smear.
Medium- to fine-grained sand:	Exhibits a less gritty feel and smear which becomes softer and less gritty with an increase in the fine sand fraction.
Fine-grained sand:	Exhibits a relatively soft feel and a much less gritty smear than the coarser sand components.
Silt:	Components less than about 10 percent of the total weight can be identified by a slight discoloration of the fingers after smear of a moist sample. Increasing silt increases discoloration and softens the smear.

Sedimentation Test – A small sample of soil is shaken in a test tube filled with water and allowed to settle. The time required for the particles to fall to a distance of 4 inches is about ½ minute for particle sizes coarser than silt. About 50 minutes would be required for particles of 0.005 mm or smaller (often defined as “clay size”) to settle out.

Visual Characteristics – Sand and gravel particles can be readily identified visually, however, silt particles are generally indistinguishable to the eye. With an increasing silt component, individual sand grains become obscured, and when silt exceeds about 12 percent, it masks almost entirely the sand component from visual separation. Note that gray fine-grained sand visually appears siltier than the actual silt content.

Fine-grained (clay and silt)

Soils with more than 50% of the particles finer than the No. 200 sieve (0.074 mm) and the fines are silts and clays.

A table of USC symbols and names for fine-grained soils is presented here.

USCS Symbols and Names for Fine-grained Soils

USCS Symbol	Typical Names
ML	Inorganic silts and very fine sands, rock flour, silty, or clayey fine sands, or clayey silts with slight plasticity
CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
OL	Organic silts and organic silty clays of low plasticity
MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
CH	Inorganic clays or high plasticity (residual clays), fat clays
OH	Organic clays of medium to high plasticity, organic silts
Pt	Peat and other highly organic soils

The following field identification tests can be used to estimate the degree of plasticity and size distribution of fine-grained soils:

Shaking (Dilatency) Test: Water is dropped or sprayed on a part of basically fine-grained soil mixed and held in the palm of the hand until it shows a wet surface appearance when shaken or bounced lightly in the hand or a sticky nature when touched. The test involves lightly squeezing the soil pat between the thumb and forefinger and releasing it alternatively to observe its reaction and the speed of the response. Soils which are predominantly silty (nonplastic to low plasticity) will show a dull dry surface upon squeezing and a glassy wet surface immediately upon releasing of the pressure. With increasing fineness (plasticity) and the related decreasing dilatency, this phenomenon becomes less and less pronounced.

Dry Strength Test: A portion of the sample is allowed to dry out and a fragment of the dried soil is pressed between the fingers. Fragments which cannot be crumbled or broken are characteristic of clays with high plasticity. Fragments which can be disintegrated with gentle finger pressure are characteristic of silty materials of low plasticity. Thus, materials with great dry strength are clays of high plasticity and those with little dry strength are predominantly silts.

Thread Test: Moisture is added or worked out of a small ball (approximately 1 ½-inch diameter) and the ball kneaded until its consistency approaches medium stiff to stiff, it breaks, or crumbles. A thread is then rolled out to the smallest diameter possible before disintegration. The smaller the thread achieved, the higher the plasticity of the soil. Fine-grained soils of high plasticity will have threads smaller than 1/32 inch in diameter. Soils with low plasticity will have threads larger than 1/8 inch in diameter.

<u>Smear Test:</u> A fragment of soil smeared between the thumb and forefinger or drawn across the thumbnail will, by the smoothness and sheen of the smear surface, indicate the plasticity of the soil. A soil of low plasticity will exhibit a rough textured, dull smear while a soil of high plasticity will exhibit a slick, waxy smear surface.

The following table presents the terms used to denote the various degrees of plasticity of soil that passes the No. 200 sieve.

Degrees of Plasticity

Descriptive Term	Degree of Plasticity	Plasticity Index Range
SILT	none	non-plastic
Clayey SILT	slight	1-5
SILT & CLAY	low	5-10
CLAY & SILT	medium	10-20
Silty CLAY	high	20-40
CLAY	very high	over 40

Highly-organic

Soils that primarily consist of organic matter. Identification markers are:

1. Dark and black and sometimes dark brown colors, although not all dark colored soils are organic.
2. Moist organic soils will oxidize when exposed to air and change from a gray/black color to a lighter brown, i.e. The exposed surface is brownish, but when the sample is pulled apart the freshly exposed surface is dark gray/black.
3. Fresh organic soils usually have a characteristic odor which can be recognized, particularly when the soil is heated.
4. Compared to non-organic soils, less effort is typically required to pull the material apart and a friable break is usually formed with a fine granular or silty texture and appearance.
5. Their workability at the plastic limit is weaker and spongier than an equivalent non-organic soil.
6. The smear, although generally smooth, is usually duller and appears siltier.

Minor Soil Types

In many soils two or more soil types are present in the soil. When the percentage of the minor soil type is ≥ 50% of the total sample, the minor soil type is given prior to the major soil type and is indicated by adding a "y" to its name; i.e. silty CLAY.

When the minor soil type percentage is between 1 and 49% of the total sample, the minor soil type is given after the major soil type is given along with an adjective term:

1. Trace – When the soil type's percentage is between 1 and 5% of the total sample.
2. Some – When the soil type's percentage is between 5 and 12% of the total sample.
3. With – When the soil type's percentage is between 13% and 49% of the total sample.

A table of soil descriptors is presented below.

Soil Descriptors

Calcareous:	Containing appreciable quantities of calcium carbonate	
Fissured:	Containing shrinkage cracks, often filled with fine sand or silt, usually more less vertical	
Interbedded:	Containing alternating layers of different soil types	
Intermixed:	Containing appreciable, random, and disoriented quantities of varying color, texture, or constituency	
Laminated:	Containing thin layers of varying color, texture, or constituency	
Layer:	Thickness greater than 3 inches	
Mottled:	Containing appreciable random speckles or pockets of varying color, texture, or constituency	
Parting:	Paper thin	
Poorly graded (well sorted):	Primarily one grain size, or having a range of sizes with some intermediate size missing	
Slickensided:	Having inclined planes of weakness that are slick and glossy in appearance and often result in lower unconfined compression cohesion	
Split graded:	Containing two predominant grain sizes with intermediate sizes missing	
Varved:	Sanded or layered with silt or very fine sand (cyclic sedimentary couplet)	
Well graded (poorly sorted):	Containing wide range of grain sizes and substantial amounts of all intermediate particle sizes	
Modifiers:	Predominant type -	≥ 50%
	With -	13% to 49%
	Some -	6% to 12%
	Trace -	1% to 5%

Inclusions

Additional inclusions or characteristics of the sample can be described by using "with" and the descriptions described above. Examples are given below:

1. With petroleum odor
2. With organic matter
3. With shell fragments
4. With mica.

Layered Soils

Soils of different types can be found in repeating layers of various thicknesses. It is important that all such formations and their thicknesses are noted. Each layer is described as if it is a nonlayered soil using the sequence for soil descriptions discussed above. The thickness and shape of layers and the geological type of layering are noted using the following descriptive terms:

Type of Layer	Thickness	Occurrence
Parting	< 1/16 inch	
Seam	1/16 inch to 0.5 inches	
Layer	0.5 inches to 12 inches	
Stratum	> 12 inches	
Pocket		Small erratic deposit
Lens		Lenticular deposit
Varved (also layered)		Alternating seams or layers of silt and/or clay and sometimes fine sand
Occasional		One or less per foot of thickness of laboratory sample inspected
Frequent		More than one per foot of thickness of laboratory sample inspected

Place the thickness designation before the type of layer, or at the end of each description and in parentheses, whichever is appropriate.

An example of a description of layered soils is:

> Medium stiff, moist to wet ¼" – ¾" interbedded seams and layers of: gray, medium plastic, silty CLAY (CL); and lt. gray, low plasticity SILT (ML); (Alluvium).

Geologic Name

The soil description should include the Field Representative's assessment of the origin of the soil unit and the geologic name, if known, placed in parentheses at the end of the soil description or in the field notes column of the boring log.

Rock

The rock's description should include as a minimum:

1. Rock type
2. Color
3. Grain size and shape
4. Texture (stratification/foliation)
5. Mineral composition
6. Weathering and alteration
7. Strength
8. Other relevant notes.

The various elements of the rock's description should be stated in the order listed above.

Example:

Limestone, light gray, very fine-grained, thin-bedded, unweathered, strong

The rock description should include identification of discontinuities and fractures. The description should include a drawing of the naturally occurring fractures and mechanical breaks.

Rock Type

Rocks are classified according to origin into three major divisions: igneous, sedimentary, and metamorphic. These three groups are subdivided into types according to mineral and chemical composition, texture, and internal structure. Engineering classifications of rocks can be based on ASTM Method C 294.

Division	Class	Type
Igneous	Coarse-grained (Intrusive)	Granite Syenite Diorite Gabbro Peridotite Pegmatite
	Fine-grained (Extrusive)	Volcanic Glass Delsite Basalt
Sedimentary	Calcareous	Limestone Dolomite
	Siliceous	Conglomerate Sandstone Quartizite Claystone Siltstone Argillite Shale Chert
Metamorphic	Foliated	Slate Phyllite Schist Amphibolite Hornfels Unfixes
	Nonfoliated	Marble Metaquartzite Serpentinite

Color

Colors should be assigned consistent with a Munsell Color Chart and recorded for both wet and dry conditions as appropriate.

Grain Size and Shape

The grain size description should be classified using the following terms:

Very Coarse-Grained:	Diameter greater than 0.187 inches (4.76 mm).
Coarse-Grained:	Diameter 0.187 inches to 0.0787 inches (4.76 mm to 2.00 mm). Individual grains can be easily distinguished by the naked eye.
Medium-Grained:	Diameter 0.0787 inches to 0.0165 inches (2.00 mm to 0.420 mm). Individual grains can be distinguished with the naked eye.
Fine-Grained:	Diameter 0.0165 inches to 0.0029 inches (0.420 mm to 0.074 mm). Individual grains can be distinguished by the naked eye with difficulty.
Very Fine-grained:	Diameter less than 0.0029 inches (0.074 mm). Individual grains cannot be distinguished by the naked eye.

The grain shape description should be classified using the following terms:

Angular:	Showing very little evidence of wear. Grain edges and corners are sharp. Secondary corners are numerous and sharp.
Subangular:	Showing definite effects of wear. Grain edges and corners are slightly rounded off. Secondary corners are slightly less numerous and slightly less sharp than in angular grains.
Subrounded:	Showing considerable wear. Grain edges and corners are rounded to smooth curves. Secondary corners are reduced greatly in number and highly rounded.
Rounded:	Showing extreme wear. Grain edges and corners are smoother off to broad curves. Secondary corners are few in number and rounded.
Well-Rounded:	Completely worn. Grain edges or corners are not present. No secondary edges or corners are present.

Texture (stratification/foliation)

Significant nonfracture structural features should be described. The thickness should be described using the following terms:

Type of Layer	Thickness	
	English	**Metric**
Thinly laminated	0.1 inches	2.5 millimeters
Laminated	0.1 to 0.5 inches	2.5 to 10 millimeters
Very thinly bedded	0.5 to 2.0 inches	1 to 5 centimeters
Thinly bedded	2.0 inches to 2 feet	5 to 50 centimeters
Thickly bedded	2 to 3 feet	0.5 to 1 meters
Very thickly bedded	3 feet	1 meter

The orientation of the bedding/foliation should be measured from the horizontal with a protractor.

Mineral Composition

A geologist, based on experience and the use of appropriate references, should identify the mineral composition. The most abundant mineral should be listed first, followed by minerals in decreasing order of abundance. For some common rock types, mineral composition need not be specified (i.e. dolomite, limestone).

Weathering and Alteration

Weathering as defined here is due to physical disintegration of the minerals in the rock by atmospheric processes while alteration is defined here as due to geothermal processes. Terms and abbreviations used to describe weathering or alteration are:

RS Residual Soil – The original minerals of the rock have been entirely weathered to secondary minerals, and the original rock fabric is not apparent. The material can be easily broken.

C Completely Altered or Weathered – The original minerals of the rock have been almost entirely changed to secondary minerals, even though the original fabric may be intact. The material can be easily broken.

H Highly Altered or Weathered – The rock is weakened to such an extent that a sample with a 2-inch minimum diameter can be broken readily by hand across the rock fabric. More than half the rock material is decomposed or altered. Fresh rock is present in a discontinuous framework or as corestones.

M Moderately Altered or Weathered – rock is discolored and noticeably weakened, but sample with a 2-inch minimum diameter cannot usually be broken by hand, across the rock fabric. Less than half of the rock material is decomposed or altered. Fresh or discolored rock is present either as a continuous framework or as corestones.

S Slightly Altered or Weathered – Rock is slightly discolored, but not noticeably lower in strength than fresh rock.

F Fresh – Rock shows no discoloration, no loss of strength, or any other effect of weathering.

Rock Strength

A common qualitative assessment of strength can be used while logging of rock core during drilling. Terms and abbreviations used to describe weathering or alteration are:

ES Extremely Strong – Specimen can only be chipped with geological hammer.

VS Very Strong – Specimen requires many blows of geological hammer to fracture it.

S Strong – Specimen requires more than one blow of geological hammer to fracture it.

MS Medium Strong – Cannot be scraped or peeled with a pocketknife. Specimen can be fractured with a single firm blow of geological hammer.

W Weak – material crumbles under firm blows with the sharp end of a geological hammer. Can be peeled by a pocketknife with difficulty.

VW Very Weak Rock – Brittle or tough, may be broken in the hand with difficulty. Can be peeled with a pocketknife.

Descriptors and abbreviations used to describe rock hardness are:

S	Soft - Reserved for plastic material alone.
F	Friable - Easily crumbled by hand, pulverized or reduced to powder and is too soft to be cut with a pocketknife.
LH	Low Hardness - Can be gouged deeply or carved with a pocketknife.
MH	Moderately Hard - Can be readily scratched by a knife blade; scratch leaves heavy trace of dust and scratch is readily visible after the powder has been blown away.
H	Hard - Can be scratched with difficulty; scratch produces little powder and is often faintly visible; traces of the knife steel may be visible.
VH	Very Hard - Cannot be scratched with pocketknife. Leaves knife steel marks on surface.

Rock Discontinuity

Discontinuity is the general term for any mechanical discontinuity in a rock mass having zero or low tensile strength. It is the collective term for most types of joints, weak bedding planes, weak schistocity planes, weakness zones, and faults. The following symbols are recommended for the type of rock mass discontinuities.

F	Fault
J	Joint
Sh	Shear
Fo	Foliation
V	Vein
B	Bedding

The spacing of discontinuities is the perpendicular distance between adjacent discontinuities. The spacing should be measured in feet to the nearest tenth, perpendicular to the planes in the set.

EC	Extremely close spacing	<0.07 ft
VC	Very close spacing	0.07 – 0.2 ft
C	Close spacing	0.2 – 0.66 ft
M	Moderate spacing	0.7 – 2 ft
W	Wide spacing	>2 – 6.6 ft
EW	Extremely wide spacing	>6.6 ft

The discontinuities should be described as closed, open, or filled. Aperture is used to describe the perpendicular distance separating the adjacent rock walls of an open discontinuity in which the intervening space is air or water filled. Width is used to describe the distance separating the adjacent rock walls of filled discontinuities. The following terms should be used to describe apertures:

Aperture	Description	
<0.1 mm 0.1 – 0.25 mm 0.2 0.25 – 0.5 mm	Very tight Tight Partly open	“Closed Features”
0.5 – 2.5 mm 2.5 – 10 mm >10 mm	Open Moderately open Wide	“Gapped Features”
1 10 cm 1 10 – 100 cm >1 m	Very wide Extremely wide Cavernous	“Open Features”

The following terms are recommended to describe the width of discontinuities such as thickness of veins, fault gouge filling, or joints openings.

W	Wide	0.5 – 2.0 inches
MW	Moderately wide	0.1 – 0.5 inches
N	Narrow	0.05 – 0.1 inches
VN	Very narrow	<0.05
T	Tight	0

For the thickness of faults or shears that are not thick enough to be represented on the boring log and are greater than 2-inches thick, record the measured thickness numerically in feet to the nearest tenth of a foot.

The following terms should be used to describe the planarity of discontinuities:

Wa Wavy

Pl Planar

St Stepped

Amplitude = A

Wavelength = γ

Measured in feet.

The following terms should be used to describe the surface roughness of discontinuities:

VR	Very Rough – Near right-angle steps and ridges occur on the discontinuity surface.
R	Rough – Some ridges and side- angle steps are evident; asperities are clearly visible; and discontinuity surface feels very abrasive.
Sr	Slightly Rough – Asperities on the discontinuity surfaces are distinguishable and can be felt.
S	Smooth – Surface appears smooth and feels so to the touch.
Slk	Slickensides – Visual evidence of striations or a smooth glassy appearing finish.

Filling is the term for material separating the adjacent rock walls of discontinuities. The perpendicular distance between the adjacent rock walls is termed the width of the filled discontinuity. The type of discontinuity infilling should be described using the following terms:

C	Clay	Fe	Iron Oxide
Sd	Sand	g	Gypsum/Talc
H	Healed	q	Quartz
Ch	Chlorite	N	None
Ca	Calcite	O	Other (describe)

The amount of infilling in discontinuities should be described using the following terms:

St	Surface stain
Sp	Spotty
P	Partially filled half surface or opening is filled
F	Filled
N	None

Fracture Description

The location of each naturally occurring fracture and mechanical break is shown in the fracture column of the rock core log. The naturally occurring fractures are numbered and described using the terminology described above for discontinuities.

The naturally occurring fracture and mechanical breaks are sketched in the drawing column.

Dip angles of fractures should be measured using a protractor and marked on the log. For nonvertical borings, the angle should be measured and marked as if the boring was vertical. If the rock is broken into many pieces less than ½ inch to 1-inch long, the log may be crosshatched in that interval, or the fracture may be shown schematically.

The number of naturally occurring fractures observed in each foot of core should be recorded in the fracture frequency column. Mechanical breaks, thought to have occurred due to drilling, are not counted. The following criteria can be used to identify natural breaks:

1. A rough brittle surface with fresh cleavage planes in individual rock minerals indicates an artificial fracture.
2. A generally smooth or somewhat weathered surface with soft coating or infilling materials, such as talc, gypsum, chlorite, mica, or calcite obviously indicates a natural discontinuity.
3. In rocks showing foliation, cleavage or bedding it may be difficult to distinguish between natural discontinuities and artificial fractures when these are parallel with the incipient weakness planes. If drilling has been carried out carefully then the questionable breaks should be counted as natural features, to be on the conservative side.
4. Depending upon the drilling equipment, part of the length of core being drilled may occasionally rotate with the inner barrels in such a way that grinding of the surfaces of discontinuities and fractures occurs. In weak rock types it may be very difficult to decide if the resulting rounded surfaces represent natural or artificial features. When in doubt, the conservative assumption should be made; i.e., assume that they are natural.
5. It may be useful to keep a separate record of the frequency of artificial fractures (and associated lower RQD) for assessing the possible influence of blasting on the weaker sedimentary and foliated or schistose metamorphic rocks.

The results of core logging (frequency and RQD) can be strongly time dependent and moisture content dependent in the case of certain varieties of shales and mudstones having relatively weakly developed digenetic bonds. A not infrequent problem is “discing,” in which an initially intact core separates into discs on incipient planes, the process becoming noticeable perhaps within minutes of core recovery. The phenomena are experienced in several different forms:

1. Stress relief cracking (and swelling) by the initially rapid release of strain energy in cores recovered from areas of high stress, especially in the case of shaley rock.

2. Dehydration cracking experienced in the weaker mudstones and shales which may reduce RQD from 100 to 0 percent in a matter of minutes, the initial integrity possibly being due to negative pore pressure.
3. Slaking cracking experienced by some of the weaker mudstones and shales when subjected to wetting.

All these phenomena make core logging of *frequency* and RQD unreliable. Whenever such conditions are anticipated, an engineering geologist should log core as it is recovered and at subsequent intervals until the phenomenon is predictable. An added advantage is that the engineering geologist can perform mechanical index tests, such as the point load or Schmidt hammer test, while the core is still in a saturated state.

5. Drilling information:

- Drill rig manufacturer, model, and driller (if applicable)
- Geologist or geotechnical engineer
- Project name, sample point identification, and location
- Date samples obtained (and times if required)
- Type of sampler (e.g., split spoon, Shelby, California), measurements or method of advancing boring or equipment, method of driving sampler, and weight of hammer
- Drill fluids (if applicable)
- Ground surface or grade elevation (if known)
- Depth penetrated and blow counts/6-inch interval of penetration for ASTM 1586-84 and sample number (if applicable)
- Closed hole intervals and advancement (if applicable)
- Recovery
- Strata changes and changes within samples
- Sampling tool behavior
- Drill string behavior
- Use(s) of borehole
- Disposition(s) of residual soil or cuttings
- Signature or sampling of log (as required).

1. Summary

The purpose of this Standard Operating Procedure (SOP) is to define the general procedures and typical equipment for installation of groundwater monitoring wells and piezometers for Shell projects in Hartford and Roxana, Illinois. A piezometer is simply a small diameter monitoring well. Therefore, the equipment and procedures for building a piezometer are the same as those used to install a monitoring well. The step-by-step procedures described herein are sufficiently detailed to allow field personnel to be familiar with proper installation techniques of any size monitoring well.

2. Other SOPs referenced in this SOP:

- SOP No. 3 Calibration and Maintenance of Field Instruments
- SOP No. 4 Decontamination
- SOP No. 8 Field Reporting and Documentation
- SOP No. 5 Utility Clearance Procedures
- SOP No. 12 Grouting Procedures
- SOP No. 17 Logging
- SOP No. 20 Well Development
- SOP No. 28 Soil Sampling
- SOP No. 29 Soil Probe Operation
- SOP No. 38 Methanol Preservation Sampling

3. Equipment

The following is an equipment list typical for well drilling and installation:

- Drill rig capable of installing wells of the desired diameter to the desired depth in the expected formation materials and conditions
- Well casing and well screen
- Bentonite pellets or chips
- Filter pack sand
- Portland Type I or II Cement and powdered bentonite for grouting
- Protective well casing with locking cap
- Appropriate decontamination supplies as specified in SOP No. 4 Decontamination

- Location map
- Plastic bags (Ziploc or similar)
- Self-adhesive labels
- Weighted tape measure
- Water level or Interface probe
- Deionized or distilled water
- Appropriate health and safety equipment as specified in the Health and Safety Plan (HASP)
- Field book
- Boring log sheets
- Well construction form
- Plastic sheeting, if necessary
- Roll-off box and/or drums for containment of cuttings and Decontamination and/or development water (if necessary).

4. Procedures

Decontamination

Between well installation locations, all drilling and installation equipment will be decontaminated according to the protocols listed in SOP No. 4 Decontamination.

Instrument Calibration

Before going into the field, the sampler shall verify that field instruments are operating properly. Refer to SOP No. 3 Calibration and Maintenance of Field Instruments, as well the manufacturer's instructions for more information.

Drilling and Well Installation Procedures

Drilling Technique

Boreholes will be advanced using drilling methods specified in the Work Plan or other project document and a drill rig capable of completing the monitor well(s) to the depth(s) specified in the Scope of Work. Before drilling, well locations will be numbered and staked. The necessary permits and utility clearances (SOP No. 5 Utility Clearance Procedures) will be obtained prior to commencement of drilling activities. Appropriate health and safety measures will be followed during drilling and well installation activities as specified in the Health and Safety Plan (HASP).

During the drilling operation, the cuttings from the boring will be containerized or placed directly onto the ground or on plastic. Refer to the project IDW Coordinator for additional information, guidance, and disposal.

Monitor Well Drilling Operations

The procedures for drilling are as follows:

- Set up drilling rig at staked and cleared borehole location.
- Record location, date, time and other pertinent information in the field book and on the boring log.
- Advance borehole of appropriate size using hollow-stem augers or similar. Refer to SOP No. 29 Soil Probe Operation if a Geoprobe® -style drilling rig is being used.
- Collect samples at the predetermined intervals, if appropriate, for sample description and/or chemical analysis as specified in the Work Plan. See SOP No. 17 Logging, SOP No. 28 Soil Sampling, and SOP No. 38 Methanol Preservation Sampling (Terra Core® sampler) for further instructions.
- Complete the borehole to the desired depth.

Well Design Specifications

The following general specifications will be:

Boring Diameter: The boring will be of sufficient diameter to allow for the accurate placement and proper installation of the screen, riser, filter pack, seal, and grout.

Well Casing: Well riser will consist of new threaded, flush joint, PVC or stainless steel. Well diameter and thickness will be determined prior to the start of work. Risers will extend approximately 2 to 3-feet above the ground surface for stick-up surface completions, or a sufficient depth below ground surface to accommodate an expandable well cap and lock with the flush-mount surface completion vault. The tops of all well casings will be fitted with expandable locking caps.

Well Screens: Screen length for each well will be project specific and determined prior to the start of work (typically 5 to 10 ft in length). Well screens will consist of new threaded, flush joint, PVC or stainless steel (depending on project requirements) pipe with factory-machine slots/ wrapped screen with an inside diameter equal to or greater than that of the well casing. The slot size will be designed to be compatible with aquifer and sand pack material and may vary on different projects. The schedule thickness of a PVC screen will be the same as that of the well casing. All screen bottoms will be fitted with a cap or plug of the same composition as the screen and should be within 0.5 feet from the open part of the screen. Traps or sumps may be used.

Well Installation Procedure

The following procedures will be initiated within 12 consecutive hours of boring completion for uncased holes or partially cased holes and within 48 consecutive hours for fully cased holes. Once installation has begun, no breaks in the installation procedure will be made if no unusual conditions are encountered until the well seal has been placed and hydrated.

The procedure for monitoring well installation is as follows:

1. Decontaminate all well materials according to SOP No. 4 Decontamination. Following decontamination, all personnel that handle the casing will don a clean pair of gloves.
2. Measure each section of casing, and screen, to nearest 0.01 feet.
3. Assemble screen and casing as it is lowered into the borehole.
4. Lower screen and casing to about 6 inches above the bottom of the boring.
5. Record the level of top of casing and calculate the screened interval. Adjust screen interval by raising assembly to desired interval if necessary and add sand to raise the bottom of the boring.
6. Calculate and record the volume of the filter pack, bentonite seal, and grout required for existing boring conditions.
7. Begin adding filter pack sand around the annulus of the casing a few feet at a time. Repeated depth soundings shall be taken to monitor the level of the sand.
8. Allow sufficient time for the filter sand to settle through the water column outside the casing before measuring the sand level.
9. Extend the filter pack sand to about 2 feet above the top of the well screen, unless otherwise specified for the scope of work.
10. Following sand filter pack placement in the shallow wells, install a minimum 2 feet thick seal of bentonite pellets or chips by slowly adding the pellets to avoid bridging. The thickness of the completed bentonite seal shall be measured before the pellets are allowed to swell. The completed bentonite seal shall be allowed to hydrate for a minimum of 20 minutes before proceeding with the grouting operations.

11. Grout the remaining annulus from the top of the bentonite seal to about 3 feet below the surface as measured after the augers are removed. The grout will be mixed and tremied into the borehole until the annulus is completely filled in accordance with procedures in SOP No. 12 Grouting Procedures. The base of the tremie pipe should be placed approximately 5 feet above the bentonite seal.
12. After the grout sets for 24 hours it will be checked for settlement. If necessary, additional grout or bentonite chips will be added to top off the annulus.
13. The proper protector, concrete pad and bollards, if required, will be installed according to specifications in this SOP. Bollards, and possibly the stick-up protective casing, will be painted a high visibility color.
14. AECOM personnel will clearly mark the well number at each location in some way.

Well Installation Specifications:

Filter Pack: The annular space around the well screen will be backfilled with clean, washed, silica sand sized to perform as a filter between the formation material and the well screen. The filter pack will extend about two feet above the screen and may be tremied into place. The final depth to the top of the filter pack will be measured directly using a weighted tape measure or rod and not by using volumetric calculation methods. The grain size of the filter pack will be shown on the well construction log.

Bentonite Seal and Grout: A minimum 2-feet thick bentonite pellet/chip seal will be placed in the annulus above the filter pack. The thickness of the seal may vary slightly based on site conditions. The thickness of the seal will be measured immediately after placement, without allowance for swelling. Bentonite slurry seals should have a thick batter-like consistency. Slurry seals will have a maximum placement thickness of 8 feet. High-solids bentonite or cement-bentonite grout will then be placed from the top of the bentonite seal to the ground surface. The cement grout will consist of a mixture of Portland cement (ASTM C150) and clean water as described in SOP No. 12 Grouting Procedures. The grout will be placed by pumping through a tremie pipe. The lower end of the tremie pipe will be kept within 5 feet of the top of the bentonite seal. Grout will be pumped through the tremie pipe until undiluted grout flows from the annular space at the ground surface. The tremie pipe will then be removed and more grout added to compensate for settling. After 24 hours, the drilling contractor will check the site for grout settlement and add more grout to fill any depression. This will be repeated until firm grout remains at the surface.

Protection of Well: AECOM personnel will, at all times during the progress of the work, take precautions to prevent tampering with the wells or entrance of foreign material into them. Upon completion of a well, a suitable cap will be installed to prevent foreign material from entering the well. The wells will be enclosed in a steel protective casing. Steel casings will be, at a minimum, 4-inches in diameter and will be provided with locking caps and locks. All locks will be keyed alike. If the well is to be a stickup a 1/4-inch drainage hole can be drilled in the protective steel casing centered approximately 1/8-inch above the internal mortar collar for drainage. The well designation will be painted or otherwise marked on the protective casing. Marking will be done prior to well development. A minimum 2-feet by 2-feet, 4 to 8-inch-thick concrete pad, sloped away from the well, should be constructed around the protective casing at the final ground level elevation. Three or four 2-inch-diameter or larger steel posts will be equally spaced around the well, for stick-up surface completions, and embedded in separate concrete filled holes just outside of the concrete pad. The protective steel posts should extend approximately 1 foot above the well riser. Any well that is to be temporarily removed from service or left incomplete due to delay in construction, will be capped with a watertight cap and equipped with a "vandal-proof" cover satisfying applicable state or local regulations or recommendations.

Once the well is installed and surface completion is finished, the new monitoring well will be developed and surveyed within 30 days. Refer to SOP No. 20 Well Development for additional information regarding development of a well.

5. Documentation

Observations and data acquired in the field during drilling and installation of wells will be recorded to provide a permanent record. A boring log will be completed for each boring according to the procedures outlined in SOP No. 17 Logging.

Additional documentation for well construction will be recorded in the field book according to SOP No. 8 Field Reporting and Documentation and will typically include the following:

- Date
- Time
- Personnel
- Weather
- Subcontractors
- Health and Safety monitoring equipment and readings

- Grout, sand, and bentonite volume calculations prior to well installation
- The quantity and composition of the grout, seals, and filter pack actually used during construction
- Screen slot size (in inches), slot configuration, outside diameter, nominal inside diameter, schedule/thickness, composition, and manufacturer
- Coupling/joint design and composition
- Protective casing composition and nominal inside diameter
- Start and completion dates
- Discussion of all procedures and any problems encountered during drilling and well construction.

In addition, the well installation details will be shown in a diagram which will be drawn in the field book. Each well diagram will consist of the following (denoted in order of decreasing depth from ground surface):

- Reference elevation for all depth measurements
- Project and site names
- Well number
- Date(s) of installation
- The depth at which the hole diameter changes (if appropriate)
- The depth of the static water level at the time of drilling and date of measurement(s)
- Total depth of completed well
- Depth of any grouting or sealing
- Nominal hole diameter(s)
- Amount of cement used for grouting or sealing
- Depth and type of well casing
- Description (to include length, internal, diameter, slot size, and material of well screen(s)
- Any sealing off of water-bearing strata
- Static water level upon completion of the well and after development

- Drilling date(s)
- Other construction details of monitoring well including grain size of well filter pack material and location of all seals and casing joints.

1. Objective

The purpose of this Standard Operating Procedure (SOP) is to define the standard procedure and typical equipment for sampling with the use a hydraulically advanced direct push GeoProbe® (or similar) to obtain representative subsurface soil samples for geologic logging and physical and chemical laboratory testing for Shell projects in Hartford and Roxana, Illinois.

2. Other SOPs Referenced within this SOP

- SOP No. 4 – Decontamination
- SOP No. 5 – Utility Clearance Procedures
- SOP No. 8 – Field Reporting and Documentation
- SOP No. 12 – Grouting Procedures
- SOP No. 17 – Logging
- SOP No. 28 – Soil Sampling

3. Equipment

The following equipment is typically used:

- Hydraulic percussion hammer Geoprobe® or similar rig
- Probe/sample rods (macro core or dual-tube)
- Acetate liners
- Liner caps
- Disposable sample retainers
- Photoionization detector (PID)
- Surveyor's stakes, pin flags, spray paint or similar
- Stainless steel knife and resealable plastic bags
- Sample containers
- Decontamination equipment
- Health and safety equipment
- Field data sheets

- Field book
- Waterproof or permanent ink pen
- Appropriate health and safety equipment as specified in the Health and Safety Plan (HASP)

4. Procedure

The general procedure for using the Geoprobe® equipment for sampling is as follows. Prior to sampling crews will begin monitoring breathing zone according to requirements in the project Health and Safety Plan (HASP). The specific soil probe operation procedures may vary slightly based on individual drilling subcontractors' procedures for soil probe operation.

A. Locate boring using facility drawings and/or site base map to check utilities. Refer to SOP No. 5 Utility Clearance Procedures.

B. Hydraulically push or drive probe rods with acetate sample liner, or dual tube system with acetate liner to the first sample depth.

C. Remove probe/inner rods and retrieve acetate liner. Visually log and classify the soil (SOP No. 17 Logging), select sample specimen, if necessary, for physical and/or chemical testing (SOP No. 28 Soil Sampling). Record information on field data sheets and/or in field book.

D. Decontaminate the sampler (SOP No. 4 Decontamination)

E. Replace sampler acetate liner with a new/clean liner.

F. Insert acetate sample liner and attached rods in exiting probe hole and push or drive sampler to the next sample depth, repeat sampling procedure.

G. Repeat Geoprobe® sampling until the target depth is reached.

H. Record total depth.

I. Retrieve probe rods.

J. Backfill probe hole with bentonite grout or similar as required by the work plan unless a monitoring well, piezometer, soil vapor probe or similar installation is to be completed (refer to appropriate SOP for an installed feature or SOP No.12 Grouting Procedures).

K. Place survey stake, pin flag, or similar at boring location.

L. Record data collected on boring log, or other field paperwork, and in field book (refer to SOP No 8. Field Reporting and Documentation).

M. Decontaminate equipment (SOP No. 4 Decontamination).

N. Perform equipment blank (EB) as needed

5. Decontamination

Refer to the HASP for exclusion zone setup and personnel decontamination guidance; refer to SOP No. 4 Decontamination for equipment decontamination procedures.

1. Objective

The purpose of this Standard Operating Procedure (SOP) is to define the standard procedure and typical equipment for collection of groundwater profiling samples within hydraulically advanced GeoProbe® (or similar) hollow drill rods and well screens using a peristaltic pump or ball and check valve for Shell projects in Hartford and Roxana, Illinois.

During groundwater profiling activities, groundwater samples are collected at predetermined intervals. Sampling intervals are specified in the scope of work for a specific project/task. In order to lessen drawdown within the hollow drill rods, a pump that minimizes disturbance to the groundwater is operated at the lowest possible flow rate. Purging is performed until specific parameters have stabilized over three consecutive flow-through cell volumes or until one hour of purge time has elapsed, whichever occurs first. Therefore, the groundwater samples collected are representative of the water bearing formation and hydraulically isolated from the water in the casing.

2. Other SOPs Referenced within this SOP

- SOP No. 3 – Calibration and Maintenance of Field Instruments
- SOP No. 4 – Decontamination
- SOP No. 5 – Utility Clearance Procedures
- SOP No. 8 – Field Reporting and Documentation
- SOP No. 10 – Well Gauging Measurements
- SOP No. 12 – Grouting Procedures
- SOP No. 18 – Low Flow Groundwater Purging and Sampling
- SOP No. 26 - Sample Control Custody

3. Equipment

Equipment typically used during well purging and sampling:

- Polyethylene tubing
- Ball and check valve
- Disposable latex or nitrile gloves
- Assorted tools (knife, screwdriver, etc.)
- Pump and required accessories (described in more detail in following section)

- Water level indicator and/or water/product interface probe with 0.01-foot increments
- Graduated cylinder, measuring cup or similar
- Water quality parameter instrument with necessary sensors
- Flow-through cell
- Calibration fluids
- Paper towels or Kimwipes
- Calculator
- Field book
- Groundwater Sampling Form
- Waterproof pen or permanent marker
- Plastic buckets with lids
- 55-gallon drums or truck-mounted tank
- Plastic sheeting
- Appropriate decontamination equipment (see SOP No. 4 Decontamination)
- Cooler with ice
- Sample containers and labels
- Chain-of-Custody form
- Appropriate health and safety equipment (e.g., photoionization detector (PID)).

4. Sampling Procedure

This section provides the step-by-step procedure for collecting groundwater profile samples in the field. Observations made during groundwater purging and sampling should be recorded in a field book in accordance with procedures described in SOP No. 8 Field Reporting and Documentation, and/or on field paperwork

A. Any reusable equipment used in the profile sampling procedure that could contact groundwater should be properly decontaminated before each use (see SOP No.4 Decontamination).

B. Equipment should be calibrated based on the manufacturers' instructions. Refer to SOP No. 3 Calibration and Maintenance of Field Instruments for more information.

C. Underground utilities at the location of each soil probe will be cleared prior to commencement of probing activities (SOP No. 5 Utility Clearance Procedures).

D. Following utility clearance, the sampler will be advanced to the predetermined depth and opened. A groundwater measurement of the water within the screen and rods will be collected to the nearest 1/100th of a foot (SOP No. 10 Well Gauging Measurements). Measurements will be recorded in the field book and on any pertinent field forms. The volume of water within the screen and rods will then be calculated.
(DTB - DTW) = WH (feet); (WH)*(πr^2) * 1gal/0.134cf=x gallons[1] within screen/rods

E. Following measurement of the static groundwater elevation, the appropriate equipment will be slowly and carefully placed in the rods. If the rods have light or dense non-aqueous-phase liquids (LNAPLs or DNAPLs) care should be taken to place sampling equipment below or above the NAPL respectively. When placing the tubing in the rods, the water intake (i.e., ball and check valve assembly) should be set near the middle or slightly above the middle of the screened interval. If the screen length allows, the water intake should be at least two feet from the bottom of the screen.[2]

F. Tubing should be connected from the pump to a flow-through cell. New tubing should be used for each profiling interval.

G. The pump should be started at a low flow rate, approximately 100 mL/min or the lowest flow rate possible. Refer to SOP No. 18 Low Flow Groundwater Purging and Sampling for additional low flow procedure information. The diameter of the rods and of the water level/interface probe may preclude the ability to check water levels during purging and sampling activities.

H. Allow water to flow through the flow-through cell. Parameter readings should be documented on the groundwater sampling form and/or in the logbook. The time between parameter measurements is calculated as follows.

$$T = \frac{V}{Q}$$, where

T = time between measurements (minutes)

[1] DTB = depth to bottom; DTW = depth to water; WH = water column height
[2] Placing the water intake near the top of the water column can cause stagnant water from the casing to be purged but placing the water intake near to the bottom of the well can cause mobilization and entrainment of settled solids from the bottom of the well.

V = volume of the flow-through cell (liters)

Q = purge flow rate (liters per minute)

I. In most cases, purging will continue until specific parameters have stabilized over three consecutive flow-through cell volumes. **Table 1** provides guidelines that may be used for parameter stabilization as specified by USEPA, ASTM, and in the Nielsen and Nielsen Technical Guidance on Low-Flow Purging and Sampling and Minimum-Purge Sampling (Nielsen and Nielsen, 2002). These guidelines are to be used in combination with professional judgment. **Table 2** provides the guidelines to be used for Roxana, WRR and Rand groundwater profiling activities. **Table 2** combines relevant stabilization guidelines from **Table 1** in combination with limitations in accuracy for readings collected by the YSI Pro DSS (typical low flow and groundwater profiling equipment used on the Rand and Roxana groundwater projects).

Table 1. Stabilization Guidelines for Low-Flow Sampling

Parameter	**Stabilization Guidelines**		
	EPA	**ASTM**	**Nielsen & Nielsen**
DO	+/- 10% or <0.5 mg/L	+/- 10% or +/-0.2 mg/L, whichever is greatest	+/- 10% or +/-0.2 mg/L, whichever is greatest
ORP	+/- 10 mV	+/- 20 mV	+/- 20 mV
PH	+/- 0.1 units	+/- 0.2 units	+/- 0.2 units
Conductivity	+/- 3%	+/- 3%	+/- 3%
Temperature	+/- 3%	Not Specified	+/- 0.2 ºC
Turbidity	+/- 10% or <5 NTU	Not Specified	Not Specified

Table 2. Stabilization Guidelines used for Rand, WRR and Roxana GW Sampling

Parameter	**Stabilization Guidelines** (using above standards combined with YSI Pro DSS, or similar accuracies)
DO	+/- 10% or +/-0.2 mg/L, whichever is greatest
ORP	+/- 20 mV
PH	+/- 0.2 units
Specific Conductivity	+/- 5% or +/-2µs/cm
Temperature	Not Specified; Monitor and record
Turbidity	Visually Sediment Free, when practical; Monitor and record

J. After the relevant parameters have stabilized or the required purging time has elapsed, the flow-through cell should be disconnected or bypassed for sampling. A new pair of disposable latex or nitrile gloves should be put on immediately before sampling. Samples will be collected by allowing the groundwater to flow from the tubing directly into the laboratory supplied containers. Do NOT allow the sample tubing to come into contact with the sample bottles, and do NOT place sample bottles on the ground (e.g., place bottles in a plastic tub or similar).

K. The constituents should be sampled for in the order given below:

- VOCs – Vials should be filled completely so that the water forms a convex meniscus, then capped so that no air space exists in the vial. Turn the vial over and tap it to check for bubbles. If air bubbles are observed in the sample vial, remove the lid and attempt to fill the vial two more times, (being careful not to dump out any groundwater currently in the vial). If air bubbles are present twice more, discard the sample vial and repeat the procedure with a new vial. If, after three attempts, air bubbles are still in the vial, make a note of this and place the vial in the cooler.
- Gas sensitive parameters (e.g., ferrous iron, methane, alkalinity)
- Semivolatile organic compounds
- Petroleum hydrocarbons
- Metals (unfiltered)
- Any filtered analytes (use in-line filters if possible).

L. Immediately place all samples on ice inside a cooler.

M. Each sample container should be identified with the Sample ID, location, requested method of analyis, preservatives, date and time of sampling event, and samplers' initials.

N. The sample time and constituents to be analyzed for should be recorded in the field book and/or on the groundwater sampling form.

O. Chain-of-custody procedures should be started (SOP No. 26 Sample Control and Custody Procedures).

P. Sample equipment should be decontaminated (SOP No. 4 Decontamination) or replaced as applicable.

Q. The rods/screen should then be advanced to the next predetermined profiling depth and the process of purging and sampling repeated.

R. Upon completion of each boring, the hole will be sealed with bentonite grout from the bottom up using the GeoProbe® rods as a tremie pipe and the surface will be returned to the original condition (SOP No. 12 Grouting Procedures). Purge water will be placed in 55-gallon drums (or similar) that are labeled, sealed, and staged at a pre-determined location on-site (refer to the IDW Coordinator for more information). The drill rig unit and rods will be decontaminated between profiling holes using a steam pressure washer or similar (SOP No. 4 Decontamination). Decontamination water will be containerized in 55-gallon drums (or similar) that are labeled, sealed, and staged at a predetermined location on-site (refer to the IDW Coordinator for more information).