Remedial Investigation Work Plan

Mayville PFAS Site
D907050
Village of Mayville
Chautauqua County

April 2025

Prepared by
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Region 9
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Work Plan Certification

I, Joshua M. Vaccaro certify that I am currently a NYS registered professional engineer and that this April 2025 Remedial Investigation Work Plan for the Mayville PFAS Site was prepared in accordance with all applicable statutes and regulations and in substantial conformance with the DER Technical Guidance for Site Investigation and Remediation (DER-10).

Joshua M. Vaccaro   April 30, 2025

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Acronyms and Abbreviations

AFFF	Aqueous Film Forming Foam
ASP	Analytical Services Protocol
ASTM	American Society for Testing and Materials
CAMP	Community Air Monitoring Plan
CCR	Construction Completion Report
COCs	constituents of concern
DER	Division of Environmental Remediation
DER-10	NYSDEC Technical Guidance for Site Investigation and Remediation
DO	Dissolved Oxygen
DPW	Department of Public Works
DUSRs	Data Usability Summary Reports
E&E	Ecology and Environment Engineering and Geology, P.C
EDDs	Electronic Data Deliverables
FAP	Field Activities Plan
FBGS	feet below ground surface
FWRIA	Fish and Wildlife Resource Impact Analysis
gpm	Gallons Per Minute
HASP	Health and Safety Plan
HDPE	High Density Polyethylene
ID	Inside Diameter
IDW	Investigation Derived Waste
I&R	Investigation and Remediation
IRM	Interim Remedial Measure
mL/min	Milliliter per minute
MS/MSD	Matrix Spike/Matrix Spike Duplicate
ng/L	Nanograms Per Liter
NTP	Notice to Proceed
NTUs	Nephelometric Turbidity Units
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
NYSDOT	New York State Department of Transportation
OU	Operable Unit
OD	Outer Diameter
ORP	Oxidation-Reduction Potential
PCBs	Polychlorinated Biphenyls
PFAS	Per- and Polyfluoroalkyl Substances
PID	Photoionization Detector
PFNA	Perfluorononanoic Acid
PFOA	Perfluorooctanoic Acid
PFOS	Perfluorooctanesulfonic Acid
PLS	Professional Land Surveyor

ppb	Parts Per Billion
ppt	Parts Per Trillion
PPE	Personal Protective Equipment
PVC	Poly-Vinyl Chloride
QAPP	Quality Assurance Project Plan
RI	Remedial Investigation
RIWP	Remedial Investigation Work Plan
SC	Site Characterization
SOW	Scope of Work
SPLP	Synthetic Precipitation Leaching Procedure
SVOCs	Semi-volatile Organic Compounds
TAL	Target Analyte List
TCL	Target Compound List
TCMB	Town of Chautauqua Municipal Building
TICs	Tentatively Identified Compounds
TOR	Top of Rock
TSOW	Technical Scope of Work
µg/kg	Micrograms Per Kilogram
USCS	Unified Soil Classification System
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
UUSCO	Unrestricted Use Soil Cleanup Objective
VOCs	Volatile Organic Compounds
WA	Work Assignment

1.0 Introduction

This workplan presents the Remedial Investigation (RI) activities to be performed at the Mayville PFAS Site (Site) located at 2 Academy Street, Mayville Chautauqua County, New York. The RI activities will be completed in accordance with New York State Department of Environmental Conservation (NYSDEC) Technical Guidance for Site Investigation and Remediation (DER-10). To complete the RI scope of work (SOW), NYSDEC has assigned Work Assignment (WA) No. D009807-35 Notice to Proceed (NTP) to Ecology and Environment Engineering and Geology, P.C. (E&E). NYSDEC has also retained the services of Labella Associates, Inc. (LaBella) through NYSDEC's standby Investigation and Remediation (I&R) contract (callout No. 152656). Laboratory analytical services will be performed by Eurofins Environment Testing Northeast, LLC using NYSDEC's standby lab contract (callout No. 152837).

The Site has been designated as a "D-site" which indicates that the site is a drinking water contamination site. *"D-Sites"* are limited in scope to *"drinking water contamination sites,"* defined under ECL 27-1201(3) as *"any area or site that is causing or substantially contributing to the contamination of one or more public drinking water supplies."* The Site has been assigned Site No. D907050 and spans throughout the Village of Mayville. The objective of the RI is to investigate environmental media (surface water, sediment, surface soil, subsurface soil, and groundwater) to determine the nature and extent of contamination caused by the historical use of aqueous film forming foam (AFFF) to fight flammable liquid fires. AFFF is known to contain per- and polyfluoroalkyl substances (PFAS) including the contaminant of primary concern at this site--perfluorononanoic acid (PFNA).

2.0 Site Description and History

The boundary of the Mayville PFAS Site (Site No. D907050) is approximately 15.6-acres and is located in the Village of Mayville, Chautauqua County (see Figure 1). The site encompasses three (3) tax parcels (262.06-1- 23.1, 262.06-1-23.2, and 262.06-1-23.3). The Site is comprised of an open field, a wooded area to the southwest, a parking lot, and one (1) structure containing the Chautauqua County Emergency Service Building. North of the site is the Chautauqua County Municipal Building and additional parking areas. Several residential properties are located directly adjacent to the Site, to the south and east. Nearby waterbodies include Mud Creek and Chautauqua Lake. Mud Creek is located approximately 0.5-miles to the southwest and Chautauqua Lake is 0.85-miles to the east. On the southwest portion of the Site, a drainage collection system exists below the open field. The extent of the drainage capture has still not been defined. On the south end of the Site, there is an outfall that discharges water from the drainage collection system. The discharge ultimately travels to a roadway ditch along Route 430 (West Chautauqua Street or Sherman-Mayville Road) and continues southwest in the direction of Mud Creek.

Although the boundary of the Site has been limited to three tax parcels, the investigation area expands outside the Site and throughout the Village of Mayville. Past investigations have occurred along Route 430, Patterson Street, Morris Street, and at Lakeside Park.

2.1 Operable Units

NYSDEC has divided the Site into three operable units (OUs) (see Figure 2). An operable unit represents a portion of a remedial program for a site that for technical or administrative reasons can be addressed separately to investigate, eliminate, or mitigate a release, threat of a release, or exposure pathway resulting from the site contamination.

- Operable Unit 01 (OU-01) corresponds to the remedial program located at 2 Academy Street in the Village of Mayville. OU-01 is comprised of three tax parcels totaling 15.6-acres.

- Operable Unit 02 (OU-02) corresponds to the downgradient areas located along Patterson Street. The extent of OU-02 has not been defined as further investigation is required.
- Operable Unit 03 (OU-03) corresponds to the areas located further downgradient along Morris Street. The extent of OU-03 has not been defined as further investigation is required.

Each of the OUs referenced above are identified on Figure 2.

2.2 Site Features and Use

Past investigations have referred to OU-01 as the Town of Chautauqua Municipal Building (TCMB) property. This OU contains a grass field, a wooded area to the east, and a small building. The building is actively used as an emergency response center, operated by Chautauqua County. The grass field is constructed of multiple tiers and was formally used as a football field. A natural gas line was recently identified within the investigation area. The line runs from a natural gas well located approximately 900-feet southeast of the TCMB and resurfaces on the south corner of the TCMB. The Upper Tier was filled in sometime in early 2000s with asphalt millings from a local highway project, historic boring logs indicate that the Upper Tier contains 16-feet of asphalt millings and other fill material. The Lower Tier of the former football field is known to contain a drainage system, presumed to be constructed of clay tile. Due to distressed vegetation identified in aerial imagery and non-uniform snow melt observed in the field, the extent of the system is expected to span the entire footprint of the lower field. Water collected by the system is conveyed to a discharge pipe located in the wooded area south of the Lower Tier. The investigation will take place on both the Upper and Lower Tiers of the former football field.

For investigation purposes, OU-02 is centered around Patterson Street and encompasses the Town of Chautauqua Highway Garage along with the wooded areas located north and south of Patterson Street. Previous investigations have referred to this area of investigation as Patterson Street investigation area, as Patterson Street extents through

OU-02. The Village of Mayville municipal Supply Well No. 3 is located within OU-02. The extent of OU-02 has not been defined at this time.

For investigation purposes, OU-03 is located the furthest downgradient from OU-01 and is closest in proximity to Chautauqua Lake. Previous investigations have referred to this area of investigation as Morris Street investigation area, as Morris Street extents through OU-03. Historic investigations in OU-03 have taken place at the Village of Mayville Department of Public Works (DPW) buildings located along Morris Street. Municipal Supply Wells No. 1 and the location of former Supply Well No. 2 are located within the extent of this OU. The extent of OU-03 has not been defined at this time.

A Figure displaying the investigation areas and the OUs as above referenced above can be found on Figure 2.

2.3 Site Background and Previous Investigations

In response to the elevated detections of PFNA in the municipal supply wells in the Village of Mayville, the NYSDEC initiated an investigation in December 2020 to identify potential source areas of PFNA. Tasks completed during the preliminary investigation included a site reconnaissance, interviews with locals and Village officials, the installation of six (6) monitoring wells, and the collection and analysis of samples from various environmental media (water supply wells, surface water, sediment, groundwater, and surface soils). The investigation within the Village of Mayville was previously sub-divided into six focus areas: Morris Street, Patterson Street, Mud Creek, the TCMB, Lakeside Park, and Maple Drive East. The TCMB and Lakeside Park locations were selected and investigated as potential source areas due to the reported use of firefighting foam at both locations.

As NYSDEC's investigation expanded, samples were collected in various phases. The initial phase occurred on December 15, 2020. During this event, groundwater samples were collected from all four (4) Village water supply wells and three (3) existing monitoring wells adjacent to the supply wells, and one (1) surface water sample was collected from Mud Creek near Morris Street. PFNA was detected in Supply Well 1 at a concentration of

280 nanograms per liter (ng/L, or parts per trillion [ppt]), in Supply Well 2 at 140 ppt, and in Supply Well 3 at 390 ppt. PFNA was not detected at Supply Well 4 or the existing monitoring wells adjacent to the supply wells. PFNA was detected at a low level (2.6 ppt) in the surface water sample collected from Mud Creek.

Since elevated levels of PFNA were detected in three of the four Village of Mayville public water supply wells, the New York State Department of Health (NYSDOH), in consultation with the Chautauqua County Department of Health and Village of Mayville officials, recommended that nearby private wells be evaluated to determine if they contained similar contamination. A coordinated effort between NYSDEC, NYSDOH, Chautauqua County Department of Health, and Village of Mayville officials resulted in the sampling of private wells located within the vicinity of the site. The samples were analyzed for six (6) of the most common per- and polyfluoroalkyl substances (PFAS) including PFNA, perfluorooctanesulfonic acid (PFOS), and perfluorooctanoic acid (PFOA). Results from the December 2020 sampling event indicated that PFNA contamination was not detected in the private wells. One additional private well along Sherman-Mayville Road (Route 430) was sampled in September 2021 and analyzed for a list of twenty-one (21) PFAS compounds; all results were non-detect.

A second phase of sampling occurred on January 7, 2021. Samples collected during this event included: two (2) additional groundwater samples from existing wells; three (3) surface water samples from Mud Creek near Morris Street, Sherman-Mayville Road, and Bloomer Road; surface water and sediment samples from the outfall of a subsurface drainage system at the TCMB; four (4) surface soil samples at the TCMB in an area where firefighting foam use was reported; and two (2) surface soil samples at Lakeside Park in an area where firefighting foam use was reported. PFNA was not detected in the groundwater samples from the two existing wells. Within Mud Creek (from upstream to downstream), PFNA was detected at a concentration of 0.28 ppt at the Bloomer Road sample location, it was not detected at the Sherman-Mayville Road sample location, and it was detected at a concentration of 1.6 ppt at the Morris Street sample location. The surface water sample from the TCMB outfall contained PFNA at a concentration of 6,300 ppt, in addition to having elevated concentrations of several other PFAS compounds; the collocated sediment sample at this location contained PFNA at a concentration of 8.2 micrograms per kilogram (µg/kg, or parts per billion [ppb]). PFNA concentrations in the surface soil samples collected at the TCMB ranged from 16 to 680 ppb and at Lakeside Park the concentrations ranged from 0.52 to 17 ppb.

A third phase of sampling occurred on January 12, 2021. Groundwater samples were collected from each of the six (6) new monitoring wells (MW-02 through MW-07) installed by NYSDEC in late December 2020/early January 2021 along Morris Street, Patterson Street, and the TCMB for the purposes of this investigation. PFNA concentrations were identified at the following locations: Morris Street up to 290 ppt (MW-03), Patterson Street up to 16 ppt (MW-04), and in the TCMB area up to 110,000 ppt (MW-07).

Significant concentrations of PFNA and other PFAS compounds, including PFOA, were detected in surface soil and groundwater samples from the former upper football field at the TCMB. This area had previously been used for fire training activities which included the use of AFFF foams. The outfall for the drainage system for the former football field on the Lower Tier at the TCMB also displayed elevated levels of PFNA and other PFAS compounds. A topographic map displaying the Village of Mayville is presented on Figure 1. As shown in Figure 1, a northwest to southeast trending topographic ridge, underlain by a bedrock ridge, is in the vicinity of North Erie/South Erie Street (Route 394). The TCMB source area appears to be located on the southwestern flank of this ridge and groundwater flow from the source area is likely to the southwest to south, towards Supply Wells 1 through 3. Supply Well 4 is located on the northeastern flank of this topographic/bedrock ridge. The sample results from Supply Well 4, along with an evaluation of the local topography and geology, indicate that there is likely a drainage divide between Supply Well 4 and the TCMB source area. Based upon current data, the source of PFNA at the TCMB does not appear to represent a potential threat to Supply Well 4.

NYSDEC conducted follow-up sampling events in March and April 2021. On March 11, 2021, a total of five (5) surface water samples were collected from surface drainages and groundwater seeps in the TCMB, Patterson Street, and Route 430 (Sherman-Mayville Road) areas to evaluate potential contaminant migration pathways from the former football field at the TCMB. Of the five (5) samples collected, two (2) samples displayed elevated concentrations of PFAS compounds. The outfall for the drainage system for the former football field on the Lower Tier at the TCMB, which was previously sampled on January 7, 2021, again displayed elevated levels of PFAS along with a surface water sample collected from the drainage ditch along the south side of Route 430. On April 14, 2021, five (5) samples of AFFF concentrates provided by the Chautauqua County Office of Emergency Services (4 samples) and the Village of Mayville Fire Department (1 sample) were submitted for laboratory Total Oxidizable Precursor (TOP) assay analysis to evaluate the properties of products that may have been used for fire training exercises at the TCMB.

In August 2021, NYSDEC initiated Phase I of a Supplemental Investigation to further characterize the PFAS contamination in the Village of Mayville. The investigation was conducted from August 23 to August 27, 2021, by personnel from NYSDEC and LiRo Engineers, Inc. (LiRo). Groundwater samples were again collected from the Village supply wells and all existing groundwater monitoring wells to re-assess groundwater conditions in the Village of Mayville. Three (3) surface water and four (4) sediment samples were collected at the TCMB outfall, the drainage rill in the woods just downstream of the TCMB outfall, and the drainage ditch located along the south side of Route 430 to further evaluate surface water contaminant migration pathways and impacts to drainage sediments. At the TCMB, forty (40) additional surface soil samples were collected in a gridded pattern across the area where AFFF foam was reportedly sprayed during training exercises at the former upper football field. At Lakeside Park, fifteen (15) additional surface soil samples were collected in areas where AFFF or training foams may have been sprayed. Following the collection of the samples, the sample locations were surveyed by a licensed surveyor.

Between February and June 2023, personnel from LiRo set up a datalogger at the discharge pipe located at the TCMB. The datalogger quantified flow volumes and measured the duration of the peak flow events over the course of four months. Data collected from this exercise is presented in the July 14, 2023, Letter Report titled *TCMB Field Drainage Discharge Pipe - Flow Monitoring*.

In September 2023, LiRo personnel collected groundwater samples from MW-1 through MW-7 and TW-2 and water samples from Mayville Supply Wells 1, 3, and 4 (sample IDs: SW-1A [before GAC treatment], SW-1B [after GAC treatment], SW-3, and SW-4) for PFAS analysis by Draft Method 1633.

In November 2023, LiRo personnel collected 20 additional surface soil samples at the TCMB and eleven additional surface water samples and 7 additional sediment samples starting at the TCMB outfall and continuing southwest along Route 430 to Mud Creek. Surface water and sediment samples were generally collected at each location; however, the roadside drainage channels along the sides of Route 430 northeast of Patterson Street are concrete-lined and no sediment was present for collection at 4 sampling locations. A surface water sample was also collected from Mud Creek near Morris Street.

During the November 2023 sampling along Route 430, NYSDEC personnel had a discussion with a local resident who had been a member of the Mayville Fire Department for several years. He revealed that the Fire Department may have disposed of some off-specification containers of AFFF concentrate about 20 years ago behind the Town of Chautauqua Highway Department buildings on 50 Patterson Street; the supplier reportedly told them that it would degrade over time. He also noted that the Fire Department had performed training with fire-fighting foam around a former pond located south of the Highway Department buildings (the pond shows up on aerial photos going back to at least 1994 but was filled-in circa 2016). These potential AFFF release areas are ~2000 feet upgradient of the Mayville Water Supply Wells on Morris Street and warrant further investigation as potential PFAS sources.

2.4 Site Topography and Surface Water Flow

Mayville, New York is located in the Cattaraugus Hills Section of the Allegheny Plateau Region of New York State, which is the northernmost portion of the Appalachian Plateau Physiographic Province (NYSDOT 2013). The landscape is characterized by relatively flat-topped to rounded uplands dissected by fluvial and glacial valleys. Glacial deposits are present along these flat-top ridges and along the sides of valleys and are easily discernible in topographic and shaded relief maps as drumlin fields, especially west and south of Mayville.

The Village of Mayville itself is located on the crest and flanks of a northwest-southeast trending hill that plunges into Chautauqua Lake at its southeastern edge. North Erie Street demarcates the longitudinal crest of the hill. The TCMB, located just to the southwest of North Erie Street on Academy Street presumably lies west of the drainage divide created by this hilltop, and any overland flow or drainage ditches would flow southwest towards the Mud Creek valley as, for example, along West Chautauqua Street. Supply Wells 1 through 3 are situated in the Mud Creek Valley located west of the village proper. Supply Well 4 is located north of the northeastern flank of the ridge.

The ground surface elevation drops significantly from the top of the ridge to the valleys on both sides of the ridge; approximately 120 feet on the northeastern side and 160 feet on the southwestern side. Located at the top of the ridge, the TCMB is approximately 0.35-mile to the north of Supply Well 3 on Patterson Street. The elevation difference between Supply Well 3, located near the eastern side of the Mud Creek Valley, and the TCMB is approximately 160 feet. Supply Well 3 is less than 0.5-mile to the northwest of Supply Wells 1 and 2 on Morris Street. Supply Wells 1 and 2 are near the center of the Mud Creek Valley and the elevation difference between Patterson Street and Morris Street is approximately 20 feet lower. A topographic contour map of the Village is provided on Figure 1.

The upper and lower tiers on TCMB property (OU-01) had previously been used for fire training activities which included the spraying of AFFF foams (see Figure 3 and also

Section 2.3). The outfall for the drainage system for the former football field on the lower tier at the TCMB also displayed elevated levels of PFNA and other PFAS compounds. Flow from the outfall has created a small drainage rill that flows to the south and enters a concrete-lined highway ditch located along the north side of Route 430 (West Chautauqua Street). The ditch transports the discharge from the former field southwestward towards Bloomer Road/Patterson Street. The surface drainage enters an underground drainage structure before reaching Bloomer Road/Patterson Street. The location of where the drainage then flows was not identified during previous site visits, but it is believed to flow southward under West Chautauqua Street toward Patterson Street. Further evaluation of the drainage flow will be conducted during future site visits.

Historic atlases from 1867 and 1881 display a former “Mill Race” that originated in the vicinity of West Chautauqua Street and Bloomer Road and extended through the Village southeastward to mills located near the intersection of Erie and Water Streets, directly on Chautauqua Lake. The mill race appears to have been located near the current location of Patterson Street and was reportedly filled sometime subsequent to 1881. The former mill race could be a potential migration pathway for surface water originating at the TCMB.

2.5 Regional Geology and Local Geology

The geology of the Mayville area is complex due to variations in glacial deposits and the topography of the underlying bedrock. Bedrock geology across the area is primarily shale and siltstones. The Geologic Map of the State of New York (Rickard and Fischer 1970) indicates that bedrock at the site is the Devonian Conneaut Group, which is further subdivided into the Ellicott and Dexterville Formations. The contact between the Ellicott and Dexterville members crops out in the Chautauqua Gorge at 1,380 to 1,400 feet above mean sea level (ft amsl), making the Ellicott formation the likely candidate for the underlying bedrock on the hill in Mayville and Dexterville the plausible underlying formation beneath the Mud Creek valley sediments (Baird and Lash 1990).

The bedrock ridge where the Village of Mayville is located is mantled by a thin layer of glacial till. The glacial till across the site consists of unconsolidated geologic deposits which extend out into Chautauqua Lake.

The Mud Creek valley is an alluvial plain dissected by the meandering Mud Creek, which flows from northwest to southeast and discharges into Chautauqua Lake just south of Lakeside Park. The surface sediments in the Mud Creek Valley are post-glacial lacustrine and fluvial deposits. These units are interpreted to be the top 10 to 15 feet of sandy silt material in historical boring logs.

The underlying stratigraphic sequence of the Mud Creek Valley includes a series of outwash deposits interspersed within thicker sequences of glacial till and glaciolacustrine (glacial lake) deposits above bedrock. The outwash units are comprised of poorly sorted (well-graded) sands and gravels and are the primary water-bearing zones in overburden throughout the Mud Creek Valley. These zones appear discontinuous in cross-section due to their channelized geometry and possible erosion by successive glacial advances. In three dimensions these zones may be more continuous than depicted in cross-section. Two of these channels or stringers are intercepted by the screened or open intervals of Supply Wells 1 through 3.

The measured depth to bedrock along the northwest-southeast axis of the Mud Creek valley ranges on the order of greater than 100 fbgs. Specifically, deeper wells located less than ¼-mile to the southwest and southeast of Supply Wells 1 and 2 had depths of 130.6 fbgs (a nearby Farm Well) and 120 fbgs (North Chautauqua Lake Sewer District Well) to shale bedrock. The depth to shale bedrock at a private water supply well ~1/2-mile to the west-southwest of Supply Well 3 (nearer to the center of the Mud Creek Valley) was 160.5 fbgs.

2.6 Hydrogeology

It is assumed that the general shallow groundwater flow in the Mud Creek Valley is downslope and toward Mud Creek, with eventual discharge to Chautauqua Lake. However, the water-bearing units tapped by the Supply Wells are all confined or semi-confined and may vary from this assumption. According to the Wellhead Protection

Program (WHPP), static water levels collected in 1992 from Well 1 and from five monitoring wells (MW-1, TW-2-92, TW-3-92, TW-4-92, and TW-5-92) in the semi-confined unit where Well 1 is located, indicated a southeasterly flow direction and a potentiometric surface gradient of approximately 0.003 foot/foot (Chautauqua County Department of Health 1996).

Six (6) monitoring wells (MW-2 through MW-7) were installed by the NYSDEC within the Village of Mayville. Depth to groundwater in these wells ranged from artesian (MW-2 at Morris Street, near Supply Wells 1 and 2) to 9.5 fbgs (MW-4 at Patterson Street, adjacent to Supply Well 3). Due to the scale of this investigation, groundwater flow varies based on location. Groundwater elevation data is not yet available for analysis since the survey of the monitoring wells is pending.

Well 3 is screened in a deeper zone of sand and gravel that is approximately 18 feet thick below a confining or leaky confining layer, and above bedrock, which was assumed to be a no-flow boundary in the WHPP. At test well TW-1, located approximately 300 feet east of Supply Well 3, the water-producing sand and gravel unit thins and is encountered at a depth of 52 to 58 fbgs (6 feet thick), with bedrock encountered at 62 fbgs. At new monitoring well MW-5, located approximately 650 feet southwest of Supply Well 3, water-bearing sand and gravel units were encountered at depths of 4.5 to 14 fbgs, 30 to 37 fbgs, and 49 to 58 fbgs, the deepest of which is interpreted to be laterally continuous with the unit intercepted by Well 3.

Groundwater on the Lower Tier at the TCMB is drained by a system of drainage tile that discharges from a 16-inch diameter corrugated galvanized-steel pipe into the wooded area located southwest of the southern corner of the former field and ultimately into the drainage ditch along West Chautauqua Street as discussed previously.

At the TCMB in MW-6, the soil column was largely unsaturated at the time of installation; however, groundwater was measured at a depth of 5.5 fbgs in the well once installed. At MW-7, the soil column was also unsaturated except in shallow fill where some water was present, and the well was screened more deeply than this saturated interval. The depth to water was 9.7 fbgs after well installation. Based on similarities to other upland sites in Western New York, the primary zone of groundwater flow in a shallow sequence of till is often at the overburden-bedrock interface, with groundwater flow direction following the topographic gradient. Boring logs and well construction diagrams for the wells noted above, and other wells in the project areas, are provided in Appendix F.

The measured depth to bedrock along the northwest-southeast axis of the Mud Creek valley ranges on the order of approximately 100 to 200 fbgs based on two well logs. At the eastern margin of the valley, near the base of the hill in Mayville, bedrock is shallower at a depth of approximately 60 fbgs.

Boring logs in the Mud Creek Valley indicate a sequency of glacio-fluvial outwash deposits interspersed within thicker sequences of glacial till above bedrock. The outwash layers and channels are the primary water-bearing zones intercepted by the production wells. Overlying this sequence are post-glacial lacustrine and fluvial deposits. This unit is present in boring logs from wells throughout the Mud Creek Valley and is interpreted to be the top 10 to 15 feet of sandy silt material in the stratigraphic sequence.

Glacial Outwash channels and stringers comprised of poorly sorted (well-graded) sands and gravels are the primary water-bearing zones in overburden throughout the Mud Creek valley. These zones appear discontinuous in cross-section due to their channelized geometry and possible intermittent erosion by successive glacial advances. According to the Wellhead Protection Program (WHPP), Wells 1 and 2 are installed in zone of sand and gravel that is approximately 5 feet thick and artesian (Chautauqua County Department of Health 1996).

No recent water level dataset is available for the overburden in the Mud Creek valley. According to the WHPP, static water levels were collected from five monitoring wells and Well 1 in 1992 and indicated a southeasterly flow direction and a potentiometric surface gradient of approximately 0.003 foot/foot.

3.0 Remedial Investigation Activities

RI field activities will be comprised of a soil boring investigation, a groundwater investigation, and a site survey. The primary objectives for the RI are to further delineate the known source areas, evaluate other potential sources areas, assess contaminant migration, develop an understanding of subsurface geology and local hydrogeology, and to refine the nature and extent of contamination throughout the Village of Mayville.

The RI is expected to take 6 months to complete, depending upon the weather. Following field activities, the data collected will be assessed to determine if further investigation is warranted. The results of the RI and any supplemental investigation will be presented in a RI Report. Given the scale of the proposed RI, the investigation will be parsed out into phases. Detailed below are the anticipated phases of the RI:

- Phase I – Soil Boring Program (OU-01 and OU-02)
- Phase II - Overburden and Bedrock Well Installation (OU-01)
- Phase III - Overburden Well Installation (OU-02 and OU-03)
- Phase IV – Well Development
- Phase V - Groundwater Sampling

Prior to outlining the proposed RI work, general items applicable to the RI activities will be completed and prepared. These activities include:

- A site-specific Health and Safety Plan (HASP) will be prepared for the investigation activities based on the generic HASP and site-specific HASP template.
- A CAMP will be implemented during all ground intrusive activities in accordance with DER-10 Appendix 1A NYSDOH Generic CAMP. The CAMP will include real-time monitoring for volatile organic compounds (VOCs) and particulates (i.e., dust) at one upwind and one downwind perimeter location during ground intrusive

activities. The CAMP will be implemented by LaBella field staff overseeing investigation activities.

- Investigation activities, including sample collection and analysis, will be completed in accordance with NYSDEC DER-10, Guidelines for Sampling and Analysis of PFAS under NYSDEC's Part 375 Programs, the HASP, CAMP, Field Activities Plan (FAP), and Quality Assurance Project Plan (QAPP).
- Unless noted otherwise, environmental samples collected will be submitted for laboratory for analysis of PFAS (40 compound list) by United States Environmental Protection Agency (USEPA) Method 1633.
- The detection limits for PFAS compounds will be accordance with the *April 2023 Sampling, Analysis, and Assessment of PFAS Under NYSDEC's Part 375 Remedial Programs* (Aqueous – 2 ng/L; Solids – 0.5 µg/kg).
- In addition to the environmental sampling described below, quality control samples consisting of field duplicate and matrix spike/matrix spike duplicate (MS/MSD) samples will be collected in accordance with the QAPP (i.e., at a frequency of one per 20 sample matrix). Additionally, equipment blanks will be collected for analysis of PFAS in accordance with the QAPP (i.e., at a frequency of one per piece of non-dedicated sampling equipment per 20 samples).
- The laboratory will provide NYSDEC Category B data deliverable packages (as described in DER-10) for PFAS analyses and any environmental assessment samples collected. Category A deliverables will be provided for waste characterization parameters. Data Usability Summary Reports (DUSRs) for the analytical results, except for any waste characterization analyses, will be prepared. The DUSR will provide an evaluation of analytical data with the primary objective of determining whether or not the data, as presented, satisfies the project specific criteria for data quality and use. Electronic Data Deliverables (EDDs) in EQuIS format will be submitted to NYSDEC and the results will be presented in the RI Reports.

3.1 Utility Clearance

Prior to intrusive activities, UDig NY (Call 811) will be contacted by LaBella a minimum of three business days in advance of the work. Any subsurface utilities/structures/anomalies will be identified on the ground surface with spray paint and/or pin flags. Any soil boring and monitoring well repositioning required due to identified subsurface utilities/structures/anomalies will be discussed with the NYSDEC prior to subsurface advancement.

3.2 Community Air Monitoring Program

Community air monitoring requires real-time monitoring for VOCs and particulates (i.e., dust) at the downwind perimeter of each designated work area when certain activities are in progress at the site. The community air monitoring is not intended for use in establishing action levels for worker respiratory protection. Rather, its intent is to provide a measure of protection for the downwind community (i.e., off-site receptors including residences and businesses and on-site workers not directly involved with the subject work activities) from potential airborne contaminant releases as a direct result of investigative work activities. The Community Air Monitoring Plan provided in Appendix A specifies action levels which require increased monitoring, corrective actions to abate emissions, and/or work shutdown for the RI. NYSDEC and NYSDOH will be notified of monitoring results which exceed the action levels set by the CAMP, including the duration and actions taken in response to any such exceedance. These notifications will be provided to the NYSDEC and NYSDOH within one business day. CAMP data summaries will be sent to the NYSDEC and NYSDOH on a weekly basis and exceedances will be documented in Daily Field Reports.

3.3 Soil Boring Investigation

The soil investigation will assess the soil conditions at the TCMB (OU-01) and Patterson Street (OU-02) operable units. The soil boring investigation at the TCMB will further delineate the extent of subsurface soil contamination on the Upper Tier. To date there has been no subsurface soil investigation completed on the Lower Tier; during the RI the subsurface soil conditions of the Lower Tier will be evaluated. On Patterson Street, the RI will evaluate other potential source areas based on anecdotal accounts of AFFF releases. Proposed drilling locations for each OU are shown on Figures 4 and 5.

A total of 34 soil borings will be installed during the RI. Soil borings will be installed using the direct-push method to various depths depending on the area of investigation. Subsurface soils will primarily be collected using a dual-tube sampling system. At locations where refusal or difficult drilling conditions are encountered, boreholes will be advanced using 3.25-inch ID hollow-stem augers (HSAs) and the dual-tube sampling system will be used to collect the soil samples from undisturbed soil ahead of the HSAs.

Subsurface soil samples will be screened for indications of contamination (visual, olfactory, and photoionization detector (PID)) and characterized using the Unified Soil Classification System (USCS). Upon retrieval, each soil sample will be described for: percent recovery, soil type, color, moisture content, texture, grain size and shape, consistency, evidence of staining or other chemically related impacts, and any other relevant observations. Screening will be performed in approximate 4-foot intervals unless observations warrant deviation. All information pertaining to the borehole will be recorded on the boring field log.

Analytical samples will be collected at either 2-foot or 4-foot intervals depending on the investigation location.

2-Foot Sample Intervals:

- A composite sample will be collected over the entire 2-foot interval following screening.
- If sample recovery is less than 75%, changes to the sampling methodology will be discussed with the driller to improve recovery and resulting determination of sample intervals..
- If recovery remains insufficient, the field geologist may reduce the sample frequency with DEC approval.

- In the event recovery is less than 75% while resampling, the material generated from both runs may be combined to provide enough volume to collect an analytical sample.
- Following the second attempt, the next depth interval may be advanced.

4-Foot Sample Intervals:

- A 2-foot composite sample will be collected from the 4-foot run.
- The specific depth of the analytical sample will be selected based on any variations noted while logging the sample interval, including:
  - Any change in subsurface material;
  - The presence of water bearing zones; and
  - Visual and/or olfactory observations.
- If no variations are observed, an analytical sample will be composited from the middle 2-feet of the interval.

The sample frequency for each investigation location is detailed in the subsequent sections and on Table 1B.

Following sample collection at the TCMB, the depth to the top of bedrock will be confirmed (expected to be within 20 to 28 fbgs) for purposes of contouring the bedrock surface. Drill cuttings and any other investigation derived waste (IDW) will be managed in accordance with DER-10 3.3(e). Specifically, drill cuttings from soil borings will be placed in sealed New York State Department of Transportation (NYSDOT)-approved drums or roll-offs and labeled for subsequent characterization and disposal.

3.3.1 Soil Borings – TCMB Upper Tier (OU-01)

On the Upper Tier of the TCMB property (OU-01), continuous soil sampling will be completed at 16 boring locations. A natural gas line for the TCMB was recently identified within the investigation area of the Upper Tier. In effort to avoid utility strike, locations will terminate at a depth of 16 fbgs or whenever fill material is no longer identified. Select locations may be completed to top of rock (TOR), these locations will be determined in the field Based on the historic log for MW-7, the anticipated depth to the TOR is 27 fbgs. Additional footage has been incorporated into the drilling estimate to account for variation in depth to the TOR (estimate of 28 fbgs). Samples will be collected along a 50-foot grid as shown on Figure 4. Soil boring locations will be identified based on the coordinates of historic surface soil sample locations detailed on Table 5. A handheld GPS unit will be used to locate historic sample locations. If locations cannot be identified, best efforts will be made to locate the new sampling grid based on the existing location of MW-7 and other existing site features.

One composite sample will be collected at every 2-foot depth interval for each of the first 4 borings installed adjacent to the previously identified source area (surrounding MW-7); shown on Figure 4 as a green dashed circle. Outside the immediate vicinity of the source area, samples will be collected and analyzed every 4 feet for the remaining 12 sample locations. Details regarding analytical sample collection are specified in **Section 3.3, Soil Boring Investigation**. All samples will be analyzed for the 40-PFAS compound via USEPA Method 1633.

3.3.2 Soil Borings – TCMB Lower Tier (OU-01)

On the Lower Tier of the TCMB property (OU-01), continuous soil sampling will be completed at nine (9) boring locations to the TOR. Samples will be collected along a 120-foot grid as shown on Figure 2. Based on the historic log for MW-6, the anticipated depth to the TOR is 18.5 fbgs. Additional footage has been incorporated into the drilling estimate to account for variation to depth to TOR (estimate of 20 fbgs). Boring locations will be marked out prior to mobilization and will be selected to ensure underground utilities such as the drainage collection system and other utility lines are not encountered. Details regarding analytical sample collection are specified in **Section 3.3, Soil Boring Investigation**. One sample will be collected at every 4-foot depth interval and analyzed for the 40-PFAS compound via USEPA Method 1633.

3.3.3 Soil Borings – Patterson Street (OU-02)

On Patterson Street (OU-02), continuous soil sampling will be completed at nine (9) boring locations to a depth of 24 fbgs. Boring locations will be marked out prior to mobilization and will be selected within and around the vicinity of the suspected footprint of the former pond located south of the Patterson Street Highway Department Garage. The soil borings proposed along Patterson Street are shown on Figure 5. In the top 8 feet of each location, one sample will be collected from every 2-foot depth interval. From 8 to 24 fbgs, one sample will be collected from each 4-foot depth interval. Details regarding analytical sample collection are specified in **Section 3.3, Soil Boring Investigation**. All samples will be analyzed for the 40-PFAS compound via USEPA Method 1633.

3.3.4 Subsurface Soil Analysis

All samples collected from soil borings will be analyzed for the 40 PFAS compounds via USEPA Method 1633, with a reporting limit of 0.5 µg/kg. In addition, approximately 20% of subsurface soil locations will be submitted for the full suite analyses, including VOCs, semi-volatile organic compounds (SVOCs), Target Analyte List (TAL) metals, cyanide, polychlorinated biphenyls (PCBs), pesticides, herbicides, and 1,4-dioxane. Samples for the full suite of analyses will be selected in the field with bias towards areas of visual staining, elevated PID readings, presence of fill, etc. In the absence of physical indicators of potential contamination, samples for the full suite of analyses will be selected from locations and depth intervals at random.

En-core samplers, Terracore kits, or equivalent will be used to collect RI VOC soil samples in accordance with Method 5035. Remaining samples will be collected and placed into pre-cleaned laboratory provided sample bottles, cooled to 4ºC in the field, and transported under chain-of-custody command to a Pace (a NYSDOH Environmental Laboratory Approval Program (ELAP)-certified analytical laboratory). Soil samples will be analyzed in accordance with USEPA SW-846 methodology with equivalent NYSDEC Category B deliverables to allow for independent data usability assessment. Sampling protocols for PFAS in soil is further detailed in Appendix D.

3.3.5 Borehole Abandonment

If the boreholes can be fully advanced using direct push methods (i.e., the resultant boreholes are 2.25-inch diameter), borings will be backfilled using soil collected during advancement of the soil boring, or alternatively with bentonite chips. Where augers are advanced, each borehole will be tremie grouted using a cement/bentonite grout from the refusal depth to ground surface upon completion.

3.4 Groundwater Investigation

The groundwater investigation will be conducted across each of the operable units located throughout the Village of Mayville (see Figures 6, 7, and 8). In total, up to 32 overburden and three bedrock monitoring wells will be installed during the RI. Overburden monitoring wells will be installed in various zones depending on the subsurface conditions specific to the area of the investigation. The three bedrock wells will be installed at the TCMB (OU-01) and will be advanced 15 feet into competent rock. Monitoring wells will be used to assess groundwater flow and contaminant migration.

As part of the RI, groundwater samples will be collected for laboratory analysis from 45 wells. This includes eight existing overburden monitoring wells and municipal Supply Wells 1 and 3. Groundwater data will be used to assess groundwater conditions and to evaluate water quality throughout the Village of Mayville. Prior to sample collection, each of the newly installed monitoring wells will be developed. Monitoring well gauging, development, and groundwater sample collection details are discussed in the following sections.

3.4.1 Overburden Groundwater Investigation

Overburden wells will be installed at each operable unit including the TCMB (OU-01), Patterson Street (OU-02), and Morris Street (OU-03). In OUs -02 and -03, monitoring wells will be installed to screen various depths. The number of wells and anticipated screened intervals are detailed below.

TCMB – OU-01

Six overburden wells are planned for the investigation area of OU-01 (see Figure 6). Four wells are proposed on the Upper Tier and two wells on the Lower Tier. Based on the well construction for MW-7, reworked highway fill was identified to a depth of 16 fbgs, below which lie layers of silty sand, clayey silt and coarse gravel. Monitoring wells planned for the Upper Tier will be screened to capture the depth where water is first encountered previously identified at 6 fbgs and the silty sand layer identified at a depth of 16 to 20 fbgs. Dependent on field conditions, monitoring wells constructed on the upper tier may require 15-foot screens.

Based on the boring log for MW-6 and the change in elevation, the reworked highway fill is not present on the Lower Tier of the TCMB. As a result, the subsurface material of the Lower Tier is constructed of more native material and the depth to TOR is approximately 10-feet less than the Upper Tier. Overburden monitoring wells installed on the Lower Tier will be screened to straddle coarse angular gravel and sandy silt layers previously identified between 8 and 18 fbgs.

Patterson Street – OU-02

Twenty-two overburden monitoring wells are proposed across OU-02 (see Figure 7). Overburden wells installations will consist of shallow (12) and deep (10) co-located wells to assess the groundwater conditions at various depths. At the location of MW-4 and MW-5, deep wells were previously installed to a depth of around 67 fbgs. Under the scope of this RI, shallow wells will be installed adjacent to these locations. The newly installed shallow and deep well clusters will be located north of Route 430, north and south of Patterson Street, and south of the Town of Chautauqua Highway Garage. Subsurface stratigraphy will be sampled and logged for the deepest well of the paired clusters. The anticipated screened interval for the shallow wells is 30 to 40 fbgs, while the anticipated screened interval for the deep wells is a sand and gravel unit roughly 60 to 70 fbgs; however, screened intervals will be selected in the field based on the depths and types of subsurface materials encountered.

Morris Street – OU-03

Four overburden monitoring wells are proposed within OU-03 (see Figure 8). Both a shallow and deep overburden well are planned on the eastern side of OU-03, located in Pearl Gravit Memorial Park. The boring log from the closest monitoring well (MW-3) indicates that this well was screened from 30.5 to 40.5 fbgs. Subsurface stratigraphy will be sampled and logged for the deepest well of the paired cluster. The anticipated screened intervals for the shallow well and deep well in Gravit Memorial Park is 30 to 40 fbgs and 60 to 70 fbgs. The two remaining wells proposed for OU-03 will be installed adjacent to MW-03. The shallow overburden well will be installed with a screened interval of 5 to 15 fbgs and the deep overburden well will screen 60 to 70 fbgs. The specified screened intervals may be adjusted in the field based on the depth and type of subsurface material encountered.

3.4.2 Overburden Monitoring Well Installation

The monitoring wells will be installed using a truck-mounted rotary drilling rig equipped with 4.25-inch ID HSAs. All overburden wells will be constructed of 2-inch inside diameter (ID), threaded, Schedule 40 PVC with 10 to 15-foot 0.010-inch slot well screens. A sand pack will be placed a minimum of 1 foot above the screened interval of the well and a bentonite pellet or chip seal will be placed above the sand pack to within 2 feet of grade. Flush-mounted road boxes installed in concrete pads will be used at the ground surface to complete the wells and the surrounding surface will be restored to preexisting conditions. In circumstances where flush-mounted road boxes are not needed, steel stickup protective casings, along with protective bollards (if needed), will be installed in concrete pads to complete the wells and the surrounding surface will be restored to preexisting conditions. Prior to mobilization, locations will be assessed to determine accessibility and completion details. Each monitoring well cover will be labeled with the designated well ID.

3.4.3 Bedrock Groundwater Investigation

Three bedrock monitoring wells will be installed at the TCMB (OU-01). One bedrock well will be installed on the Upper Tier and two bedrock wells will be installed on the Lower Tier. Bedrock wells will be installed as specified below.

3.4.4 Bedrock Monitoring Well Installation

The three bedrock borings will be advanced using 6.25-inch hollow stem augers to the TOR. Once competent rock has been encountered, a diamond core bit will be advanced 5-feet into rock and the core will be collected. The borehole will then be reamed using a nominal 6-inch diameter roller bit to create a rock socket. A 4-inch inside diameter (ID) steel casing will be grouted into the rock socket to seal off the bedrock from the overburden. Grout will be installed in the annulus between the borehole and steel casing by means of a tremie-pipe to seal the casing. The grout material will consist of Type I Portland cement mixed with either a powdered or granular bentonite. The grout will be prepared in accordance with American Society for Testing and Materials (ASTM) Method D5092, such that approximately 3 to 5 pounds of bentonite is mixed with 6½ to 7 gallons of water per 94-pound sack of cement. After the grout has cured for a minimum of 24 hours, the boreholes will be advanced an additional 10 feet into competent rock using a HQ (3-7/8-inch diameter) wireline rock core barrel equipped with a diamond cutting bit. All bedrock wells will be left as open hole construction. If competent bedrock is not encountered, 2-inch PVC screens will be installed into the bedrock borehole.

The core barrel will be advanced in intervals or ‘runs’ of up to 5 feet in length. After each 5-foot run is complete, the core will be extracted from the borehole and placed into a wooden core box. The field geologist will photograph the core and log the core for:

- Length of rock recovered;
- Percent of the run recovered;
- Rock quality designation (RQD);
- Rock type;

- Evidence of weathering;
- Presence and orientation of fractures and voids; and
- Any visible or olfactory observations.

If fractures are found to contain any mobile product during drilling, measures will be taken to prevent the downward migration of the impacts. These measures may include backfilling the boring and drilling a new boring using telescoping casing techniques or over-drilling the boring and using telescoping casing techniques.

During the coring process it may be necessary to continuously circulate water to cool the diamond bit and to clear the drill cuttings from the borehole. Potable water for this task will be provided from a source that is sampled for PFAS prior to use. If necessary, the potable water will be transported to the drilling location by hose or support truck. Circulation water will be either lost to the formation or brought back to the ground surface via pumping and contained in a tub. At the conclusion of coring, water retained in the tub will be decanted into a drum to separate out the drilling mud. The remaining fluids will be containerized in drums for proper off-site disposal or treatment. Samples of rock core will not be collected for laboratory analysis. Bedrock well installation details, including core logs, and construction logs will be included in the RI Report.

Bedrock wells will be completed with flush-mounted road boxes in concrete pads at the ground surface and the surface conditions will be restored to preexisting conditions. Each monitoring well cover will be labeled with the designated well ID.

3.4.5 Monitoring Well Development

Newly installed monitoring wells will be developed after the grout seal has sufficiently cured. Development will be completed using a Waterra Pump to remove the fine-grained material which may have settled within the well, to remove water which may have been introduced during the drilling process, and to provide hydraulic communication with the surrounding formation. Dedicated HDPE tubing and equipment compatible for PFAS protocols will be used. Properly developing a monitoring well will ensure that a representative groundwater sample and water level measurements can be obtained.

Groundwater monitoring wells must be developed in accordance with ASTM D5521. Overburden monitoring wells shall be developed until the monitoring well has reached equilibrium and turbidity of the purge water is measured to 50 nephelometric turbidity units (NTUs) or less. Bedrock monitoring wells will be developed until at least three well volumes and the volume of water lost during drilling is removed. . Groundwater parameters will be measured and recorded prior to development, after removal of each well volume during development (at a minimum), and at the conclusion of development. Parameters will include turbidity, pH, temperature, specific conductance, oxidation-reduction potential (ORP), and dissolved oxygen (DO). Water levels will be measured prior to and at the conclusion of development. During well development, stability will be established as three consecutive readings as outlined below:

- water level;
- pH (± 0.1 pH units);
- temperature (±3% of measurement);
- turbidity (± 10% of measurement);
- DO (± 10% of measurement);
- ORP (±10mV); and
- specific conductance (± 3% of measurement).

If stability is not achieved, development will be considered complete and cease after the total volume removed exceeds three times the volume of lost water plus 5 standing well volumes.

3.4.6 Groundwater Sampling

No sooner than one week following well development, groundwater samples will be collected from the 9 existing and 35 newly installed monitoring wells. Prior to groundwater sampling, a round of water levels will be collected from all monitoring wells and from designated points along Mud Creek using an electronic water level meter. Water levels will be measured to the nearest 0.01 foot. Measurements will be collected based on a reference point marked on each well casing and the existing reference markers along Mud Creek. Wells will be gauged for total well depth and depth to water and recorded in the field logbook. Water level measurements will be used to prepare groundwater surface elevation contour maps.

Following water level measurements, field personnel will purge and sample monitoring wells using low-flow sampling techniques such as a peristaltic or bladder pump. Dedicated HDPE and silicone tubing and equipment compatible for PFAS protocols will be used. If the well yield is too low to support low-flow purging (i.e., the water level does not stabilize), then a minimum of three standing well volumes of water will be purged or the well will be purged dry using the pump or an HDPE bailer prior to sampling.

Prior to sample collection, groundwater will be purged from each well at a rate less than 500 milliliter per minute (mL/min) while maintaining a generally consistent water level. Groundwater sampled will be collected between 100 and 250 ml/min. Field measurements will be recorded for:

- water level (drawdown of no more than 0.3 feet);
- pH (± 0.1 pH units);
- temperature (± 3% of measurement);
- turbidity (± 10% of measurement);
- DO (± 10% of measurement);
- ORP (± 10mV); and
- specific conductance (± 3% of measurement).

Low-flow purging will be considered complete when field parameters stabilize and turbidity measurements fall below 50 NTU, or when continuous stable field parameters readings are obtained. Upon stabilization of field parameters, groundwater samples will be collected and analyzed.

Groundwater sampling methods will conform with protocol acceptable for the collection of PFAS samples as outlined in Appendix D. Sampling personnel will wear nitrile gloves while handling sample containers. Groundwater samples will also be collected from Supply Wells 1 and 3 prior to any treatment system. Samples will be collected from sampling spigots at each Supply Well in coordination with the local DPW.

3.4.7 Groundwater Analysis

All groundwater samples will be analyzed for the 40 PFAS compounds via USEPA Method 1633, with a reporting limit of 2 ng/L. In addition, approximately 20% of monitoring wells samples will be submitted for the full suite analyses, including VOCs, SVOCs, TAL metals, cyanide, polychlorinated biphenyls (PCBs), pesticides, herbicides, and 1,4-dioxane. A total of 9 full suite groundwater samples will be collected. Wells selected for full suite analysis will be selected in the field based on factors such as location, depth, and well yield and will be evenly distributed across the three operable units.

All groundwater samples will be collected and placed into pre-cleaned laboratory provided sample bottles, cooled to 4ºC in the field, and transported under chain-of-custody command to a NYSDOH ELAP-certified analytical laboratory.

3.5 Surface Water and Sediment Sampling

Up to 10 co-located surface water and sediment samples will be collected as part of the RI. Samples will be collected from various locations downgradient of the TCMB discharge, including directly downgradient of the TCMB discharge, along roadway ditches of Route 430, and from Mud Creek. Approximate locations are shown on Figure 9. Actual locations will be selected in the field with input from NYSDEC. Samples will be collected to assess downgradient contaminant distribution as a result of the surface discharge. Surface water and sediment samples will be submitted for analysis of PFAS via USEPA Method 1633. One QA/QC sample will be collected for each media. Sampling protocols for PFAS in surface waters and sediment is further detailed in Appendix D.

3.6 Outfall Water Quality Characterization Sampling

Water samples will be collected from the outfall pipe located at the southern end of the lower field in OU-01 to inform the design of an interim remedial measure (IRM) for water treatment. Sampling will be conducted at three separate times under varying flow conditions, preferably including low, average, and high flow. The exact timing and sequencing of sampling will be dependent on weather conditions. Samples collected at the outfall location will be submitted for laboratory analysis of water quality parameters that may impact treatment technology selection. Water samples will be submitted for laboratory analysis of VOCs, total organic carbon, alkalinity (total), chloride, anions, TAL metals, chromium (hexavalent), total suspended solids, total dissolved solids, oil & grease, pH, biological oxygen demand, ammonia, hardness, methylene blue active substances assay, and PFAS. Table 4 contains a summary of analytical methods to be used. At the time of collection, general water quality measurements, including temperature, pH, ORP, conductivity, turbidity, and dissolved oxygen will be measured using a suitable multiparameter water quality meter. Additionally, the flow rate will be measured using a timing device and suitable container (such as a 5-gallon bucket or larger as needed to estimate volume). The flow rate will be calculated using the volume collected during the recorded time interval. General water quality measurements and flow will be recorded and documented throughout each of the three sampling events

Collection of PFAS samples will be conducted in accordance with the NYSDEC's PFAS guidance (NYSDEC 2023) and any subsequent updates. QA/QC samples will not be collected for the general water chemistry samples. NYSDEC Category A laboratory deliverables are required for the general water chemistry parameters. NYSDEC Category B deliverables containing all data necessary to perform full data validation are required for the PFAS results.

3.7 Quality Assurance/Quality Control (QA/QC)

QA/QC procedures will be performed in accordance with DER-10. Specific activities that apply to the implementation of this sampling plan include, except where otherwise noted in this work plan:

- Collect field duplicates at a rate of 1 per 20 samples per matrix;
- Collect additional volume for matrix spike/matrix spike duplicate (MS/MSD) analysis at a rate of 1 per 20 samples per matrix;
- Collect at least one equipment rinsate blank daily from sampling equipment. Typically, one sample per matrix per day will be collected for all analyses performed on that matrix. Additional rinsate blanks will be collected for PFAS analysis to include dedicated sampling equipment such as sampling pump bladders, tubing, bailers, etc. Laboratory-supplied, analyte-free water will be used for rinsate blanks;
- Document all data and observations on field data sheets, electronic logs, and/or in the field logbooks;
- Operate and calibrate all field instruments in accordance with operating instructions as supplied by the manufacturer unless otherwise specified; and
- Ensure all laboratory deliverables are reviewed and validated by a qualified chemist prior to release.

3.8 Decontamination

Every attempt will be made to use dedicated sampling equipment during the RI. Dedicated HDPE will be used for each monitoring well. If non-dedicated equipment is required, the equipment will be decontaminated, at a minimum, with a non-phosphate detergent (i.e., Alconox®) and PFAS-free water mixture, rinsed with PFAS-free water, and air-dried before each use. All sources of water used for equipment decontamination should be verified in advance to be PFAS-free through laboratory analysis or certification. If a potable water source is to be used for equipment decontamination, collect one sample per source location and test for PFAS by USEPS method 1633. The sample(s) shall be collected from the container/tank that will be used to transport and store the water. All decontaminated sampling equipment will be kept in a clean environment prior to sample collection. Heavy equipment, such as an excavator (if used) and drilling tools, will be decontaminated by the subcontractor. Prior to arrival on-site drilling activities, the augers, rods, Macrocore, split spoons, and other pertinent equipment will be steam cleaned or washed with a non-phosphate detergent and water solution. This cleaning procedure will be used between each sample location. Steam cleaning activities will be performed in a designated on-site decontamination area. During and after the cleaning processes, direct contact between the equipment and the ground surface will be avoided. Plastic polyethylene sheeting and/or clean support structures (e.g., pallets, sawhorses) will be used.

3.9 Investigation Derived Wastes

IDW generated as a result of the RI activities will include soil, groundwater, and miscellaneous solid waste. The management of each waste stream is described below:

- Water generated during the RI, as a result of drilling activities, groundwater purge and development, and any water generated from decontamination (rinse and wash activities) will be containerized in NYSDOT approved 55-gallon drums or poly-tanks. Following the RI, IDW water will be characterized and treated on-site or taken off-site for disposal;
- Concrete, asphalt, and soil cuttings will be containerized in NYSDOT approved 55-gallon drums or lined and covered roll-offs for characterization and off-site disposal;
- For disposal purposes, waste generated during the investigation will be segregated based on investigation area. Materials generated from known and potential source areas will be managed separate from areas less likely to contain contaminant impacts; and
- Used personal protective equipment (PPE) and disposable sampling equipment will be bagged as regular refuse and disposed as solid waste, unless grossly contaminated.

All containerized materials will be clearly marked to indicate the contents of the containers, the date of collection, and the source of the material. Materials containerized for off-site disposal will be staged at a predetermined location agreed on with the NYSDEC and Site property owners. Disposal of IDW will be scheduled following the completion of the RI.

3.10 Waste Characterization

An estimated eight waste characterization samples will be collected during the investigation and analyzed for TCLP VOCs, TCLP SVOCs, TCLP metals, PFAS, PCBs, ignitability, corrosivity, and reactivity to fulfill landfill waste characterization requirements for disposal. Waste will be characterized separately based on investigation area and material type to determine final disposal arrangements.

3.11 Site Survey

A NYS-licensed land survey will be contracted by E&E to survey the sample locations and significant Site physical features. The surveyor will collect locations and elevations of monitoring wells and soil, surface water, and sediment sampling locations including elevations of adjacent ground surface, top of protective casing elevations, and top of polyvinyl chloride (PVC) riser elevations. Reference elevations for bedrock wells will be collected from the top of inner-steel casing. Horizontal coordinates shall be provided in NYS Plane West Zone (survey feet) using North American Datum of 1983 (NAD83) to a minimum accuracy of ±0.5 foot and in geographic Latitude/Longitude. Vertical elevations are to be provided in feet relative to the North American Vertical Datum of 1988 (NAVD88) to an accuracy of ±0.05 foot reported to 0.01 foot.

For the purpose of design of the IRM, the surveyor will also establish site control and identify the boundaries of the parcel, public rights-of-way, and roads associated with OU-01 parcel ID 262.06-1-23.1 (2 Academy Street). Pertinent property information such as municipality boundaries and property lines shall be located and marked as part of the boundary survey, in addition to key site features including the edge of pavement, sidewalks, approximate tree line, drainage features, etc. The surveyor shall also perform a topographic survey of an approximately 1.5-acre area of this parcel 6-inch contours. This data will be used for IRM site plans.

3.12 Fish and Wildlife Resource Impact Analysis

A Fish and Wildlife Resource Impact Analysis (FWRIA) will be conducted by E&E in accordance with NYSDEC DER-10 and the NYSDEC Guidance Document *"Fish and Wildlife Impact Analysis for Inactive Hazardous Waste Sites".* The scope of work for the FWRIA includes components associated with Step I of the FWRIA process, including wetland and waterbody delineations, ecological cover-type classification and mapping, evaluation of habitat quality and determination of complete ecological pathways and receptors (in coordination with the NYSDEC) through the comparison of site soils, sediments, surface water, and groundwater to ecological screening criteria. The results of this analysis will determine whether or not further evaluation is required for specific pathways and/or receptors in order to establish whether constituents of concern (COCs) at the Site may affect fish and wildlife resources.

If it is determined that further analysis is required based on this analysis and consultation with the NYSDEC and NYSDOH, additional scope and costs can be provided to complete criteria-specific and toxic analyses (Step II of the FWRIA Process), evaluate ecological effects of remedial alternatives (Step III), further delineate and determine fish and wildlife requirements for implementation of remedial actions (Step IV), and develop a monitoring program for the Site (Step V).

4.0 Remedial Investigation Reporting

Throughout the RI, daily field reports will be prepared by E&E and provided to the NYSDEC. The field reports will include a description of the tasks performed, any deviations from the work plan, and preliminary data such as boring logs, photographs, and purge logs. Well boring logs will be prepared by a licensed New York State Professional Geologist or a geologist-in-training eligible to become a Professional Geologist with a minimum of 10-years' experience as a geologist. On-site staff from E&E will prepare preliminary field logs and will provide the logs to the NYSDEC as they become available. At the completion of the RI field activities, the results of the investigation will be drafted into a RI Report. The RI report will include:

- Executive summary;
- Site background (including history and previous investigations;
- Descriptions of field activities performed;
- Text describing nature and extent of contamination, contaminant fate and transport, and comparison to appliable or relevant and appropriate requirements;
- Data tables presenting tabulated analytical data;
- Field observations, field measurements, and validated laboratory analytical data;
- Site figures including groundwater contours, cross-sections, and contaminant isopleth figures which present laboratory analytical data and field observations of overburden soil, bedrock cores, overburden and bedrock groundwater;
- Geologic profiles summarizing both field observations and laboratory results;
- Integration of field observations and measurements with laboratory analytical data to refine the site conceptual model;
- Qualitative Human Health Exposure Assessment (QHHEA), as required by DER-10 Appendix 3B; and
- Appendices to the reports will include all pertinent data used to support the RI efforts, including validated laboratory analytical results, stratigraphic boring logs, well construction diagrams, and all field well development and sampling sheets.

5.0 Project Schedule

The anticipated schedule for the RI is outlined on Figure 10. The RIWP was made available for public comment in February 2025. The field work will be scheduled during the second quarter of 2025 and will begin as soon as possible based on subcontractor availability and weather conditions. Due to the large scale of this investigation, careful planning and coordination of activities will have to be performed around operational logistics and constraints. Assumptions have been made in the schedule regarding the duration of the field activities.

The tentative start date for field work is April 28, 2025, and will be conducted on the following proposed schedule:

- May 2025 – Soil boring investigation in OU-1 and OU-2. This work is expected to take between 3 and 4 weeks depending on the drilling conditions and the methods ultimately employed.
- Late May - June 2025 – Overburden and bedrock well installations in OU-1. This work is expected to take approximately 2 weeks to complete.
- –June 2024 – Monitoring well installations in OU-2, and OU-3. This work is expected to take approximately 6 weeks to complete.
- June - July 2025 – Groundwater sampling event. This work is expected to take approximately 2 weeks to complete.

All drilling and sampling activities will be contingent upon property access restrictions, driller availability, and suitable weather conditions. Upon completion of the field work and receipt of all of the analytical samples the schedule for reporting is as follows:

- July 2025 – Data Tabulation and Validations
- August - September 2025 – RI Report Preparation and updates to Conceptual Site Model
- October 2025 – RI Report Review
- November 2025 – RI Report Finalization

6.0 References

Baird, G.C. and Lash, G.G. 1990. Devonian Strat and Paleoenvironments: Chautauqua County Region: New York State.

Chautauqua County Department of Health. 1996. *Chautauqua County Wellhead Projection Program Phase II: Delineation of Wellhead Protection Area,* November.

Ecology and Environment Engineering and Geology, P.C. (E & E). 2020a. *Master Quality Assurance Project Plan (QAPP) for New York State Department of Environmental Conservation Projects*, May 2020.

_________. 2020a. *Field Activities Plan (FAP) for the Division of Environmental Remediation Standby Engineering Services Contract D009807*, May 2020.

New York State Department of Environmental Conservation (NYSDEC). 2023. *Sampling, Analysis, and Assessment of Per- and Polyfluoroalkyl Substances (PFAS)*, April 2023.

_________. 2010. *DER-10, Technical Guidance for Site Investigation and Remediation*, May 2010.

New York State Department of Transportation (NYSDOT). 2013. *Geotechnical Design Manual, Office of Technical Servies, Geotechnical Engineering Bureau, Chapter 3, pp. 3-1 to 3-84*, June 17.

Rickard, L.V., and Fischer, D.W., 1970, The Geologic Map of the State of New York, New York State Museum and Science Service, March.

Figures

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Figure 5 Proposed Soil Borings (OU-02)
Figure 6 Proposed Monitoring Wells (OU-01)
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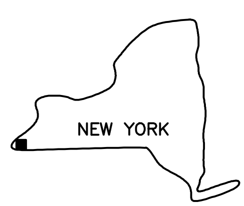
Figure 9 Proposed Surface Water and Sediment Sample Locations
Figure 10 Remedial Investigation Project Schedule

REFERENCE

7.5 MINUTE SERIES TOPOGRAPHIC QUADRANGLE
CHAUTAUQUA, NEW YORK, 2023
HARTFIELD, NEW YORK, 2023
SHERMAN, NEW YORK, 2023
WESTFIELD, NEW YORK, 2023

NEW YORK STATE | Department of Environmental Conservation



QUADRANGLE LOCATION

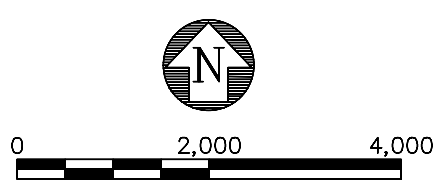


FIGURE 1 – SITE LOCATION
MAYVILLE PFAS INVESTIGATION
VILLAGE OF MAYVILLE, NEW YORK

Orthoimagery from New York State GIS Clearinghouse
accessed May 2024 (https://orthos.dhses.ny.gov/)

Prepared By:

ecology and environment engineering and geology, p.c.

Prepared For:

NEW YORK STATE Department of Environmental Conservation

Figure 2 - Operable Units and Existing Well Locations
Mayville PFAS Site
Mayville, New York

Orthoimagery from New York State GIS Clearinghouse
accessed May 2024 (https://orthos.dhses.ny.gov/)

Legend

Existing Monitoring Wells

Approximate Operable Unit Boundary

Scale in Feet

0 100 200

N

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New York State Department of Environmental Conservation

Figure 3 - Town of Chautauqua Municipal Building (OU-1)
Mayville PFAS Site
Mayville, New York

Orthoimagery from New York State GIS Clearinghouse
accessed May 2024 (https://orthos.dhses.ny.gov/)

Legend

- Existing Overburden Wells
- Historical Surface Soil Sampling Locations
- Proposed Soil Borings

Scale in Feet

0 50 100 150 200

N

Notes

1) Green circle delimits proposed soil borings with 2-foot sampling interval frequency.
2) Best attempts will be made to co-locate the proposed soil boring locations in the Upper Tier with historical surface sample locations.

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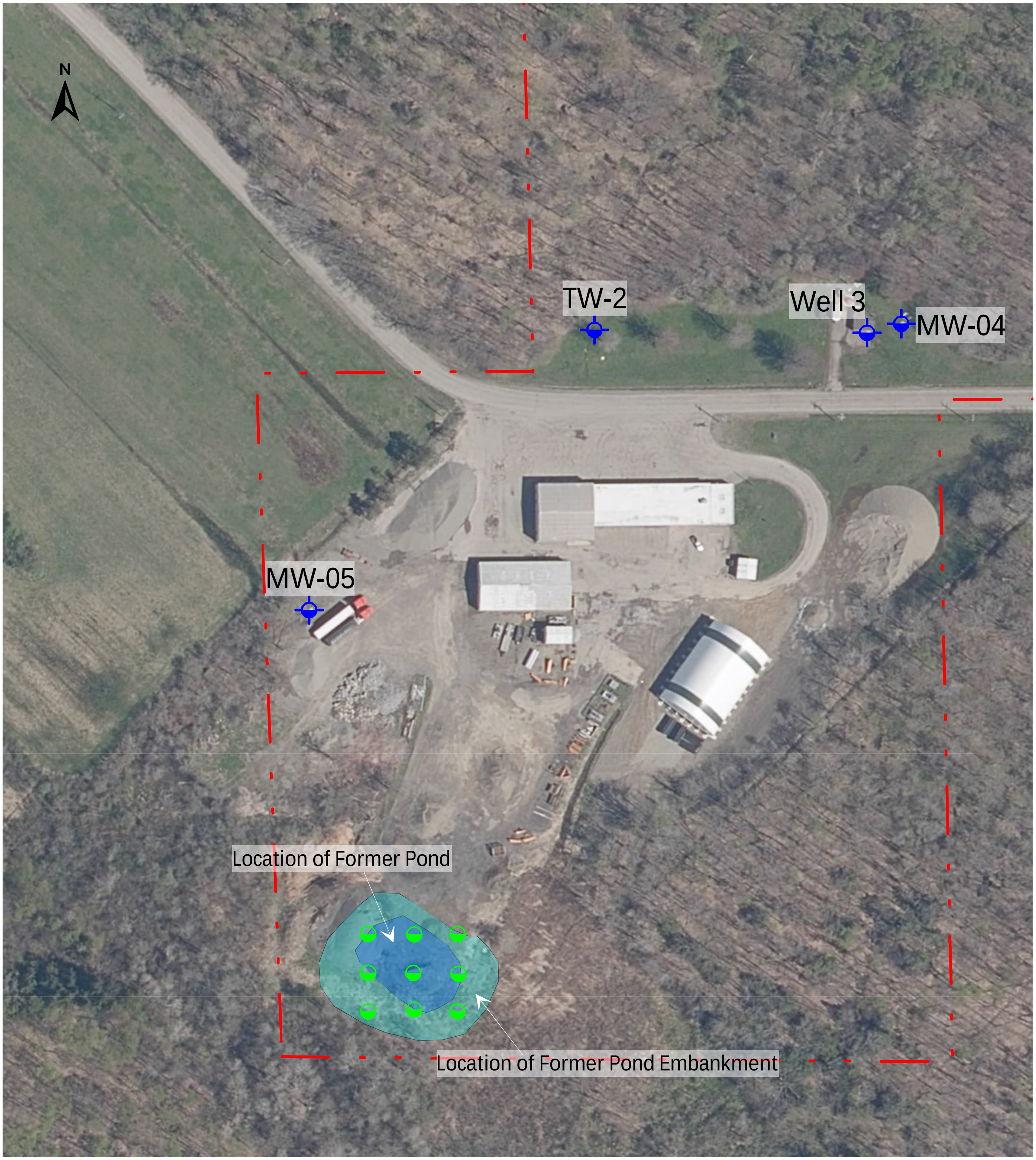
Figure 4 - Proposed Soil Borings (OU-1)
Mayville PFAS Site
Mayville, New York



Orthoimagery from New York State GIS Clearinghouse
accessed May 2024 (https://orthos.dhses.ny.gov/)

Legend

Existing Wells

Proposed Soil Borings

Approximate Operable Unit Boundary

Scale in Feet

0 50 100 150 200

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ecology and environment
engineering and geology, p.c.

Prepared For:

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Figure 5 - Proposed Soil Borings (OU-2)
Mayville PFAS Site
Mayville, New York

Orthoimagery from New York State GIS Clearinghouse
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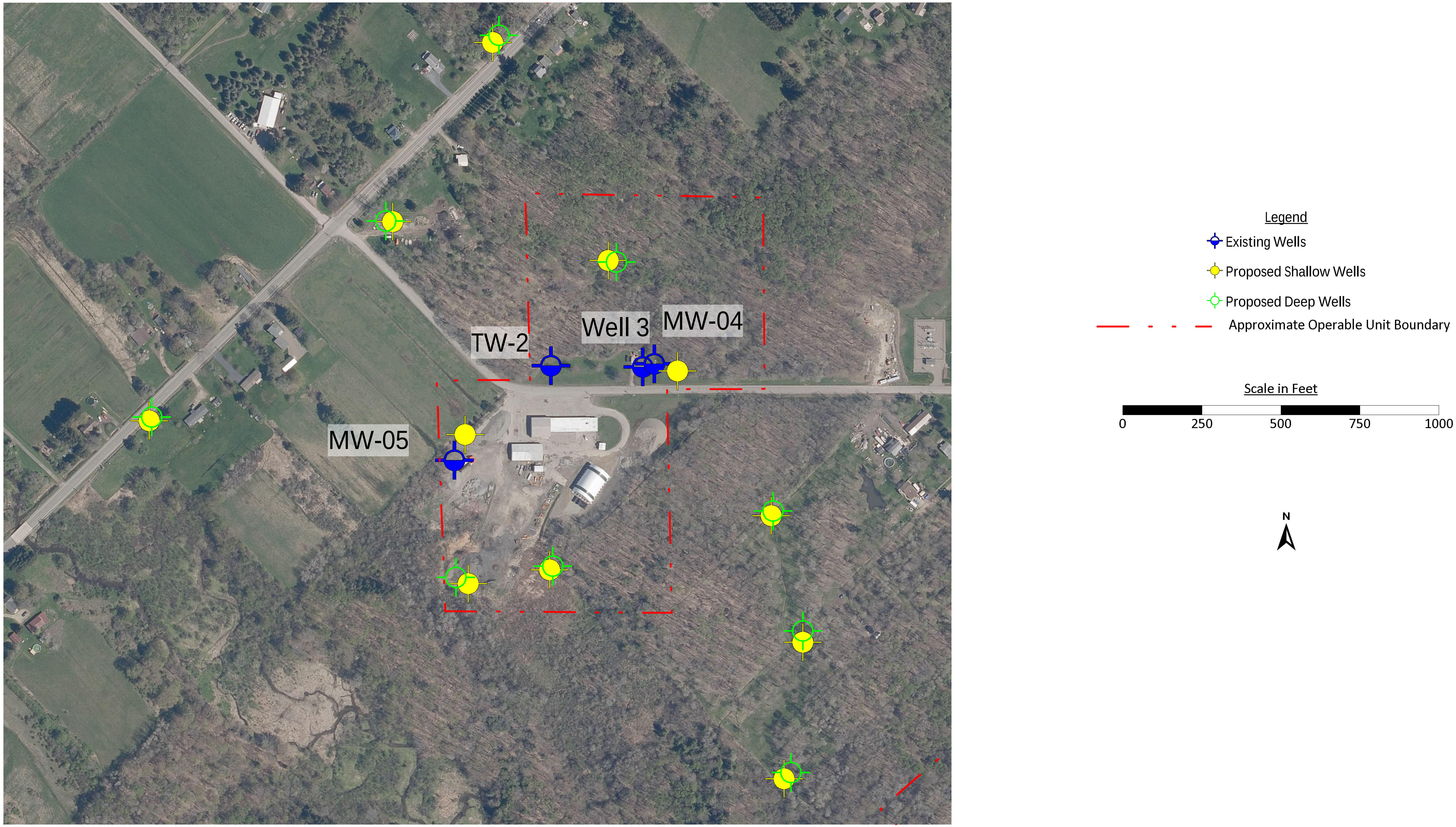
Figure 6 - Proposed Monitoring Wells (OU-1)
Mayville PFAS Site
Mayville, New York



Orthoimagery from New York State GIS Clearinghouse accessed May 2024 (https://orthos.dhses.ny.gov/)

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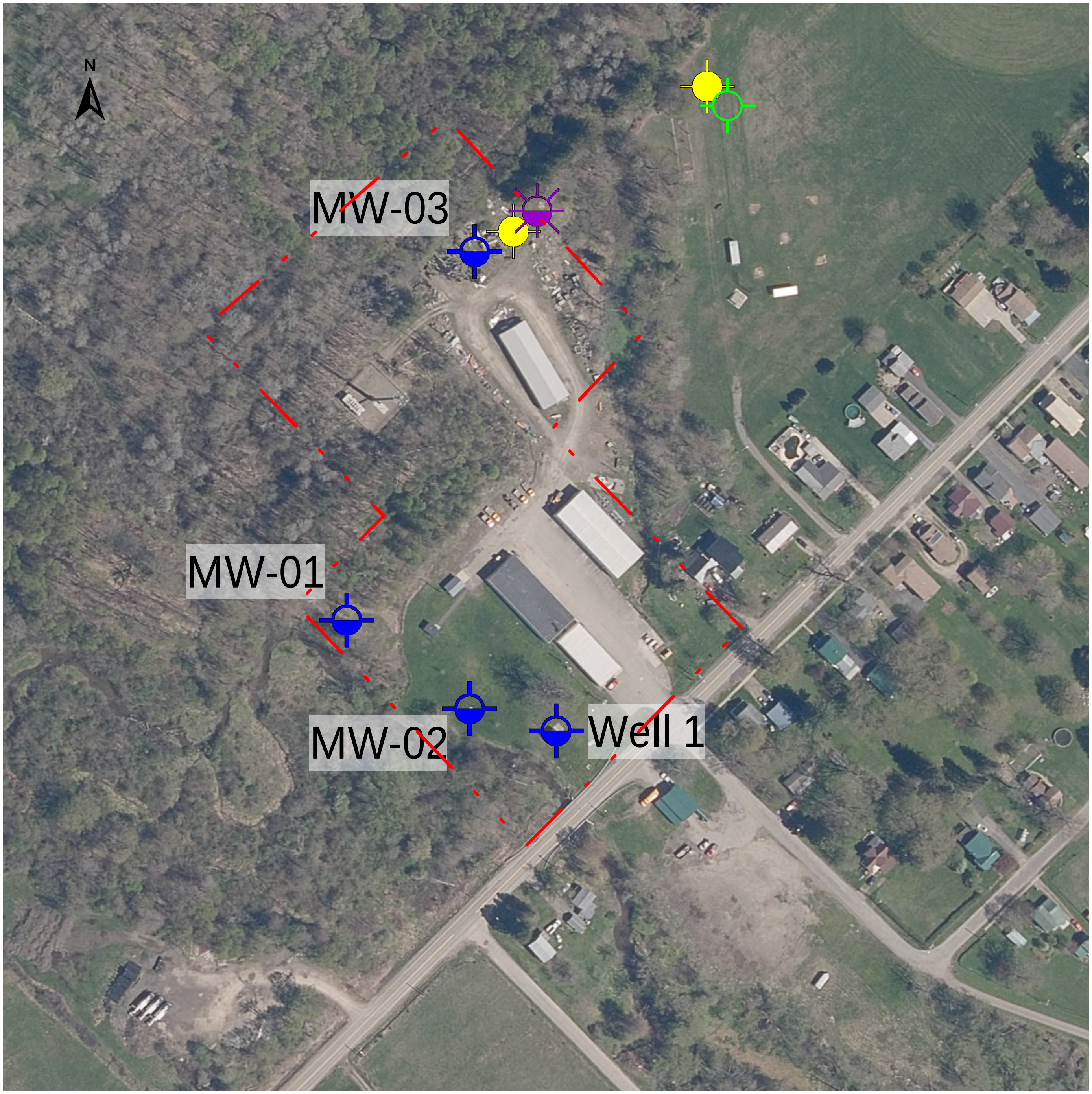
ecology and environment engineering and geology, p.c.

Prepared For:

New York State Department of Environmental Conservation

Figure 7 - Proposed Monitoring Wells (OU-2 and Surrounding Areas)
Mayville PFAS Site
Mayville, New York



Orthoimagery from New York State GIS Clearinghouse
accessed May 2024 (https://orthos.dhses.ny.gov/)

Scale in Feet

0 100 200 300 400

Legend

Existing Wells

Proposed Near-Surface Well

Proposed Shallow Wells

Proposed Deep Wells

Approximate Operable Unit Boundary

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Figure 8 - Proposed Monitoring Wells (OU-3)
Mayville PFAS Site
Mayville, New York

Orthoimagery from New York State GIS Clearinghouse accessed May 2024 (https://orthos.dhses.ny.gov/)

Legend

Historical Sample Locations

Tentative Proposed Sediment and Surface Water Locations

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Scale in Feet

0 200 400 600

Prepared For:

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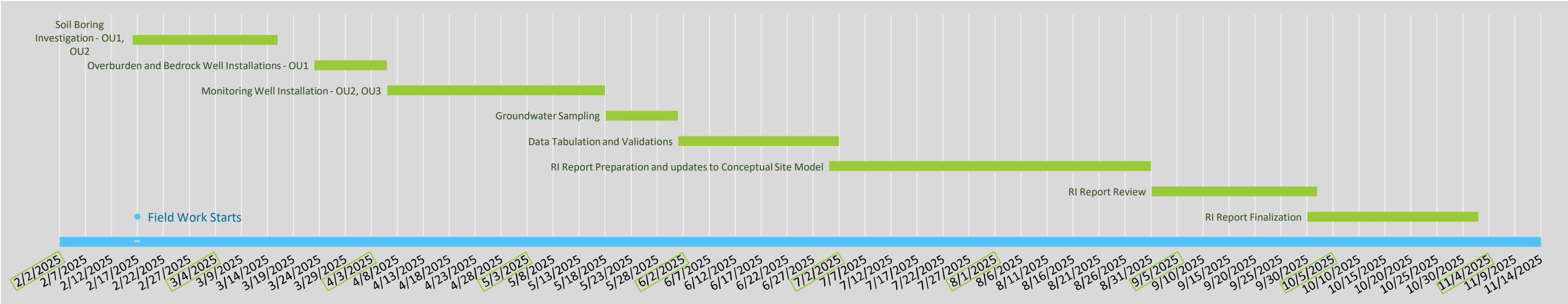
Figure 9 - Proposed Surface Water and Sediment Sample Locations
Mayville PFAS Site
Mayville, New York

Figure 10
Remedial Investigation Project Schedule

Mayville PFAS Site
Mayville, New York

No.	Start Date	End Date	Task	Duration in days
1	2/17/2025	3/14/2025	Soil Boring Investigation - OU1, OU2	26
2	3/24/2025	4/4/2025	Overburden and Bedrock Well Installations - OU1	12
3	4/7/2025	5/16/2025	Monitoring Well Installation - OU2, OU3	40
4	5/19/2025	5/30/2025	Groundwater Sampling	12
5	6/2/2025	6/30/2025	Data Tabulation and Validations	29
6	7/1/2025	8/29/2025	RI Report Preparation and updates to Conceptual Site Model	60
7	9/1/2025	9/30/2025	RI Report Review	30
8	10/1/2025	10/31/2025	RI Report Finalization	31



Prepared By:

ecology and environment engineering and geology, p.c.

Prepared For:

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Tables

Table 1A	Soil Boring Advancement (Phase I)
Table 1B	Collection of Subsurface Soil Analytical Samples (Phase I)
Table 2A	Monitoring Well Drilling (Phase II & III)
Table 2B	Collection of Groundwater Analytical Samples (Phase II & III)
Table 3	Collection of Analytical Samples Along Route 430
Table 4	Sampling Analysis and QA/QC Summary
Table 5	Historic Surface Soil Coordinates

Table 1A - Soil Boring Advancement (Phase I)					
Operable Unit	**Location**	**Well Type**	**Number of Locations**	**Anticipated Depth (ft)**	**Total Footage (ft)**
OU-01	TCMB -Upper Tier	Overburden - Shallow	16	16	256
	TCMB - Lower Tier		9	20	180
OU-02	Patterson St.	Overburden - Shallow	9	24	216
					652

Table 1B - Collection of Subsurface Soil Analytical Samples (Phase I)					
Operable Unit	**Location**	**Number of Locations**	**Anticipated Depth**	**Sample Interval (ft)**	**Number of Samples**
OU-01	TCMB -Upper Tier	4	16	2	32
	TCMB -Upper Tier	12	16	4	48
	TCMB - Lower Tier	9	20	4	45
OU-02	Patterson St.	9	8	2	36
			16	4	36
					197

Table 2A - Monitoring Well Drilling (Phase II & III)							
Operable Unit	**Location**	**Well Type**	**Number of Locations**	**Anticipated Depth (ft)**	**Screen Length (ft)**	**Total Overburden Footage (ft)**	**Total Bedrock Footage (ft)**
OU-01	TCMB -Upper Tier	Overburden - Shallow	4	28	15	112	-
		Bedrock	1	43	10 (open hole)	28	15
	TCMB - Lower Tier	Overburden - Shallow	2	20	10	40	-
		Bedrock	2	35	10 (open hole)	40	30
OU-02	Patterson St.	Overburden - Shallow	12	40	10	480	-
		Overburden - Deep	10	70	10	700	-
OU-03	Morris St.	Overburden - Shallow	1	15	10	15	-
			1	40	10	40	-
		Overburden - Deep	2	70	10	140	-
						1,595	***45***

Table 2B - Collection of Groundwater Analytical Samples (Phase II & III)				
Operable Unit	**Location**	**Well Type**	**Number New Wells**	**Existing Wells**
OU-01	TCMB -Upper Tier	Overburden - Shallow	4	1
		Bedrock	1	-
	TCMB - Lower Tier	Overburden - Shallow	2	1
		Bedrock	2	-
OU-02	Patterson St.	Overburden - Shallow	12	-
		Overburden - Deep	10	3
		Supply Well 3	-	1
OU-03	Morris St.	Overburden - Shallow	2	3
		Overburden - Deep	2	-
		Supply Well 1	-	1
			35	***10***
		Total Number of Groundwater Samples	**45**	

Table 3 - Collection of Analytical Samples Along Route 430			
Operable Unit	Location	Media	
		Surface Water Samples	Sediment Samples
OU-01 / OU-02	Along Route 430 (To Be Determined)	10	10

Table 4 - Sampling Analysis and QA/QC Summary

Project Phase	Matrix	Analysis	Method	Field Samples	Duplicates	Equipment Blank	MS/MSD	Totals	Report Deliverable	Turnaround Time	Validated (Y/N)	Delivery Address
Intrim Remedial Measure Sampling	Surface Water	PFAS 40	Method 1633	5	-	-	-	5	B	10	N	Maddy Hanford WSP 40 La Riviere Drive Suite 320 Buffalo, NY 14202
		Volatile organic compounds, TCL	SW-846 8260D	3	-	-	-	3	B	10	N	
		Total organic carbon	5310B	3	-	-	-	3	A	10	N	
		Alkalinity, total	SM 2320B	3	-	-	-	3	A	10	N	
		Orthophosphate	SM 4500	3	-	-	-	3	A	10	N	
		Anions (bromide, fluoride, nitrate, nitrite, sulfate, chloride)	300.0	3	-	-	-	3	A	10	N	
		Sulfide	4500-S	3	-	-	-	3	A	10	N	
		Metals, TAL	SW-846 (6010 & 7470)	3	-	-	-	3	A	10	N	
		Chromium, hexavalent	7196A	3	-	-	-	3	A	10	N	
		Total Suspended Solids	ASTM 2540D	3	-	-	-	3	A	10	N	
		Total Dissolved Solids	SM 2540C	3	-	-	-	3	A	10	N	
		Oil & Grease	1664	3	-	-	-	3	A	10	N	
		pH	150.1	3	-	-	-	3	A	10	N	
		Biological oxygen demand - 5 day	SM 5210B	3	-	-	-	3	A	10	N	
		Ammonia	SM 4500-NH3 B	3	-	-	-	3	A	10	N	
		Hardness	SM 2340B	3	-	-	-	3	A	10	N	
		Methylene blue active substances (MBAS) assay	SM 5540C	3	-	-	-	3	A	10	N	
Soil Boring Investigaiton (Phase I)	Soil	PFAS 40	Method 1633	197	10	10	20	237	B	10	Y	Andrew Benkleman LaBella Associates 300 Pearl Street Suite 130 Buffalo, NY 14202
		TCL Volatiles + 10	SW-846 8260D	9	1	1	2	13	B	10	Y	
		TCL Semivolatiles + 20	SW-846 8270	9	1	1	2	13	B	10	Y	
		Cyanide	SW-846 9014	9	1	1	2	13	B	10	Y	
		Pesticides	SW-846 8081B	9	1	1	2	13	B	10	Y	
		Herbicides	SW-35 8151	9	1	1	2	13	B	10	Y	
		TCL PCBs	SW-846 8082A	9	1	1	2	13	B	10	Y	
		TAL Inorganics	SW-846 6010D	9	1	1	2	13	B	10	Y	
		Mercury	SW-846 7471B	9	1	1	2	13	B	10	Y	
To Be Determined	Surface Water	PFAS 40	Method 1633	10	1	1	2	14	B	10	Y	
	Sediment	PFAS 40	Method 1633	10	1	1	2	14	B	10	Y	
	Drilling Water	PFAS 40	Method 1633	5	-	-	-	-	B	10	N	
Groundwater Investigation (Phase V)	Groundwater	PFAS 40	Method 1633	45	3	3	6	57	B	10	Y	
		TCL Volatiles + 10	SW-846 8260D	9	1	1	2	13	B	10	Y	
		TCL Semivolatiles + 20	SW-846 8270	9	1	1	2	13	B	10	Y	
		Cyanide	SW-846 9014	9	1	1	2	13	B	10	Y	
		Pesticides	SW-846 8081B	9	1	1	2	13	B	10	Y	
		Herbicides	SW-35 8151	9	1	1	2	13	B	10	Y	
		TCL PCBs	SW-846 8082A	9	1	1	2	13	B	10	Y	
		TAL Inorganics	SW-846 6010D	9	1	1	2	13	B	10	Y	
		Mercury	SW-846 7471B	9	1	1	2	13	B	10	Y	
		1,4 Dioxane	SW-846 8270 SIM	9	1	1	2	13	B	10	Y	
Waste Characterization	Soil	PFAS 40	SW-846 8327	8	-	-	-	8	A	10	N	
		TCLP VOCs	SW-846 8260D	8	-	-	-	8	A	10	N	
		TCLP SVOCs	SW-846 8270E	8	-	-	-	8	A	10	N	
		TCLP Metals	SW-846 6010D / 7470A	8	-	-	-	8	A	10	N	
		PCBs	SW-846 8082A	8	-	-	-	8	A	10	N	
		Ignitability	SW-846 1030	8	-	-	-	8	A	10	N	
		Reactivity (Cyanide)	SW-846 9014	8	-	-	-	8	A	10	N	
		Corrosivity	SW-846 1110A	8	-	-	-	8	A	10	N	
		Percent Solids	SM 2540G	8	-	-	-	8	A	10	N	
		pH	SW-846 9045C	8	-	-	-	8	A	10	N	

Table 5 - Historic Investigation Coordinates (OU-01)					
Sample ID	Northing	Easting	Latitude	Longitude	Elevation
SS-1	822237.34	897767.55	42.2530848	-79.5087189	1491.980
SS-1	822238.15	897766.40	42.2530869	-79.5087232	1492.361
SS-2	822199.06	897761.23	42.2529795	-79.5087407	1490.160
SS-2	822199.04	897761.58	42.2529795	-79.5087394	1490.169
SS-3	822224.66	897728.16	42.2530488	-79.5088639	1489.700
SS-3	822225.43	897728.43	42.2530509	-79.5088629	1489.730
SS-4	822182.85	897718.62	42.2529338	-79.5088975	1487.760
SS-4	822183.07	897718.40	42.2529344	-79.5088983	1487.656
SS-5	822356.64	897745.32	42.2534114	-79.5088058	1495.917
SS-6	822321.93	897780.02	42.2533172	-79.5086763	1495.369
SS-7	822285.83	897815.39	42.2532192	-79.5085442	1494.717
SS-8	822250.04	897850.64	42.2531221	-79.5084126	1494.714
SS-9	822215.05	897885.65	42.2530271	-79.5082818	1494.730
SS-10	822179.35	897921.03	42.2529302	-79.5081498	1494.918
SS-11	822143.50	897955.60	42.2528329	-79.5080207	1494.052
SS-12	822322.90	897708.69	42.2533178	-79.5089398	1491.921
SS-13	822286.01	897742.70	42.2532176	-79.5088127	1492.612
SS-14	822251.11	897778.49	42.2531229	-79.5086791	1492.917
SS-15	822215.67	897814.07	42.2530267	-79.5085462	1492.520
SS-16	822180.53	897849.13	42.2529313	-79.5084154	1492.850
SS-17	822144.64	897884.33	42.2528339	-79.5082839	1492.227
SS-18	822109.12	897919.33	42.2527375	-79.5081532	1492.152
SS-19	822289.08	897672.01	42.2532239	-79.5090739	1489.374
SS-20	822253.15	897706.35	42.2531263	-79.5089456	1489.790
SS-21	822216.67	897741.14	42.2530272	-79.5088156	1490.255
SS-22	822180.98	897776.82	42.2529304	-79.5086824	1490.354
SS-23	822146.30	897811.58	42.2528363	-79.5085527	1490.025
SS-24	822111.39	897847.76	42.2527415	-79.5084176	1489.771
SS-25	822075.34	897882.45	42.2526437	-79.5082881	1489.693
SS-26	822254.45	897636.03	42.2531278	-79.5092054	1485.701
SS-27	822219.15	897671.31	42.2530320	-79.5090736	1487.295
SS-28	822183.90	897706.48	42.2529363	-79.5089423	1487.311
SS-29	822148.53	897742.31	42.2528403	-79.5088086	1487.548
SS-30	822112.49	897777.18	42.2527425	-79.5086784	1487.238
SS-31	822076.66	897811.75	42.2526452	-79.5085492	1487.493
SS-32	822041.02	897846.52	42.2525484	-79.5084194	1486.331
SS-33	822220.00	897600.81	42.2530322	-79.5093341	1476.961
SS-34	822184.01	897635.61	42.2529345	-79.5092041	1476.054
SS-35	822148.71	897670.59	42.2528387	-79.5090735	1475.951
SS-36	822113.39	897706.37	42.2527428	-79.5089399	1475.766
SS-37	822077.98	897741.22	42.2526467	-79.5088098	1475.575
SS-38	822041.82	897776.34	42.2525486	-79.5086786	1475.547
SS-39	822006.15	897813.14	42.2524518	-79.5085413	1475.273
SS-40	822411.76	897737.52	42.2535624	-79.5088368	1495.787
SS-41	822430.14	897712.19	42.2536121	-79.5089311	1494.792
SS-42	822411.27	897695.46	42.2535598	-79.5089922	1493.264
SS-43	822385.76	897705.28	42.2534901	-79.5089549	1493.660
SS-44	822359.89	897726.06	42.2534198	-79.5088771	1494.917
SS-45	822359.65	897674.71	42.2534176	-79.5090667	1490.790
SS-46	822325.21	897637.48	42.2533220	-79.5092029	1488.880
SS-47	822289.83	897600.67	42.2532238	-79.5093374	1485.210
SS-48	822255.83	897565.97	42.2531295	-79.5094642	1478.060
SS-49	822185.52	897564.65	42.2529365	-79.5094662	1474.580
SS-50	822149.53	897599.32	42.2528388	-79.5093367	1474.460
SS-51	822114.35	897634.36	42.2527433	-79.5092059	1474.570
SS-52	822078.98	897670.09	42.2526473	-79.5090725	1474.740
SS-53	822043.58	897704.98	42.2525512	-79.5089423	1474.860
SS-54	822007.29	897740.05	42.2524527	-79.5088113	1474.610
SS-55	822044.55	897633.8	42.2525518	-79.5092052	1455.340
SS-56	822009.13	897668.72	42.2524556	-79.5090748	1454.300
SS-57	821972.9	897703.92	42.2523573	-79.5089433	1452.970
SS-58	821974.71	897632.47	42.2523601	-79.5092073	1448.860
SS-59	821938.35	897667.73	42.2522614	-79.5090756	1448.500
SS-60	821867.72	897665.98	42.2520675	-79.5090792	1447.560
MW-6	821787.09	897840.43	42.2518515	-79.5084317	1446.599
MW-7	822209.05	897748.75	42.2530066	-79.5087872	1490.110
TOP RISER	822209.34	897748.68	42.2530074	-79.5087875	1489.700

Analytical Samples Collected Every 4'

Analytical Samples Collected Every 2'

Appendices (following tables)

Appendix A – Community Air Monitoring Plan (CAMP)

Appendix B – Generic Quality Assurance Project Plan (QAPP)

Appendix C – Field Activities Plan (FAP)

Appendix D – PFAS Guidance and Protocols

Appendix E – Historic Boring Logs and Well Construction Diagrams

Appendix A

Community Air Monitoring Plan (CAMP)

Appendix 1A
New York State Department of Health
Generic Community Air Monitoring Plan

Overview

A Community Air Monitoring Plan (CAMP) requires real-time monitoring for volatile organic compounds (VOCs) and particulates (i.e., dust) at the downwind perimeter of each designated work area when certain activities are in progress at contaminated sites. The CAMP is not intended for use in establishing action levels for worker respiratory protection. Rather, its intent is to provide a measure of protection for the downwind community (i.e., off-site receptors including residences and businesses and on-site workers not directly involved with the subject work activities) from potential airborne contaminant releases as a direct result of investigative and remedial work activities. The action levels specified herein require increased monitoring, corrective actions to abate emissions, and/or work shutdown. Additionally, the CAMP helps to confirm that work activities did not spread contamination off-site through the air.

The generic CAMP presented below will be sufficient to cover many, if not most, sites. Specific requirements should be reviewed for each situation in consultation with NYSDOH to ensure proper applicability. In some cases, a separate site-specific CAMP or supplement may be required. Depending upon the nature of contamination, chemical- specific monitoring with appropriately-sensitive methods may be required. Depending upon the proximity of potentially exposed individuals, more stringent monitoring or response levels than those presented below may be required. Special requirements will be necessary for work within 20 feet of potentially exposed individuals or structures and for indoor work with co-located residences or facilities. These requirements should be determined in consultation with NYSDOH.

Reliance on the CAMP should not preclude simple, common-sense measures to keep VOCs, dust, and odors at a minimum around the work areas.

Community Air Monitoring Plan

Depending upon the nature of known or potential contaminants at each site, real-time air monitoring for VOCs and/or particulate levels at the perimeter of the exclusion zone or work area will be necessary. Most sites will involve VOC and particulate monitoring; sites known to be contaminated with heavy metals alone may only require particulate monitoring. If radiological contamination is a concern, additional monitoring requirements may be necessary per consultation with appropriate DEC/NYSDOH staff.

Continuous monitoring will be required for all ground intrusive activities and during the demolition of contaminated or potentially contaminated structures. Ground intrusive activities include, but are not limited to, soil/waste excavation and handling, test pitting or trenching, and the installation of soil borings or monitoring wells.

Periodic monitoring for VOCs will be required during non-intrusive activities such as the collection of soil and sediment samples or the collection of groundwater samples from existing monitoring wells. “Periodic” monitoring during sample collection might reasonably consist of taking a reading upon arrival at a sample location, monitoring while opening a well cap or overturning soil, monitoring during well baling/purging, and taking a reading prior to leaving a sample location. In some instances, depending upon the proximity of potentially exposed individuals, continuous monitoring may be required during sampling activities. Examples of such situations include groundwater sampling at wells on the curb of a busy urban street, in the midst of a public park, or adjacent to a school or residence.

VOC Monitoring, Response Levels, and Actions

Volatile organic compounds (VOCs) must be monitored at the downwind perimeter of the immediate work area (i.e., the exclusion zone) on a continuous basis or as otherwise specified. Upwind concentrations should be measured at the start of each workday and periodically thereafter to establish background conditions, particularly if wind direction changes. The monitoring work should be performed using equipment appropriate to measure the types of contaminants known or suspected to be present. The equipment should be calibrated at least daily for the contaminant(s) of concern or for an appropriate surrogate. The equipment should be capable of calculating 15-minute running average concentrations, which will be compared to the levels specified below.

1. If the ambient air concentration of total organic vapors at the downwind perimeter of the work area or exclusion zone exceeds 5 parts per million (ppm) above background for the 15-minute average, work activities must be temporarily halted and monitoring continued. If the total organic vapor level readily decreases (per instantaneous readings) below 5 ppm over background, work activities can resume with continued monitoring.

2. If total organic vapor levels at the downwind perimeter of the work area or exclusion zone persist at levels in excess of 5 ppm over background but less than 25 ppm, work activities must be halted, the source of vapors identified, corrective actions taken to abate emissions, and monitoring continued. After these steps, work activities can resume provided that the total organic vapor level 200 feet downwind of the exclusion zone or half the distance to the nearest potential receptor or residential/commercial structure, whichever is less - but in no case less than 20 feet, is below 5 ppm over background for the 15-minute average.

3. If the organic vapor level is above 25 ppm at the perimeter of the work area, activities must be shutdown.

4. All 15-minute readings must be recorded and be available for State (DEC and NYSDOH) personnel to review. Instantaneous readings, if any, used for decision purposes should also be recorded.

Particulate Monitoring, Response Levels, and Actions

Particulate concentrations should be monitored continuously at the upwind and downwind perimeters of the exclusion zone at temporary particulate monitoring stations. The particulate monitoring should be performed using real-time monitoring equipment capable of measuring particulate matter less than 10 micrometers in size (PM-10) and capable of integrating over a period of 15 minutes (or less) for comparison to the airborne particulate action level. The equipment must be equipped with an audible alarm to indicate exceedance of the action level. In addition, fugitive dust migration should be visually assessed during all work activities.

1. If the downwind PM-10 particulate level is 100 micrograms per cubic meter (mcg/m^3) greater than background (upwind perimeter) for the 15-minute period or if airborne dust is observed leaving the work area, then dust suppression techniques must be employed. Work may continue with dust suppression techniques provided that downwind PM-10 particulate levels do not exceed 150 mcg/m^3 above the upwind level and provided that no visible dust is migrating from the work area.

2. If, after implementation of dust suppression techniques, downwind PM-10 particulate levels are greater than 150 mcg/m^3 above the upwind level, work must be stopped and a re-evaluation of activities initiated. Work can resume provided that dust suppression measures and other controls are successful in reducing the downwind PM-10 particulate concentration to within 150 mcg/m^3 of the upwind level and in preventing visible dust migration.

3. All readings must be recorded and be available for State (DEC and NYSDOH) and County Health personnel to review.

December 2009

Appendix 1B
Fugitive Dust and Particulate Monitoring

A program for suppressing fugitive dust and particulate matter monitoring at hazardous waste sites is a responsibility on the remedial party performing the work. These procedures must be incorporated into appropriate intrusive work plans. The following fugitive dust suppression and particulate monitoring program should be employed at sites during construction and other intrusive activities which warrant its use:

1. Reasonable fugitive dust suppression techniques must be employed during all site activities which may generate fugitive dust.

2. Particulate monitoring must be employed during the handling of waste or contaminated soil or when activities on site may generate fugitive dust from exposed waste or contaminated soil. Remedial activities may also include the excavation, grading, or placement of clean fill. These control measures should not be considered necessary for these activities.

3. Particulate monitoring must be performed using real-time particulate monitors and shall monitor particulate matter less than ten microns (PM10) with the following minimum performance standards:

(a) Objects to be measured: Dust, mists or aerosols;
(b) Measurement Ranges: 0.001 to 400 mg/m3 (1 to 400,000 :ug/m3);
(c) Precision (2-sigma) at constant temperature: +/- 10 :g/m3 for one second averaging; and +/- 1.5 g/m3 for sixty second averaging;
(d) Accuracy: +/- 5% of reading +/- precision (Referred to gravimetric calibration with SAE fine test dust (mmd= 2 to 3 :m, g= 2.5, as aerosolized);
(e) Resolution: 0.1% of reading or 1g/m3, whichever is larger;
(f) Particle Size Range of Maximum Response: 0.1-10;
(g) Total Number of Data Points in Memory: 10,000;
(h) Logged Data: Each data point with average concentration, time/date and data point number
(i) Run Summary: overall average, maximum concentrations, time/date of maximum, total number of logged points, start time/date, total elapsed time (run duration), STEL concentration and time/date occurrence, averaging (logging) period, calibration factor, and tag number;
(j) Alarm Averaging Time (user selectable): real-time (1-60 seconds) or STEL (15 minutes), alarms required;
(k) Operating Time: 48 hours (fully charged NiCd battery); continuously with charger;
(l) Operating Temperature: -10 to 50^{o} C (14 to 122^{o} F);
(m) Particulate levels will be monitored upwind and immediately downwind at the working site and integrated over a period not to exceed 15 minutes.

4. In order to ensure the validity of the fugitive dust measurements performed, there must be appropriate Quality Assurance/Quality Control (QA/QC). It is the responsibility of the remedial party to adequately supplement QA/QC Plans to include the following critical features: periodic instrument calibration, operator training, daily instrument performance (span) checks, and a record keeping plan.

5. The action level will be established at 150 ug/m3 (15 minutes average). While conservative,

this short-term interval will provide a real-time assessment of on-site air quality to assure both health and safety. If particulate levels are detected in excess of 150 ug/m3, the upwind background level must be confirmed immediately. If the working site particulate measurement is greater than 100 ug/m3 above the background level, additional dust suppression techniques must be implemented to reduce the generation of fugitive dust and corrective action taken to protect site personnel and reduce the potential for contaminant migration. Corrective measures may include increasing the level of personal protection for on-site personnel and implementing additional dust suppression techniques (see paragraph 7). Should the action level of 150 ug/m3 continue to be exceeded work must stop and DER must be notified as provided in the site design or remedial work plan. The notification shall include a description of the control measures implemented to prevent further exceedances.

6. It must be recognized that the generation of dust from waste or contaminated soil that migrates off-site, has the potential for transporting contaminants off-site. There may be situations when dust is being generated and leaving the site and the monitoring equipment does not measure PM10 at or above the action level. Since this situation has the potential to allow for the migration of contaminants off-site, it is unacceptable. While it is not practical to quantify total suspended particulates on a real-time basis, it is appropriate to rely on visual observation. If dust is observed leaving the working site, additional dust suppression techniques must be employed. Activities that have a high dusting potential--such as solidification and treatment involving materials like kiln dust and lime--will require the need for special measures to be considered.

7. The following techniques have been shown to be effective for the controlling of the generation and migration of dust during construction activities:

(a) Applying water on haul roads;
(b) Wetting equipment and excavation faces;
(c) Spraying water on buckets during excavation and dumping;
(d) Hauling materials in properly tarped or watertight containers;
(e) Restricting vehicle speeds to 10 mph;
(f) Covering excavated areas and material after excavation activity ceases; and
(g) Reducing the excavation size and/or number of excavations.

Experience has shown that the chance of exceeding the 150ug/m3 action level is remote when the above-mentioned techniques are used. When techniques involving water application are used, care must be taken not to use excess water, which can result in unacceptably wet conditions. Using atomizing sprays will prevent overly wet conditions, conserve water, and provide an effective means of suppressing the fugitive dust.

8. The evaluation of weather conditions is necessary for proper fugitive dust control. When extreme wind conditions make dust control ineffective, as a last resort remedial actions may need to be suspended. There may be situations that require fugitive dust suppression and particulate monitoring requirements with action levels more stringent than those provided above. Under some circumstances, the contaminant concentration and/or toxicity may require additional monitoring to protect site personnel and the public. Additional integrated sampling and chemical analysis of the dust may also be in order. This must be evaluated when a health and safety plan is developed and when appropriate suppression and monitoring requirements are established for protection of health and the environment.

Appendix 1C
DEC Permits Subject to Exemption

In accordance with section 1.10, exemptions from the following permit programs may be granted to the person responsible for conducting the remedial programs undertaken pursuant to section 1.2:

Air - Title 5 permits
Air - State permits
Air - Registrations
Ballast Discharge
Chemical Control
Coastal Erosion Hazard Areas
Construction of Hazardous Waste Management Facilities
Construction of Solid Waste Management Facilities
Dams
Excavation and Fill in Navigatable Waters (Article 15)
Flood Hazard Area Development
Freshwater Wetland
Hazardous Waste
Long Island Wells
Mined Land Reclamation
Navigation Law - Docks
Navigation Law - Floating Objects
Navigation Law - Marinas
Non-Industrial Waste Transport
Operation of Solid Waste Management Facilities
Operation of Hazardous Waste Management Facilities
State Pollution Discharge Elimination Systems (SPDES)
Stream Disturbance
Tidal Wetlands
Water Quality Certification
Water Supply
Wild, Scenic and Recreational Rivers

Appendix B

Generic Quality Assurance Project Plan (QAPP)

Master Quality Assurance Project Plan (QAPP) for New York State Department of Environmental Conservation Projects

May 2020

Prepared for:

NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION
625 Broadway
Albany, New York 12233

Prepared by:

ECOLOGY AND ENVIRONMENT ENGINEERING AND GEOLOGY, P.C.
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List of Abbreviations and Acronyms

AAS	atomic absorption spectroscopy
ASP	Analytical Services Protocol
ASTM	American Society for Testing and Materials
CAD	computer-aided design
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act of 1980
CM	construction management
COC	chain-of-custody
CPR	cardiopulmonary resuscitation
DOT	(United States) Department of Transportation
DUSR	Data Usability Summary Report
E & E	Ecology and Environment Engineering and Geology, P.C.
ECL	Environmental Conservation Law
EDD	electronic data deliverable
ELAP	Environmental Laboratory Accreditation Program
EPA	(United States) Environmental Protection Agency
FS	Feasibility Study
FSP	field sampling plan
GC/MS	gas chromatography/mass spectrometry
GPS	Global Positioning System
GIS	geographic information system

List of Acronyms (Cont.)

IATA	International Air Transport Association
ICP	inductively coupled plasma
ICS	interference check sample
IDW	investigation-derived waste
IRM	interim remedial measure
LCS	laboratory control sample
MDL	method detection limit
mL	milliliter
mL/min	milliliters per minute
MS/MD	matrix spike/matrix duplicate
MS/MSD	matrix spike/matrix spike duplicate
MSB	matrix spike blank
NELAP	National Environmental Laboratory Accreditation Program
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
OVA	organic vapor analyzer
PARCCS	precision, accuracy, representativeness, completeness, comparability, and sensitivity
PCB	polychlorinated biphenyl
PE	performance evaluation
PID	photoionization detector
PPE	personal protection equipment
ppm	parts per million
PSA	preliminary site assessment
QA/QC	quality assurance/quality control
QAPP	Quality Assurance Project Plan

List of Acronyms (Cont.)

QMP	Quality Management Plan
RA	remedial action
RD	remedial design
RI	Remedial Investigation
RPD	relative percent difference
SARA	Superfund Amendments and Reauthorization Act of 1986
SDG	sample delivery group
SI	site inspection
SOP	Standard Operating Procedure
SOW	scope of work
SVOC	semi-volatile organic compound
TCLP	toxicity characteristic leaching procedure
TRPH	total recoverable petroleum hydrocarbon
VOA	volatile organic analysis
VOC	volatile organic compound

Distribution List

Party	Affiliation and Title	Revision	Date Sent
QAPP Original Distribution			
Marcia Meredith Galloway, CQA, CQM	E & E QA Director	3	May 2020
Michael Morgante, P.E.	E & E Contract Manager	3	May 2020
	E & E Project Manager(s)	3	May 2020
David Gardner	NYSDEC Contracts	3	May 2020
	NYSDEC QA Officer	3	May 2020

Revision List

Revision	Modifications	Distributed
1	Updated to NYSDEC ASP 2005 and other new methods	July 2007
2	Updated Table A-2 methods to 49 CFR Part 136 March 2007 revision; updated Table A-3 to include GPS; updated data management section; updated several references to guidance documents; and other minor updates	April 2011
3	General updates to language, methodologies, guidelines, and personnel for inclusion with new NYSDEC contract D009807.	May 2020

Distribution List (Cont.)

Laboratory Distribution and Approval

All E & E subcontract laboratories working on NYSDEC projects must perform work in compliance with this QAPP. The following revision has been sent to subcontract laboratories. The laboratories must sign the bottom of this page and return to the E & E QA Director.

Party	Affiliation and Title	Revision	Date Sent
QAPP Original Distribution			
Subcontract laboratories	See list maintained by E & E QA Director	1	April 2020

Revision List

Revision	Modifications	Distributed
1	Updated to NYSDEC ASP 2005 and other new methods	July 2007
2	Updated Table A-2 methods to 49 CFR Part 136 March 2007 revision; updated Table A-3 to include GPS; updated data management section; updated several references to guidance documents; and other minor updates	April 2011
3	General updates to language, methodologies, guidelines, and personnel for inclusion with new NYSDEC contract D009807.	May 2020

This page must be completed and returned to E & E with each revision of the QAPP.

Laboratory certifies that it will conduct analytical services in compliance with QAPP unless modified by any project-specific requirements listed in the site-specific QAPP or approved laboratories exceptions or clarifications in the subcontract supplemental agreement.

Executed this ______ day of ______________, 20

____
Subcontractor Laboratory

____
Signature

____
Name

____
Title

1 Project Management

This Quality Assurance Project Plan (QAPP) has been prepared by Ecology and Environment Engineering and Geology, P.C.(E & E) in support of projects performed for the New York State Department of Environmental Conservation (NYSDEC), under Contract No. D009807. This QAPP also supports work performed by Ecology and Environment Engineering and Geology, P.C. or Ecology and Environment, Inc., for other contracts in New York State.[1]

The QAPP is applicable to any project implemented by E & E personnel that is subject to regulatory oversight by NYSDEC or that must be conducted in accordance with NYSDEC regulations.

This QAPP has been prepared in accordance with "United States Environmental Protection Agency (EPA) Requirements for Quality Assurance Project Plans," final, EPA QA/R-5 (March 2001) and incorporates NYSDEC requirements. This QAPP presents the policies, organization, objectives, functional activities, and specific quality assurance/quality control (QA/QC) procedures that will be employed by E & E to ensure that all technical data generated are accurate, representative, and ultimately capable of withstanding judicial scrutiny. These activities will be implemented under the requirements of E & E's comprehensive QA program as documented in the corporate Quality Management Plan (QMP).

The QAPP is formatted to address the four major sections listed in the EPA QAPP guidance document: Project Management, Data Generation and Acquisition, Assessment and Oversight, and Data Validation and Usability.

1.1 Project Organization

The organizational chart for the environmental investigation, design, or construction project work in New York is presented as Figure 1-1. The Project Manager and project team members are primarily responsible for implementation of the QA program on NYSDEC related projects. All project communications are directed through the Project Manager. The Project Manager is the primary point of

[1] All references to E & E personnel are applicable to both Ecology and Environment Engineering and Geology, P.C. or Ecology and Environment, Inc. personnel if the contract is held by that corporate entity.

contact for the NYSDEC Project Manager and technical staff. The Contract Manager and QA Officer for the NYSDEC contract provide independent review functions to verify that the projects are implemented in accordance with applicable QA documents. The E & E Responsible Engineer is responsible for independent oversight of projects involving engineering services for design and construction. The roles and specific QA responsibilities of key project personnel are described below.

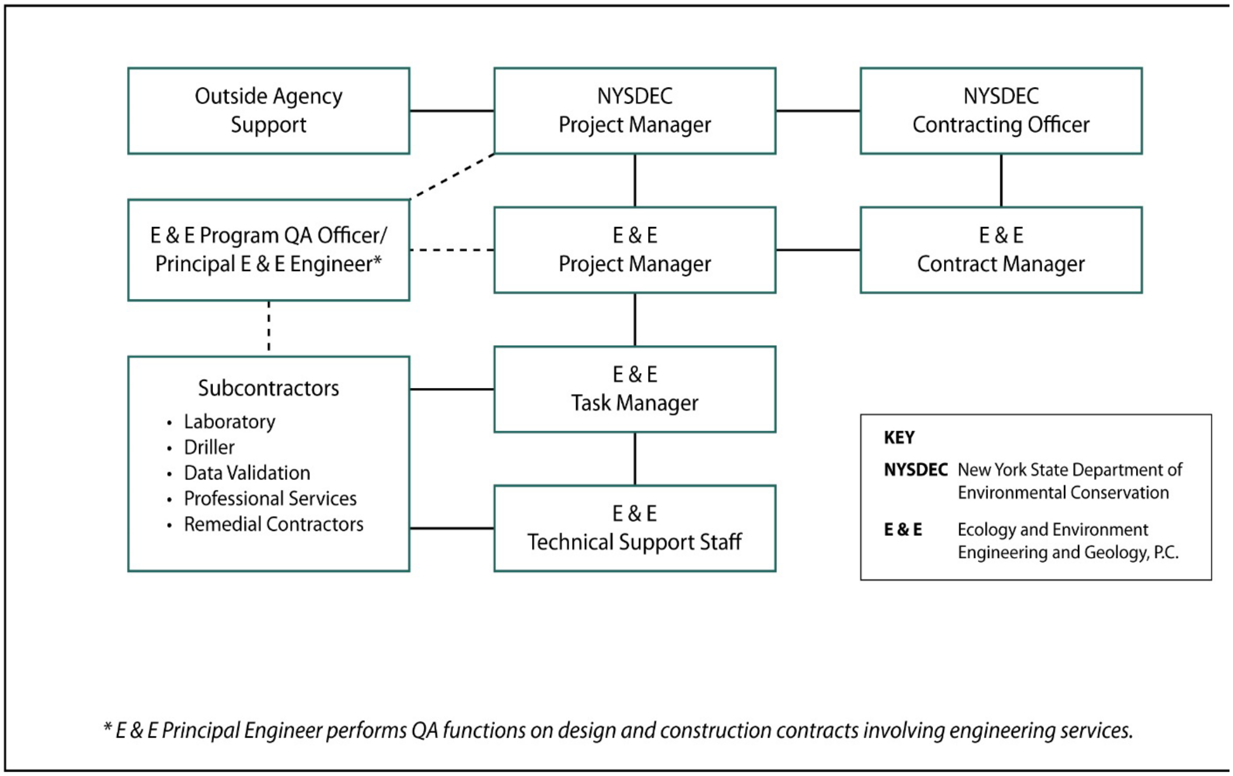

Figure 1-1 Project Organization Chart

Contract Manager

E & E designates a Contract Manager for all New York State projects. The Contract Manager will assign Project Managers, oversee implementation of all schedules and budgets, and establish and interpret all contract policies and procedures. The Contract Manager has access to appropriate E & E resources in order to maintain technical quality. He or she will coordinate contract activities with the NYSDEC Contracting Officer.

Project Manager

The Project Manager is responsible for QA/QC functions for all task-specific operations on NYSDEC projects, and will coordinate with the Contract Manager on issues that impact the overall quality of E & E performance on the NYSDEC contract.

The Project Manager will also be responsible for the overall quality of work performed under project activities as it relates to the following specific roles:

- Overseeing day-to-day performance including all technical and administrative operations;
- Interfacing frequently with the NYSDEC Project Manager and technical staff;
- Tracking schedules and budgets and managing of mobilization and contract closeout activities;
- Selecting and monitoring Task Managers;
- Managing the development of detailed work plans; and
- Reviewing and approving all final reports and other work products.

Task Managers

Task Managers will be assigned to direct specific work activities. Task Managers are responsible for leading and coordinating the day-to-day activities of the field effort or other assigned task. The Task Manager carries out the specific QA/QC responsibilities of the Project Manager for work performed under their task.

Program QA Officer

The Program QA Officer is responsible for oversight of all QA/QC activities for NYSDEC projects. The QA Officer will remain independent of day-to-day, direct project involvement but will have the responsibility for ensuring that all project and task-specific QA/QC requirements are met. The QA Officer will have direct access to corporate executive staff, as necessary, to resolve any QA/QC problems, disputes, or deficiencies. The QA Officer's specific duties include:

- Reviewing and approving the QAPP;
- Conducting field and laboratory audits in conjunction and keeping written records of the audits;
- Coordinating with the NYSDEC technical staff, Project Manager, Task Managers, and laboratory management to ensure that QA objectives appropriate to the project are set and that laboratory and field personnel are aware of these objectives; and

- Recommending, implementing, and/or reviewing actions taken in the event of QA/QC failures in the laboratory or field.

Project Chemist
The Project Chemist is responsible for data validation and verification, generation of Data Usability Summary Reports (DUSRs), and independent assessment of the hard copy and electronic analytical data. The Project Chemist will report nonconformance with QC criteria (including an assessment of the impact on data quality objectives) to the appropriate managers.

Technical Support Staff
The technical support staff for this program will be drawn from E & E's pool of corporate resources. The technical support staff will implement project and site tasks, analyze data, and prepare reports/support materials. All support personnel assigned will be experienced professionals who possess the degree of specialization and technical competence necessary to perform the required work effectively and efficiently.

Laboratories
Laboratories providing analytical services will be selected as appropriate to meet the project requirements. All laboratories will be certified by the New York State Department of Health (NYSDOH) Environmental Laboratory Accreditation Program (ELAP) for the methods that they are contracted to perform.

The laboratory QA programs are reviewed and approved by the QA Officer or the Project Chemist and will be submitted to NYSDEC for approval. Copies of the laboratory QA manuals are available on request. The laboratory must provide an experienced Project Manager and a QA Officer that is independent of the day-to-day operations of the laboratory. The specific duties of the laboratory Project Manager and QA Officer for NYSDEC activities include:

- Reviewing the QAPP to verify that analytical operations will meet project requirements;
- Documenting review and approval of QAPP on distribution page;
- Reviewing receipt of all sample shipments and notifying the Project Manager and Project Chemist of any discrepancies within one day of receipt;
- Rapidly notifying the E & E Project Manager and Project Chemist regarding laboratory nonconformance with the QAPP or analytical QA/QC problems affecting project samples; and
- Coordinating with the E & E Project Manager and Project Chemist, and laboratory management to implement corrective actions approved by NYSDEC or others as applicable.

Other Subcontractors

The professional services, drilling, surveying, remedial action, or other subcontractors are responsible for implementing the subcontracts and applicable portions of this QAPP as provided in the subcontract package. Subcontractors are responsible for rapid notification to the E & E Project Manager and/or Task Manager regarding nonconformance with the QAPP or QA/QC problems affecting NYSDEC. Subcontractors must coordinate with E & E's project management staff to implement corrective actions approved by NYSDEC.

1.2 Problem Definition/Background

NYSDEC has retained E & E to perform the full range of hazardous waste site and engineering services including preliminary site assessment (PSA), site inspection (SI), immediate investigation work assignment (IIWA), remedial investigation/feasibility study (RI/FS), interim remedial measure (IRM), remedial design (RD), remedial action (RA), construction management (CM), and post-construction and community relations support. All investigations awarded under this contract are conducted to meet the requirements of the New York State Environmental Conservation Law (ECL) and the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986. All work is to be carried out consistent with NYSDEC and EPA requirements, protocols, and guidance.

1.3 Project Description

The work covered by this QAPP is defined under the Schedule I generic scope of work (SOW) in the Standby Contract(s) for engineering services (investigations, design, and construction) for remedial sites. If necessary, site-specific QAPP information will be provided as an appendix to the field sampling plan (FSP). Other E & E projects that fall under NYSDEC regulatory requirements also will be implemented under this QAPP.

1.4 Quality Objectives and Criteria

Quality objectives are qualitative or quantitative statements derived from the systematic planning process. Quality objectives are used to clarify the goals of the project and define the appropriate type of data to collect to support project decisions. General quality objectives for NYSDEC projects are summarized in Table A-1 in Appendix A.

Acceptance and performance criteria establish the quality and quantity of data needed to meet the project quality objectives. General acceptance or performance criteria for the collection, evaluation, or use of environmental data for NYSDEC projects are outlined in Section 2.5, Analytical Methods. Quality objectives or acceptance and performance criteria applicable to a project are specified in the site-specific QAPP or work plan.

1.4.1 Data Assessment Definitions

Acceptance and performance criteria are often specified in terms of precision, accuracy, representativeness, completeness, comparability and sensitivity (PARCCS) parameters. Numerical acceptance criteria cannot be assigned to all PARCCS parameters, but general performance goals are established for most data collection activities. Numerical goals for analytical methods are presented in Section 2.4. Data assessment procedures throughout the QAPP clearly outline the steps to be taken, responsible individuals, and implications if QA objectives are not met. PARCCS parameters are briefly defined below.

Precision

Precision measures the reproducibility of measurements under a given set of conditions. Specifically, it is a quantitative measure of the variability of a group of measurements compared to their average value, usually stated in terms of standard deviation or coefficient of variation. It also may be measured as the relative percent difference (RPD) between two values. Precision includes the interrelated concepts of instrument or method detection limits and multiple field sample variance. Sources of this variance are sample heterogeneity, sampling error, and analytical error.

Accuracy

Accuracy measures the bias of the measurement system. Sources of this error are the sampling process, field contamination, preservation, handling, sample matrix, sample preparation, and analysis. Data interpretation and reporting may also be significant sources of error. Typically, analytical accuracy is assessed through the analysis of spiked samples and may be stated in terms of percent recovery or the average (arithmetic mean) of the percent recovery. Blank samples are also analyzed to assess sampling and analytical bias (i.e., sample contamination). Background measurements similarly assess measurement bias.

Representativeness

Representativeness expresses the degree to which data represent a characteristic of a population, a parameter variation at a sampling point, or an environmental condition. Representativeness is a qualitative parameter, which is most concerned with proper design of the measurement program. Sample/measurement locations may be biased (judgmental) or unbiased (random or systematic). For unbiased schemes, sampling must be designed not only to collect samples that represent conditions at a sample location, but also to select sample locations, which represent the total area to be sampled.

Completeness

Completeness is defined as the percentage of measurements performed that are judged to be valid. Although a quantitative goal must be specified, the completeness goal is the same for all data uses—that a sufficient amount of *valid* data be generated. It is important that critical samples are identified and plans are made to ensure that valid data are collected for them.

Comparability

Comparability is a qualitative parameter expressing the confidence with which one dataset may be compared to another. Sample data should be comparable with other measurement data for similar samples and sample conditions. This goal is achieved through the use of standard techniques to collect and analyze samples.

Sensitivity

Sensitivity is related to the reporting limit and is the capability of a method or instrument to detect a given analyte at a given concentration and to reliably quantitate the analyte at that concentration. Sensitivity is evaluated through comparison of the laboratory reporting limits to applicable standards and/or screening level criteria.

1.5 Special Training/Certification

E & E is committed to providing vigorous training in health and safety procedures, the proper use of protective equipment, and overall policy objectives. General training requirements for NYSDEC activities are as follows:

- E & E employees that participate in on-site activities must have completed the 40-hour health and safety training program and the cardiopulmonary resuscitation (CPR)/first aid certification course. To continue such participation, each employee must successfully complete a minimum of 8 hours of refresher training, annually; and
- All personnel shipping samples must complete the United States Department of Transportation (DOT) hazardous materials transportation training and certification, including training in specific International Air Transport Association (IATA) regulations (air shipments).

1.6 Documentation and Records

The E & E Program QA Officer will approve the QAPP and maintain the most current approved version of the document. The E & E Project Manager is responsible for providing the most current copy of the QAPP and other planning documents to the project team members.

In addition to the QAPP and other planning documents, the primary documentation for the project is field records and analytical data packages. Requirements for field records are documented in E & E Standard Operating Procedures (SOPs) for Field Activities Logbooks and Geological Logging and are described briefly below. Requirements for analytical data packages for NYSDEC activities are also described below. The remainder of the QAPP describes additional project documentation and record requirements for QA/QC assessments, data validation, data management, and other areas.

1.6.1 Field Documentation

Sample Identification

In general, samples will be identified using the format described below. Sample identification may vary from project to project. Each sample will be labeled, chemically preserved (if required), and sealed immediately after collection. To minimize handling of sample containers, labels will be completed prior to sample collection as practicable. The sample label will be completed using waterproof ink and will be firmly affixed to sample containers and protected with clear tape or by using waterproof labels. The sample label will give the following information:

- Date and time of collection;
- Unique sample name/number;
- Analyses requested; and
- Preservation.

Each sample will be referenced by sample name/number in the logbook and on the chain-of-custody (COC) record.

Individual samples will be identified by a unique alphanumeric code. The recommended identification for normal field samples (non-quality-control) will be identified using the convention below:

SSS-MC-XXX-##-##-[date]

SSS - Three letter code for site name

MC - Matrix code as designated below

XXX - Sequential sample number

##-## - Sample depth intervals (if applicable)

[date] - Sample date in YYYYMMDD format

For quality control samples, the following indications may be added to the end of the sample identification:

-D - Field Duplicate
-F - Field Filtered
-S - Split Sample

The matrix codes (MC) are as follows:

AS - Bulk Asbestos
AS - Sub-slab Vapor
BA - Indoor Air from Basement or Crawlspace
DW - Drinking Water
EB - Equipment Blank
FA - Indoor Air, First Floor (not basement)
GS - Soil Gas
GW - Groundwater
IDW - Waste
OA - Outdoor Air
SE - Sediment
SB - Subsurface Soil
SS - Surface Soil
SW - Surface Water
TB - Trip Blank
IDW - Waste

Samples collected with an additional volume for matrix spike/matrix spike duplicates (MS/MSD) will be designated on the COC.

Field Logs and Data Forms

Field logs and data forms are necessary to provide sufficient data to enable participants to reconstruct events that occurred during the project and to refresh the memory of field personnel should they be called upon to give testimony during legal proceedings. Field logs also should document any deviations from the work plan, QAPP, or other applicable planning document. Procedures for recording information are specified in the Field Activities Logbook SOP. All field logs will be kept in a bound notebook containing numbered pages unless a specific field form is completed. All entries will be made in waterproof ink and the time of the entry will be recorded. The top of each page of the logbook or field form will contain the E & E project number, project name, and date that the entries on that page were recorded. No pages will be removed for any reason. Corrections will be made according to the procedures given later in this section. The field logs will include both site- and task-specific information.

Recording of information related to site activities is the responsibility of the Field Team Leader and will include a complete summary of the day's activities at the site and any communications outside the project team. Site information includes:

- Name of the person making the entry (signature);
- Names of team members, subcontractors, and visitors on site;
- Levels of personal protection equipment (PPE):
  - Level of protection originally used,
  - Changes in protection, if required, and
  - Reasons for changes; and
- Time spent on site.

Task-specific information may be recorded in multiple field logbooks. The task-specific information will include:

- Drilling information, including:
  - Method employed,
  - Diameter of borehole and well casing,
  - Materials used,
  - Depth of borehole, and
  - Well construction (if appropriate);
- Documentation on samples collected, including:
  - Construction of existing wells (if appropriate),
  - Sampling location and sample identification number,
  - Sampling depth for subsurface soil and surface water (if depth-specific surface water samples are collected) samples,
  - Flow rate of water from in-place plumbing (500 milliliters per minute [mL/min]) for samples of existing water supplies,
  - Sampling date, time, and personnel,
  - Sample sequence (order in which samples were collected),
  - Equipment used (including the use of fuel-powered units/motors during surface water sampling),
  - Type of sample (e.g., grab, composite, QC) and matrix,
  - Amount of each subsample or aliquot (if sample is a composite), and
  - Sample preservation and verification of preservation;
- Types of field QC samples, including when and where they were collected. The description of rinsate sample collection should include the equipment rinsed and the actual field samples collected with that equipment prior to collection of the rinsate;

- Information regarding well purging including:
  - Depth to water and total well depth,
  - Calculations used for volume purged,
  - Volume purged,
  - Equipment used,
  - Field measurements,
  - Length of purge time, and
  - Date and time well was purged;
- Drum inventory:
  - Type of drum and description of contents, and
  - Description of material in the drum and which layers were sampled (if performed);
- Field equipment used, equipment identification numbers, and calibration information;
- On-site measurement data;
- Field observations and remarks;
- Weather conditions;
- Decontamination procedures;
- Unusual circumstances or difficulties; and
- Initials of person recording information.

Corrections to Documentation Notebook

As with any data logbooks, no pages will be removed for any reason. If corrections are necessary, they must be made by drawing a single line through the original entry (so that the original entry can still be read) and writing the corrected entry alongside. The correction must be initialed and dated. Most corrected errors will require a footnote explaining the correction.

Photographs

Photographs will be taken as directed by the Field Team Leader. Documentation of a photograph is crucial to its validity as a representation of an existing situation. The following information will be noted in the task log concerning photographs:

- Date, time, location, and direction photograph was taken;
- Description of the photograph taken;

- Reasons why the photograph was taken; and
- Sequential number of the digital photo.

1.6.2 Laboratory Data Reporting

The data deliverable packages for all project work (except long-term monitoring) should meet the Category B Deliverable requirements listed below:

- A sample delivery group narrative;
- Contract laboratory sample information sheets;
- Data package summary forms;
- Chain of Custody forms;
- Test analyses results for samples and QC (including tentatively identified compounds for analysis of volatile and semi-volatile organic compounds);
- Surrogate recoveries;
- Blank results;
- Spike recoveries;
- Duplicate results;
- Confirmation (lab check/QC) samples;
- Internal standard area and retention time summary;
- Chromatograms;
- Raw data files; and
- Other specific information as described in the NYSDECs most current guidance.

The data deliverable packages for long-term monitoring events should meet the Category A Deliverable requirements listed below:

- A sample delivery group narrative;
- Contract laboratory sample information sheets;
- Data package summary forms;
- Chain of Custody forms;
- Test analyses results for samples and QC (including tentatively identified compounds for analysis of volatile and semi-volatile organic compounds); and
- Chromatograms, if requested.

The laboratory will provide an electronic data deliverable (EDD), as an excel file, that matches all data provided on the pdf report. Electronic data report requirements are described in Section 2.10.

Within 24 hours of sample receipt, the laboratory will provide a sample receipt file and copy of the COC. All sample receipt files and reports will be provided to E & E via a delivery method agreed upon by the Project Manager and specified in the delivery/purchase order.

The analytical reports will include the sample aliquot analyzed, final extract volume, and dilution factor. The analytical reports also will include the laboratory reporting limit and method detection limit (MDL) for all target compounds. These limits will be corrected for percent moisture and all dilution factors. Any compounds found less than the reporting limit, but greater than the MDL will be reported and qualified with a “J” flag as estimated.

QC reports must provide a summary report or batch identifier clearly linking all QC results to actual field sample results. QC summary reports must include the laboratory control limits and flag any result reported outside control limits. The case narrative must include an explanation of all QC results reported outside control limits. The laboratory must provide copies of any nonconformance or corrective action forms associated with data in the laboratory report.

For organic analytes reported in both Category A and Category B deliverables, the laboratory must report results of the most concentrated extract analysis in order to achieve the lowest quantitation limits.

1.6.3 Record Retention

All records related to the project must be stored in secure areas consistent with requirements in E & E’s QMP. All records related to the analytical effort must be maintained by the laboratory in lockable filing cabinets or stored on a secure computer server for at least five years (i.e., samples collected, accepted, and examined; procedures used, and personnel involved; and document test conditions, observations, and results of analyses)cost information, scheduling, custody transfers, and management records). E & E shall maintain complete and accurate books, records, documents, accounts and other evidence directly pertinent to performance on a secure area for a period of six years after the end of the calendar year in which the final report is issued.

Types of records to be maintained by E & E in addition to the final technical reports for NYSDEC include the following:

- Field logbooks, sampling documents, field screening data, photographs, QA/QC records, and any other supporting documentation for collection of field samples;

- Administrative records including time cards, costing, and scheduling information; and
- Client correspondence, subcontractor records, minutes of meetings, and any related project management records.

Types of records to be maintained by the laboratory in addition to the analytical report for the NYSDEC include the following:

- Complete COC records from sample receipt to destruction. Sample destruction records must contain information on the manner of final disposal;
- Supporting documentation for any nonconformance or corrective action forms supplied in the analytical report or related to the analysis of project samples;
- Computer records stored on a secure server that is backed up daily of cost information, scheduling, laboratory COC transfers, and laboratory management records;
- All laboratory notebooks including raw data such as readings, calibration details, and QC results; and
- Hard copies of data system printouts (i.e., chromatograms, mass spectra, and inductively coupled plasma [ICP] data files).

2 Data Generation and Acquisition

This section of the QAPP contains descriptions of all aspects of the implementation of field, laboratory and data handling procedures to meet the requirements of NYSDEC activities. The QAPP provides the basis for ensuring that appropriate methods are used and thoroughly documented. These procedures will be adapted, as appropriate, to meet the objectives of each NYSDEC project as described in the appropriate work plan.

2.1 Sampling Process Design

The sampling process design is documented in the work plan or in the FSP for each site. The FSP will include a project schedule and a summary table listing the type of samples collected, the sampling locations, the rationale for selecting the locations, sample handling procedures, analytical methods, and the number and type of QA/QC samples.

2.2 Sampling Methods

The sampling methods are documented in the work plan or in the FSP. E & E's sampling SOPs serve as the basis for sampling procedures.

In general, sampling at a site will progress from clean areas to contaminated areas. This minimizes the potential for cross contamination of samples and, subsequently, eliminates data anomalies or misinterpretation of the extent of contamination. The order of sample collection at a specific location normally proceeds as follows:

1. Volatile organic compounds (VOCs) or other volatile parameters (e.g. methane, ethane, ethylene or gasoline range organics);
2. Extractable organics (including semi-volatile organic compounds [SVOCs], pesticides, herbicides, polychlorinated biphenyls [PCBs], or diesel range organics);
3. Oil and grease;
4. Total metals;
5. Dissolved metals;
6. Microbiological samples;

7. Other inorganics or general chemistry parameters (e.g., sulfate, chloride, phosphorus, or nitrite/nitrate); and
8. Physical parameters (including ignitability, corrosivity, and reactivity).

This sequence helps maintain the representativeness of samples and analytical results.

The remainder of this section describes typical procedures for equipment decontamination and the handling of investigation-derived waste (IDW), and sample containers, preservatives, holding times, packing, and shipping. Specific procedures for each site are provided in the work plan or in the FSP.

2.2.1 Equipment Decontamination

Sampling methods and equipment are chosen to minimize decontamination requirements and the possibility of cross-contamination. Equipment or supplies that cannot be effectively decontaminated (e.g., sample tubing or rope) will be disposed of after sampling. Investigation/sampling equipment will be cleaned at the site prior to use, between sampling locations, and prior to transport off-site. Decontamination of field equipment will be noted in the field logbook. If it is necessary to make decontamination procedure changes in the field, the changes will be noted in the logbook. Otherwise, a notation will be made each day that decontamination was conducted as specified in the work plan or in the FSP. Rinsate blanks will be collected to verify the effectiveness of decontamination procedures. If field blanks indicate poor techniques, the QA Officer and Project Manager will ensure techniques are modified and samplers trained appropriately.

All decontamination will be performed in accordance with NYSDEC-approved procedures. Decontamination of large equipment will consist of the following:

- Removal of foreign matter; and
- High-pressure steam cleaning.

Decontamination of heavy equipment will be performed by the subcontractor and will be performed in a decontamination pad as described in the contract.

The following alternative procedures will be used for smaller equipment and may also be employed for downhole tooling such as split spoons and Geoprobe rods or routine sampling equipment:

- Initially remove all foreign matter;
- Scrub with brushes in a laboratory-grade detergent solution (e.g., Alconox);
- Rinse with potable water followed by a rinse with deionized or distilled water; and

- Allow to air dry.

If sampling for metals is conducted, then an additional rinse with a 10% nitric acid solution will be added between the potable and deionized water rinses.

Sensitive down-hole devices that only contact water (e.g., water level indicator and miniTROLL pressure transducer) may be decontaminated by triple rinsing with deionized or distilled water. Decontamination shall be performed in accordance with best practices to minimize cross-contamination of clean equipment.

Fluids generated during decontamination will be handled according to procedures described in Section 2.2.2.

2.2.2 Investigation-Derived Waste (IDW)

Unless otherwise directed by NYSDEC staff, all IDW will be handled in a manner consistent with requirements in the work plan and applicable federal and state regulations. IDW includes disposable sampling equipment and PPE, purge and development waters, drilling fluids, soil cuttings, and decontamination fluids. Waste streams will not be mixed and will be segregated to the maximum extent possible.

Investigation-derived soils and water will be field-screened for organic vapors with an organic vapor analyzer (OVA) or photoionization detector (PID) and visual inspected to initially determine whether these wastes are potentially contaminated. In order to minimize the generation of drummed wastes and the costs associated with storage, testing, transportation, and disposal of drums, IDW will be handled in the following manner:

- **Soil cuttings from boreholes:** as much of the soil cuttings as possible will be used as backfill. Remaining cuttings that are not significantly contaminated (OVA or PID readings of 5 parts per million [ppm] or less and lack of staining, sheen, etc.) will be spread on the ground near the site of generation if the location is in a suitably undeveloped area. If this is not possible or if contamination is suspected, the excess soil cuttings will be drummed;
- **Soil cuttings from monitoring well boreholes:** cuttings that are not significantly contaminated (OVA or PID readings of 5 ppm or less and lack of staining, sheen, etc.) will be spread on the ground near the site of generation if the location is in a suitably undeveloped area. If this is not possible or if contamination is suspected, the excess soil cuttings will be drummed;
- **Development and purge waters from monitoring wells and decontamination water:** water that is not significantly contaminated (OVA or PID readings of 5 ppm or less, lack of sheen, etc.) will be discharged to the surface in the area where it was generated only if the area is suitably undeveloped (e.g., not paved and not on residential property). If the water cannot be discharged

to the surface, then it may be discharged to the municipal sanitary sewer system pending receipt of a temporary discharge permit from the local sewer department. Alternatively, significantly contaminated waters or waters that cannot be discharged will be drummed; and

- **Used sampling equipment and PPE:** unless field screening indicates that PPE and other solid wastes are contaminated to the level that they cannot be disposed of as non-hazardous waste, this material will be double-bagged and disposed of off-site as non-regulated solid waste.

Wastes that need to be drummed will be placed in DOT approved 55-gallon drums and stored at a central storage location selected by NYSDEC, pending analysis and disposal. Drums will be staged within secondary containment units and covered with a plastic tarp if stored outside. All drums containing IDW will be labeled as to their contents, the site name, location where the material was generated, and date the waste was generated. Composite samples of like wastes will be collected for toxicity characteristic leaching procedure (TCLP) VOCs, TCLP SVOCs, TCLP pesticides/herbicides, TCLP metals, PCBs, corrosivity (pH), reactivity, and ignitability. A waste disposal firm will then be subcontracted to haul the waste off-site to an appropriate disposal facility as either solid or hazardous waste. E & E will coordinate drum hauling with the NYSDEC project manager to ensure that NYSDEC is available to sign the waste shipping manifest(s), as legally NYSDEC is the waste generator.

2.3 Sample Handling and Custody

2.3.1 Sample Containers

The volumes and containers required for sampling activities are indicated in Table A-2 in Appendix A. Prewashed sample containers will be provided by the laboratory and will be wide-mouth jars with Teflon-lined caps unless otherwise indicated. The laboratory must use an approved specialty container supplier, which prepares containers in accordance with EPA bottle-washing procedures. The laboratory must maintain a record of all sample bottle lot numbers shipped in the event of a contamination problem. Trip blanks will be transported to the site inside the same box as volatile organic analysis (VOA) vials or as the air sampling canisters.

For air samples, laboratories will follow cleaning procedures and checking for canisters as outlined in Method TO-15 and the NYSDOH Guidance for Soil Vapor Intrusion. Laboratories are required to certify that containers are clean and provide copies of the certification in the data package.

2.3.2 Sample Preservation and Holding Times

All samples requiring preservation will be collected in containers pre-preserved by the laboratory supplier. If field preservation is necessary, preservation will be performed immediately after collection and transportation to the site office. A clean, disposable pipette or a premeasured, single-use, glass ampule will be used to transfer liquid preservatives to the sample container. Care will be taken to avoid contact between the pipette or ampule and the sample or sample container. Solid preservatives will be transferred to the sample container using a clean, stainless-steel spoon. The sample preservation will be checked on representative samples by pouring the sample into a clean cup and testing with pH paper to determine if a sufficient amount of preservative has been used. Preserved samples for VOA will be tested on an extra vial at a rate of approximately 10%. Use of additional preservative also will be recorded in the logbook. Field blanks, which require preservation, will be preserved with a volume of reagent equal to the volume of reagent used in the samples that the blanks represent. A list of preservatives and holding times for each type of analysis are indicated in Table A-2. If the project-specific analyses are not specified in Table A-2, the work plan or FSP must address preservation requirements and holding times for the non-target analyses.

Reagents used for preservation are reagent-grade and are supplied by the laboratory or approved chemical supplier. The laboratory must maintain traceability records on preservatives in the event of potential field contamination of samples. Each bottle is received from the laboratory and must be clearly labeled with laboratory name, type of chemical, lot number, and expiration date. Field personnel should record the date used in the field, site name, and E & E project number on the label or in the site logbook. Fresh sample containers and preservatives will be obtained from laboratory stocks prior to mobilization for each sampling event. Preservatives stored on site will be disposed of after use unless containers are sealed and stored under COC in a secure area. No preservatives will be used passed the expiration date.

Sample preservation will be verified at the laboratory at receipt or prior to analysis for VOCs. The preservation or pH will be recorded in the logbook. If samples are improperly preserved, a corrective action form will be submitted to the laboratory project manager for follow-up action. The laboratory will notify the Project Chemist or Project Manager to implement corrective action in the field.

Methods for the analysis of soils, sediments, or solid matrices for VOCs will be used in conjunction with Method 5035A: Closed-System Purge-and-Trap and Extraction for Volatile Organics in Soil and Waste Samples. The recommended collection technique for Method 5035A calls for the transfer of a 5-gram aliquot of sample to a tarred empty 40-mL VOA vial or two pre-tarred VOA vials with 5 mL of deionized water, one pre-tarred vial with methanol, and one 2-ounce container for dry weight analysis (only if no other tests are required). The sample is iced at 4°C for transport to the lab. The laboratory will refrigerate VOA vials at 4°C ±2°C for 48 hours or less or preserve by freezing at <-7°C within 48 hours of receipt to extend holding time to 14 days.

2.3.3 Sample Handling

The transportation and handling of samples must be accomplished in a manner that not only protects the integrity of samples but also prevents any detrimental effects due to the possible hazardous nature of the samples. Regulations for packaging, marking, labeling, and shipping of hazardous materials are promulgated by the DOT in 49 CFR 171 through 177. E & E trains all staff responsible for the shipment of samples in these regulations. Procedures for sample packing and shipping are documented in an E & E SOP.

Sample Packaging

Samples must be packaged carefully to avoid breakage or contamination and must be shipped to the laboratory at proper temperatures. The following sample packaging requirements will be followed:

- Sample bottle lids must never be mixed. All sample lids must stay with their original containers;
- Shipping coolers must be partially filled with packing materials and ice (when required) to prevent bottles from moving and breaking during shipping;
- Environmental samples are to be cooled (when required). Wet ice packaged in sealable, plastic bags will be used to cool samples during shipping. Ice is not to be used as a substitute for packing materials;
- Any remaining space in the cooler should be filled with inert packing material such as bubble wrap. Under no circumstances should material such as sawdust or sand be used;
- A duplicate custody record must be placed in a plastic bag and taped to the inside of the cooler lid. Custody seals are affixed to the outside of the sample cooler; and
- All containers for a given sample will be shipped in the same cooler when possible. In cases where samples for volatile analysis would be shipped in several coolers on a single day, VOA vials will be consolidated into a single cooler to minimize the number of required trip blanks.

Shipping Containers

Environmental samples will be properly packaged and labeled for transport and dispatched to the laboratory facility. The SOP procedure will be followed to mark and label sample shipments. A separate COC record must be prepared for each shipping container. The following requirements for shipping containers will be followed.

Sample shipping containers will generally be commercially purchased coolers (e.g., Coleman coolers) or boxes provided from the laboratory for air canisters. Each container will be custody-sealed for shipment, as appropriate. The container custody seal will consist of filament tape wrapped around the package at least twice and custody seals affixed in such a way that access to the container can be gained only by cutting the filament tape and breaking a seal.

Field personnel will make arrangements for transportation of samples to the laboratory. In most cases, samples will be shipped using an overnight express carrier (e.g., Federal Express). Field personnel will provide the laboratory with a shipment schedule and notify them of deviations from planned activities. The field personnel will notify the laboratory of all of samples intended for Saturday delivery, no later than 3 p.m. (Eastern Time) on Thursday.

2.3.4 Sample Custody

Formal sample custody procedures begin when the precleaned sample containers leave the laboratory or upon receipt from the container vendor. The laboratory must follow written and approved SOPs for shipping, receiving, logging, and internally transferring samples. Sample identification documents must be carefully prepared so that sample identification and COC can be maintained and sample disposition controlled. Sample identification documents include:

- Field notebooks;
- Sample labels;
- Custody seals; and
- COC records.

The primary objective of COC procedures is to provide an accurate written or computerized record that can be used to trace the possession and handling of a sample from sampling through completion of all required analyses. A sample is in custody if it is:

- In a team member’s physical possession;
- In a team member’s view;
- Locked up; or
- Kept in a secured area that is restricted to authorized personnel.

Field Custody Procedures
Precleaned sample containers will be relinquished by the laboratory to the Field Team Leader. The Field Team Leader will record receipt of the sample containers in the project logbook. The following field custody procedure will be used for collection of samples:

- As few persons as possible should handle samples;
- Coolers or boxes containing cleaned bottles should be sealed with a custody tape seal during transport to the field or while in storage prior to use;
- The sample collector is personally responsible for the care and custody of samples collected until they are transferred to another person or dispatched properly under COC rules;
- The sample collector will record sample data in the field logbook; and
- The Field Team Leader will determine whether proper custody procedures were followed during the fieldwork and decide if additional samples are required.

Chain-of-Custody Record
The COC form must be fully completed by the field technician designated by the Project Manager as responsible for sample shipment to the appropriate laboratory for analysis. A duplicate copy of the COC should be maintained by the field staff for record (e.g., carbonless copy, photocopy, or photograph). In addition, if samples are known to require rapid turnaround in the laboratory because of project time constraints or analytical concerns (e.g., extraction time or sample retention period limitations), the person completing the COC record should note these constraints. The custody record also should indicate any special preservation techniques necessary or whether samples need to be filtered. Copies of COC records are maintained with the project file.

Custody Seals
Custody seals are preprinted, adhesive-backed seals with security slots designed to break if the seals are disturbed. DOT-approved sample shipping containers are sealed in as many places as necessary to ensure security. Seals must be signed and dated before use. Upon receipt at the laboratory, the custodian must check and document on a cooler receipt form that seals on boxes are intact.

2.3.5 Laboratory Custody Procedures
All laboratory custody procedures must maintain a system that provides for sample log-in, sign-out and sign-in of samples to and from individual analysts, data storage and reporting, and sample disposal. These procedures must ensure continuous documentation of sample custody from receipt to disposal. Procedures used by the laboratory must meet all NYSDEC requirements. Laboratories must

complete a cooler receipt form documenting the temperature and condition of samples upon receipt. The form must be provided in the laboratory data package.

The laboratory must submit sample receipt documents for each set of samples received. A sample delivery group (SDG) is defined as a batch of up to 20 samples collected during one calendar week. Samples shipped on Friday will normally conclude an SDG. The sample receipt documents consist of the Sample Receipt file, a pdf of the COC, and a pdf of the laboratory log report showing the tests selected. These documents must be provided to E & E's Project Manager and/or Project Chemist within 24 hours of sample receipt. The sample receipt file will be used to check field IDs so that corrections can be implemented before the final report is produced, and to ensure that the appropriate tests have been selected.

The laboratory must implement, practice, and maintain programs for managing waste disposal. E & E and NYSDEC markings must be removed from all sample containers prior to disposal. Waste disposal procedures must include use of a certified hauler and meet Federal and State regulations.

2.4 Analytical Method Requirements

Analytical method requirements will be documented in the appropriate work plan or FSP. The specific implementation of analytical methods will be documented in laboratory SOPs. Laboratory SOPs and the QA program will be reviewed and approved as part of the procurement process.

2.4.1 Standard Laboratory Analytical Procedures

Analytical methods in support of NYSDEC activities must be performed in compliance with the most current guidance by the issuing entity (i.e., EPA, NYSDOH, Centers for Disease Control). The analytical methods are based on the following guidelines:

1. 40 CFR Part 136, Guidelines Establishing Test Procedures for the Analysis of Pollutants under the Clean Water Act;
2. "Standard Methods for the Examination of Water and Wastewater," APHA/AWWA/WEF, 23rd ed, 2017;
3. "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods," EPA Publication SW-846, 3rd ed, Final updates I(1993), II(1995), IIA(1994), IIB(1995), III(1997), IIIA(1999), IIIB(2005), IV(2008), V(2015), VI(2017-2019);
4. "Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air," 2nd ed, EPA/625/R-96/010b, January 1999;
5. American Society for Testing and Materials (ASTM);
6. New York State Department of Health analytical methods; and

7. "NIOSH Manual of Analytical Methods (NMAM)," Fifth edition, December 2017.

The laboratory must be accredited by the NYSDOH ELAP for all analytical methods for which the NYSDOH provides certification. Laboratories also must be accredited by the National Environmental Laboratory Accreditation Program (NELAP) approved by NYSDOH or related accrediting authority.

Table A-2 lists all analyses that may be performed for NYSDEC projects. Reporting limits for analyses that are typically performed for NYSDEC projects are provided in Appendix B to this QAPP. Reporting limits for any additional methods will be included in the site-specific QAPP.

E & E anticipates that laboratories will use the most current method available and/or recommended by EPA. The actual methods for the project will be reviewed and approved as part of the project planning process.

2.5 Quality Control

QC data are necessary to determine precision and accuracy and to demonstrate the absence of interferences and/or contamination of glassware and reagents. Field QC will include field duplicates, trip blanks, field equipment blanks, and miscellaneous field QC samples. Field QC samples will be preserved, documented, and transported in the same manner as the samples they represent. Laboratory-based QC will consist of standards, replicates, spikes, and blanks. Method QC limits for analyses are defined in each individual laboratory SOP and are either statistically based on method performance or based on method requirements. General quality control limits (from EPA Region 2 SOPs) are provided in Appendix B for routine analyses. If project-specific quality control limits are required, they will be provided in a site-specific QAPP.

2.5.1 Field Quality Control Samples

The collection of field QC samples and the conditions, under which the samples were collected, will be documented in the field logbook. Unless otherwise directed by NYSDEC, the field QC samples listed below will be collected and analyzed at the frequency listed in Table 2-1.

Table 2-1 Field Quality Control Guidelines

QC Sample	Description
Field Duplicate	One per matrix per 20 samples for each analysis.
Field Equipment Blank	One per equipment per 20 samples for each analysis. Only equipment sets that are subject to decontamination require equipment blanks. Dedicated or disposal equipment does not require equipment blanks.

Table 2-1 Field Quality Control Guidelines

QC Sample	Description
Field Background Samples	Per sampling day for indoor air samples as specified in the guidance for soil vapor intrusion.
Trip Blank	One per shipment for each cooler in which aqueous samples for VOC analysis are shipped. Trip blanks are analyzed for all VOC methods designated for samples.

Field Duplicate Samples

Field duplicate samples will be collected at the rate one per 20 project samples of the same matrix. Duplicate soil samples will be prepared by collecting equal aliquots from the same sample source and placing them in separate sample bottles. Duplicate water samples will be prepared by collecting successive volumes of water and placing them in separate bottles. Duplicate air samples will collected with a tubing splitter. Duplicate samples will be shipped with the samples they represent and will be analyzed in the same manner.

The RPD between the concentration in the original and duplicate sample measures the overall precision of the field sampling and analytical method. Unless otherwise specified in the data validation SOP, field duplicates are evaluated against an RPD of 50% for both soil and aqueous samples. If all other laboratory QC criteria are met, RPD results outside control limits indicate potential matrix effects. Significant deviations in RPD results of field duplicates are assessed to evaluate whether data met all quality objectives for the project.

Trip Blanks

Trip blanks are collected to establish that the transport of sample bottles to and from the field does not result in contamination of the sample from external sources. Trip blanks will be collected for, and in conjunction with, only VOA for aqueous samples. If the 40-milliliter (mL) VOA vials are shipped to the field team by the laboratory sample custodian, a representative number of vials filled with analyte-free water (preserved, capped, and labeled) will accompany the shipment to and from the laboratory. Trip blanks will be treated in the same manner as the VOA samples they represent and will be taken to representative field sample sites but remain unopened. Trip blanks will be sent with each sample-shipping container that contains aqueous samples for VOA.

Trip blanks for air canisters are not required but may be requested on a project-specific basis. Air canister trip blanks will be treated in the same manner as the normal samples they represent and will be taken to representative field sample sites but remain unopened.

Field Equipment Blanks

Field equipment blanks are blank samples (also called rinsate blanks) designed to demonstrate that sampling equipment has been properly prepared and cleaned before field use and that cleaning procedures between samples are sufficient to minimize cross-contamination. Field equipment blanks will be prepared in the field using an approved water source. Sampling of the water source may also be required if analyte-free water is not obtained from the lab. The field equipment blank will be preserved, documented, shipped, and analyzed in the same manner as the samples it represents. Equipment blanks will be collected at the rate of one per 20 samples, per equipment set.

An equipment set is all sampling equipment required to collect one sample. For example, one soil sample equipment set may include a stainless-steel bowl, a stainless-steel trowel, and a bucket auger. Samples collected with dedicated or disposable equipment do not require equipment blank samples.

Field equipment and trip blanks serve to demonstrate contamination-free procedures in the field and during sample transport. The goal is for field blanks to be free of contamination. Low-level contamination may be present, but must be less than five times the level found in associated samples. If contamination is greater, the sample results are qualified as non-detect at an elevated-reporting limit. If field blank contaminants are also present in the method blank, or are typical laboratory contaminants, or are not present in project samples, then no further action is required. All other sources of contamination must be investigated as part of the corrective action process. Sample results that do not meet quality objectives after qualification, re-sampling may be required. The QA Officer, Project Chemist, and Project Manager must determine potential changes in field procedures to eliminate contamination sources prior to re-sampling.

Miscellaneous Field QC Samples

This type of QC sampling involves analysis of investigation water sources and monitoring well drilling fluids (if used). Because the water supply source is used in decontamination and well drilling activities, it may be necessary to determine the possibility for the introduction of outside contaminants. Drilling fluids (muds) that are used during well installation may also be analyzed in order to assess the possibility of such constituents affecting groundwater samples.

Field background samples are required for air sampling events. Results of the background sample are used in the assessment process to determine whether contamination is site-related or significant.

2.5.2 Laboratory Quality Control Analyses

Analytical performance is monitored through QC samples and spikes, such as laboratory method blanks, surrogate spikes, QC check samples, matrix spikes, matrix spike duplicates, matrix duplicate samples, and duplicate injections (see Table

2-2). All QC samples are applied on the basis of a laboratory batch. Batches do not exceed 20 samples excluding associated field and laboratory QC samples. The QC samples associated with sample preparation include method blanks, laboratory control samples (LCSs) (also called matrix spike blanks [MSB] by NYSDEC), matrix spikes, and duplicates. The run batch represents all samples analyzed together in the run sequence. The run sequence is typically limited to 24 hours unless defined differently for the analytical method. For some analyses, such as volatile organics, the run batch is equivalent to the preparation batch. The QC samples associated with the run sequence include calibration standards, instrument blanks, and reference standards. Unless otherwise directed by NYSDEC staff, the laboratory QC samples listed below will be collected and analyzed at the frequency listed in Table 2-2.

Instances may arise where high sample concentrations, nonhomogeneity of samples, or matrix interferences preclude achieving detection limits or associated QC target criteria. In such instances, data will not be rejected *a priori* but will be examined on a case-by-case basis. The laboratory will report the reason for deviations from these detection limits or noncompliance with QC criteria in the case narrative.

Table 2-2 Laboratory Quality Control Sample Guidelines

QC Sample	Description
MB	One per matrix per preparation batch for each analysis.
LCS/MSB	One per matrix per preparation batch for each analysis. The LCS/MSB must contain all target analytes of concern at the site.
Surrogate Spikes	All samples analyzed for organic methods.
Internal Standards	All samples analyzed by GC/MS methods.
MS/MSD	One per matrix per SDG for each analysis. The spike solution must contain a broad range of the analytes of concern at the site. The overall frequency of MS/MSD on project samples must be at least one set per 20 samples.
MS/MD	One per matrix per SDG for metals and general chemistry methods. The spike solution must contain a broad range of analytes of concern at the site. The overall frequency of MS/MD on the project samples must be at least one set per 20 samples.
Serial Dilution/Post Digestion Spike	All samples analyzed for metals.

Key:
SDG = Sample Delivery Group.
LCS = Laboratory Control Samples.
MSB = Matrix Spike Blank.
MS/MD = Matrix Spike/Matrix Duplicate.
MS/MSD = Matrix Spike/Matrix Spike Duplicate.
MB = Method Blank.

Laboratory Method Blank

Laboratory method blanks serve to demonstrate a contamination-free environment in the laboratory. The goal is for method blanks to be free of contamination. Low-level contamination may be present, but must be less than the reporting limit. If contamination is greater, samples are reanalyzed. If contaminants are present in the method blank but not in project samples, no further action is required. All sources of contamination that are not common laboratory contaminants as defined in the method SOPs must be investigated as part of the corrective action process. Sample results must not be blank subtracted unless specifically required by the analytical method.

Surrogate Standards

Surrogate recoveries must be within QC criteria for method blanks and LCSs to demonstrate acceptable method performance. If surrogate recoveries are outside QC criteria for method blanks or LCSs, corrective action is required and the Project Chemist should be notified. Surrogate recoveries in the samples indicate the method performance on the particular sample matrix. Surrogate recoveries that are outside QC criteria for a sample indicate a potential matrix effect. Matrix effects must be verified based on review of recoveries in the method blank or LCS, sample reanalysis, or evaluation of interfering compounds. If matrix interference problems are indicated, sample clean-up procedures must be implemented.

Laboratory Control Sample

LCS recoveries must be monitored on control charts, and laboratory QC criteria must be established for each method and matrix using a minimum of 30 points. QC criteria should be updated annually. The LCS recovery must be within the control limits to demonstrate acceptable method performance. Sporadic marginal failures of a few target analytes reported when greater than five target analytes are required are allowed as part of the data review guidance. If LCS recoveries are outside QC criteria for more than a few target analytes, recoveries are significantly low, or the compounds were detected in the samples, then corrective action is required. After corrective action is complete, sample re-analysis is required for failed parameters. If LCS recoveries exceed the QC criteria, and that parameter is not found in any samples, re-analysis is not necessary. For any other deviations from LCS control limits that cannot be resolved by sample re-analysis within holding times, the Project Chemist must be notified immediately. If critical samples are affected, the Project Manager may determine that re-sampling is required.

Matrix Spike Sample

MS recoveries are a measure of the performance of the method on the sample being analyzed. Field and trip blanks must not be chosen for spiking. MS recoveries outside the control limits applied to the LCS indicate matrix effects. Sample clean-up procedures may be warranted for samples with severe matrix effects. The laboratory should notify the Project Chemist of these instances to determine an appropriate corrective action.

Matrix Spike Duplicate Sample

The MSD sample is commonly prepared in conjunction with the MS sample. The MSD is prepared from a separate portion of the sample and processed with the same additions as the MS. The MSD is prepared for methods that do not typically show concentrations of target analytes above MDLs, such as organic methods. The RPD between the recoveries in the MS and MSD measures the precision of the analytical method on actual project samples. QC criteria for RPDs are generally 20% for waters and 35% for soils unless the laboratory provides additional statistical criteria.

Matrix Duplicate Sample

The duplicate is prepared for methods that typically show concentrations of target analytes above MDLs, such as metals and wet chemistry methods. The RPDs between recoveries in the original and duplicate measures the precision of the analytical method on the actual project samples. QC criteria for RPDs are generally 20% for waters and 35% for soils unless the laboratory provides additional statistical criteria.

If all other QC criteria are met, RPD results outside control limits indicate potential matrix effects. The laboratory should investigate significant deviations in the RPD results by observing the sample to determine any visual heterogeneity or reviewing sample chromatograms for matrix interference. If visual observation does not indicate a potential problem, the sample may be reanalyzed. Potential matrix effects are reported in the case narrative.

Instrument Blanks

Instrument or reagent blanks are analyzed in the laboratory to assess laboratory instrument procedures as possible sources of sample contamination. Instrument blanks are part of the laboratory corrective action if method blanks show contamination or the analyst suspects carryover from a high concentration sample. Instrument blank results are reported on a laboratory corrective action form.

QC Check Standards

A QC check standard is obtained from a different source or at a minimum a lot different from that of the calibration standard. A check standard result is used to validate an existing concentration calibration standard file or calibration curve. The check standard provides information on the accuracy of the instrumental analytical method, independent of various sample matrices. Check standards are analyzed with each new calibration curve.

Internal standard area counts for water and solid sample analysis for all samples must be in the inclusive range of 50% to 200%, and retention time must not vary more than ±10 seconds of its associated 12-hour calibration standard (i.e., opening

Continuing Calibration Verification or mid-point standard from Initial Calibration).

The serial dilution analysis (a five-fold dilution) must agree within a 10% difference of the original determination after correction for the dilution if the analyte concentration is sufficiently high (concentration in the original sample is >50 times [50x] the MDL).

The post-digestion spike (%R) must be within the acceptance limits of 75% to 125%. However, spike recovery limits do not apply when the native sample concentration is greater than 4x the spike concentration added.

Other Laboratory QC Samples

The laboratory performs analysis of other QC samples or standards, depending on the analytical method. Method-specific QC samples or standards include internal standard spikes for gas chromatography/mass spectrometry (GC/MS) methods; post-digestion spikes and serial dilutions for metals analysis; and interference check samples (ICSs) for ICP analysis.

Blind QC Check Samples

Types of blind QC check samples include external performance evaluation (PE) samples provided by an outside certifying agency and internal QC samples submitted for routine analysis by the laboratory QA officer. The laboratory must pass NYSDOH proficiency test samples as part of the approval process (see proficiency test results for the subcontract laboratories in Appendix C). If methods are used that are not included in NYSDOH approval process, blind QC samples may be submitted to the laboratory to evaluate method performance.

2.6 Instrument/Equipment Testing, Inspection, and Maintenance

All laboratory and field instruments and equipment used for sample analysis must be serviced and maintained only by qualified personnel. Laboratory instrument maintenance procedures will be evaluated to verify that there will be no impacts on analysis of project samples due to instrument malfunction. For example, the laboratory must have duplicate instrumentation and/or major laboratory instruments (e.g., GC/MS, ICP, atomic absorption spectroscopy [AAS]) maintained under service agreements with the manufacturer that require rapid respond by manufacturer-approved service agents.

Field instruments will be rented through approved suppliers that have manufacturer-approved maintenance programs.

2.6.1 Field Equipment Maintenance

Field equipment will be checked upon receipt to verify that instruments are in working condition and that the rental company provided appropriate calibration records or certifications. On-site operation will be performed in accordance with manufacturer manuals. If any problems occur, the instrument will be replaced immediately. Equipment purchased for the contract will be maintained in accordance with manufacturer guidance.

2.6.2 Laboratory Equipment Maintenance

The laboratory must maintain a stock of spare parts and consumables for all analytical equipment. Routine preventive maintenance procedures should be documented in SOPs. Maintenance performed on each piece of equipment must be documented in a maintenance logbook. Daily checks of the laboratory deionized water and other support systems are required. The laboratory must operate backup instrumentation for most of its analytical equipment in the event of major instrument failure or have an alternative approached to ensure analytical work proceeds within holding times with no adverse impacts on data quality.

2.7 Instrument/Equipment Calibration and Frequency

All instruments and equipment used during sampling and analysis will be operated and calibrated according to the manufacturer's guidelines and recommendations, as well as criteria set forth in applicable analytical methodology references. Personnel properly trained in these procedures will perform operation and calibration of all instruments. Documentation of all field maintenance and calibration information will be maintained in the field logbook. Table A-3 lists typical monitoring equipment used during fieldwork. This equipment is representative of instruments typically required for NYSDEC projects. All equipment used for the NYSDEC projects will be NYSDEC-owned or rented. All field personnel receive annual refresher training on the field operation of all health and safety related equipment, which includes calibration procedures. Brief descriptions of calibration procedures for major field instruments are listed on Table A-3.

E & E requires laboratories to use the most current method available for calibration criteria. For example, EPA no longer allows the use of the grand mean to evaluate calibration linearity for organic methods. E & E requires that the most stringent method criteria be met for all compounds of concern at site. Unless modified by the method, E & E requires at least a five point curve for all calibrations for organics and a minimum of three calibration points for inorganics; exclusion of points is not allowed to meet criteria without technical justification. Any manual integration performed for calibrations needs to be documented with the rationale and included in the data package. Manual integrations of internal standards or surrogates in calibrations are not allowed.

2.8 Inspection/Acceptance of Supplies and Consumables

Measures are established in E & E's QMP to assure that purchased material, equipment, and services whether purchased directly or through contractors or subcontractors conform to procurement documents. Documentation regarding the purchase of material, equipment, and services is prepared, reviewed, and approved in accordance with requirements set forth in the QMP and E & E subcontracting procedures.

Procedures for the procurement, inspection, maintenance and management of equipment and supplies for NYSDEC activities are documented in E & E's Government Property Procurement SOP. All field supplies and equipment will be procured as part of the contract and maintained by the technical team. Supplies and equipment will be inspected on receipt at the site to verify that the correct materials were received.

2.9 Non-Direct Measurements

For data acquired from non-direct measurement sources include the following:

- Physical information such as descriptions of sampling activities and geologic logs;
- State and local environmental agency files;
- Reference computer databases and literature files; and
- Historical reports on a site and subjective information gathered through interviews.

Data from non-direct measurements will be reviewed and used as indicated in the work plan. Data from all non-direct measurement sources are stored as indicated in Section 1.6.

2.10 Data Management

Data management procedures track samples and results from work plan generation to the final report. The field data include approved work planning tables, Global Positioning System (GPS) data, labels, field sampling forms, COC forms, and logbooks. The field team leader will review all field data for accuracy. Any field data not loaded into the GPS will be recorded in the logbook.

Electronic data will be provided in accordance with the most recent version of NYSDEC's standardized EDD format. If required for the project, the laboratory may also provide an alternative EDD format if specified in the project-specific delivery/purchase order.

The E & E Project Chemist (see resumes provided in Appendix D) will process the EDD to verify that appropriate data quality criteria established in the specific laboratory SOP and/or general validation guidance (see Appendix B) are met. The Project Chemist will review all laboratory and field data to verify the results against the hard copy and check for transcription errors. The EDDs will be checked for completeness using EQuIS® electronic data processor. The Project Chemist will verify qualifiers added by the laboratory are appropriate and add any additional data validation qualifiers. Qualifiers assigned based on validation of laboratory and field QC results will be entered into EQuIS® manually. If a data package is determined to be unusable, the Project Chemist will immediately contact the laboratory. Once verified or validated, the EQuIS® database will be accessible to other users via EQuIS® Enterprise, a Web-based version data management system for project managers with read-only access. The EQuIS® database will be used to create tables for the final report.

The EQuIS® database will be stored in a secure area on E & E's network with access limited to data management specialists designated by the Project Manager. The central database can be electronically linked to E & E's geographic information system (GIS)/computer aided drafting (CAD) systems, risk assessment programs, and other final data user models and statistical programs. The data for the report will be uploaded to GIS and transferred to other data users as a GIS layer. Data storage, access, and security will follow the procedures described in the EPA's National Geospatial Data Policy sections. A data evaluation report will include information on GIS processing. Data users may enter additional electronic data such as risk-based criteria for comparison of results. This data will be stored in separate tables in the database and linked to the actual results. Any data from outside sources will include a description of the data, a reference to the source, and the date updated. Outside data will be checked prior to use verify that current values are used.

3 Assessment and Oversight

E & E's assessment and oversight procedures will be implemented in accordance with the QMP. The QMP outlines general roles and responsibilities for the project team.

3.1 Assessment and Response Actions

E & E's overall assessment activities include management assessments, development of SOPs, and performance evaluations. Management assessments include weekly meetings and conference calls to evaluate project readiness and staff utilization. Assignment of qualified personnel, maintenance of schedules and budgets, and quality of project deliverables are verified as part of these assessments. The development of SOPs and performance evaluations are used to provide trained and qualified personnel for the project.

E & E's technical assessment activities include peer review, data quality reviews, and technical system audits (i.e., laboratory and field). Procedures for assessment and audit of data quality are described in Section 4 of this QAPP. Procedures for peer review and technical assessments are summarized briefly below.

Both overall and direct technical assessment activities may result in the need for corrective action. E & E's approach to implementing a corrective action response program for both field and laboratory situations is summarized briefly below. The NYSDEC QA Officer has stop work authority on all NYSDEC projects that may have negative quality impacts prior to completion of corrective actions.

3.1.1 Peer Review

E & E implements peer review for all project deliverables including work plans, QAPPs, draft and final reports, and technical memoranda. The peer review process provides for a critical evaluation of the deliverable by an individual or team to determine if the deliverable will meet established criteria, quality objectives, technical standards, and contractual obligations. The Project Manager will assign peer reviewers, when the publications schedule is established. The publications staff will be responsible for ensuring all peer reviewers participate in the review process and approve all final deliverables. For technical memoranda and other project documents, the Project Manager will be responsible for obtaining principal review and approval.

3.1.2 Technical Systems Assessments

The entire project team is responsible for ongoing assessment of the technical work performed by the team, identification of nonconformance with the project objectives, and initiation, implementation and documentation of corrective action. Independent performance and systems audits are technical assessments that are a possible part of the QA/QC program. The following describes types of audits conducted, frequency of these audits, and personnel responsible for conducting audits.

Field Audits

Field audits are performed under the direction of the QA Officer. The need for field audits will be determined during project planning and indicated in the work plan. Field audits will be documented on E & E field audit checklists. Field audits will be typically performed during the early field programs.

Field Inspections

The Project Manager will be responsible for inspecting all field activities to verify compliance of activities with project plans.

Laboratory Audits

The laboratory must implement a comprehensive program of internal audits to verify compliance of their systems with SOPs and QA manuals.

NYSDOH must certify the laboratory and will perform external systems audits at an approximate frequency of once a year. External audits include reviews of analytical capabilities and procedures, COC procedures, documentation, QA/QC, and laboratory organization. These audits also include analysis of blind PE samples.

The QA Officer or designee may also audit laboratories. These audits are typically performed to verify laboratory capabilities and implementation of any complex project requirements or in response to a QC nonconformance identified as part of the data review process.

3.1.3 Corrective Action

Corrective actions will be implemented as needed. In conjunction with the QA Officer and Laboratory QA Coordinator, the Project Manager is responsible for initiating corrective action and implementing it in the field and office, and the laboratory project manager is responsible for implementing it in the laboratory. It is their combined responsibility to see that all sampling and analytical procedures are followed as specified and that the data generated meet the prescribed acceptance criteria. Specific corrective actions necessary will be clearly documented in the logbooks or analytical reports.

Field Situations

The need for corrective action in the field may be determined by technical assessments or by more direct means such as equipment malfunction. Once a problem has been identified, it may be addressed immediately or an audit report may serve as notification to project management staff that corrective action is necessary. Immediate corrective actions taken in the field will be documented in the project logbook. Corrective actions may include, but are not limited to:

- Correcting equipment decontamination or sample handling procedures if field blanks indicate contamination;
- Recalibrating field instruments and checking battery charge;
- Training field laboratory personnel in correct sample handling or collection procedures; and
- Accepting data with an acknowledged level of uncertainty.

After a corrective action has been implemented, its effectiveness will be verified. If the action does not resolve the problem, appropriate personnel will be assigned to investigate and effectively remediate the problem. Corrective actions recommended by NYSDEC personnel will be addressed in a timely manner.

Laboratory Situations

Out-of-control QC data, laboratory audits, or outside data review may determine the need for corrective action in the laboratory. Corrective actions may include, but are not limited to:

- Reanalyzing samples, if holding times permit;
- Correcting laboratory procedures;
- Recalibrating instruments using freshly prepared standards;
- Replacing solvents or other reagents that give unacceptable blank values;
- Training additional laboratory personnel in correct sample preparation and analysis procedures; and
- Accepting data with an acknowledged level of uncertainty.

The laboratory corrective actions must be defined in analytical SOPs. Any deviations from approved corrective actions must be documented and approved by the Project Chemist.

Whenever corrective action is deemed necessary by the Project Chemist or NYSDEC technical staff, the laboratory project manager will ensure that the following steps are taken:

- The cause of the problem is investigated and determined;
- Appropriate corrective action is determined;
- Corrective action is implemented and its effectiveness verified by the laboratory QA officer; and
- Documentation of the corrective action verification is provided to the Project Chemist and NYSDEC staff in a timely manner.

3.2 Reports to Management

For reports to management include the following:

- **Audit Reports** - Audit reports are prepared by the audit team leader immediately after completion of the audit. The report will list findings and recommendations and will be provided to the Project Manager and QA Officer.
- **Data Usability Summary Report** - A DUSR will be completed by the Project Chemist and provided to the NYSDEC technical staff in the appendix of the report. Impacts on the usability of data will be tracked by adding qualifiers to individual data points as described in Section 4.
- **Project Status Reports** - Project status reports are completed by the Project Manager to document the overall assessment of the project on a monthly basis. E & E's Contract Manager and the NYSDEC technical staff use reports to track the overall quality of performance on projects in regard to schedule, budgets, and other issues.

Upon completion of a project sampling effort, analytical and QC data will be included in a comprehensive technical report that summarizes field activities and provides a data evaluation. A discussion of the validity of results in the context of QA/QC procedures will be made and the DUSR will be provided.

Serious analytical problems will be reported immediately to NYSDEC personnel. Time and type of corrective action (if needed) will depend on the severity of the problem and relative overall project importance. Corrective actions may include altering procedures in the field, conducting an audit, or modifying laboratory protocol.

All documents and data are to be submitted to NYSDEC in an electronic format and must be submitted in accordance with NYSDEC's electronic submission protocols. Information on the format of data submissions is available at http://www.dec.ny.gov/chemical/62440.html. Information on document submission is available at http://www.dec.ny.gov/regulations/2586.html.

4 Data Validation and Usability

E & E will implement procedures for data validation and usability described below. These procedures will be adapted, if necessary, to meet project-specific requirements as determined in the work plan or FSP. Data validation will be performed by qualified chemists as outlined in NYSDEC DER-10 (see Appendix D for resumes of chemists).

4.1 Data Review, Validation, and Verification Requirements

All data generated will be reviewed by comparing accuracy and precision results for the QC samples to the QC criteria outlined in the subcontracted laboratory SOPs and/or validation guidance provided in Appendix B. The following types of data will be reviewed:

- Analytical reporting limits and target compounds will be compared to project-specific limits outlined in the site-specific QAPP or delivery/purchase order;
- Holding times will be verified against Table A-2;
- QC summary data for surrogates, method blanks, LCS, and MS/MSD samples will be compared to criteria listed in Appendix B or the site-specific QAPP;
- Field QC results for field duplicates and blanks will be compared to criteria listed in Section 2.5.1;
- Calibration summary data will be checked by the laboratory to verify that all positive results for target compounds were generated under an acceptable calibration as defined by the analytical method. Any deviations will be noted in the case narrative and reviewed by the Project Chemist;
- Field data such as sample identifications and sample dates will be checked against the laboratory report; and
- Any raw data files from the field and laboratory will not be reviewed unless there is a significant problem noted with the summary information.

4.2 Validation and Verification Methods

The data review scheme for analytical results from the receipt of the analytical data through the validated report is described below. The laboratory is responsible for performing internal data review. The laboratory data review must include 100% analyst review, 100% peer review, and 100% review by the laboratory project manager or designated QC reviewer to verify that all project-specific requirements are met. All levels of laboratory review must be fully documented and available for review if requested or if a laboratory audit is performed.

After receipt from the laboratory, project data will be validated using the following steps:

Evaluation of Completeness

The Project Chemist checks the electronic files for compliance with required format and the project target compounds and units. If errors in loading are found, the EDD files will be returned to the laboratory and the Project Chemist will request resubmission. The Project Chemist also verifies that the laboratory information matches the field information and that the following items are included in the data package:

- COC forms and laboratory sample summary forms;
- Case narrative describing any out-of-control events and summarizing analytical procedures;
- Data report forms (i.e., Form I);
- QA/QC summary forms; and
- Chromatograms documenting any QC problems.

If the data package is incomplete or contains errors, the Project Chemist will request that the laboratory provides a revised data package. The laboratory must provide a revised data package within five business days in accordance with the subcontract.

Evaluation of Compliance

The Project Chemist will review all processed files and add data qualifiers for outliers. If QC data are provided in the EDD, the results will be used to verify compliance electronically. If no QC data are provided in the EDD, the reports will checked manually. Additional compliance checks on representative portions of the data are briefly outlined below:

- Review chromatograms, mass spectra, and other raw data if provided as backup information for any apparent QC anomalies;
- Review of calibration summaries or any other QC samples not provided in the EDD by the laboratory;
- Ensure that all analytical problems and corrections are reported in the case narrative and that appropriate laboratory qualifiers are added;

- For any problems identified, review concerns with the laboratory, obtain additional information if necessary, and check all related data to determine the extent of the error;
- Project chemists will follow qualification guidelines in EPA Region 2 data validation SOPs or EPA *National Functional Guidelines for Superfund Organic Superfund Methods Data Review,* EPA-540-R-2017-002 (January 2017) or EPA *National Functional Guidelines for Inorganic Superfund Methods Data Review,* EPA-540-R-2017-001 (January 2017), but will use the specific method criteria for evaluation. The DUSR will be completed as specified in NYSDEC *DER-10/Technical Guidance for Site Investigation and Remediation; Appendix 2B, Guidance for Data Deliverables and the Development of Data Usability Summary Reports* (May 2010); and
- E & E data validation criteria are incorporated into checklists for some methods.

Data Review Reporting

The Project Chemist will perform the following reporting functions:

- Alert the Project Manager to any QC problems, obvious anomalous values, or discrepancies between the field and laboratory data, that may impact data usability;
- Discuss QC problems in a DUSR for each laboratory report. DUSR will include a short narrative and print out of qualified data;
- Prepare analytical data summary tables of qualified data that summarize those samples and analytes for which detectable concentrations were exhibited including field QC samples; and
- At the completion of all field and laboratory efforts, summarize planned versus actual field and laboratory activities and data usability concerns in the technical report.

4.3 Reconciliation with User Requirements

For routine assessments of data quality, E & E will implement the data validation procedures described in Section 4.2 and assign appropriate data qualifiers to indicate limitations on the data. The Project Chemist will be responsible for evaluating precision, accuracy, representativeness, comparability, completeness, and sensitivity of data using procedures described in Section 2.5 of this QAPP. Any deviations from analytical performance criteria or quality objectives for the project will be documented in the DUSR provided to the data users for the project.

The QA Officer or Project Chemist will work with the final users of the data in performing data quality assessments. The data quality assessment may include some or all of the following steps:

- Data that are determined to be incomplete or not usable for the project will be discussed with the project team. If critical data points are involved which impact the ability to complete project objectives, data users will report immediately to the Project Manager. The Project Manager will discuss resolution of the issue with NYSDEC technical staff and implement necessary corrective actions (for example re-sampling);
- Data that are non-detect but have elevated reporting limits due to blank contamination or matrix interference will be compared to screening values. If reporting limits exceed the screening values, then results will be handled as incomplete data as described above; and
- Data that are qualified as estimated will be used for all project decision making. If an estimated result is close to a screening value, then there is uncertainty in any conclusions as to whether the result exceeds the screening value. The data user must evaluate the potential uncertainty in developing recommendations for the site. If estimated results become critical data points in making final decisions on the site, the Project Manager and NYSDEC technical staff should evaluate the use of the results and may consider the data point incomplete.

The assessment process involves comparing analytical results to screening values and background concentrations to determine if the contamination present is site-related (i.e., above background levels) or significant (i.e., above screening values). Additional data assessment may be performed on a site-by-site basis.

A Tables

Table A-1 General Data Quality Objectives

Data Collection Activity	Quality Objectives	Standards[a]	Acceptability/ Performance Criteria[b]
Sampling and Analysis	To have samples and analytical results that accurately represents the nature and extent of contamination at the site. Data must be of sufficient quality to meet all regulatory requirements and allow assessment of impacts on human health by comparison to New York State criteria or background values. Data also may be used for long-term monitoring or to meet regulatory permit requirements. In these cases, data must meet the requirements of the permit.	■ NYSDEC Ambient Water Quality Standards and Guidance Values ■ NYSDOH Soil Vapor Intrusion Guidance Values ■ NYSDEC Remedial Program Soil Cleanup Objectives ■ NYSDEC Guidelines for Sampling and Analysis of PFAS	■ Data must be collected under an approved FSP using approved SOPs. Data must meet the acceptance and performance criteria documented in Section 2 of this QAPP. ■ Reporting limits should be below risk-based screening values for 90% of target analytes and 100% of critical analytes of concern. ■ Data must be compared to standards.
Field Screening Analysis	To have samples and analytical results that effectively indicate the nature and extent of contamination at the site. Technical personnel use data to determine the best locations to collect samples for laboratory analysis.	■ None	■ Data must be collected under an approved FSP using approved SOPs. Data must meet the acceptance and performance criteria for the screening method. ■ Reporting limits should be below anticipated concentrations of critical analytes of concern.
Subsurface Logging	To provide a description of the subsurface soils that is consistent and accurate, and to record drilling and sampling procedures and well construction details.	■ E & E SOPs (including Geologic Logging and Monitoring Well Installation)	■ Accurate, consistent, signed, and legible documentation as described in SOPs. ■ Unconsolidated materials described according to the Unified Soil Classification System. ■ Rock/soil material described using standard geologic nomenclature.
Surveying	To relate project work locations (including sample, monitoring well, and test pit locations) to existing local benchmarks.	■ Surveying subcontract ■ Differential correction for GPS data	■ Relation of all survey points to existing/known benchmarks. ■ Accurate horizontal coordinates (±0.5 foot for wells; ±3 feet for GPS locations). ■ Accurate vertical elevations (±0.01 foot) for permanent monitoring well locations.
Field Records	To document all field activities and to allow accurate representation field events in the final report. Records must be capable of withstanding legal scrutiny.	■ Section 2 of the QAPP ■ E & E SOPs (Field Activities Logbooks)	■ Consistency between field and laboratory data. ■ Clear and legible documentation for sample collection and equipment decontamination for final report.

Table A-1 General Data Quality Objectives

Data Collection Activity	Quality Objectives	Standards[a]	Acceptability/ Performance Criteria[b]
Outside Records	To use the most current reference values, reports, or data from outside sources in data assessments and recommendations for the site.	None	■ All versions of data or standards must be the most current values available. ■ Data or standards must be accurately incorporated into the final report.
Data Review and Assessment	To review and verify data are generated according to the QAPP and assign data qualifiers as necessary to indicate limitations on data usability.	■ NYSDEC DER-10 ■ EPA Region 2 Data Validation SOPs ■ EPA National Functional Guidelines	■ Data must be reviewed by Project Chemist meeting the minimum NYSDEC qualifications. ■ Data qualifiers or changes to data must be documented in a DUSR.

Notes:

[a] Major standards.
[b] Major or noteworthy acceptability criteria. All performance criteria must be verified using procedures listed in the QAPP.

Key:

DER = Division of Environmental Remediation.
GPS = Global Positioning System.
NYSDEC = New York State Department of Environmental Conservation.
NYSDOH = New York State Department of Health.
SOP = Standard Operating Procedure.
QAPP = Quality Assurance Project Plan.

Table A-2 Summary of Analytical Methods, Preservatives, and Holding Times

Parameter	Method	Containers/Preservative for Solid Samples[a]	Containers/Preservative for Aqueous or Air Samples[a]	Holding Time for Solid Samples[a]	Holding Time for Aqueous or Air Samples[a]
Routine Analysis					
VOCs and related tests	SW-846 8260C/D SW-846 8021B EPA 624.1 EPA 524.2 EPA 502.2	Two pre-weighed 40-mL vials with stir bar and deionized water, one pre-weighed 40-mL vial with stir bar and methanol, and one 4-oz. container (for dry weight)	Three 40-mL glass vials with septa, preserved with HCl pH <2	48 hours for analysis, or freeze to <-7˚C and 14 days for analysis following freezing	14 days for waters with chemical preservative, and 7 days for unpreserved
SVOCs and related tests	SW-846 8270D/E EPA 625.1	One 4-oz. glass jar	Two 1-L amber glass bottles	14 days/40 days[b]	7 days/40 days[b]
Pesticides	SW-846 8081B EPA 608.3	One 4-oz. glass jar	Two 1-L amber glass bottles	14 days/40 days[b]	7 days/40 days[b]
PCBs	SW-846 8082A EPA 608.3	One 4-oz. glass jar	Two 1-L amber glass bottles	14 days/40 days[b]	7 days/40 days[b]
Metals	SW-846 6010C/D SW-846 6020A/B EPA 200.7 EPA 200.8	One 4-oz. glass jar	One 250-mL HDPE bottle preserved HNO_3 to pH <2	180 days	180 days
Mercury	SW-846 7471B/7470A EPA 1631E	One 4-oz. glass jar (may be combined with metals)	One 250-mL HDPE bottle preserved HNO_3 to pH <2 (may be combined with metals)	28 days	28 days
Air/Vapor Samples					
VOCs	TO-15[g]	NA	1.0, 2.0, or 6.0 L Summa Canister (depending on lab availability	NA	30 Days

Table A-2 Summary of Analytical Methods, Preservatives, and Holding Times

Parameter	Method	Containers/Preservative for Solid Samples[a]	Containers/Preservative for Aqueous or Air Samples[a]	Holding Time for Solid Samples[a]	Holding Time for Aqueous or Air Samples[a]
Solid Waste					
Ignitability	SW-846 Chapter 8 (8.1)	One 4-oz. glass jar	One 250-mL HDPE bottle	40 days	40 days
Corrosivity (as pH)	SW-846 Chapter 8 (8.2)	One 4-oz. glass jar	One 250-mL HDPE bottle	ASAP	ASAP
Reactivity	Cyanide: SW-846 9012B/9014 Sulfide: SW-846 9034	One 4-oz. glass jar	One 250-mL HDPE bottle	28 days	28 days
TCLP Extraction	SW-846 Chapter 8 (8.3) 1311	Various (see below)	Various (see below)	see individual tests below	see individual tests below
TCLP Metals/	SW-846 6010C/D	One 8-oz. glass jar	One 1-L HDPE bottle[c]	180 days to TCLP extraction[d]	180 days to TCLP extraction[d]
TCLP Mercury	SW-846 7470A	One 8-oz. glass jar (may be combined with metals)	One 1-L HDPE bottle[c] (may be combined with metals)	28 days to TCLP extraction[d]	28 days to TCLP extraction[d]
TCLP Volatile Organics	SW-846 8260C/D	One 125-mL VOA jar	Three 40-ml glass vials with septa[c]	14 days to TCLP extraction[d]	7 days to TCLP extraction[d]
TCLP Semi-volatile Organics	SW-846 8270D/E	One 8-oz. glass jar	Two 1-L amber glass bottles[c]	14 days to TCLP extraction[d]	7 days to TCLP extraction[d]
TCLP Pesticides	SW-846 8081B	One 8-oz. glass jar	Two 1-L amber glass bottles[c]	14 days to TCLP extraction[d]	7 days to TCLP extraction[d]
TCLP Herbicides	SW-846 8151A	One 8-oz. glass jar	Two 1-L amber glass bottles[c]	14 days to TCLP extraction[d]	7 days to TCLP extraction[d]
TCLP STARS Semi-volatile Organics	SW-846 8270D/E	One 8-oz. glass jar	Two 1-L amber glass bottles[c]	14 days to TCLP extraction[d]	7 days to TCLP extraction[d]
TCLP STARS Volatile Organics	SW-846 8021B or 8260C/D	One 125-mL VOA jar	Three 40-mL glass vials with septa[c]	14 days to TCLP extraction[d]	7 days to TCLP extraction[d]

Table A-2 Summary of Analytical Methods, Preservatives, and Holding Times

Parameter	Method	Containers/Preservative for Solid Samples[a]	Containers/Preservative for Aqueous or Air Samples[a]	Holding Time for Solid Samples[a]	Holding Time for Aqueous or Air Samples[a]
Additional Methods					
Hardness	EPA 130.1	NA	One 500-mL HDPE bottle (can combine with metals) preserved HNO_3 to pH <2	NA	180 days
pH	EPA 150.2	NA	To be performed in the field	NA	ASAP
Specific Conductance	EPA 120.1	NA	One 250-mL HDPE bottle	NA	28 days
TDS	SM 2540C	NA	One 1-L HDPE bottle	NA	24 hours
TSS	SM 2540D	NA	One 1-L HDPE bottle	NA	7 days
TVS	SM 2540E	NA		NA	
Priority Pollutant Metals	EPA 200.7	One 4-oz. glass jar	One 500-mL HDPE bottle preserved HNO_3 to pH <2	180 days, 28 days for mercury	180 days, 28 days for mercury
Alkalinity	EPA 310.2	NA	One 250-mL HDPE bottle	NA	14 days
Nitrate or Nitrite	EPA 352.1/353.2/ 300.0/300.1 SW-846 9056	One 4-oz. glass jar	One 250-mL HDPE bottle	48 hours	48 hours
Nitrate-Nitrite	EPA 353.2/300.0/300.1	One 4-oz. glass jar	One 250-mL HDPE bottle preserved H_2SO_4 to pH <2	28 days	28 days
Orthophosphorus	EPA 365.1/365.3/ 300.0/300.1	NA	One 250-mL HDPE bottle	NA	48 hours
Total Phosphorus	EPA 365.1/365.3/365.4	One 4-oz. glass jar	One 250-mL HDPE bottle preserved H_2SO_4 to pH <2	28 days	28 days
Chloride, Bromide, Sulfate, Fluoride	EPA 300.0/300.1 SW-846 9056 or individual methods	One 4-oz. glass jar	One 250-mL HDPE bottle	28 days	28 days
COD	EPA 410.3/410.4	NA	One 250-mL HDPE bottle (can combine with ammonia and TKN) preserved H_2SO_4 to pH <2	NA	28 days

Table A-2 Summary of Analytical Methods, Preservatives, and Holding Times

Parameter	Method	Containers/Preservative for Solid Samples[a]	Containers/Preservative for Aqueous or Air Samples[a]	Holding Time for Solid Samples[a]	Holding Time for Aqueous or Air Samples[a]
Oil/Grease (HEM or SGT-HEM)	EPA 1664A	One 4-oz. glass jar	One 1-L amber glass bottle preserved H_2SO_4 to pH <2	28 days	28 days
Chromium, Hexavalent	SW-7196A EPA 218.6 SM 3500-Cr	One 4-oz. glass jar	One 250-mL HDPE bottle unpreserved or preserved pH of 9.3 to 9.7 with an ammonia sulfate buffer solution	30 days to extraction, 7 days from extraction to analysis	24 hours from collection
Chlorinated Dioxins and Furans	SW-846 8280A SW-846 8290	One 4-oz. glass jar	Two 1-L amber glass bottles	30 days to extraction/completely analyzed in 45 days	30 days to extraction/completely analyzed in 45 days
Cyanide	SW-846 9010C/9012B	One 4-oz. glass jar	One 250-mL HDPE bottle preserved NaOH to pH >12	14 days	14days
TOX	SW-846 9020B	NA	One 250-mL amber glass preserved H_2SO_4 to pH <2	NA	28 days
pH	SW-846 9045C/9040B	One 4-oz. glass jar	One 125-mL HDPE bottle	ASAP	ASAP
Total Phenols	EPA 420.1	One 4-oz. glass jar	One 500-mL amber glass preserved H_2SO_4 to pH <2	28 days	28 days
Total Organic Carbon	Lloyd Kahn; SM 5310B, C, or D; ASTM D2579-93 (A or B)	One 4-oz. glass jar	One 250-mL glass preserved H_2SO_4 to pH <2	28 days	28 days
Total Glycol	DEC 89-9	One 4-oz. glass jar	One 1-L glass	28 days	14 days
Specific Gravity	SM 2710F	NA	Can combine with other analyses (requires 500 mL)	NA	40 days
TKN	EPA 351.2	One 4-oz. glass jar	One 250-mL HDPE bottle (can combine with COD and ammonia) preserved H_2SO_4 to pH <2	28 days	28 days

Table A-2 Summary of Analytical Methods, Preservatives, and Holding Times

Parameter	Method	Containers/Preservative for Solid Samples[a]	Containers/Preservative for Aqueous or Air Samples[a]	Holding Time for Solid Samples[a]	Holding Time for Aqueous or Air Samples[a]
Ammonia	EPA 350.1	One 4-oz. glass jar	One 250-mL HDPE bottle (can combine with COD and TKN) preserved H_2SO_4 to pH <2	28 days	28 days
BOD_5	SM 5210B	NA	One 1-L HDPE bottle	NA	48 hours
Methylene Blue Activated Substances Assay	SM 5540C	NA	One 1-L HDPE bottle	NA	48 hours
1,4-Dioxane	SW-846 8270D/E SIM EPA 522	One 4-oz. glass jar	Two 1-L amber glass bottles	14 days/40 days[b]	7 days/40 days[b]
PFAS	537 Modified ISO 25101	One 9-oz. HDPE jar	One 1-L HDPE bottle	28 days	28 days
Halogenated Volatile Organics	EPA 601 SW-846 8010A	Two pre-weighed 40-mL vials with stir bar and deionized water, one pre-weighed 40-mL vial with stir bar and methanol, and one 4-oz. container (for dry weight)	Three 40-mL glass vials with septa, preserved with HCl pH <2	48 hours for analysis, or freeze to <-7˚C and 14 days for analysis following freezing	14 days for waters with chemical preservative, and 7 days for unpreserved
Volatile Aromatics	EPA 602	NA	Three 40-mL glass vials with septa, preserved with HCl pH <2	NA	14 days for waters with chemical preservative, and 7 days for unpreserved
Non-Halogenated Volatile Organics	EPA 8015C	Two pre-weighed 40-mL vials with stir bar and deionized water, one pre-weighed 40-mL vial with stir bar and methanol, and one 4-oz. container (for dry weight)	Three 40-mL glass vials with septa, preserved with HCl pH <2	48 hours for analysis, or freeze to <-7˚C and 14 days for analysis following freezing	14 days for waters with chemical preservative, and 7 days for unpreserved

Table A-2 Summary of Analytical Methods, Preservatives, and Holding Times

Parameter	Method	Containers/Preservative for Solid Samples[a]	Containers/Preservative for Aqueous or Air Samples[a]	Holding Time for Solid Samples[a]	Holding Time for Aqueous or Air Samples[a]
Phenols	EPA 604 SW-846 8041A	One 4-oz. glass jar	Two 1-L amber glass bottles	14 days/40 days[b]	7 days/40 days[b]
Polynuclear Aromatic Hydrocarbons	EPA 610 SW-846 8100	One 4-oz. glass jar	Two 1-L amber glass bottles	14 days/40 days[b]	7 days/40 days[b]
Organophosphorus Compounds	SW-846 8141B	One 4-oz. glass jar	Two 1-L amber glass bottles	7 days/40 days[b]	7 days/40 days[b]

[a] All samples to be cooled to 4°C except for metals analysis samples shipped alone. Sample containers must have Teflon-lined lids. Holding times are based on time from sample collection.
[b] Holding time is seven days for aqueous samples or 14 days for solid samples from collection to extraction and 40 days from extraction to analysis.
[c] TCLP analysis of water samples assumes less than 0.5% solids.
[d] Time listed is from sample collection to TCLP extraction.

Key:
ASAP = As soon as possible.
BOD_5 = Biochemical oxygen demand-5.
BTX = Benzene, toluene, xylene.
COD = Chemical oxygen demand.
EPA = U.S. Environmental Protection Agency.
HDPE = High-density polyethylene.
HEM = Hexane extractable material.
HNO_3 = Nitric acid.
H_2SO_4 = Sulfuric acid.
L = Liter.
mL = Milliliter.
NA = Not applicable.
NaOH = Sodium hydroxide.
oz. = Ounce.
PFAS = Per- and polyfluoroalkyl substances
PCBs = Polychlorinated biphenyls.
SGT = Silica gel treated
SM = Standard Methods for the Examination of Water and Wastewater.
STARS = NYSDEC Spill Technology and Remediation Series (Memorandum No. 1 [1992]).
SVOCs = Semi-volatile organic compounds.
TAL = Target Analyze List.
TCL = Target Compound List.
TCLP = Toxicity characteristic leaching procedure.
TDS = Total dissolved solids.
TKN = Total Kjeldahl nitrogen.
TOX = Total Organic Halides.
TSS = Total suspended solids.
TVS = Total volatile solids.
VOC = Volatile organic compounds.

Table A-3 General Field Equipment and Calibration Procedures

Instrument or Equipment	Description[a]	Field Calibration Procedure	Acceptability/ Performance Criteria	Responsible Personnel
Organic Vapor Analyzer (OVA)	Flame Ionization Detector to provide continuous data on organic vapor concentrations. Unit must be Class I, Division 1, Grade A,B,C,D. Unit must have rechargeable battery, range of 0 to 1,000 ppm, and ultra-high purity hydrogen as fuel source.	Units are factory calibrated to remain with performance specification for an excess of 6 months. During field use, a carbon filter is used with the OVA to distinguish methane from other organics. The unit is checked daily with a Bump Test to ensure the response to detect organic vapors. The unit is checked weekly with calibration gas to ensure the response is consistent. If needed, the unit will be re-calibrated to manufacturer specifications. When the OVA is used to screen samples (except samples for headspace analysis), periodic ambient air readings will also be recorded in the logbook.	A carbon filter must remove sources of organic vapors other than methane (i.e., marker). Instrument must detect organic vapors without filter. Response should be checked daily to ensure the response to detect organic vapors and weekly with calibration gas. The accuracy will depend on the application.	Field Team Leader, Project Geologist
4 Gas Meter	Multi-Rae to provide continuous gas monitoring for four parameters, typically hydrogen sulfide, carbon monoxide, oxygen, and lower explosive limit (LEL).	Calibrate the instrument once per day prior to sample collection. Perform maintenance as needed during field activities. Verify the instrument is operating correctly at 30-minute intervals when conducting sampling within building/structures.	Alarm must sound during calibration procedure. Battery must have sufficient charge for operation. Blocking the sample line probe and observing the drop of the flow indicator float checks flow system.	Field Team Leader, Project Geologist

Table A-3 General Field Equipment and Calibration Procedures

Instrument or Equipment	Description[a]	Field Calibration Procedure	Acceptability/ Performance Criteria	Responsible Personnel
O_2 Explosimeter	Gas monitor designed to simultaneously monitor areas for oxygen deficiency and dangerous levels of combustible gas. Units must be equipped with sample pumps and hoses to measure gases in a confined space. Range O_2 - 0 to 25%, LEL - 0 to 100%, H_2S - 0 to 200 ppm, and CO - 0 to 999 ppm. Not all units have the additional capability to detect hydrogen sulfide or H_2S or carbon dioxide.	Procedures for field calibration of the O_2/explosimeter on a daily basis are as follows: ■ Inspect instrument to ensure entry and exit ports are clear; ■ Turn the switch to ON position; ■ Allow the meters to stabilize and then press the reset button; ■ Check the battery level; ■ Calibrate the oxygen meter in background area to 20.8% by using the calibrate knob; ■ Adjust the explosimeter to zero by using the zero knob; and ■ Check alarm levels by adjusting the calibrate knob for oxygen levels and the zero knob for explosimeter levels and note the readings when the alarm sounds. Return readings to normal and depress the reset button.	Alarm must sound during calibration procedure. Battery must have sufficient charge for operation. Blocking the sample line probe and observing the drop of the flow indicator float checks flow system. If flow system is not functioning, return unit for repairs.	Field Team Leader, Project Geologist
pH/Conductivity, Temperature, Dissolved Oxygen (DO), Oxidation Reduction (ORP), and Turbidity Meter	Meter designed for field use with battery operation. The unit must contain separate pH, temperature, conductivity, DO, and ORP probes in one unit.	Before use, pH, specific conductance, DO, and ORP probes need to be calibrated or tested for responsiveness. The meter will be calibrated according to manufacturer guidelines. Calibration solutions of known concentration will be used for calibration and may available be an all-in-one solution or separate solutions for each parameter. The probes should be rinsed with deionized water between each calibration solution and following calibration. Used calibration solution is to be discarded.	Turbidity ±10% or ±1 NTU, whichever is greater ORP and DO ±10% pH ±0.01 pH Conductivity at ±2% FSD Temperature ±3% The instrument will be checked with a pH standard at the end of the sampling day or if there is reason to suspect the calibration has changed.	Project Geologist, Sampler
Turbidity Meter	Nephelometer designed for field use with battery operation. Range 0.01 to 1,000 NTU.	The unit is factory calibrated. Field procedures involve checking the unit's responsiveness at least once a day using factory supplied standards. The responsiveness should be checked on the 0 to 10 range, 0 to 100 range, and 0 to 1,000 range.	±10%	Sampler

Table A-3 General Field Equipment and Calibration Procedures

Instrument or Equipment	Description[a]	Field Calibration Procedure	Acceptability/ Performance Criteria	Responsible Personnel
Photoionization detector (PID)	The PID is a portable, non-destructive trace gas analyzer. Units for site characterization must have a range of 0 to >2,000 ppm and a 10.6 or 11.7 eV lamp (e.g., MiniRAE 3000). Units for indoor air monitoring must have a range of 1 ppb to 2,000 ppm and a 10.6 eV lamp (e.g., ppb RAE Plus). Calibration check gas (e.g., isobutylene) must be provided with unit.	In the field, PIDs will be calibrated at the start of each field event by the field team. If a significant change in weather occurs during the day (i.e., change in humidity or temperature, if the unit is turned off for an extended period, or at 15 minute intervals when conducting sampling within buildings/structures, then a Bump Test must be performed to ensure the response to detect organic vapors. If the unit does not appear to be responding correctly, have the unit sniff 100 ppm cal gas and determine the reading. If the unit is reading 100 ppm or close to it, then it is OK. If not, depending on how far off it is, either dry out the unit on a heater (due to potential fogging of the lamp), or send the unit back to the rental company for in-house calibration.	Meter must give consistent background readings. Response should be checked daily to ensure the response to detect organic vapors and checked with calibration gas as needed. The accuracy will depend on the application and contaminant of concern ionization potential.	Field Team Leader, Project Geologist
Global Positioning System (GPS)	Trimble GeoXT or GeoXH handheld GPS units.	Trimble GeoXT/GeoXH handheld GPS units do not require field calibration. To verify accuracy, the field team will collect three divergent GPS location points at nearby, known, fixed structures such as bridges, road intersections, or large buildings.	Horizontal accuracy to less than 1 meter. Not applicable for vertical measurements.	Field Team Leader
	Differential GPS with Real Time Kinematic processing	For survey grade work, a first order benchmark (horizontal, vertical, or both depending on the requirements of the work) is required. Therefore, no calibration is necessary.	Horizontal and vertical accuracy of ±2 centimeters.	Subcontractor
Water Level Indicator	Measure water level.	Not applicable.	Replace indicator if fails to function.	Field Team Leader

[a] Description is for typical equipment; equivalent units may be used.

Key:
- ev = Electron volts.
- NTU = Nephelometric Turbidity Unit.
- ppm = Parts per million.

B Laboratory Performance Criteria

Table B-1: Reporting List and Minimum Reporting Limits for Routine Analysis Target Compound List

	CAS Number	Class GA[1], µg/L Type H(WS)	Notes	Type E	Notes	Unrestricted SCO[2], mg/kg	Notes
Volatile Organic Compounds							
1,1,1-Trichloroethane (TCA)	71-55-6	5	S, POC			0.68	
1,1,2,2-Tetrachloroethane	79-34-5	5	S, POC			NA	
1,1,2-Trichloro-1,2,2-Trifluoroethane	76-13-1	5	S, POC			NA	
1,1,2-Trichloroethane	79-00-5	1	S			NA	
1,1-Dichloroethane	75-34-3	5	S, POC			0.27	
1,1-Dichloroethene	75-35-4	5	S, POC			0.33	
1,2,3-Trichlorobenzene	87-61-6	5	S, POC			NA	
1,2,4-Trichlorobenzene	120-82-1	5	S, POC			NA	
1,2-Dibromo-3-Chloropropane	96-12-8	0.04	S*			NA	
1,2-Dibromoethane	106-93-4	0.0006	S*			NA	
1,2-Dichlorobenzene	95-50-1	3	S, 3			1.1	
1,2-Dichloroethane	107-06-2	0.6	S			0.02	
1,2-Dichloropropane	78-87-5	1	S			NA	
1,3-Dichlorobenzene	541-73-1	3	S, 3			2.4	
1,4-Dichlorobenzene	106-46-7	3	S, 3			1.8	
2-Hexanone	591-78-6	50	G			NA	
Acetone	67-64-1	50	G			0.05	
Benzene	71-43-2	1	S			0.06	
Bromochloromethane	74-97-5	5	S, POC			NA	
Bromodichloromethane	75-27-4	50	G			NA	
Bromoform	75-25-2	50	G			NA	
Bromomethane	74-83-9	5	S, POC			NA	
Carbon Disulfide	75-15-0	60	G			NA	
Carbon Tetrachloride	56-23-5	5	S			0.76	
Chlorobenzene	108-90-7	5	S, POC			1.1	
Chloroethane	75-00-3	5	S, POC			NA	
Chloroform	67-66-3	7	S			0.37	
Chloromethane	74-87-3	5	S, POC			NA	
Cis-1,2-Dichloroethylene	156-59-2	5	S, POC			0.25	
Cis-1,3-Dichloropropene	10061-01-5	0.4	S*, 4			NA	
Cyclohexane	110-82-7	NA				NA	
Dibromochloromethane	124-48-1	50	G			NA	
Dichlorodifluoromethane	75-71-8	5	S, POC			NA	
Ethylbenzene	100-41-4	5	S, POC			1	
Isopropylbenzene (Cumene)	98-82-8	5	S, POC			NA	
m-Xylene (1,3-Dimethylbenzene)	108-38-3	5	S, POC			NA	
Methyl Acetate	79-20-9	NA				NA	
Methyl Ethyl Ketone (2-Butanone)	78-93-3	50	G			0.12	

Table B-1: Reporting List and Minimum Reporting Limits for Routine Analysis Target Compound List

	CAS Number	Class GA[1], µg/L Type H(WS)	Notes	Type E	Notes	Unrestricted SCO[2], mg/kg	Notes
Methyl Isobutyl Ketone (4-Methyl-2-Pentanone)	108-10-1	NA				NA	
Methylcyclohexane	108-87-2	NA				NA	
Methylene Chloride	75-09-2	5	S, POC			NA	
o-Xylene (1,2-Dimethylbenzene)	95-47-6	5	S, POC			NA	
p-xylene (1,4-Dimethylbenzene)	106-42-3	5	S, POC			NA	
Styrene	100-42-5	5	S, POC			NA	
Tert-Butyl Methyl Ether	1634-04-4	10	G			0.93	
Tetrachloroethylene (PCE)	127-18-4	5	S, POC			1.3	
Toluene	108-88-3	5	S, POC			0.7	
Trans-1,2-Dichloroethene	156-60-5	5	S, POC			0.19	
Trans-1,3-Dichloropropene	10061-02-6	0.4	S*, 4			NA	
Trichloroethylene (TCE)	79-01-6	5	S, POC			NA	
Trichlorofluoromethane	75-69-4	5	S, POC			NA	
Vinyl Chloride	75-01-4	2	S			NA	
Semi-volatile Organic Compounds							
1,2,4,5-Tetrachlorobenzene	95-94-3	5	S, POC, 5	10	G	NA	
1,4-Dioxane (P-Dioxane)	123-91-1	1	MCL, 6			0.1	
2,3,4,6-Tetrachlorophenol	58-90-2			1	S, 7	NA	
2,4,5-Trichlorophenol	95-95-4			1	S, 7	NA	
2,4,6-Trichlorophenol	88-06-2			1	S, 7	NA	
2,4-Dichlorophenol	120-83-2	5	S, POC	1	S, 7	NA	
2,4-Dimethylphenol	105-67-9	50	G	1	S, 7	NA	
2,4-Dinitrophenol	51-28-5	10	G	1	S*, 7	NA	
2,4-Dinitrotoluene	121-14-2	5	S, POC			NA	
2,6-Dinitrotoluene	606-20-2	5	S, POC			NA	
2-Chloronaphthalene	91-58-7			10	G	NA	
2-Chlorophenol	95-57-8			1	S, 7	NA	
2-Methylnaphthalene	91-57-6	NA	†			NA	
2-Methylphenol (o-Cresol)	95-48-7			1	S, 7	0.33	
2-Nitroaniline	88-74-4	5	S, POC			NA	
2-Nitrophenol	88-75-5			1	S, 7	NA	
3,3'-Dichlorobenzidine	91-94-1	5	S, POC			NA	
3-Nitroaniline	99-09-2	5	S, POC			NA	
4,6-Dinitro-2-Methylphenol	534-52-1			1	S*, 7	NA	
4-Bromophenyl Phenyl Ether	101-55-3	NA				NA	
4-Chloro-3-Methylphenol	59-50-7			1	S, 7	NA	
4-Chloroaniline	106-47-8	5	S, POC			NA	
4-Chlorophenyl Phenyl Ether	7005-72-3	NA				NA	
4-Methylphenol (p-Cresol)	106-44-5			1	S, 5	0.33	

Table B-1: Reporting List and Minimum Reporting Limits for Routine Analysis Target Compound List

		Class GA[1], µg/L					
	CAS Number	Type H(WS)	Notes	Type E	Notes	Unrestricted SCO[2], mg/kg	Notes
4-Nitroaniline	100-01-6	5	S, POC			NA	
4-Nitrophenol	100-02-7			1	S*, 5	NA	
Acenaphthene	83-32-9			20	G	20	
Acenaphthylene	208-96-8	NA				100	
Acetophenone	98-86-2	NA				NA	
Anthracene	120-12-7	50	G			100	
Atrazine	1912-24-9	7.5	S			NA	
Benzaldehyde	100-52-7	NA				NA	
Benzo(A)Anthracene	56-55-3	0.002	G†			1	
Benzo(A)Pyrene	50-32-8	0	S†, ND			1	
Benzo(B)Fluoranthene	205-99-2	0.0020	G†			1	
Benzo(G,H,I)Perylene	191-24-2	NA	†			100	
Benzo(K)Fluoranthene	207-08-9	0.0020	G†			0.8	
Benzyl Butyl Phthalate	85-68-7	50	G			NA	
Biphenyl (Diphenyl)	92-52-4	5	S, POC			NA	
Bis(2-Chloroethoxy) Methane	111-91-1	5	S, POC			NA	
Bis(2-Chloroethyl) Ether (2-Chloroethyl Ether)	111-44-4	1	S			NA	
Bis(2-Chloroisopropyl) Ether	108-60-1	5	S, POC			NA	
Bis(2-Ethylhexyl) Phthalate	117-81-7	5	S			NA	
Caprolactam	105-60-2	NA				NA	
Carbazole	86-74-8	NA				NA	
Chrysene	218-01-9	0.0020	G†			1	
Dibenz(A,H)Anthracene	53-70-3	NA	†			0.33	
Dibenzofuran	132-64-9	NA				7	
Diethyl Phthalate	84-66-2	50	G			NA	
Dimethyl Phthalate	131-11-3	50	G			NA	
Di-N-Butyl Phthalate	84-74-2	50	S			NA	
Di-N-Octylphthalate	117-84-0	50	G			NA	
Fluoranthene	206-44-0	50	G†			100	
Fluorene	86-73-7	50	G†			30	
Hexachlorobenzene	118-74-1	0.04	S			0.33	
Hexachlorobutadiene	87-68-3	0.5	S			NA	
Hexachlorocyclopentadiene	77-47-4	5	S, POC			NA	
Hexachloroethane	67-72-1	5	S, POC			NA	
Indeno(1,2,3-C,D)Pyrene	193-39-5	0.0020	G†			0.5	
Isophorone	78-59-1	50	G			NA	
Naphthalene	91-20-3		†	10	G	12	
Nitrobenzene	98-95-3	0.4	S			NA	
N-Nitrosodi-N-Propylamine	621-64-7	NA				NA	

Table B-1: Reporting List and Minimum Reporting Limits for Routine Analysis Target Compound List

	CAS Number	Class GA[1], µg/L Type H(WS)	Notes	Type E	Notes	Unrestricted SCO[2], mg/kg	Notes
N-Nitrosodiphenylamine	86-30-6	50	G			NA	
Pentachlorophenol	87-86-5			1	S*, 7	0.8	
Phenanthrene	85-01-8	50	G†			NA	
Phenol	108-95-2			1	S, 7	0.33	
Pyrene	129-00-0	50	G†			100	
Metals							
Aluminum	7429-90-5	NA				NA	
Antimony	7440-36-0	3	S‡			NA	
Arsenic	7440-38-2	25	S			13	
Barium	7440-39-3	1000	S			35	
Beryllium	7440-41-7	3	G			7.2	
Cadmium	7440-43-9	5	S			2.5	
Calcium	7440-70-2	NA				NA	
Chromium, Total	7440-47-3	50	S			NA	
Chromium, Hexavalent	18540-29-9	NA				1	9
Chromium, Trivalent	16065-83-1	NA				30	9
Cobalt	7440-48-4	NA				NA	
Copper	7440-50-8	200	S			50	
Iron	7439-89-6			300	S	NA	
Lead	7439-92-1	25	S			63	
Magnesium	7439-95-4	35000	G			NA	
Manganese	7439-96-5			300	S	1600	
Nickel	7440-02-0	100	S			30	
Potassium	7440-09-7	NA				NA	
Selenium	7782-49-2	10	S			3.9	
Silver	7440-22-4	50	S			2	
Sodium	7440-23-5	20000	G			NA	
Thallium	7440-28-0	0.5	G‡			NA	
Vanadium	7440-62-2	NA	G			NA	
Zinc	7440-66-6	2000		5000	G	109	

Table B-1: Reporting List and Minimum Reporting Limits for Routine Analysis Target Compound List

	CAS Number	Class GA[1], µg/L Type H(WS)	Notes	Type E	Notes	Unrestricted SCO[2], mg/kg	Notes
Mercury							
Mercury	7439-97-6	0.7	S			0.18	
Cyanide							
Cyanide, Total	57-12-5	200	S			27	9
Polychlorinated Biphenyls‡							
PCB-1016	12674-11-2	0.09	S, 8			NA	
PCB-1221	11104-28-2	0.09	S, 8			NA	
PCB-1232	11141-16-5	0.09	S, 8			NA	
PCB-1242	53469-21-9	0.09	S, 8			NA	
PCB-1248	12672-29-6	0.09	S, 8			NA	
PCB-1254	11097-69-1	0.09	S, 8			NA	
PCB-1260	11096-82-5	0.09	S, 8			NA	
PCB-1262	37324-23-5	0.09	S, 8			NA	
PCB-1268	11100-14-4	0.09	S, 8			NA	
Organochlorine Pesticides‡							
Aldrin	309-00-2	0	S, ND			0.005	
Alpha BHC	319-84-6	0.01	S			0.02	
Alpha Endosulfan	959-98-8	NA				2.4	10
Beta BHC	319-85-7	0.04	S			0.036	
Beta Endosulfan	33213-65-9	NA				2.4	10
cis-Chlordane	5103-71-9	0.05	S			0.094	
Delta BHC	319-86-8	0.04	S			0.04	
Dieldrin	60-57-1	0.004	S			0.005	
Endosulfan Sulfate	1031-07-8	NA				2.4	10
Endrin	72-20-8	0	S, ND			0.014	
Endrin Aldehyde	7421-93-4	5	S, POC			NA	
Endrin Ketone	53494-70-5	5	S, POC			NA	
Gamma BHC	58-89-9	0.05	S			0.1	
Heptachlor	76-44-8	0.04	S			0.042	
Heptachlor Epoxide	1024-57-3	0.03	S			NA	
Methoxychlor	72-43-5	35	S			NA	
P,P'-DDD	72-54-8	0.3	S			0.0033	
P,P'-DDE	72-55-9	0.2	S			0.0033	
P,P'-DDT	50-29-3	0.2	S			0.0033	
Toxaphene	8001-35-2	0.06	S			NA	
trans-Chlordane	5103-74-2	0.05	S			NA	

Table B-1: Reporting List and Minimum Reporting Limits for Routine Analysis Target Compound List

		Class GA[1], µg/L					
	CAS Number	Type H(WS)	Notes	Type E	Notes	Unrestricted SCO[2], mg/kg	Notes

Key:

E = Refers to Aesthetics of Fresh Groundwater

G = Refers to Water Quality Guidance Value

GA = Refers to Fresh Groundwater

H(WS) = Refers to Human Consumption of Fresh Groundwater

MCL = Maximum Contaminant Level

µg/L = micrograms per liter

mg/kg = milligrams per kilogram

NA = Water Quality Standard or Guidance is not Available

ND = Water Quality Standard is Non-Detect Value

POC = Principal Organic Contaminant

S = Refers to Water Quality Standard Value

SCO = Soil Cleanup Objective

* = Typical laboratory reporting limits may not meet the listed screening criteria. If these analytes are project-specific compounds, then different methodology may be required.

† = If polycyclic aromatic hydrocarbons (PAHs) are project-specific compounds of concern, use of selected ion monitoring (SIM) methodology may be required to meet the screening criteria.

ǂ = If the selected metals are project-specific compounds of concern, use of mass spectrometry detection may be required to meet the screening criteria.

‡ = If polychlorinated biphenyls or organochloride pesticides are project-specific compounds of concern, t

Notes:

1. New York State Department of Environmental Conservation, Technical and Operational Guidance Series Memorandum #1.1.1: *Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations,* 1998 (with updates), Class GA Groundwater Standards and Guidance Values.
2. New York State Department of Environmental Conservation, 6 NYCRR 375-6.8(a), Unrestricted Use Soil Cleanup Objectives.
3. Applies to each isomer (1,2-, 1,3-, and 1,4-dichlorobenzene) individually.
4. Applies to the sum of cis- and trans-1,3-dichloropropene, CAS Nos. 10061-01-5 and 10061-02-6, respectively.
5. Applies to each isomer (1,2,3,4-, 1,2,3,5-, 1,2,4,5-tetrachlorobenzene) individually.
6. New York State Department of Health recommended maximum contaminant level. New York State Department of Environmental Conservation recommends that the reporting limit for 1,4-dioxane should be no higher than 0.35 µg/L (June 2019).
7. Applies to the sum of all phenolic compounds (total phenol).
8. Applies to the sum of all polychlorinated biphenyl substances.
9. The SCO for this specific compound (or family of compounds) is considered to be met if the analysis for the total species of this contaminant is below the SCO.
10. SCO is the sum of endosulfan I, endosulfan II, and endosulfan sulfate.

Table B-2: Reporting List and Reporting Limits for Per- and Polyfluoroalkyl Substances

	Abbreviation	CAS Number	Aqueous Samples[1]	Solid Samples[1]
Per- and Polyfluoroalkyl Substances				
Perfluorobutanesulfonic acid	PFBS	375-73-5	NA	NA
Perfluorohexanesulfonic acid	PFHxS	355-46-4	NA	NA
Perfluoroheptanesulfonic acid	PFHpS	375-92-8	NA	NA
Perfluorooctanesulfonic acid	PFOS	1763-23-1	2	0.5
Perfluorodecanesulfonic acid	PFDS	335-77-3	NA	NA
Perfluorobutanoic acid	PFBA	375-22-4	NA	NA
Perfluoropentanoic acid	PFPeA	2706-90-3	NA	NA
Perfluorohexanoic acid	PFHxA	307-24-4	NA	NA
Perfluoroheptanoic acid	PFHpA	375-85-9	NA	NA
Perfluorooctanoic acid	PFOA	335-67-1	2	0.5
Perfluorononanoic acid	PFNA	375-95-1	NA	NA
Perfluorodecanoic acid	PFDA	335-76-2	NA	NA
Perfluoroundecanoic acid	PFUA/PFUdA	2058-94-8	NA	NA
Perfluorododecanoic acid	PFDoA	307-55-1	NA	NA
Perfluorotridecanoic acid	PFTriA/PFTrDA	72629-94-8	NA	NA
Perfluorotetradecanoic acid	PFTA/PFTeDA	376-06-7	NA	NA
6:2 Fluorotelomer sulfonate	6:2 FTS	27619-97-2	NA	NA
8:2 Fluorotelomer sulfonate	8:2 FTS	39108-34-4	NA	NA
Perfluroroctanesulfonamide	FOSA	754-91-6	NA	NA
N-methyl perfluorooctanesulfonamidoacetic acid	N-MeFOSAA	2355-31-9	NA	NA
N-ethyl perfluorooctanesulfonamidoacetic acid	N-EtFOSAA	2991-50-6	NA	NA

Key:

NA = Not Available

1. New York State Department of Environmental Conservation, Guidelines for Sampling and Analysis of PFAS, Under NYSDEC's Part 375 Remedial Programs, January 2020.

Table B-3: Organic Analyses Data Validation Quality Control Guidances

Matrix	Method	Analysis	Method Blank	Laboratory Control Sample (LCS) Laboratory Control Sample (LCSD)	Matrix Spike (MS) Matrix Spike Duplicate (MSD)	Initial Calibration (IC) Initial Calibration Verification (ICV)
AIR	GC/MS	VOCs	If Blank Result < RL, Sample Result must be ≥ 2x the RL If Blank Result > RL, Sample Result must be ≥ RL and > blank concentration If Blank Result = RL, Sample Result must be > RL (Except for common laboratory contaminants)	Lower Acceptance Limit ≤ %R ≤ Upper Acceptance Limit % RPD ≤ Acceptance Limit	Not applicable	RRF > Minimum RRF %RSD ≤ ± Maximum %RSD
AQ/SO	GC/MS	TRACE VOA	If Blank Result < RL, Sample Result must be ≥ 2x the RL If Blank Result > RL, Sample Result must be ≥ RL and > blank concentration If Blank Result = RL, Sample Result must be > RL (Except for common laboratory contaminants)	Not applicable	Lower Acceptance Limit < %R < Upper Acceptance Limit Apply the action to only the field sample used to prepare the Matrix Spike sample.	RRF > Minimum RRF %RSD ≤ ± Maximum %RSD
AQ/SO	GC/MS	LOW/MED VOA	If Blank Result < RL, Sample Result must be ≥ the RL If Blank Result > RL, Sample Result must be ≥ RL and > blank concentration If Blank Result = RL, Sample Result must be > RL (Except for common laboratory contaminants)	Not applicable	Lower Acceptance Limit < %R < Upper Acceptance Limit Apply the action to only the field sample used to prepare the Matrix Spike sample.	RRF > Minimum RRF %RSD ≤ ± Maximum %RSD
AQ/SO	GC/MS	SVOC	If Blank Result < RL, Sample Result must be ≥ the RL If Blank Result ≥ RL, Sample Result must be ≥ RL and ≥ blank concentration	Not applicable	Lower Acceptance Limit < %R < Upper Acceptance Limit Apply the action to only the field sample used to prepare the Matrix Spike sample.	RRF > Minimum RRF %RSD ≤ ± Maximum %RSD
AQ/SO	GC/ECD	PEST	If Blank Result < RL, Sample Result must be ≥ the RL If Blank Result > RL, Sample Result must be ≥ RL and ≥ blank concentration If Blank Result = RL, Sample Result must be > RL	Lower Acceptance Limit < %R < Upper Acceptance Limit	Lower Acceptance ≤ %R; RPD ≤ Upper Acceptance Limit	%RSD within allowable limits
AQ/SO	GC/ECD	PCBS	If Blank Result < RL, Sample Result must be ≥ the RL If Blank Result > RL, Sample Result must be ≥ RL and ≥ blank concentration If Blank Result = RL, Sample Result must be > RL	Lower Acceptance Limit < %R < Upper Acceptance Limit for Aroclor 1016 and Aroclor 1260 and surrogates	Lower Acceptance Limit < %R < Upper Acceptance Limit Apply the action to only the field sample used to prepare the Matrix Spike sample.	%RSD within allowable limits
AQ/SO	GC/ECD	HERBICIDES	If Blank Result < RL, Sample Result must be ≥ 5x the RL If Blank Result > RL, Sample Result must be ≥ 5x the RL and > 5x blank concentration	Lower Acceptance Limit < %R < Upper Acceptance Limit	Lower Acceptance Limit < %R < Upper Acceptance Limit	%RSD ≤ ± Maximum %RSD

Table B-3: Organic Analyses Data Validation Quality Control Guidances

Matrix	Method	Analysis	Continuing Calibration Verification (CCV)	Internal Standard	Surrogates	Instrument Performance Check (IPC)
AIR	GC/MS	VOCs	RRF > Minimum RRF %D ≤ ± Maximum %D	Area counts ≥ 60% but ≤ 140% of CCV or midpoint standard from initial calibration RT difference < 20.0 seconds between samples and CCV or midpoint standard from initial calibration	Not applicable	Not applicable
AQ/SO	GC/MS	TRACE VOA	RRF > Minimum RRF %D within the inclusive Opening Maximum %D limits	50% ≤ Area response ≤ 200% of the opening CCV or mid-point standard from initial calibration	Lower Acceptance Limit ≤ %R ≤ Upper Acceptance Limit	Not applicable
AQ/SO	GC/MS	LOW/MED VOA	RRF > Minimum RRF %D within the inclusive Opening Maximum %D limits	Area counts ≥ 50% but ≤ 200% of 12-hour standard, opening CCV, or mid-point standard from initial calibration RT difference ≤ 30.0 seconds between samples and 12-hour standard, opening CCV, or mid-point standard from initial calibration	Lower Acceptance Limit ≤ %R ≤ Upper Acceptance Limit	Not applicable
AQ/SO	GC/MS	SVOC	RRF > Minimum RRF %D within the inclusive Opening Maximum %D limits	50% ≤ Area response ≤ 200% of the opening CCV, or mid-point standard from initial calibration RT shift between sample/blank and opening CCV or mid-point standard from initial calibration < 10.0 seconds	Lower Acceptance Limit ≤ %R ≤ Upper Acceptance Limit	Not applicable
AQ/SO	GC/ECD	PEST	%D, time elapsed, and RT are within acceptable limits	Not applicable	Lower Acceptance Limit ≤ %R ≤ Upper Acceptance Limit; RT within RT window	Resolution Check Mixture ≥ 80% for primary column, ≥ 50% for confirmation column if indivudual standard mixture is used Resolution Check Mixture must be ≥ 60.0% if two Individual Standard Mixtures are used Performance Evaluation Mixture must be ≥ 90% for IC and CCV on each GC column
AQ/SO	GC/ECD	PCBS	%D, time elapsed, and RT are within acceptable limits	Not applicable	Lower Acceptance Limit ≤ %R ≤ Upper Acceptance Limit; RT within RT window	Not applicable
AQ/SO	GC/ECD	HERBICIDES	%D, time elapsed, and RT are within acceptable limits	Not applicable	Lower Acceptance Limit ≤ %R ≤ Upper Acceptance Limit; RT within RT window	Positive sample results %D on the two GC columns < 25.0%

Table B-3: Organic Analyses Data Validation Quality Control Guidances

Matrix	Method	Analysis	Cleanup Check	Field Duplicate (FD)	Percent Solid
AIR	GC/MS	VOCs	Not applicable	Sample and its field duplicate RPD < 50%	Not applicable
AQ/SO	GC/MS	TRACE VOA	Not applicable	Sample and its field duplicate RPD < 50%	Not applicable
AQ/SO	GC/MS	LOW/MED VOA	Not applicable	Sample and its field duplicate RPD < 50%	Not applicable
AQ/SO	GC/MS	SVOC	Not applicable	Sample and its field duplicate RPD < 50%	SO Samples: Percent solids for a sample > 30%
AQ/SO	GC/ECD	PEST	Florisil Cartridge Performance Check: Lower Acceptance Limit ≤ %R ≤ Upper Acceptance Limit GPC Performance Check: Lower Acceptance Limit ≤ %R ≤ Upper Acceptance Limit (SO samples only)	Sample and its field duplicate RPD < 50%	Not applicable
AQ/SO	GC/ECD	PCBS	Not applicable	Sample and its field duplicate RPD < 50%	Not applicable
AQ/SO	GC/ECD	HERBICIDES	Not applicable	Not applicable	Not applicable

Table B-3: Organic Analyses Data Validation Quality Control Guidances

Matrix	Method	Analysis	Method Blank

Key:

%D	=	Percent Difference
%R	=	Percent Recovery
%RSD	=	Percent Relative Standard Deviation
AQ	=	Aqueous
EDC	=	Electron Capture Detector
GC	=	Gas Chromatrography
GPC	=	Gel Permeation Chromatography
MDL	=	Method Detection Limit
MS	=	Mass Spectrometry
PCBS	=	Polychlorinated biphenyl
PEST	=	Pesticides
RL	=	Reporting Limit
RPD	=	Relative Percent Difference
RRF	=	Relative Response Factor
RT	=	Retention Time
SE	=	Sediment
SO	=	Solids
SVOC	=	Semi Volatile Organic Compounds
VOA	=	Volatile Organic Compounds

Table B-4: Inorganic Analyses Quality Control Guidances

Matrix	Method	Analysis	Method Blank	Initial Calibration Blank (ICB) Continuing Calibration Blank (CCB)	Laboratory Control Sample (LCS) Laboratory Control Sample (LCSD)	Matrix Spike (MS) Matrix Spike Duplicate (MSD)
AQ/SO	ICP-AES ICP-MS	METALS	If Blank Result > RL, Sample Result must be ≥ 10x the Blank Result If Blank Result ≥ MDL but ≤ RL, Sample Result must be Non-detect	If Blank Result > RL, Sample Result must be ≥ the Blank Result If Blank Result ≥ MDL but ≤ RL, Sample Result must be Non-detect	Lower Acceptance Limit < %R < Upper Acceptance Limit	Lower Acceptance Limit < %R < Upper Acceptance Limit If Out - PDS must be evaluated for further qualifcation
AQ/SO	CVAA	MERCURY	If Blank Result > RL, Sample Result must be ≥ 10x the Blank Result If Blank Result ≥ MDL but ≤ RL, Sample Result must be Non-detect	If Blank Result > RL, Sample Result must be ≥ the Blank Result If Blank Result ≥ MDL but ≤ RL, Sample Result must be Non-detect	Not applicable	Lower Acceptance Limit < %R < Upper Acceptance Limit
AQ/SO	Colorimetric	CYANIDE	If Blank Result > RL, Sample Result must be ≥ 10x the Blank Result If Blank Result ≥ MDL but ≤ RL, Sample Result must be Non-detect	If Blank Result > RL, Sample Result must be ≥ the Blank Result If Blank Result ≥ MDL but ≤ RL, Sample Result must be Non-detect	Not applicable	Lower Acceptance Limit < %R < Upper Acceptance Limit If Out - PDS must be evaluated for further qualifcation

Table B-4: Inorganic Analyses Quality Control Guidances

Matrix	Method	Analysis	Post Digestion Spike (PDS)	Serial Dilution	Initial Calibration (IC) Initial Calibration Verification (ICV)	Continuing Calibration Verification (CCV)
AQ/SO	ICP-AES ICP-MS	METALS	Lower Acceptance Limit ≤ %R ≤ Upper Acceptance Limit	Required only when the initial concentration is > 50x the MDL; Lower Acceptance Limit < %D < Upper Acceptance Limit	Lower Acceptance Limit ≤ %R ≤ Upper Acceptance Limit	Lower Acceptance Limit ≤ %R ≤ Upper Acceptance Limit
AQ/SO	CVAA	MERCURY	Not applicable	Not applicable	Lower Acceptance Limit ≤ %R ≤ Upper Acceptance Limit	Lower Acceptance Limit ≤ %R ≤ Upper Acceptance Limit
AQ/SO	Colorimetric	CYANIDE	Lower Acceptance Limit ≤ %R ≤ Upper Acceptance Limit	Not applicable	Lower Acceptance Limit ≤ %R ≤ Upper Acceptance Limit	Lower Acceptance Limit ≤ %R ≤ Upper Acceptance Limit

Table B-4: Inorganic Analyses Quality Control Guidances

Matrix	Method	Analysis	Internal Standard	Interference Check Sample (ICS)	Laboratory Replicate (LR)
AQ/SO	ICP-AES ICP-MS	METALS	ICP-MS only: Lower Acceptance Limit < %RI< Upper Acceptance Limit, original sample reanalyzed at 2-fold dilution, and % RI of diluted sample analysis is between Lower Acceptance Limit and Upper Acceptance Limit	Lower Acceptance Limit < %R < Upper Acceptance Limit	AQ Samples: Both original sample and duplicate sample > 5x the RL and < 20% RPD SO Samples: Both original sample and duplicate sample > 5x the RL and < 35% RPD
AQ/SO	CVAA	MERCURY	Not applicable	Not applicable	AQ Samples: Both original sample and duplicate sample > 5x the RL and < 20% RPD SO Samples: Both original sample and duplicate sample > 5x the RL and < 35% RPD
AQ/SO	Colorimetric	CYANIDE	Not applicable	Not applicable	AQ Samples: Both original sample and duplicate sample > 5x the RL and < 20% RPD SO Samples: Both original sample and duplicate sample > 5x the RL and < 35% RPD

Table B-4: Inorganic Analyses Quality Control Guidances

Matrix	Method	Analysis	Field Duplicate (FD)	Field/Rinsate/Trip Blank	Percent Solid
AQ/SO	ICP-AES ICP-MS	METALS	AQ Samples: Sample and its field duplicate ≥ 5x the RL and RPD < 20% Sample and its field duplicate RPD > 20% and ≤ 5x the RL SO Samples: Sample and its field duplicate ≥ 5x the RL and RPD < 50% Sample and its field duplicate RPD > 50% and ≤ 5x the RL	If Blank Result > RL, Sample Result must be ≥ 10x the Blank Result If Blank Result ≥ MDL but ≤ RL, Sample Result must be Non-detect	SE Samples: Percent solids in sediment for a sample > 50%
AQ/SO	CVAA	MERCURY	AQ Samples: Sample and its field duplicate ≥ 5x the RL and RPD < 20% Sample and its field duplicate RPD > 20% and ≤ 5x the RL SO Samples: Sample and its field duplicate ≥ 5x the RL and RPD < 50% Sample and its field duplicate RPD > 50% and ≤ 5x the RL	If Blank Result > RL, Sample Result must be ≥ 10x the Blank Result If Blank Result ≥ MDL but ≤ RL, Sample Result must be Non-detect	SE Samples: Percent solids in sediment for a sample > 50%
AQ/SO	Colorimetric	CYANIDE	AQ Samples: Sample and its field duplicate ≥ 5x the RL and RPD < 20% Sample and its field duplicate RPD > 20% and ≤ 5x the RL SO Samples: Sample and its field duplicate ≥ 5x the RL and RPD < 50% Sample and its field duplicate RPD > 50% and ≤ 5x the RL	If Blank Result > RL, Sample Result must be ≥ 10x the Blank Result If Blank Result ≥ MDL but ≤ RL, Sample Result must be Non-detect	SE Samples: Percent solids in sediment for a sample > 50%

Table B-4: Inorganic Analyses Quality Control Guidances

Matrix	Method	Analysis	Method Blank

Key:

%D	=	Percent Difference
%R	=	Percent Recovery
%RI	=	Percent Relative Intensities
%RSD	=	Percent Relative Standard Deviation
AES	=	Atomic Emission Spectroscopy
AQ	=	Aqueous
CVAA	=	Cold Vapor Atomic Absorption
ICP	=	Inductively Coupled Plasma
MDL	=	Method Detection Limit
MS	=	Mass Spectroscopy
RL	=	Reporting Limit
RPD	=	Relative Percent Difference
RRF	=	Relative Response Factor
RT	=	Retention Time
SE	=	Sediment
SO	=	Solids

Table B-5: PFAS and CDD/CDF Analyses Quality Control Guidances

Matrix	Method	Analysis	Method Blank	Laboratory Control Sample (LCS) Laboratory Control Sample (LCSD)	Matrix Spike (MS) Matrix Spike Duplicate (MSD)	Initial Calibration/ Initial Calibration Verification (IC/ICV)
AQ/SO	LC/MS/MS	PFAS	No detections in the Blank Result > the RL	70% < %R < 130%	70% < %R < 130%	%RSD < 20% R^2 < 0.990 Low-level calibration check > 50% or < 150% Mid-level calibration check > 70% or < 130% ICV recovery > 70% or < 130%
AQ/SO	HRGC/HRMS	DIOXINS/FURANS	Blank Result must not contain any 2,3,7,8-substituted CDD/CDF > the minimum levels specified in Table 2 of Method 1613B[1]	Lower Acceptance Limit < %R < Upper Acceptance Limit	Not required by method.	%RSD for the RRF from the 17 unlabeled standards must be ≤ 20%, and those for the 15 labeled reference compounds must be ≤ 35% Isotope Dilution: RR % coefficient of variation must be > 20% over the 5 point range Internal Standard: RF is calculated and the percent coefficient of variation must be 35% over the 5 point range

Table B-5: PFAS and CDD/CDF Analyses Quality Control Guidances

Matrix	Method	Analysis	Continuing Calibration Verification (CCV)	Isotope Dilution	Internal Standard
AQ/SO	LC/MS/MS	PFAS	70% < %D < 130%	50% < %R < 150% 25% < %R < 150% for poor responding analytes Isotope Dilution Analyte (IDA) Recovery > 10%	Not applicable
AQ/SO	HRGC/HRMS	DIOXINS/FURANS	RRTs of native and labeled CDD's and CDF's within the limits	Refer to "Initial Calibration/ Initial Calibration Verification (IC/ICV)"	Absolute RT < 25.0 minutes on primary column and < 15 minutes on secondary column of 12-hour standard response factor (RF) % coefficient of variation must be > 35% of the 5 point range 50% ≤ Area response ≤ 100% of the internal standard area.

Table B-5: PFAS and CDD/CDF Analyses Quality Control Guidances

Matrix	Method	Analysis	Labeled Compounds	Compound Identification	Clean-up Check
AQ/SO	LC/MS/MS	PFAS	Not applicable	Not applicable	Not applicable
AQ/SO	HRGC/HRMS	DIOXINS/FURANS	25% < %R < 150%	2,3,7,8 substituted analytes found present and the corresponding labeled compound or internal standard in the sample extract, must show relative retention times at the peak height within the limits Non-2,3,7,8 substituted compounds (tetra through octa) found present, the retention time must be within the window established by the Window Defining Solution, for the corresponding homologue Identification of a GC peak as a PCDF can only be made if no signal having a S/N ≤ 2.5 is detected at the same time in the corresponding PCDPE channel.	%R of the clean-up standard within the recommended range

Table B-5: PFAS and CDD/CDF Analyses Quality Control Guidances

Matrix	Method	Analysis	Chromatograph Resolution	Field Duplicate (FD)	Precision and Recovery
AQ/SO	LC/MS/MS	PFAS	Not applicable	RPD < 30%	Not applicable
AQ/SO	HRGC/HRMS	DIOXINS/FURANS	For primary column the peak separation between the unlabeled 2,3,7,8-TCDD and the peaks representing any other TCDD analyte resolved with a valley ≤ 25% Last eluting tetra chlorinated congener (1,2,8,9-TCDD) and the first eluting penta chlorinated congener (1,3,4,6,8-PeCDF) separated properly RRT of peaks representing an unlabeled 2,3,7,8- substituted CDD or CDF must be within the limits	25% relative difference for 2,3,7,8-substituted analytes and 50% for the rest of the analytes	IPR standard deviation (s) and average concentration (x) passed criteria OPR standard passed the concentration criteria limits

Table B-5: PFAS and CDD/CDF Analyses Quality Control Guidances

Matrix	Method	Analysis	Relative ion abundance	Signal to Noise Ratio (S/N)
AQ/SO	LC/MS/MS	PFAS	Not applicable	At least 3:1
AQ/SO	HRGC/HRMS	DIOXINS/FURANS	Relative ion abundance criteria for CDDs/CDFs must be met Relative ion abundance criteria for the labeled compounds, cleanup, and internal standard must be met	The signal to noise ratio (S/N) for the GC signal present in every SICP, including the ones for the labeled standards must be ≥ 10. Integrated ion current for each characteristic ion of the analyte identified as positive, must be at least 2.5 times background noise and must not have saturated the detector. Integrated ion current for the labeled compounds, internal standards, and cleanup standard characteristic ions must be at least 10 times background noise.

Table B-5: PFAS and CDD/CDF Analyses Quality Control Guidances

Matrix	Method	Analysis	Branched and Linear Isomers
AQ/SO	LC/MS/MS	PFAS	Must have a qualitative or quantitative standard should also be present in the secondary ion transition. Target analyte peaks should be integrated properly and consistently when compared to standards.
AQ/SO	HRGC/HRMS	DIOXINS/FURANS	Not applicable

Table B-5: PFAS and CDD/CDF Analyses Quality Control Guidances

Matrix	Method	Analysis	Method Blank	Laboratory Control Sample (LCS) Laboratory Control Sample (LCSD)	Matrix Spike (MS) Matrix Spike Duplicate (MSD)	Initial Calibration/ Initial Calibration Verification (IC/ICV)

Key:

%D	=	Percent Difference
%R	=	Percent Recovery
%RSD	=	Percent Relative Standard Deviation
AQ	=	Aqueous
CDD	=	Chlorinated Dibenzo-p-Dioxin
CDF	=	Chlorinated Dibenzofuran
GPC	=	Gel Permeation Chromatography
HRGC	=	High Resolution Gas Chromatography
HRMS	=	High Resolution Mass Spectroscopy
IPR	=	Initial Precision and Recovery
LC	=	Liquid Chromatography
MS	=	Mass Spectroscopy
OPR	=	Ongoing Precision and Recovery
PCDF	=	Polychlorinated Dibenzofurans
PCDPE	=	polychlorinated diphenylether
PFAS	=	Per- and Polyfluoroalkyl substances
RL	=	Reporting Limit
RPD	=	Relative Percent Difference
RR	=	Relative Response
RRF	=	Relative Response Factor
RT	=	Retention Time
SE	=	Sediment
SO	=	Solids

Note:

1. U.S. Environmental Protection Agency Office of Water Engineering and Analysis Division, Method 1613 Tetra- through Octa-Chlorinated Dioxins and Furans by Isotope Dilution HRGC/HRMS, Revision B, October 1994

C Laboratory ELAP Certifications and Proficiency Results

Information to be provided after laboratory selection is complete.

D Resumes of Data Validation Staff

Marcia M. Galloway, CQA, CMQ/OE

QA Officer/Corporate QA Director

Key Accomplishments Relevant to the NYSDEC Standby Contract:

- Quality Assurance Officer (QAO) for of all E & E NYSDEC contracts since 1989.
- Certified Quality Manager and Auditor with 32 years' experience.
- Demonstrated ability to prepare QAPPs, perform data review in accordance with NYSDEC requirements, manage third-party data validation, oversee analytical services, and perform analytical QA/QC audits and report reviews for large-scale programs such as the NYSDEC Standby.

SOW Elements:

- ☒ Site Characterization
- ☒ Phased RI/FSs
- ☒ Remedial Design (RD)
- ☒ Engineering Services/Remedial Construction
- ☒ Analytical QA/QC
- ☒ Site Response Activities/IRMs
- ☒ Site Management
- ☒ Citizen Participation
- ☒ HASP Development/Review
- ☒ PRP/Third Party Oversight
- ☒ SVI Investigation

Ability to Fulfill Duties: Ms. Galloway's previous experience as QAO on the NYSDEC Standby Contract attests to her ability to fulfill the same role on this new contract. Ms. Galloway is dedicated to working on this contract.

Project Experience

QAO for New York State Projects. Ms. Galloway has served as the QAO for all environmental site investigation, engineering, and construction management projects in New York State during the last 29 years. She provides independent QA reviews of both field and analytical operations. She coordinates with project and laboratory management personnel to establish data quality objectives (DQOs) for CERCLA and RCRA investigations and ensures that project goals are met. She is answerable to the corporate president for E & E; as such, she has the authority to override project management decisions that adversely impact QA/QC or contradict the QAPP. Ms. Galloway develops and reviews QAPPs, sampling plans, and QC plans, ensuring that all planning documents are consistent with federal and state guidelines, as well as contract QA requirements. She oversees third-party validation and performs validation of analytical data; ensures the assignment of data qualifiers and ensures that discrepancies are resolved; and identifies final action items. She prepares and reviews data usability summary reports (DUSRs) to verify their consistency with NYSDEC guidance and EPA Region 2 data validation SOPs. Ms. Galloway also has overseen the implementation of data management program Equis as E & E's secure centralized database for work in NYS including staff training and incorporation of EAP Region 2 MEDD requirements and NYS technical screening criteria.

EDUCATION

M.S., Analytical Chemistry, Indiana University

B.A., Chemistry, summa cum laude, Bowdoin College

CERTIFICATIONS

Certified Manager of Quality/Organizational Excellence (CMQ/OE), American Society for Quality

Certified Quality Auditor (CQA), American Society for Quality

OSHA TRAINING

40-hour HAZWOPER (6/8/1990)
8-hour Refresher (2/23/2018)

ADDITIONAL PROFESSIONAL TRAINING

16-hour course, uniform federal policy for QAPPs, Naval Civil Engineer Corps Officers School, 2006

8-hour course, sampling design, Department of Defense, Environmental Monitoring and Data Quality Workshop, Atlanta, Georgia

PROFESSIONAL AFFILIATIONS

American Chemical Society
American Society of Quality

NYSDEC Standby and Other Contracts, New York State. Ms. Galloway is E & E's QAO for all E & E contracts with NYSDEC. She ensures program compliance with NYSDEC technical memoranda and QA/QC requirements; provides laboratory oversight; and provides data validation, interpretation, and reporting. The programs include E & E's four successive, multiyear Standby contracts; the separate multisite Phase II investigation contract; and a site-specific contract for the CERCLA RI/FS addressing halogenated VOC contamination at the Mead Property in Ulster County. For the New York State Office of General Services, Ms. Galloway also was QAO for E & E's project supporting closure of the Rush Landfill.

Under the NYSDEC Standby contract, Ms. Galloway oversaw the development of a master QAPP applicable to all sites. She incorporated the requirements of NYSDEC Analytical Services Protocol, established a related scope of services for subcontract laboratories, then developed a summary site-specific QAPP then developed for each site. The format streamlined production and review and saved costs. Ms. Galloway also developed an electronic data validation program to process EDDs. The program provided an independent assessment of data compliance with NYSDEC requirements for data usability, allowed laboratory data to be cost-effectively evaluated without a third-party data validation, and streamlined data reported for Phase II investigations.

Toledo Harbor, Western Lake Erie Basin, Ohio. Ms. Galloway was the lead scientist for the USACE project *Influence of Open-Lake Placement of Dredged Material on Western Lake Erie Basin Harmful Algal Blooms (HABs)* in Toledo Harbor. The purpose of this study was to assess the potential of phosphorus release from open-lake disposal of dredged material from Toledo Harbor and its potential influence on the phosphorus budget that may promote HAB development in the Western Lake Erie Basin (WLEB). She developed the sampling and analysis plan and contributed to the final report for a coordinated field sampling/laboratory testing and modeling program designed to assess the relative contribution of open-lake placement of Toledo Harbor dredged material to bioavailable phosphorus, water clarity/turbidity, and HABs production in the WLEB.

"Thanks, Marcia. We absolutely appreciate the A-1 efforts from the entire team. Both the report and presentation have hit the mark. Great technical work and coordination. Let's get through the presentation and notch this up as a complete success."

Mike Asquith, Project Manager, USACE Buffalo District (August 29, 2014)

The investigation found that open-lake placement of Toledo Harbor dredge material does not play a role in HAB development and that it protects the fragile Lake Erie ecosystem. As a result, Mike Asquith said, "...this investigation offers substantial, positive social and economic impacts for the Toledo and greater Great Lakes region because it demonstrates that Toledo Harbor maintenance dredging plans continue to be environmentally sustainable. We expect that the investigation will set the standard for future studies and questions pertaining to perceived connections among the placement of dredged material in open water and HABs." Ms. Galloway and team also assisted USACE by presenting study findings to regulatory agencies and other stakeholders.

Buffalo Harbor State Park – Gallagher Beach, Buffalo, New York. Ms. Galloway was the lead chemist for the fast-paced site investigation for the New York State Office of Parks, Recreation and Historic Preservation (OPRHP) to evaluate the potential environmental concerns at Gallagher Beach prior to OPRHP opening the beach for public use. She oversaw the sampling, laboratory analysis, and data evaluation for quick turnaround soil, groundwater, sediment, storm water, and surface water sampling; temporary groundwater monitor well installation; and sanitary sewer sampling.

Endicott Areawide Study, Endicott, New York. Under E & E's Standby contract with NYSDEC, Ms. Galloway supported E & E's $2.7-million, multiyear site investigation/soil vapor intrusion study in private residences and other structures to investigate potential contaminant sources. The project has significant community involvement. Her responsibilities included work plan development and close coordination with regulators (NYSDEC, NYSDOH, and the Broome County Health Department) regarding soil vapor sampling and analytical requirements. She oversaw the review and reporting of soil-gas, groundwater, indoor air, and sub-slab vapor sample data. She performed laboratory audits and addressed needs for data quality and reproducibility.

Greenpoint Site, Brooklyn, New York. E & E conducted a site-specific program for NYSDEC concerning this site, which comprises about 52 of 160 acres that have been contaminated by a spill of about 20 million gallons of petroleum products. Ms. Galloway provided QA and laboratory oversight for studies at multiple properties, including an indoor air investigation for over 50 homes; an ambient air investigation to determine if conditions in Newtown Creek had affected area air quality; an RI/FS for the 3-acre Apollo Street property, and periodic PRP oversight and sampling. She met with NYSDEC team members in the planning stages to help establish DQOs and has assisted NYSDEC in reviewing a variety of project-related documents. In 2008, at the DOD Environmental Monitoring and Data Quality Workshop in Atlanta, she presented a well-received paper on the on the quality issues encountered and lessons learned during the soil vapor intrusion investigations.

NYSDEC Costing Tool, New York State. For NYSDEC's Department of Environmental Remediation (DER), Ms. Galloway has been managing several projects involving the development of online spreadsheet costing applications intended to help DER's remedial program project managers statewide develop better cost estimates for work performed under various NYSDEC laboratory and engineering standby contracts.

Buffalo River Contaminated Sediment, New York. Ms. Galloway served as the project manager for E & E's participation in the GLLA project to clean up contaminated sediment at the Buffalo River AOC. The project coordination team includes the EPA GLNPO, the Buffalo Niagara Waterkeeper, NYSDEC, USACE, EPA Region 2, and Honeywell International, Inc. For GNLPO, E & E is conducted numerous sediment sampling phases on the lower 6 miles from the river's confluence with Cazenovia Creek to the Buffalo Ship Canal. Under her leadership, E & E performed data management, review, and assessment of chemical data. E & E experts in habitat restoration, ecological risk, and hydrological modeling participated in teams for the development of the FS and provided QC checks. She also led the unique RD that incorporated the USACE dredging of the contaminated sediments in the federal channel in 2011 prior to the EPA dredging in 2012, coordination of disposal in the USACE confined disposal facility (CDF), addressing a high concentration PCB area in accordance with Toxic Substances Control Act of 1976 regulations, and determining the approach for dredging next to 21 critical structures. The design also includes integrated habitat restoration design at five dredging sites, totaling 24 acres. Ms. Galloway was responsible for developing the Joint Permit Application and supporting the SEQR process.

Eighteenmile Mile Creek Superfund Site, Newfane, New York. For the NYSDEC, USACE KC District and EPA Regions 2 and 5, under multiple projects, Ms. Galloway has supported the RI/FS of Eighteenmile Creek, a designated EPA Region 2 Superfund site. Ms. Galloway was E & E's QAO and lead chemist for the PCB Trackdown and Beneficial Use Impairment (BUI) study for Eighteenmile Creek, an Area of Concern listed in the Great Lakes Coastal Restoration Program and NYSDEC's Phase I, RI and FS of the Corridor properties. She provided QA reviews of historical data for the historic/current pollutant generator/discharge database, wrote

EPA-approved QAPPs, managed the collection of sediment and fish samples, and managed the sample analyses for PCBs and dioxin. She is currently manages E & E projects for EPA Region 2 which includes sample collection of sediment, surface water, soil, and biota over 10 field phases, interpretation of these results, preparing conceptual site models for three OUs, groundwater flow and contaminant transport modeling at upland sites, performing human health and ecological risk assessments on two OUs, and preparation of RI Reports in accordance with CERCLA guidance and requirements. E & E also completed a supplemental FS for EPA's OU2. For EPA Region 2, E & E is currently working on data validation, evaluation and planning for completing human health and ecological risk assessments, supplemental RI and FS for OU3.

Griffiss Air Force Base (AFB), Rome, New York. For the USACE Kansas City District, she was QAO/lead chemist for supplemental and natural attenuation investigations to support FS activities at 31 RI areas of concern and for preliminary assessment/expanded SI sampling and analysis programs at several areas of interest. She prepared a QC plan for all sampling, analysis, and remedial design activities. She performed field audits of sampling, sample handling, and field analytical work to ensure compliance with the work plan and USACE QA/QC requirements. She also planned, set up, and oversaw the operation of a field laboratory for volatile organic compounds (VOC) analysis. Ms. Galloway was responsible for the laboratory analysis, electronic data processing, and validation of over 1,000 samples supporting numerous task orders at Griffiss AFB under two successive contracts. She helped manage the project-specific Access databases and developed electronic data review procedures. She prepared and reviewed data validation memoranda and QCSRs.

Hudson River PCB Cleanup, New York State. For EPA Region 2 and the USACE Kansas City District, she is QAO for E & E's project to provide management and remedial design support for the EPA-required dredging action on the historic Hudson River. The multiyear, $1.5-billion program includes construction of sediment processing and water treatment facilities, installation of rail and barge loading facilities, and development/use of innovative dredging techniques. Ms. Galloway developed the QAPP for the facility siting program; conducted field audits; and oversaw the analytical program under the EPA Contract Laboratory Program (CLP), with additional support from the USACE geotechnical laboratory. Under the CLP, Ms. Galloway oversaw field data reporting activities using EPA software. She helped to develop the electronic data processing and reporting programs under EQuiS using EPA Region 2-specific formatting.

Beneficial Use Impairment (BUI) Criteria Development for Great Lakes AOCs, New York. Under two separate contract mechanisms with EPA Region 2 and GLNPO, E & E assisted the stakeholders for the New York Great Lake AOCs in the development of final BUI delisting criteria. Ms. Galloway provided QA oversight for these projects. To recommend delisting criteria, her team reviewed guidelines of the International Joint Commission on the Great Lakes and BUI assessments from other Great Lakes AOCs. Under a similar project for GNLPO, Ms. Galloway helped host and facilitate a series of workshops for stakeholders in New York Great Lakes AOCs, including GNLPO, EPA Region 2, NYSDEC Great Lakes Program coordinators, local AOC RAP coordinators, and Canadian officials.

Sylvania Corning FUSRAP Site, Hicksville, New York. For the USACE Kansas City District, she was E & E's QAO for the RI for this 10-acre, Formerly Utilized Sites Remedial Action Program (FUSRAP) site, which was used for research, development, and fabrication of nuclear fuel elements. Ms. Galloway prepared a QAPP compliant with UFP QAPP format; performed field and laboratory audits; and oversaw subcontract laboratory services, data validation using ADR/EDMS, and preparation of QCSRs.

Shawn F. Kowal, Ph.D.

Environmental Chemist

Mr. Kowal's 8-year background in chemistry has given him extensive knowledge of analytical techniques for qualitative and quantitative analysis. At E & E, Mr. Kowal prepares quality assurance project plans (QAPPs) and field sampling plans; coordinates analytical work; manages analytical and field data; and supports the preparation of technical reports. Mr. Kowal supports field programs with sampling, operation of field monitoring equipment, and sample management using EPA's Scribe program. He also provides project oversight to ensure that data quality objectives are met by laboratories and validate analytical reports. In addition, he is trained in the EQuIS database for import and review of field and analytical data and generation of report tables.

EDUCATION

Ph.D. Chemistry, Syracuse University School of Arts and Sciences

M.S. Chemistry, Tufts University School of Arts and Sciences

B.S. Chemistry, Hartwick College

OSHA TRAINING

40-hour HAZWOPER (5/18/2018)

8-hour Refresher (2/12/2020)

Project Experience

NYSDEC Standby Program, New York State. Mr. Kowal provides data validation and report preparation for site characterization, remedial investigations, and site management activities for projects under E & E's standby contract with NYSDEC. He plans all aspects of the laboratory and analytical program including subcontract management. He prepares laboratory and field electronic data deliverables (EDDs) for submission to the State using Earthsoft's EQuIS. Mr. Kowal generates reports from the database and prepares technical evaluations of the data. He has provided these services for sites including the FMC Corporation facility in Middleport; Former Geneva Foundry in Geneva; Mr. C's Dry Cleaners in East Aurora; the Kodak/Eastman Business Park in Rochester; and the Davis Howland site in Rochester.

Mr. Kowal also provides field support in the role of sample manager and field sampler at several NYSDEC sites. He manages all aspects of field sample management, COC preparation, packaging, shipment, and tracking of samples at Kodak/Eastman Business Park, the Former Geneva Foundry, and the FMC Corporation facility.

Navajo Trustees Project, Navajo Nation. As part of Phase 2 of the Navajo Nation Abandoned Mine Lands Reclamation Program, E & E is responsible for performing 30 removal site evaluations (RSE) and two water studies. The sites were mined for uranium after World War II and left abandoned since the 1950s and 60s and consist of mine adits, buildings and foundations, mine roads, and mine waste (TENORM, overburden, etc.) stored in various sized piles and areas where the waste has been transported by wind and water. Mr. Kowal provides data validation and management for both chemical and radiological data. Radiological data is validated against Multi-Agency Radiological Laboratory Analytical Protocols (MARLAP) and American National Standards Institute (ANSI) standards.

EDUCATION

B.S., Chemistry, Buffalo State College

OSHA TRAINING

40-hour HAZWOPER (6/24/2016)

8-hour Refresher (2/26/2020)

DOT SHIPPING TRAINING

1/18/18

Eridania Marte

Environmental Chemist

A chemist located in E & E's Buffalo, New York, office, Ms. Marte prepares quality assurance project plans (QAPPs) and field sampling plans; coordinates analytical work; manages analytical and field data; and supports the preparation of technical reports. Ms. Marte supports field programs with sampling, operation of field monitoring equipment, and sample management using EPA's Scribe program. She also provides project oversight to ensure that data quality objectives are met by laboratories and validate analytical reports. In addition, she is trained in the EQuIS database for import and review of field and analytical data and generation of report tables.

Project Experience

NYSDEC Standby Program, New York State. Ms. Marte provides field sampling, data validation, and report preparation for site and remedial investigations (RIs) and long-term monitoring projects under E & E's standby contract with NYSDEC. She has provided support to field programs at FMC Corporation facility in Middleport; the former Geneva Foundry site in Geneva; Staubs Textile Services and former Elite Vogue Dry Cleaners sites, both in Rochester; Mr. C's Dry Cleaners in East Aurora; the BB&S Treated Lumber site in Southampton; and the Davis Howland and Eastman Kodak Co. sites, both located in Rochester. She also prepares laboratory and field data for submission to the State using Earthsoft's EQuIS database. She also prepares project-specific requirements for subcontract laboratories and coordinates analytical services.

Ms. Marte provides field support in the role of sample manager and field sampler at several NYSDEC sites. She participated in the field efforts at the FMC sampling events at Middleport, and the remediation efforts at the former Geneva Foundry in Geneva.

Eighteen Mile Creek Superfund Site, Lockport, New York. Ms. Marte is the project chemist for data gap analysis and RI/FS for Operable Unit (OU) 3, which addresses Eighteen Mile Creek from the north end of the OU2 creek corridor to the mouth of the Creek in Olcott, where it discharges into Lake Ontario. She manages compilation and review of historical data and creation of a project database. She uses the Scribe program, a database developed by the EPA to assist in managing field data, to document sample collection and uploads the data to the Sample Management Office portal. She is the point of contact with the laboratory and reviews the data deliverables for completeness.

Buffalo River AOC Sediment Remediation Design Support, New York. Ms. Marte manages sample collection and analytical data for the field effort to verify post-PCB concentrations at this Toxic Substances Control Act (TSCA) area. Tasks included coordinating the laboratory analysis, providing field sample management, performing data validation, and preparing the data deliverables and data summary report for the EPA for the Great Lakes Sediment Database.

Lynne M. Parker

Environmental Chemist

EDUCATION

M.S., Chemistry, University of Washington

B.S., Chemistry, Eastern Michigan University

B.S., Nursing, University of Rochester

OSHA TRAINING

40-hour HAZWOPER (2/21/2014)

8-hour Refresher (2/23/2018)

Key Accomplishments Relevant to the NYSDEC Standby Contract:

- Experienced analytical chemist with over 16 years' experience supporting clients.
- Lead data validator; environmental quality information system manager; prepares EDDs; prepares and reviews QAPPs, sampling plans, and site-specific health and safety plans; manages subcontracted analytical laboratories; interprets analytical data; and prepares technical reports.

SOW Elements:

☒ Site Characterization
☒ Phased RI/FSs
☒ Analytical QA/QC
☒ HASP Development/Review

Ability to Fulfill Duties: Ms. Parker will be available to work on NYSDEC projects. Her time on the project will be commensurate with her assigned project-specific responsibilities.

Project Experience

NYSDEC Standby Program, New York State. Ms. Parker provides data validation and data usability summary report preparation for site characterization, remedial investigation, and site management activities for numerous projects under E & E's standby contract with NYSDEC. She plans all aspects of the laboratory analytical program including subcontractor management. She prepares laboratory and field electronic data deliverables (EDDs) for submission to the State using Earthsoft's EQuIS. She is an EQuIS Professional user and manages all data for this program in E & E's secure database. Ms. Parker generates reports from the database and prepares technical evaluations of the data. She has provided these services for sites including the FMC Corporation site (residential and Royalton-Hartland School) in Middleport; Former Geneva Foundry in Geneva; Universal Waste site in Utica; Al Tech Specialty Steel site in Dunkirk; the former Adirondack Steel site in Albany; Mr. C's Dry Cleaners in East Aurora; BB&S Treated Lumber site in Southampton; Hiteman Leather in West Winfield; Davis Howland site in Rochester; and Kodak-Eastman Business Park in Rochester. Ms. Parker has also provided field support as sample manager and field sampler at Universal Waste, FMC Corporation, and Carroll Town Landfill in Frewsburg. At FMC, she successfully managed all aspects of the field sample management, COC preparation, packaging, shipment, and tracking of many thousand soil samples.

Buffalo River AOC Sediment Remediation Design Support, New York. Ms. Parker managed sample collection during the field effort to verify PCB and PAH sediment concentrations at five dredge management units for EPA GLNPO, and was the point of contact for the laboratory. She developed the field sampling plan (FSP)/QAPP addendum approved by EPA Region 2, coordinated the laboratory analysis, provided field sample management, performed data validation, and prepared the data deliverables and data summary report for the EPA for the Great Lakes Sediment Database.

Appendix C

Field Activities Plan (FAP)

10BP20E.0073.01-B5480

Field Activities Plan (FAP) for the Division of Environmental Remediation Standby Engineering Services Contract D009807

May 2020

Prepared for:

NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION

625 Broadway
Albany, New York 12233

Prepared by:

Ecology and Environment Engineering and Geology, P.C.
368 Pleasant View Drive
Lancaster, New York 14086

Field Activities Plan for New York State Department of Environmental Conservation Contract D009807

Ecology and Environment Engineering and Geology, P.C., in association with Ecology and Environment, Inc., member of WSP (hereafter collectively referred to as E & E) has prepared this generic Field Activities Plan (FAP) for the New York State Department of Environmental Conservation (NYSDEC), Division of Environmental Remediation to address the technical requirements in Attachment I - Scope of Services for work under Standby Engineering Services Contract D009807. The purpose of this document is to provide a list of the general equipment, field methods, and procedures utilized by E & E staff that will collect data for Standby Engineering Services work assignments. Any deviations from, or additions to, the information provided in this generic FAP will be detailed in documents provided as part of each work assignment.

The objective of this generic FAP is to ensure that field data collected during NYSDEC work assignments are of suitable quality to meet the various work element objectives. To meet the FAP objective, E & E maintains a comprehensive set of Standard Operating Procedures (SOPs) for the tasks that are routinely completed during NYSDEC Standby Engineering Services work assignments. In order to streamline the preparation of any site-specific field activities documents, E & E relies on these SOPs to provide the details of the means and methods for fieldwork. Descriptions of the scope, application, and rationale may be found within the appropriate sections of each individual SOP. These SOPs will be reviewed and updated as necessary to address written concerns and comments from NYSDEC throughout the term of the contract, as well as to stay current with new sampling techniques and activities.

Work assignments for NYSDEC Standby Engineering Services Contract D009807 will be conducted in accordance with the following guidance documents:

- NYSDEC's DER-10, *Technical Guidance for Site Investigation and Remediation* (http://www.dec.ny.gov/docs/remediation_hudson_pdf/der10.pdf);
- NYSDEC's *Spill Guidance Manual* (http://www.dec.ny.gov/regulations/2634.html);
- NYSDEC's *Vapor Intrusion Guidance* (https://www.dec.ny.gov/regulations/2588.html);
- New York State Department of Health (NYSDOH) *Guidance for Evaluating Soil Vapor Intrusion in the State of New York*; and
- E & E's SOPs, as applicable.

Should any protocol differences exist between these guidance documents, NYSDEC and NYSDOH guidance will prevail and will be reviewed with NYSDEC on a work-assignment-specific basis.

A list of SOPs and the Community Air Monitoring Plan (CAMP) program routinely used for NYSDEC Standby Engineering Services work assignments that are included in this FAP is provided below:

- DOC 2.1 – Logbooks
- DOC 2.7 – Activities
- ENV 3.2 – Site Control
- ENV 3.7 – Groundwater Sampling
- ENV 3.8 – Sediment Sampling
- ENV 3.12 – Surface Water Sampling
- ENV 3.13 – Surface Soil Sampling
- ENV 3.15 – Equipment Decontamination
- ENV 3.16 – Sample Handling
- ENV 3.25 – Soil VOC Sampling
- ENV 3.26 – Investigation Derived Waste Handling
- ENV 3.27 – GPS Operation
- ENV 3.30 – Soil Vapor Intrusion
- ENV 3.31 – Drum Handling
- ENV 3.32 – Unmanned Aerial Flight
- GEO 4.7 – Borehole Installation
- GEO 4.8 – Geologic Logging
- GEO 4.10 – Monitoring Well Installation
- GEO 4.11 – Well Development
- GEO 4.12 – Geoprobe Operation
- GEO 4.13 – Pump Test
- GEO 4.14 – Slug Test
- GEO 4.15 – Water Level Measurement
- GEO 4.19 – Monitoring Well Evaluation
- HS 5.3 – Drill Rig Safety
- HS 5.7 – Boating Safety
- HS 5.8 – Hand and Portable Power Tools
- HS 5.16 – Excavation and Trenching
- CAMP

Equipment and procedural guidance for collecting samples for per- and polyfluoroalkyl substances analysis is included in the following SOPs: ENV 3.7 – Groundwater Sampling; ENV 3.12 – Surface Water Sampling; and ENV 3.13 – Surface Soil Sampling.

Information related to the policies, organization, objectives, functional activities, and specific quality assurance/quality control procedures related to the collection of technical data collected during NYSDEC Standby Engineering Services contract work assignments is available in E & E's Master Quality Assurance Project Plan.

ecology and environment, inc.

STANDARD OPERATING PROCEDURE

FIELD ACTIVITY LOGBOOKS

SOP NUMBER: DOC 2.1

REVISION DATE: 6/30/2017 **SCHEDULED REVIEW DATE: 6/30/2022**

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1 Scope and Application

Proper documentation of field activities is a critical component of any field effort. This Standard Operating Procedure (SOP) establishes procedures for initiating, entering information/data into, reviewing, and maintaining/storing hard-copy field logbooks for E & E field activities. Field activities may range from simple reconnaissance to complex sampling programs. Such activities may include visual or other observations, *in situ* or *ex situ* field measurements (monitoring), biological surveys, or sample collection, as well as meetings and consultations with E & E clients, subcontractors, or other stakeholders.

Field logbooks are most commonly used for projects involving sampling, monitoring, or surveying but are also used for field activities such as a scoping site visit or oversight/ observation of engineering or construction contractors. A logbook is required to be maintained unless an approved project plan specifically eliminates the requirement. The SOP for documenting E & E activities outside of an E & E office that do not include the field activities discussed in the SOP herein is E & E SOP DOC 2.7 (Activities Log).

Field logbook documentation may be supplemented by other records (e.g., site safety forms, data collection forms, electronic data, or geotechnical logbooks). Information and data to be recorded on such forms or logbooks are addressed in the applicable SOPs.

Field observations, measurements, and samples have value to data users only to the degree that the observation, measurement, or sample is representative of a specified environment, setting, or process. Field logbooks address representativeness by documenting:

- Identification of the subject of the observation, measurement, or sampling;
- Selection of an observation, measurement, or sampling location and time that represents that subject;
- Compliance with or deviation from the work plan, sampling and analysis plan, quality assurance project plan, or other project or program plans; and
- Sufficient documentation of how the observation, measurement, or sample represents the same subject as other observations, measurements, or samples from the vicinity.

Complete, accurate, and precise logbook entries provide a legally defensible record of field activities, quality control (QC), decisions and their rationale, approved changes to planned activities, and meetings and communications. Well-written logbooks allow individuals not involved with a project to independently reconstruct the salient field activities at a later date.

This SOP is intended for use by personnel who have knowledge, training, and experience in the field activities being conducted.

2 Definitions and Acronyms

DI	Deionized
Field	Locations (sites) outside the controlled environment of an office or laboratory
Field observation	Qualitative and/or quantitative remark/statement regarding sensory inputs noted in the field

Field measurement	Quantitative determination of physical, chemical, biological, geological, or radiological properties of a matrix by measurement made in the field
Field sampling	Process of obtaining a representative portion of an environmental matrix suitable for laboratory or field measurement or analysis
E & E	Ecology and Environment, Inc.
EPA	(U.S.) Environmental Protection Agency
GPS	Global positioning system
ID	Identification
IDW	Investigation-derived waste
PM	Project manager
QA	Quality assurance
QC	Quality control
SOP	Standard operating procedure

3 Procedure Summary

E & E's Quality Management Plan gives the E & E project manager (PM) the authority to directly implement the project work activities necessary to meet technical and quality objectives. Project implementation requires, among other things, that the PM hold a kickoff meeting with appropriate team members to discuss work requirements, QC requirements and results, individual responsibilities, plans and schedules, work progress, and reporting requirements.

Prior to field activity, the PM identifies field personnel, a field team leader, and team members responsible for documenting field activities. Since there may be multiple activities with unique logbooks, there may be multiple team members responsible for documenting field activities.

The individual responsible for documenting field activities or other designated author should briefly summarize in the logbook the field activities that are planned to be conducted.

Visual or other observations, *in situ* or *ex situ* field measurements (including instrument and equipment calibrations), surveying, and sample collection information should be recorded in real time as fieldwork is conducted. Meetings, including electronic communications, with E & E, client, subcontractor, regulatory, or other personnel should be recorded. Compliance with or deviation from the work plan, sampling and analysis plan, quality assurance project plan, or other project or program plans should be documented, together with authorization for such deviations.

The field team leader and/or PM should review logbook entries on a routine basis.

4 Cautions

Logbook entry must be a priority and not left to "later." Contemporaneous documentation is important to achieve complete, accurate, and precise reporting.

Field logbooks become part of the permanent record for projects/programs and, thus, should include factual material, not opinions. Language used in logbooks should be objective and factual. Pertinent personal observations may be included, but must be clearly identified as such.

If multiple logbooks are used, a project logbook should be used to maintain control of all other logbooks.

Do not leave blank line(s) between logbook entries. Cross out blank spaces with a single line, and sign and date the cross out.

Initials should not be used in place of signatures unless specifically allowed by client requirements. Logbooks are considered evidentiary files and full signatures are required under judicial review guidelines (see EPA NEIC Policy, EPA 1991). If initials are used, a table of signatures and initials for project personnel should be recorded in the logbook.

5 Equipment and Supplies

Logbooks must be bound with consecutively numbered pages.

Entries should be made using indelible ink (preferably black).

6 Procedure

6.1 General Requirements

- Logbooks will be assigned by the PM to the field team leader. Additional logbooks may be assigned to other personnel (e.g., health and safety monitors). The PM is responsible for tracking field event logbooks.
- A separate field logbook must be maintained for each project.
- Logbook entries must be legible.
- The first entry for each day will be made on a new, previously blank page.
- No pages may be removed for any reason, even if mutilated or illegible. If a page or portion of a page is accidentally skipped during fieldwork, it should be crossed out, signed, and dated.
- Entries should be made in chronological order. Observations that cannot be recorded during field activities should be recorded as soon as possible. If logbook entries are made after field activities, the time of the activity/observation and the time that it is recorded should be noted.
- The time of each entry should be noted. It is customary to record time using a 24-hour clock.
- If corrections are necessary, they must be made by drawing a single line through the original entry in such a manner that it can still be read. Do not erase or render an incorrect notation illegible. The corrected entry should be written beside the incorrect entry, and the correction initialed and dated. Corrected errors may require a footnote explaining the correction.
- Each logbook page used during the day should be signed and dated at the bottom of each page at the end of each day (if more than one person makes entries into the logbook, each person should sign and date next to his or her entries). Signatures should be written along a single diagonal line drawn across the blank portion of any partially filled page following the last entry of the day.

- If multiple personnel are anticipated to make entries in a logbook, then a table of printed names, signatures, and initials should be recorded in the logbook.
- The field team leader should review logbook entries on a daily basis, or more frequently if appropriate. The PM should review the logbook on a weekly basis and at the close of fieldwork.
- At the completion of the field activity, the logbook must be returned to the PM to include with the project files.

6.2 Format

The following instructions provide a general format for recording a field event in a field activity logbook:

- Title Page

  The logbook title page should contain the following items:

  - Site name,
  - Site identification (ID) number,
  - Location,
  - Project name and number,
  - Start/finish date (may be completed at the end of the project), and
  - Book ___ of ___ (may be completed at the end of the project).

- First Page (for each day in the field)

  The following items should appear on the first page of the logbook prior to daily field activity entries (can be completed prior to entry into the field):

  - Date (at top of page),
  - Project name and number (at top of page),
  - Key project contact names and contact information (e.g., phone numbers),
  - General summary of proposed work (reference work plan and other documents, as appropriate), and
  - Team members and duties.

- Successive Pages (for each day in the field)

  In addition to specific activity entries and observations (refer to the remainder of Section 6 below), the following items should appear on every logbook page:

  - Date, project name, and project number at the top of each page,
  - Signature and date at the bottom of each page (if more than one person makes entries into the logbook, each person should sign and date next to his or her entries), and
  - Strikethroughs of any unused lines.

- Last Page (of project logbook entries)
    - The last page should indicate if work is continuing in subsequent logbooks or if the project is complete.

6.3 Logbook Information

Field logbook entries will contain a variety of information based on the field activities conducted (e.g., observing, monitoring, surveying, or sampling) and project requirements. In general, information recorded on field forms or electronic data does not need to be recorded in the logbook. Information also can be recorded on the first day of the field event and then noted on a daily basis whether there were any changes. The following information will generally need to be recorded, as applicable:

- Daily health and safety meetings:
    - Time conducted,
    - Leader,
    - Attendees, and
    - Summary of content.
- Outline of field activities to be performed that day.
- Arrival and departure times of E & E project personnel.
- Arrival and departure times of non-E & E personnel.
- Record of phone calls and/or other contacts (e.g., meetings, conversations, written or electronic communications) with individuals at the site, including names and affiliations.
- A site sketch identifying the site layout, features, and points of interest (with global positioning system [GPS] coordinates, as appropriate). A north arrow and rough scale should be included.
- Physical description of the site (expand on site sketch as necessary to provide a clear “picture” of the site).
- Pertinent field observations and reconnaissance methodology used to gather observations.
- Brief description of oversight procedures. Oversight activities may include:
    - Contractor activities, including operating times,
    - Contractor progress,
    - Contractor deviations from governing documents, and
    - General housekeeping and safety.
- Weather conditions, updated as necessary on successive pages if weather conditions change throughout the field day.
- Documentation of photographs, including:
    - Make and model of the camera,

  - Description of the photograph (noting specific items of interest), including the date and time,
  - Photograph number,
  - Direction or view angle of the photograph, and
  - Name of the photographer.
- Description of monitoring procedures and results.
- Information on monitoring equipment used (e.g., GPS, air monitoring, field screening):
  - Model and serial numbers,
  - Equipment preparation/calibration procedures, date and time, and results if not recorded on separate form, and
  - Field maintenance and/or repairs.
- Description of biological survey conducted (e.g., species survey, wetland survey) and results.
- Sample collection procedures and reference to applicable work plan section or SOP:
  - A sketch of individual sampling locations if no GPS coordinates are available.
  - Pre-sampling activities, such as:
    - Groundwater well purging and the number of volumes purged before sample collection, and
    - Associated data and results (e.g., well purging pH, conductivity, temperature data).
  - Sample information and observations:
    - Sample number, station location ID, programmatic ID, and/or location, including relationship to permanent reference points,
    - Names of samplers,
    - Sample description, sample depth interval, sample time, sample date, and any field screening results,
    - Sample matrix and number of aliquots if the sample is a composite,
    - Soil/sediment characteristics (e.g., grain size, plasticity, color, cohesiveness, moisture content),
    - Water quality parameters (e.g., pH, temperature, conductivity, turbidity) and water characteristics (e.g., color and odor),
    - Characteristics of biological specimens,
    - Container and preservatives used, recipient laboratory including contact information, and requested analyses, and
    - Any preservative added in the field including preservative type, lot number, and expiration date.
  - Quality assurance (QA)/quality control(QC) samples:
    - For trip blanks, indicate the source of the blanks,

        - For equipment rinsate samples, note the equipment from which the rinsate sample is collected and the source of the deioinized (DI) water, and
        - Field duplicates or replicates and a description of how the duplicate was sub-sampled.
    - Equipment and personnel decontamination procedures.
    - Shipping paper (airbill) numbers and chain-of-custody form numbers.

6.4 Work Plan Changes/Deviation

Deviation from the work plan, sampling and analysis plan, quality assurance project plan, health and safety plan, or other project or program plans should be documented, together with authorization for any deviations. Deviations (who, what, where, when, why, and how [the rationale for the change]) from the plans and the circumstances necessitating such changes should be recorded. No work plan changes or deviations may be acted upon without documented authorization from the PM.

6.5 Investigation-Derived Waste

Disposition of non-hazardous versus potentially hazardous investigation-derived waste (IDW) should be delineated in the field planning documents. The following information should be included in the logbook:

- Nature and disposition of non-hazardous wastes;
- The type and number of containers of potentially hazardous IDW generated (each drum or container should be numbered and its contents noted);
- Information relevant to characterizing IDW;
- Disposition of IDW (left on site or removed from site);
- IDW sample information should be recorded the same as other samples; and
- The type of paperwork that accompanied the waste/sample shipment (e.g., manifest).

6.6 Data Collection Forms

Certain phases of fieldwork may require the use of separate project-specific data collection forms, such as sample collection, equipment calibration, wetland survey, or daily summary forms. Use of such forms and the types of information recorded should be noted in the logbook. Information recorded on data entry forms does not need to be repeated in the logbook, but can be summarized and should be appropriately referenced for easy access.

7 Quality Assurance/Quality Control

As discussed in this SOP, important QA/QC measures for maintaining field activity logbooks include the following:

- Logbook entries should be made in real time (and not retroactively) and using indelible ink;
- On a daily basis, the individual responsible for documenting field activities should briefly summarize in the logbook the field activities that are planned to be conducted;

- Key daily activities should be recorded in the logbook;
- Logbook pages should be signed and dated as they are completed;
- Deviation from the work plan, sampling and analysis plan, quality assurance project plan, or other project or program plans should be documented, together with authorization for such deviations;
- The field team leader should review logbook entries on a daily basis, or more frequently if appropriate. The PM should review the logbook on a weekly basis and at the close of fieldwork; and
- Logbooks may be audited by quality assurance personnel from E & E or a client.

8 Special Project Requirements

Project-specific requirements will be included with the project planning documents.

9 References

United States Environmental Protection Agency (EPA). 1988. *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA.* Interim Final. EPA/540/G-89/004, October 1988.

__________. 1991. *Guidance on Oversight of Potentially Responsible Party Remedial Investigations and Feasibility Studies.* Final. EPA/540/G-91/010a.

__________. 1991. *Guidance for Performing Preliminary Assessments Under CERCLA*. EPA/540/G-91/013. September 1991.

__________. 1991. *NEIC Policies and Procedures Manual.* EPA 330/9-78-001-R. May 1978, revised August 1991.

__________. 1992. *Guidance for Performing Site Inspections Under CERCLA.* Interim Final. EPA/540-R-92-021. September 1992.

END OF SOP

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STANDARD OPERATING PROCEDURE

ACTIVITIES LOG

SOP NUMBER: DOC 2.7

DATE: 7/15/2013 **SCHEDULED REVIEW DATE: 7/15/2014**

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1 Scope and Application

Proper documentation of E & E activities conducted outside an E & E office is a critical component of any project. This Standard Operating Procedure (SOP) establishes procedures for initiating, entering information into, reviewing, and maintaining/storing hard copy logs for E & E activities outside of an E & E office environment and does not involve field survey or sampling. The standard operating procedure for documenting monitoring (e.g., oversight or observation of engineering or construction contractors) and sampling field activities is presented in E & E SOP DOC 2.1 (Field Activity Logbooks).

E & E activities may include: compliance management, providing advice, guidance, or communications support; as well as meetings and consultations with E & E clients, sub-contractors or other stakeholders.

Activities log documentation may be supplemented by other records (e.g., daily or weekly memoranda or reports).

Complete, precise and accurate log entries provide a legally defensible record of: activities; decisions, meetings and communications. Well written logs allow individuals not involved with a project to independently reconstruct the salient activities at a later date.

This E & E Activities Log SOP is intended for use by personnel who have knowledge, training and experience in the activities being conducted.

2 Definitions and Acronyms

E & E	Ecology and Environment, Inc.
PM	Project Manager
QA	Quality assurance
QC	Quality control
SOP	Standard operating procedure

3 Procedure Summary

E & E's Quality Management Plan requires the project manager (PM) direct implementation of project work activities to meet technical and quality objectives. Project implementation requires the PM hold a kickoff meeting with appropriate team members to discuss work requirements, QC requirements and results, individual responsibilities, plans and schedules, work progress, and reporting requirements.

Prior to activity, the PM identifies personnel; designates a team leader and team members responsible for documenting activities. Since there may be multiple activities with unique logs, there may be multiple team members responsible for documenting activities.

Prior to beginning an activity, the duties and responsibilities as defined by the project work plan must be accurately documented in the log and **dated** and **signed by the PM**.

Activities (and information) must be recorded in real-time as each is conducted. Meetings, including electronic communications, with E & E, client, sub-contractor, regulatory, or other personnel are to be recorded. Any requested deviation from the project work plan must be recorded and immediately brought to the attention of the team leader (if in place) and the PM. Only PM directed deviations are to be recognized for which PM authorization must be received and documented in the log.

The team leader should review log entries on a daily basis or more frequently, if appropriate. The PM should review the logs on a weekly basis and at the close of the activity. Logs may be audited by quality assurance personnel from E & E or a client.

At the completion of the assignment or as each log becomes full; logs must be submitted to the PM who in turn is responsible for storing/archiving applicable logs in the project file.

4 Cautions

Log entry must be a priority and not left to "later." Contemporaneous documentation is critical to complete, accurate and precise reporting.

Activities logs become part of the permanent record for projects/programs and, thus, should include factual material, not opinions. Language used in logs should be objective and factual. Pertinent personal observations may be included, but must be clearly identified as such.

If multiple logs are used, a project log should be used to maintain control of all other logs.

Do not leave blank line(s) between log entries. Cross out blank spaces with a single line, sign and date the cross out.

Initials should not be used in place of signatures unless specifically allowed by client requirements. Logs are considered evidentiary files and full signatures are required under judicial review guidelines (See EPA NEIC Policy 1991). If initials are used, a table of signatures and initials for project personnel should be recorded in the log.

5 Equipment and Supplies

Logs must be bound with consecutively numbered pages.

Entries should be made using indelible ink (preferably black).

6 Procedure

The following general procedure will be followed:

- Logs will be assigned by the PM to the team leader. Additional logs may be assigned to other personnel. The PM is responsible for tracking activities logs.
- A separate activities log must be maintained for each project.
- Log entries must be legible.
- The first entry for each day will be made on a new, previously blank page.
- No pages may be removed for any reason, even if mutilated or illegible. If a page or portion of a page is accidentally skipped during an activity, it should be crossed out, signed, and dated.
- Entries should be made in chronological order. Observations that cannot be recorded during activities should be recorded as soon as possible. If log entries are made after activities, the time of the activity/observation and the time that it is recorded should be noted.

- The time of each entry should be noted. It is customary to record time using a 24-hour clock.
- If corrections are necessary, they must be made by drawing a **single line** through the original entry in such a manner that it can still be read. Do not erase or render an incorrect notation illegible. The corrected entry should be written beside the incorrect entry, and the correction **initialed** and **dated**. Corrected errors may require a footnote explaining the correction.
- Each log page used during the day should be signed and dated at the bottom of each page at the end of each day (if more than one person makes entries into the log, each person should sign and date next to his or her entries). Signatures should be written along a single diagonal line drawn across the blank portion of any partially filled page following the last entry of the day.
- If multiple personnel are anticipated to make entries in a log, then a table of printed names, signatures and initials should be recorded in the log.
- At the completion of the activity, the log must be returned to the PM to include with the project files.

6.1 Format

The following instructions provide a general format and identify information to be recorded in Activities Logs:

- Title Page

The log title page should contain the following items:

  - Site name;
  - Site identification (ID) number; if applicable;
  - Location;
  - Project Name and Number;
  - Start/finish date (may be completed at the end of the project);
  - Log __ of __. (may be completed at the end of the project); and,
  - Work Plan Duties and Responsibility Summary with **PM sign-off**.

- First Page (to be completed prior to initiating the activity)

The following items should appear on the first page of the log prior to daily activity entries:

  - Date (at top of page);
  - Project Name and Number (at top of page);
  - Key project contact names and contact information (e.g., phone numbers);
  - General summary of proposed work (reference work plan and other documents, as appropriate); and,
  - Team members and duties.

- Successive Pages (for each day of the activity)

In addition to specific activity entries and observations (refer to sections 6.2, 6.3, and 6.4 below); the following items should appear on every log page:

- Date, project name and project number at the top of each page:
- Signature and date at the bottom of each page (if more than one person makes entries into the log, each person should sign and date next to his or her entries); and,
- Strikethroughs of any unused lines.

- Last Page (of project log entries)
  - The last page should indicate if work is continuing in subsequent logs or if the project is complete.

6.2 Log Information

Activities log procedures for E & E personnel conducting activities outside an E&E office are presented below.

Activities log entries will contain a variety of information based on the activities being conducted (e.g., providing advice, guidance, or communications support). The specific type of information recorded in the log will depend on the project requirements. In general, information recorded on forms or electronic media do not need to be recorded in the log.

- Logs should accurately and impartially reflect the activities performed by E & E personnel;
- Meetings
  - Purpose;
  - Attendees;
  - Summary of discussion; and,
  - Actions to be taken by whom and when;
- Telephone calls and/or other contacts/interactions (depending on the subject, include the information identified under meetings);
- Documents (hard copy and electronic) received or delivered; and the deliverer or recipient name and affiliation; and,
- Arrival and departure times of E & E project personnel.

6.3 Work Plan Changes/Deviation

Deviation from project or program plans should be highlighted together with authorization for any deviations. Deviations (who, what, where, when, why, and how [change rationale]) from the plans and the circumstances necessitating such changes should be recorded. **No work plan changes or deviations will be acted upon without documented authorization from the PM.**

6.4 Information Collection Forms

Some activities may require the use of separate project-specific information collection forms, such as daily summary records. Use of such forms and the types of information recorded should be noted in log. Information recorded on forms does not need to be repeated in the log but summarized and appropriately referenced for easy access.

7 Quality Assurance/Quality Control

Deviation from project or program plans should be highlighted together with documented authorization from the PM for any deviations.

Prior to activity, among other responsibilities, the PM should identify knowledgeable, trained, and experienced personnel; designate a team leader; and an individual responsible for documenting activities. Since there may be multiple activities with unique logs, there may be multiple individuals responsible for documenting activities.

Prior to project mobilization, the PM should lead a kickoff meeting with appropriate team members to discuss work requirements, QC requirements and results, individual responsibilities, plans and schedules, work progress, and reporting requirements.

Prior to initiating activities, the individual responsible for documenting activities or other designated author should briefly summarize the activities being conducted in the log, which the PM must then sign off on.

The team leader should review log entries on a daily basis or more frequently if appropriate. The PM should review the logs on a weekly basis and at the close of the activity. Logs may be audited by quality assurance personnel from E & E or a client.

The PM is responsible for storing/archiving applicable logs in the project file.

8 Special Project Requirements

Project or program-specific requirements that modify this procedure should be entered in this section and included with the project planning documents.

9 References

The following list sources of technical information on activities logs.

United States Environmental Protection Agency (EPA). 1991. *NEIC Policies and Procedures Manual*, U.S. EPA, EPA 33019-78-001-R, August 1991

END OF SOP

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STANDARD OPERATING PROCEDURE

SITE CONTROL PROCEDURES FOR POTENTIALLY CONTAMINATED SITES

SOP NUMBER: ENV 3.2

REVISION DATE: 11/30/2017 **SCHEDULED REVIEW DATE: 11/30/2022**

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1 Scope and Application

This Standard Operating Procedure (SOP) describes the routine procedures used by E & E field personnel for initially entering and exiting potentially contaminated sites, as well as certain other site control measures. Safe and proper entry, egress, and site control require a careful and coordinated team effort and completion of project planning documents (e.g., work plan, sampling and analysis plan, quality assurance project plan, and site-specific health and safety plan [SHASP]). The reasons for entering a potentially contaminated site may range from simple reconnaissance to complex sampling programs, and may include visual or other observations, *in situ* or *ex situ* field measurements (monitoring), emergency response, engineering and engineering oversight, or sample/data collection (biological, chemical, geological, radiological, or physical).

This SOP addresses entry and egress of contaminated sites containing hazardous, toxic, dangerous, or similar materials, substances, and wastes and is especially pertinent to the first-time entry of a new or unknown site, when the potential hazards are not yet fully defined. This SOP does not specifically address confined space entry, drum opening activities, or entry to sites suspected to be contaminated by biohazards (e.g., medical waste or biological agents such as anthrax), explosives, or fissile radioactive materials. These are not considered to be routine operations and may require specialized procedures.

Because entry to a contaminated site for the first time can carry with it health and safety considerations associated with unknown contaminants, hazards, and site conditions, this SOP touches on more health and safety-related information than normally would be addressed in a procedural SOP. E & E's Corporate Health and Safety Program (CHSP) defines corporate polices and procedures for key elements of E & E's health and safety program, including medical surveillance, training requirements, and the selection of appropriate personal protective equipment (PPE). The SHASP developed for the work, and the CHSP with which the SHASP must be compliant, constitute the safety documentation for the work activity. This SOP is not a substitute for that safety documentation.

This SOP is intended for use by E & E personnel who have knowledge, training, and experience in the field activities being conducted.

Other E & E SOPs that would typically also apply to site entry, egress, and control include the following:

- DOC 2.1, Field Activity Logbooks;
- ENV 3.15, Sampling and Field Equipment Decontamination;
- ENV 3.16, Environmental Sample Handling, Packaging, and Shipping;
- ENV 3.26, Handling Investigation-Derived Wastes;
- ENV 3.27, Procedure for Routine GPS Operation; and
- Various sampling and data collection SOPs.

2 Acronyms

ALARA	As low as reasonably achievable
CFR	Code of Federal Regulations

CGI	Combustible gas indicator
CHSD	Corporate Health and Safety Director
CHSP	Corporate Health and Safety Program
CRZ	Contamination reduction zone
dBA	Decibels as measured using the A-weighted network
DQO	Data quality objective
E & E	Ecology and Environment, Inc.
EPA	(United States) Environmental Protection Agency
FID	Flame ionization detector
FTL	Field team leader
ICAO	International Civilian Aviation Organization
LEL	Lower explosive limit
mR/hr	Milliroentgens per hour
NIOSH	National Institute for Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
PDS	Personnel decontamination station
PID	Photoionization detector
PM	Project manager
PPE	Personal protective equipment
PPM	Parts per million
QA/QC	Quality assurance/quality control
SCBA	Self-contained breathing apparatus
SHASP	Site-specific health and safety plan
SOP	Standard operating procedure
SSO	Site safety officer
USCG	United States Coast Guard

3 Procedure Summary

This SOP discusses procedures for establishing control for activities at potentially contaminated sites. It addresses background research and site categorization, work zones, the roles of field team members, communications, ambient monitoring and characterization equipment, site entry and egress, and personnel decontamination. Site-specific procedures and responsibilities are described in project planning documents.

4 Cautions

Even with diligent research, site entry, egress, and control may include incomplete understanding of current site conditions or unexpected changes in site conditions. Planning documents are living documents and need to be updated to reflect changing site conditions. E & E field personnel are expected to advise other field personnel of safety concerns as they are encountered. Cautions related to health and safety are further discussed in Section 8.

Before site entry, written permission to access and conduct activities within the property that contains the site must be obtained. Permission may be granted by the property owner or appropriate judicial authorities. Documentation of permission, in the form of a court order or written authorization, should be available for disclosure at the site during the field activities.

The decontamination of PPE will generate one or more waste streams, some of which could be potentially hazardous waste. All wastes will be handled in accordance with E & E SOP ENV 3.26, Handling Investigation-Derived Wastes, as well as project planning documents.

Agents used to decontaminate PPE and personnel, such as soaps and detergents, can be potentially damaging over time to reusable protective apparel such as gloves, hard hats, respirators, and reusable protective suits and aprons, as well as to skin. Care should be taken to ensure that the decontamination process is compatible with the PPE being decontaminated. In accordance with the CHSP, PPE should be inspected before each use to ensure its integrity.

5 Equipment and Supplies

Project planning documents will provide direction on specific equipment and supplies. The following equipment and supplies are commonly used for site entry, egress, and control for a broad-scale field investigation:

- PPE;
- Work area markers/delineators (e.g., traffic cones, barricade tape, stakes, flagging);
- Communication equipment (e.g., cellular telephones, two-way radios);
- Ambient monitoring and characterization equipment; and
- PPE decontamination supplies:
  - Plastic sheeting for ground cover,
  - Galvanized steel or similar wash basins,
  - Plastic buckets (5-gallon),
  - Long-handled brushes,
  - Spray/squeeze bottles,
  - Tables and chairs,
  - Paper towels,
  - Trash bags,
  - Non-phosphate detergent (e.g., Alconox™ or Liquinox™) or other specified decontamination agent,
  - Deionized water (e.g., American Society for Testing and Materials Type II),
  - Potable water, and
  - Waste collection drums.

6 Procedure

6.1 Site Categorization Based on Background Research

Background research occurs during project planning and is inherently linked to developing the work plan and SHASP. Data may be available from multiple sources, e.g., client records; environmental and property data clearinghouses (such as EDR®); aerial photographs; federal, state, or local agency files; national or regional databases; and the internet. Background reviews commonly look at historical land use, materials used or disposed of, data and information from previous investigations, past site conditions, litigation-related documentation, and the present activity at and condition of the site.

As necessary, a site can be classified into one of three categories (Site Categories I, II, or III) for the purposes of determining appropriate levels of personal and respiratory protection and the level of caution for initial site entry. In brief, the four levels of personal protection are:

- Level D: No chemical-protective clothing or respiratory protection;
- Level C: Chemical-protective clothing plus air-purifying respirator;
- Level B: Higher level of chemical-protective clothing plus positive-pressure self-contained breathing apparatus (SCBA); and
- Level A: Fully encapsulating protective suit plus SCBA.

Requirements for each level of protection are described in the CHSP. In accordance with the CHSP, a minimum of Level B protection is required when site respiratory and/or dermal hazards have not been identified.

Site Category I

For a Category I site, E & E personnel may enter the site and conduct site activities using Level D protection if the following conditions exist at the site:

- Background research indicates that no hazardous substances are present at the site that could present a potential respiratory hazard;
- A perimeter reconnaissance is conducted;
- Work activities are limited to non-intrusive activities such as visual inspection and non-invasive sampling, and do not include entering uncharacterized areas, structures, trenches, pits, basements, or excavations;
- Containers (e.g., drums, impoundments, tanks, etc.) of unknown or known hazardous substances are not present;
- There are no unknown or known odors of hazardous substances;
- There are no visible vapor clouds;
- The site has good natural air circulation; and
- Neither dead animals nor dead/stressed vegetation are visible.

Site Category II

A Category II site is an active investigation/remediation/construction site with workers present from other agencies or companies. E & E will determine the adequacy of existing site safety procedures based on a review of the following:

- Site history;
- Chemical and other hazards, including locations, affected media, quantities, and extent of contamination;
- Physical hazards;
- Ambient monitoring instrumentation, results, and action levels;
- Applicable industry standards (consulting with outside experts as necessary);
- Sitewide general health and safety procedures; and
- The site's ongoing health and safety program.

If the review process indicates that the existing protection procedures meet E & E corporate health and safety standards, field personnel may enter the site in the same level of protection as the other site personnel and the facility's ongoing health and safety program may be used as the basis for E & E's SHASP. If the review process indicates that a higher level of protection is required, these findings will first be discussed with the site owner/operator and other competent authorities, including the E & E Corporate Health and Safety Director (CHSD).

Site Category III

A Category III site has unknown or potentially uncontrolled contamination present, e.g., such as what might be encountered during an emergency response to a hazardous materials incident under E & E's START contracts with the United States Environmental Protection Agency (EPA). In addition to the background review discussed for Site Categories I and II, E & E will evaluate:

- The potential for a respiratory hazard;
- Whether appropriate real-time monitoring instruments are available for the hazards identified;
- The need for Level A versus Level B entry (assuming that entry using a Level C air-purifying respirator has been determined to not be adequate for the conditions); and
- The need for splash protection during initial entry.

E & E maintains Level A and Level B capabilities in selected offices. Level A work requires special training and is conducted rarely enough that it must be approved by the CHSD.

6.2 Work Zone Setup

Procedures for identifying work zones, access control points, and routes for traversing hazardous areas are described below. Actual layout of the zones, distances between zones, access points, and travel routes will vary depending on the weather, terrain, location, types of contaminants, operational areas, and boundaries of the site. Project planning documents, a site map or sketch, direct observations, and real-time ambient monitoring by field personnel will help inform these decisions.

Figure 6-1 shows a typical work zone arrangement for hazardous site work. Organizing work zones as shown on Figure 6-1 minimizes the potential for overexposure and protects the public by restricting the dispersion of hazardous substances outside the site. Figure 6-2 presents an alternative work zone setup where the exclusion zone is limited to the interior of a building. Work zones can be delineated and marked using barrier tape, rope, traffic cones, wooden stakes, signage, and similar methods. The basic types of work zones are described below.

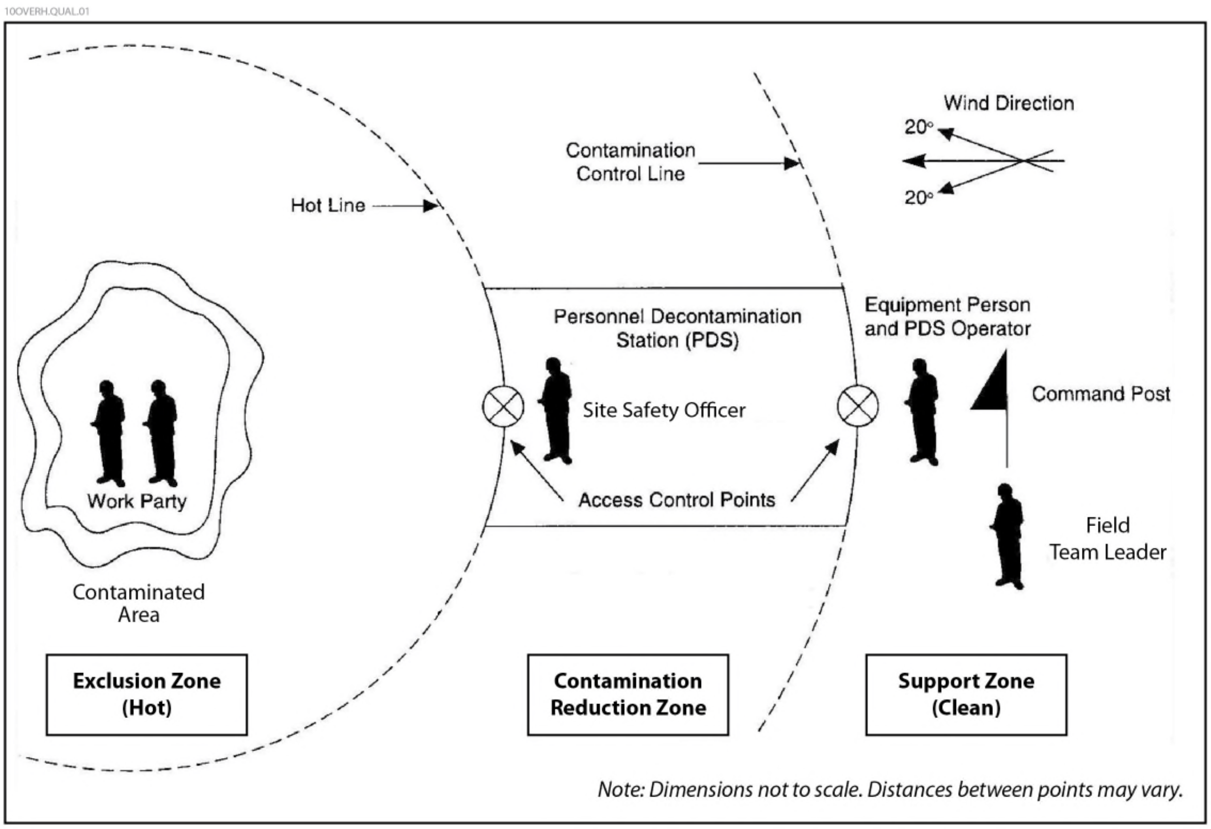

Figure 6-1 Conceptual Work Zone Setup for Potentially Contaminated Site

6.2.1 Exclusion Zone

The exclusion zone—also known as the hot zone, contamination zone, or exclusion area—is the area of known or suspected contamination. It is the area where site work activities are performed, such as characterization, sampling, and cleanup. The exclusion zone may be subdivided based on the known or suspected types or degrees of contamination/hazard, incompatible material or waste streams, and the activities to be performed.

The outer boundary of the exclusion zone is the hot line. The hot line is marked and established based on considerations such as:

- Visual survey of the area;
- Location of:
  - hazardous/toxic substances,
  - drainage, leachate, and spills, and
  - visible staining;
- Data from the initial site survey for:
  - oxygen deficiency or enrichment,
  - combustible gases,
  - organic and inorganic gases, particulates, or vapors, and
  - ionizing radiation;

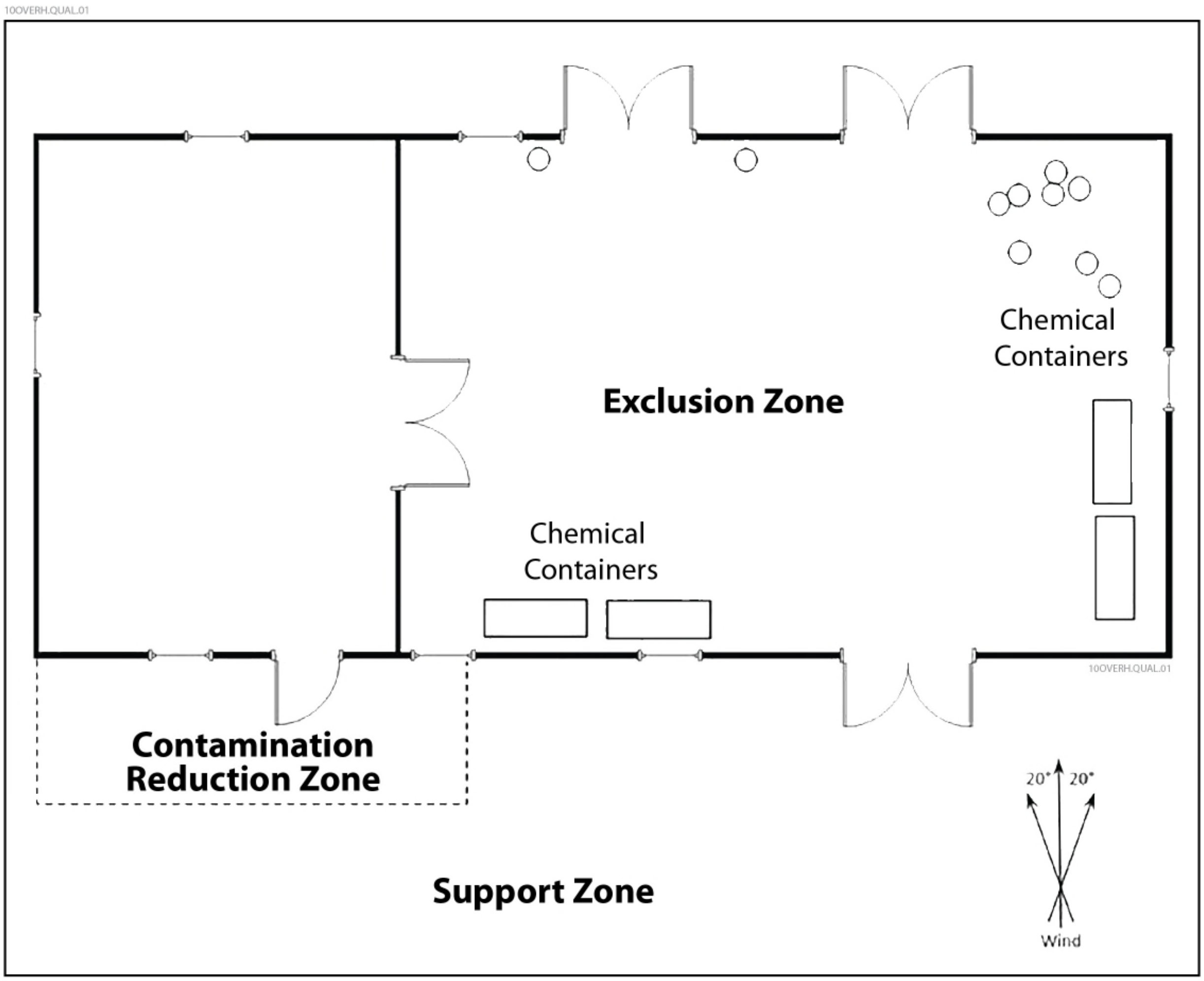

Figure 6-2 Conceptual Work Zone Setup for Potentially Contaminated Building

- The results of soil, water, or other matrix sampling;
- The distances needed to prevent an explosion or fire from affecting personnel outside the exclusion zone;
- The physical area required to safely conduct field activities; and
- Meteorological conditions and the potential for contaminants to be carried from the area by wind.

The hot line is modified as necessary as more information about the site becomes available or if conditions change. An access control point on the hot line is established through which work party personnel enter and exit the exclusion zone. Only properly protected personnel who have met all of the site safety requirements may cross the hot line, via the access control point, into the exclusion zone.

6.2.2 Contamination Reduction Zone

The contamination reduction zone—also known as the CRZ, warm zone, decontamination zone, or contamination reduction area—is the transition area between the contaminated area (exclusion zone) and the clean area (support zone). The contamination reduction zone lies between the hot line and the contamination control line. The contamination reduction zone is established to reduce the probability that the support zone could be affected by contaminants or other site hazards. The contamination control line separates the contamination reduction zone from the support zone. Access control points on the hot line and contamination control line control access to the contamination reduction zone from the exclusion zone and the support zone.

The contamination reduction zone is typically designed to facilitate:

- Personnel decontamination (at a personnel decontamination station [PDS]) and equipment decontamination;
- Equipment resupply and management, e.g., air tank changes, PPE changes, monitoring instrument maintenance and recalibration, sampling equipment and supply management, and tool management;
- Sample packaging for on-site or off-site laboratories;
- Temporary rest for the work party, potentially including wash and toilet facilities, benches/chairs, potable liquids, and protection from the weather;
- The collection and management of decontamination fluids and wastes; and
- Emergency response support: transport for injured personnel (e.g., stretcher), first aid equipment (e.g., bandages, blankets, eye wash), and containment equipment (e.g., spill absorbent, fire extinguisher).

6.2.3 Support Zone

The support zone—also known as the clean zone, cold zone, or support area—is established in a clean area. It houses the command post and administrative and other support functions required for field activities. The support zone is located based on considerations such as:

- Accessibility (e.g., security, level terrain, ease of entry and egress for vehicles);
- Resource availability (e.g., power and transportation);
- Visibility (line-of-sight with the activities in the exclusion and contamination reduction zones);
- Wind direction (upwind if possible or at least cross-wind of the exclusion zone);
- Distance (as far as practicable from the exclusion zone); and
- Visibility by the general public (as out of view from the general public as possible).

The support zone may encompass multiple facilities and activities, as follows:

- Command Post
  - Supervision of field personnel and activities,
  - Maintenance of communications, including telephone numbers and emergency lines of communication,
  - Recordkeeping, including:

        - accident reports
        - chain-of-custody records
        - daily logbooks
        - site entry/exit logs
        - manifest directories and orders
        - medical records
        - personnel training records
        - site inventories
        - site safety and evacuation route maps
        - current SHASP and planning documents
    - Interfacing with the public, including site owners/operators, government agencies and contractors, local politicians, medical personnel, media, and others,
    - Monitoring work schedules and weather changes,
    - Sample shipment,
    - Maintenance of site security, and
    - Sanitary facilities;

- First Aid
    - First aid administration,
    - Response to medical emergencies, and
    - Medical monitoring activities;

- Equipment and Supply Management
    - Supply, maintenance, and repair of communications, respiratory, and sampling equipment,
    - Maintenance and repair of vehicles,
    - Replacement of expendable supplies, and
    - Storage of monitoring equipment and supplies; and

- Field Laboratory (if applicable)

6.3 Field Personnel Organization

Only qualified personnel with knowledge, training, and experience in the field activities being conducted, and who have read and understand the project planning documents, may participate in field activities. Movement of field personnel between zones is restricted to access points and minimized to prevent potential contaminant dispersal. The number of personnel required is a function of project data quality objectives (DQOs), site-specific conditions, and the activities identified in the project planning documents. The project manager (PM) and site safety officer (SSO) will make specific field assignments based on their evaluation of potential site hazards, tasks, and site-specific safety considerations. Functionally, the following personnel typically will be present:

- Command and control personnel – field team leader (FTL), on-site manager, or supervisor;
- SSO;
- PDS operator, located in the contamination reduction zone; and
- Work party – at a minimum, two personnel to perform field activities.

These personnel roles are further described below. A typical five-member team is shown on Figure 6-1. The names of field personnel should be written on hard hats, coveralls/outer PPE, and respirators.

6.3.1 Command and Control Personnel

Command and control of field activities is exercised from the command post in the support zone, which is staffed by an FTL, an on-site manager, a command post supervisor, or equivalent, and additional support personnel as required. In an emergency response situation, this role is assigned to the incident commander.

6.3.2 Site Safety Officer

The SSO is responsible for implementing the SHASP and verifying compliance with applicable health and safety procedures. The SSO traditionally is positioned in the contamination reduction zone, near the hot line, where s/he can monitor work party activities in the exclusion zone. The SSO monitors internal communications, maintains line-of-sight with the work party, and checks site security and work party safety (e.g., fatigue, air time remaining on SCBA, and heat stress). The SSO supports the PDS operator when the work party is in the contamination reduction zone. The SSO wears PPE no more than one level below the work party and keeps full exclusion zone PPE at the ready in order to rapidly enter the exclusion zone when necessary.

6.3.3 PDS Operator

The PDS operator works in the contamination reduction zone to process work parties and equipment into the exclusion zone and assist with the decontamination of personnel and equipment returning from the exclusion zone. The PDS operator typically wears PPE no more than one level lower than the work party and facilitates the activities conducted in the contamination reduction zone.

6.3.4 Work Party

The work party performs the field activities described in the project planning documents, such as initial site entry, reconnaissance, monitoring, sampling, emergency response, engineering, or engineering oversight. To maintain the buddy system, the work party typically includes at least two personnel unless there is clear line of sight with the SSO, FTL, or other personnel and prior approval has been obtained for one team member to work in the exclusion zone. The intent of the buddy system is that each member of the work party is observed by at least one other member of the work party to facilitate rapid assistance to team members in the event of an emergency.

6.4 Communications

6.4.1 General Communications

On-site communications among work party, PDS, safety, and command and control personnel are typically accomplished through the use of cellular telephones or portable two-way radios. Hand signals, agreed upon by field personnel before entering the field, and dry-erase whiteboards also can be used if the phone or radio systems fail or otherwise become unavailable.

6.4.2 Radio Communications

Field personnel should adhere to the following radio communication guidelines:

- Each transmission should be initiated by identifying the party being reached, followed by identification of the initiator, followed by a pause for acknowledgment (e.g., "Command post, this is Jane Smith, over.").
- Each word must be pronounced clearly using plain and direct language. The International Civilian Aviation Organization (ICAO) phonetic alphabet (e.g., alpha, bravo, charlie) may be used to avoid miscommunication.
- Each message should end with "over."
- The term "out" indicates that the complete transmission is ended and no return transmission is expected.

6.4.3 Alerting Means for Emergencies

The SHASP will address:

- The audible emergency or evacuation signals to be used on site to alert team members to the existence of an on-site emergency. A hand-held air horn, vehicle horn, cell phones, and/or shouting are routinely used for this purpose.
- The identification of and contact information for local emergency services (e.g., fire, police, hospital, and emergency medical services).
- The notifications required to be made in the event of an emergency (e.g., E & E management, client, and applicable regulatory authorities).

6.5 Ambient Monitoring and Characterization Equipment

Ambient monitoring of site conditions is conducted during initial site entry and periodically thereafter as work activities are conducted. This monitoring is primarily performed for health and safety purposes, although monitoring also provides information useful for decision making for the investigation and cleanup of the site. The requirements for ambient monitoring are included in the project work plan and SHASP.

E & E personnel will not operate ambient monitoring instrumentation without having received adequate training in the operation of the instrument, interpretation of the readings, and the limitations of each instrument. Although some basic instruction is provided to E & E employees as part of initial and refresher health and safety training, personnel responsible for conducting ambient monitoring should refresh their training as part of site-specific pre-planning and preparation. Ambient monitoring instrumentation will have been calibrated according to the prescribed frequency (which varies by instrument) and field-checked daily before use.

Table 6-1 lists some typical ambient monitoring instruments and health and safety action levels. The instruments and action levels specified in the SHASP will take precedence over the information in Table 6-1.

Table 6-1 Typical Ambient Monitoring Instruments and Action Levels

Instrument	Health and Safety Action Level
Photoionization Detector (PID) (e.g., TVA 1000, MiniRAE 3000, or other multiple gas monitor) Flame Ionization Detector (FID) (e.g., TVA 1000)	**Unknown Vapors** Background to 1 part per million (ppm): Level D 1 to 5 ppm above background: Level C 5 to 500 ppm above background: Level B > 500 ppm above background: Level A
Oxygen Detector	< 19.5% or > 22.0%: Evacuate area; eliminate ignition sources; reassess conditions. 19.5 to 22.0%: Continue work in accordance with action levels for other instruments.
Combustible Gas Indicator (CGI) (e.g., MSA or RAE Systems multiple gas monitor with CGI)	≤ 10% Lower Explosive Limit (LEL): Continue work in accordance with action levels for other instruments; monitor continuously for combustible atmospheres. > 10% LEL: Evacuate area; eliminate ignition sources; reassess conditions.
Particulate (Dust) Monitor	Evaluate health and safety measures when dust levels exceed 2.5 milligrams per cubic meter.
Hydrogen Cyanide/Hydrogen Sulfide Monitor (e.g., Monitox)	≥4 ppm: Leave area and consult with SSO.
Other Analyte-specific Monitor/Indicator	Site-specific.
Air Monitor/Sampler – Breathing Zone	Site-specific.
Air Monitor/Sampler – Perimeter	Site-specific.
Noise Dosimeter	≤85 decibels as measured using the A-weighted network (dBA): Use hearing protection if exposure will be sustained throughout work shift. >85 dBA: Use hearing protection. >120 dBA: Leave area and consult with safety personnel.
Radiation Alert Monitor (e.g., Rad-mini or RAM-4)	< 0.1 milliroentgens per hour (mR/hr): Continue work in accordance with action levels for other instruments. ≥0.1 mR/hr: Evacuate area; reassess work plan and contact radiation safety specialist.
Micro R Meter or Ion Chamber	<2 mR/hr: Continue work in accordance with action levels for other instruments. 2 to 5 mR/hr: In conjunction with a radiation safety specialist, continue work and perform stay-time calculations to ensure compliance with dose limits and as low as reasonably achievable (ALARA) policy. >5 mR/hr: Evacuate area to reassess work plan and evaluate options to maintain personnel exposures ALARA and within dose limits.
Radiation Survey Ratemeter/Scaler with External Detectors (e.g., pancake Geiger-Mueller probe)	>Approximately 2 to 3 times background: Consider area to be radioactive. Consider item to be radioactively contaminated and to require decontamination for unrestricted use. Other site-specific levels as warranted.

6.6 Initial Site Entry

Initial entry helps define current site conditions and hazards and provides data used to evaluate the need for modifications to the planning documents, especially the SHASP. While maintaining communication with the SSO, the work party uses ambient monitoring and other instruments identified in the planning documents, especially the SHASP, to evaluate site hazards.

Key actions for initial entry into a potentially contaminated site typically include:

- **Actions in the Support Zone:**
  - Brief the work party,
  - Check equipment,
  - Don protective clothing,
  - Verify evacuation routes,
  - Collect instrument background readings,
  - Check lines of communication, and
  - Monitor the weather.
- **Actions in the Contamination Reduction Zone:**
  - Sign the exclusion zone entry/exit log,
  - Perform final check of communications and equipment, and
  - Enter exclusion zone via access control point.
- **Actions in the Exclusion Zone:**
  - Maintain safe distances from unsafe areas,
  - Follow prearranged, task-specific routes,
  - Complete only assigned tasks,
  - Maintain buddy system,
  - Maintain contact with the SSO,
  - Conduct ambient monitoring, allowing time for instruments to respond; take appropriate action if action levels are exceeded,
  - Photo-document site conditions,
  - Prepare or modify sketches of the work area,
  - Identify potential locations for sample/data collection, and
  - Record observations and data in a field logbook and/or digital devices.

6.7 Subsequent Entries into the Exclusion Zone

Subsequent entry into the exclusion zone is guided by the information gathered during previous entries and how the information affects DQOs. Health and safety protocols for subsequent entries will be modified as necessary consistent with information gained from prior exclusion zone entries. Subsequent entry activities may include:

- Completing unfinished tasks from initial entry;
- Collecting additional samples as determined by initial analytical or field screening results;
- Verifying previous observations;
- Collecting additional information based on the results of the initial site entry; and

- Contaminant stabilization activities (e.g., absorbent boom deployment, closing open containers, or minor containment).

6.8 Egress

The procedure for egress from the exclusion zone includes timing work activities to correspond with safety limitations, e.g., exiting the exclusion zone prior to the need to replace an SCBA (i.e., before an SCBA End of Service Time Indicator alarm indicates that only 20% to 25% of the total recommended air pressure remains in the tank). Work parties exit following the buddy system.

Planning includes carrying sufficient equipment and supplies to avoid multiple trips in and out of the exclusion zone where possible.

6.9 Personnel Decontamination Station Operation

6.9.1 PDS Design and Setup

A site-specific decontamination procedure will be developed, communicated to workers, and implemented before workers or equipment enter areas on site where the potential exists for exposure to hazardous substances. The site-specific protocol and the procedures in this SOP have been developed to minimize employee contact with hazardous substances or with equipment that has contacted hazardous substances.

The PDS is set up within the contamination reduction zone. At the PDS, personnel returning from the exclusion zone are decontaminated before re-entry into the clean support zone (see Figure 6-1). (Decontamination of items and equipment is addressed in SOP ENV 3.15, Sampling and Field Equipment Decontamination.)

The size and layout of the PDS will be described in the planning documents and will be based on the type of contaminant, the work activities to be conducted, health and safety considerations, and project DQOs. Contamination avoidance is the most effective decontamination procedure. The PDS will be located in an area that will minimize the exposure of uncontaminated personnel and equipment to contaminated personnel and equipment.

The scope and layout of the PDS will be affected by the relative use of reusable PPE (which will require decontamination) versus disposable PPE (which will require disposal as either a contaminated or noncontaminated waste). The project planning documents will specify what types of PPE and decontamination will be used for the project, which will evaluate factors such as the contaminants involved, safety, and cost (of PPE, decontamination, and waste disposal). Reusable PPE is required to be decontaminated, cleaned, laundered, maintained, or replaced as needed to maintain its effectiveness. Disposable PPE is typically used when practicable. Wet decontamination, involving the use of water and decontamination wash and rinse steps, is used to clean reusable PPE. Dry decontamination consists of limited decontamination and the removal and disposal of disposable PPE. Figure 6-3 shows a complex layout for a Level B PDS involving predominantly wet decontamination, which is discussed further in Section 6.9.2.1.

Ergonomic layout of the PDS allows work party personnel crossing the marked access point from the hot zone to move efficiently and systematically into the contamination reduction zone and between decontamination stations within the PDS. Clearly labeled signs with arrows, ropes, and/or markers delineating the proper avenue for decontamination and the boundaries of the PDS typically would be used and should be visible to personnel in their working level (Level A, B, or C). In addition to labels and markers, the PDS operator may provide verbal instruction or escort and assist workers as they exit the exclusion zone and move through the PDS.

Drop cloths, plastic sheeting, tubs, decontamination implements (e.g., long-handled brushes), and garbage cans are staged throughout the PDS, and lined/diked catchment systems might be required to direct and collect decontamination fluids. Tables, chairs, and other non-disposable furniture within the PDS are protected with plastic sheeting and decontaminated prior to removal from the contamination reduction zone. Environmental and personal monitoring equipment are also similarly protected from contamination while being held in the PDS (e.g., stored in clear plastic bags).

The PDS operator typically wears PPE no more than one level lower than the personnel entering the PDS from the exclusion zone. For example, if the work party level of protection is B, then the PDS operator should be in Level C or higher. After removal, disposable PPE should be rendered useless by cutting or tearing to prevent the inadvertent or intentional reuse of contaminated PPE.

Decontamination processes will be monitored by the PDS operator and SSO to determine their effectiveness and correct any deficiencies found. Unauthorized workers may not remove protective clothing or equipment from the PDS.

6.9.2 PDS Steps/Stations

The functions of typical PDS steps and stations are briefly described below for wet decontamination and dry decontamination.

6.9.2.1 Wet Decontamination

A wet decontamination PDS may range from a boot wash to multiple stations with wash solutions and water rinse steps. Figure 6-3 shows a complex layout for a Level B PDS involving predominantly wet decontamination. This type of PDS layout is very involved and would be used when it is necessary to reduce contamination on PPE throughout the decontamination process (for the safety of the PDS operator and the work party) and also because multiple items of reusable PPE have been worn (including outer gloves, safety boots, and respirator face mask). This layout will be modified as needed to accommodate project needs.

The scope and layout of the PDS, as well as the decontamination agents to be used, will be defined in the project planning documents. A common agent used to decontaminate PPE is a detergent such as Alconox®. Additional consultation with E & E health and safety staff is recommended to determine appropriate agents to decontaminate PPE for unique, high chemical hazard, or complex activity sites. In general, wash and rinse solution volumes should be minimized to the extent practicable to reduce waste characterization and disposal costs. A description of key steps and stations is provided below.

- **Equipment Drop and Sample Decontamination**: The equipment drop is situated in the exclusion zone near the hot line. Equipment that will be used again in the exclusion zone is segregated from equipment that is being removed from the exclusion zone. Containerized samples (and reusable sampling implements) will be decontaminated at a station established near the hot line.
- **Boot Cover and Outer Glove Wash/Rinse and Removal**: Boot covers and outer gloves (such as heavy neoprene or nitrile gloves; not surgical-type inner gloves) typically will be decontaminated and removed in the exclusion zone because those are the PPE items likely to be the most contaminated. For excessive contamination on water-resistant outer garments, the boot cover wash/rinse station can alternatively function as a gross decontamination station where the worker stands in large tubs to have dirt and

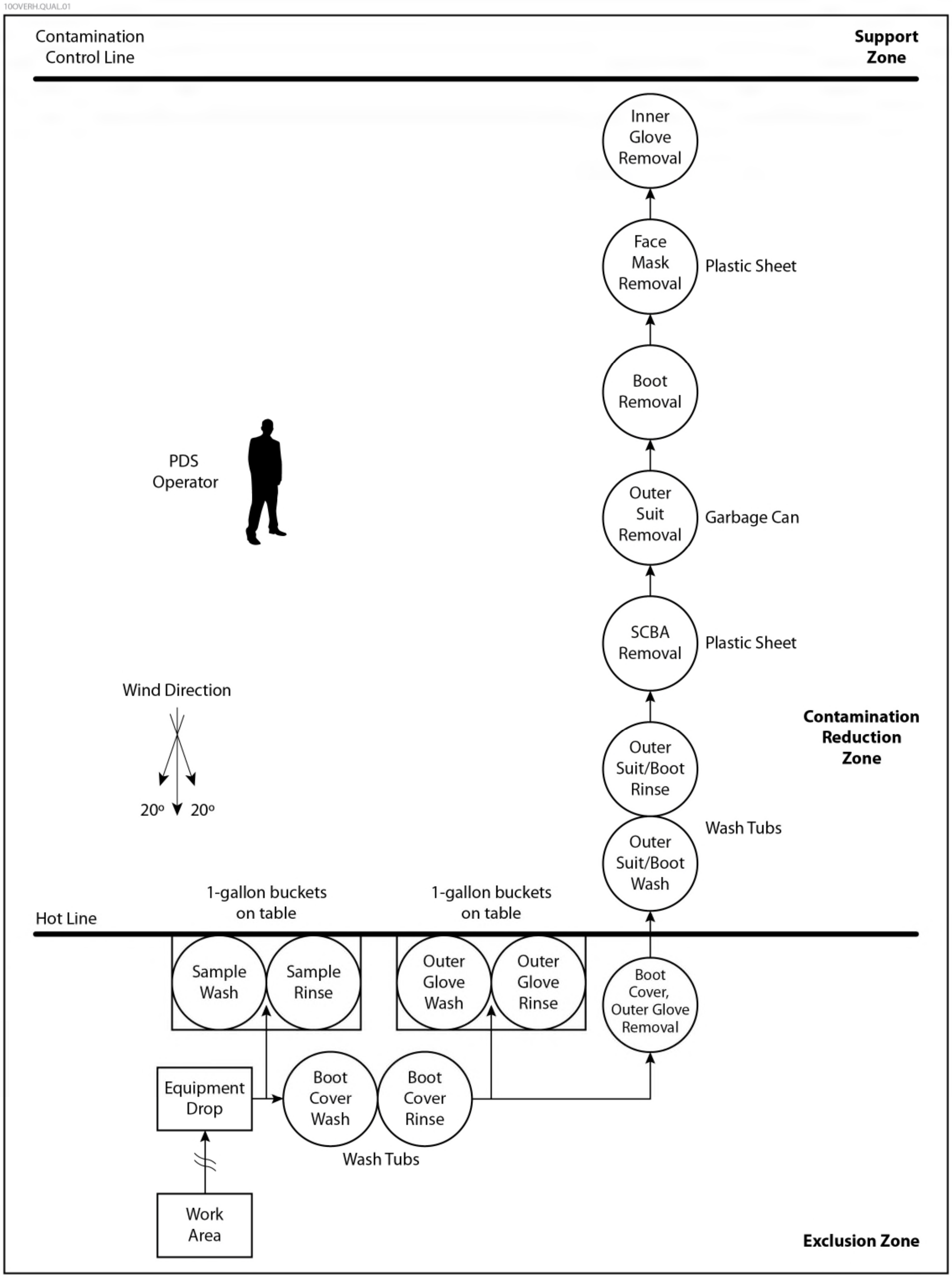

Figure 6-3 Complex PDS Layout for Level B Protection

contamination gently hosed off or removed with long-handled brushes. While at the boot cover and outer glove wash/rinse/removal stations, which are near the hot line, PDS personnel working from the PDS can replace an SCBA cylinder and the individual could return to the exclusionzone (depending on the level of contamination on the PPE, the SCBA cylinder can even be replaced without the work party member going through the boot cover and outer glove wash). PDS personnel also can resupply the work party in this general area. However, PDS personnel will not cross the hot line into the exclusion zone.

- **Outer Suit and Boot Wash/Rinse and Removal**: As needed, the outer chemical-protective suit and boots (such as neoprene boots) will be decontaminated next, followed by SCBA tank assembly removal and then outer suit removal. It is important that personal footwear and inner gloves do not become contaminated during the removal of outer PPE. The SCBA face mask will remain on the individual at this point. The SCBA tank assembly will be decontaminated or receive maintenance to be placed back into service for further work activities in the exclusion zone.
- **Face Mask and Inner Glove Removal**: The secondary (outer) inner gloves will be removed, then the face mask, and then the primary inner gloves. The face mask will be segregated for decontamination in the PDS before the face mask leaves the contamination reduction zone. In some cases, the face mask is bagged in a clean plastic bag and removed from the site for washing at the end of the day by the wearer.

After leaving the contamination reduction zone, field personnel will wash their hands and face with soap and water at the earliest opportunity. In the absence of sanitary facilities or a wash station at the job site, wet towelettes can be used. The use of hand sanitizer is not a substitute for washing with running water or wet towelettes.

If showers are used for decontamination, they will meet the requirements of 29 CFR 1910.141. If temperature conditions prevent the effective use of water, then other effective means for cleansing will be provided and used. In the unlikely event that commercial laundries or cleaning establishments are used to decontaminate protective clothing or equipment, they will be informed of the potentially harmful effects of exposure to hazardous substances.

6.9.2.2 Dry Decontamination

Similar to wet decontamination, a dry decontamination PDS may range from a single station, where all of the steps for dry decontamination are completed, to multiple stations. A dry decontamination PDS would tend to be used when low levels of contamination are expected on reusable PPE or when predominantly disposable PPE is planned to be used for the work. The level of protection will determine the number of stations needed, the layout will be modified to accommodate project needs, and the scope and layout of the PDS will be defined in the project planning documents.

Although a figure is not provided, a dry decontamination PDS is a scaled-down version of the wet decontamination PDS shown on Figure 6-3, and typically would consist of equipment drop, outer PPE removal, and inner PPE removal stations. For dry decontamination, some stations may be consolidated and wash/rinse steps involving the generation of spent decontamination fluids are eliminated. Dry decontamination can involve the limited and controlled use of moist towelettes, paper towels dampened with water, and other damp methods.

6.9.3 Emergency Decontamination

For an emergency involving the work party, such as a medical emergency, site emergency, or breach of protective clothing, routine work activities will be suspended and the work party will proceed to the contamination reduction zone. Decisions regarding the extent of decontamination in an emergency will be made on a case-by-case basis and will be based on factors such as the:

- Nature and severity of the emergency;
- Nature of the site-specific contamination; and
- Availability of outside emergency services.

In some emergencies, the time should not be taken for the affected worker to be fully processed through the PDS and only gross decontamination (or perhaps no decontamination at all) should be performed before the emergency is addressed. The procedure for emergency gross decontamination after an individual leaves the exclusion zone includes immediate removal of gross contamination and removal of outer layers of protection, while limiting contamination of the work party and PDS operator to the extent practicable. In some cases, deluging the affected work party member with large volumes of water may be the appropriate next step, while in other cases the removal of the outer layers of protection may be sufficient before rendering first aid or otherwise addressing the emergency. Appropriate techniques should be included in the SHASP and discussed before the initial site entry is performed. E & E field staff are first aid/cardiopulmonary resuscitation-trained and should follow their training. Initially, the scene should be checked for safety to determine what has happened, how many people are involved, and whether it is safe to approach the victim.

Although not necessarily an emergency, workers whose non-impermeable clothing becomes wetted with hazardous substances will immediately remove that clothing and proceed to shower, and the affected clothing will be disposed of or decontaminated before it is removed from the work zone.

6.9.4 Special Considerations for Radioactive Decontamination

Personnel decontamination on sites containing radioactive material typically follows dry decontamination methods in order to minimize the generation of radioactively contaminated decontamination fluids, which might be costly and complicated to dispose of. When liquid decontamination agents are specified for radioactive site investigations, commercial preparations are available that contain special chelating or binding agents that are often better than Alconox® at removing radioactive materials.

6.9.5 PDS Closure

When it is time to close and dismantle the PDS, equipment, furniture, and items used to operate the PDS are evaluated for the potential to be contaminated, and then are decontaminated as appropriate in accordance with SOP ENV 3.15, Sampling and Field Equipment Decontamination. Reusable items that have been decontaminated are moved to the support zone. Solid wastes generated at the PDS such as used PPE, expendables, and decontamination supplies are double-bagged and/or drummed according to the project planning documents. Spent decontamination solutions typically are drummed pending analysis and disposal. Once all items within the PDS have been decontaminated and moved to the support zone, containerized, or otherwise directed to their proper disposition, protective ground coverings are rolled or folded (starting from the hot line) and double-bagged for proper disposal. The PDS operator and command/control personnel will ensure that wastes generated from personnel decontamination are collected and containerized for proper disposal in accordance with SOP ENV 3.26, Handling Investigation-Derived Wastes.

7 Quality Assurance/Quality Control

The program/project manager will identify personnel for the field team who have knowledge, training, and experience in the field activities being conducted. Field personnel will be assigned responsibilities for implementing the procedures in this SOP. The program/project manager should also identify additional personnel, as necessary, to complete ancillary procedures (e.g., field logbook documentation, sample management, sample shipment, and waste disposal).

Prior to initiating field work, the project planning documents (e.g., work plan, sampling and analysis plan, quality assurance project plan, and SHASP) will be reviewed by field personnel to understand the planned site entry, egress, and control activities. Project planning documents will define the quality assurance/quality control (QA/QC) procedures necessary to meet project DQOs.

8 Health and Safety

Prior to entering the field, E & E field personnel will acknowledge in writing that they have read and understand the SHASP.

Unique hazards associated with entry onto a site for the first time include conditions that are not consistent with historical background documents or project planning documents, such as undisclosed or unknown chemical, toxicological, radiological, or pathogenic hazards; undisclosed or unforeseen physical hazards (e.g., unsound structures, deep holes/pits in the ground, unsafe infrastructure); and difficult terrain.

Exposure to site hazards will be controlled by following the SHASP and the hazard control measures and safe work practices it prescribes. The SHASP is required to be compliant with E & E's CHSP. The SHASP will identify the nearest medical assistance. In accordance with E & E standard practice, a daily safety meeting will be conducted for all on-site personnel prior to work activities and will address the specific hazards and hazard control measures applicable to that day's work. The daily safety meeting will be documented on E & E's Daily Safety Meeting Record form or in the field logbook.

9 Special Project Requirements

Project-specific requirements will be included with the project planning documents.

10 References

Martin, William F. and Michael Gochfeld. 2000. *Protecting Personnel at Hazardous Waste Sites.* Third Edition.

National Institute for Occupational Safety and Health (NIOSH), Occupational Safety and Health Administration (OSHA), United States Coast Guard (USCG), and United States Environmental Protection Agency (EPA). 1985. *Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities*. October 1985.

Occupational Safety and Health Administration (OSHA). *Occupational Safety and Health Standards.* U.S. Department of Labor. Title 29 of Code of Federal Regulations, Part 1910.

United States Environmental Protection Agency (EPA). *Standard Operating Safety Guides.* Publication 9285.1-03. June 1992. Washington, DC.

END OF SOP

STANDARD OPERATING PROCEDURE

GROUNDWATER WELL SAMPLING

SOP NUMBER: ENV 3.7

REVISION DATE: 9/30/2018 **SCHEDULED REVIEW DATE: 9/30/2023**

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1 Scope and Application

This Standard Operating Procedure (SOP) describes the procedures used by E & E for collecting representative water samples from groundwater wells, the most common example being a groundwater monitoring well. Every effort is typically made to ensure that each sample is representative of the water zone of interest, such as the saturated zone. This SOP also addresses some procedures that can be used to purge and sample plumbed groundwater wells such as domestic drinking water, public drinking water supply, and irrigation wells that contain a downhole well pump. Analysis of groundwater samples may be used to determine pollutant concentrations and their potential risk to public health, welfare, or the environment; extent of contaminants; or compliance with remedial standards.

This SOP addresses routine sample collection activities consisting of well purging; field measurement of water quality parameters; and collection of samples for off-site laboratory analysis of chemical, biological, radiological, or physical parameters. Specific sampling procedures may vary depending on the data quality objectives (DQOs) and regulatory requirements identified in project planning documents.

This groundwater well sampling SOP is intended for use by personnel who have knowledge, training and experience in the field sampling activities being conducted.

Other E & E SOPs that would typically also apply to groundwater well sampling include the following:

- DOC 2.1, Field Activity Logbooks;
- ENV 3.15, Sampling and Field Equipment Decontamination;
- ENV 3.16, Environmental Sample Handling, Packing, and Shipping;
- ENV 3.26, Handling Investigation-Derived Wastes; and
- GEO 4.15, Measuring Water Level and Well Depth.

2 Definitions and Acronyms

C	Celsius
DQO	Data quality objective
DO	Dissolved oxygen
E & E	Ecology and Environment, Inc.
EPA	(United States) Environmental Protection Agency
HDPE	High-density polyethylene
LDPE	Low-density polyethylene
µm	micrometer
mg/L	milligrams per liter
mL/min	milliliters per minute
mV	millivolt
NTU	Nephelometric turbidity unit

ORP	Oxidation-reduction potential
%	percent
PCB	Polychlorinated biphenyl
PFAS	Per- or polyfluoroalkyl substance
PFC	Perfluorinated compound
PTFE	Polytetrafluoroethylene (or Teflon™)
PVC	Polyvinyl chloride
QA	Quality assurance
QC	Quality control
SHASP	Site-specific health and safety plan
SOP	Standard operating procedure
SVOC	Semivolatile organic compound
VOA	Volatile organic analysis
VOC	Volatile organic compound

3 Procedure Summary

This SOP addresses purging and sampling methods primarily for groundwater monitoring wells. It also includes some procedures applicable to purging and sampling of plumbed groundwater wells such as domestic drinking water, public drinking water supply, and irrigation wells that contain a downhole well pump.

A primary goal of groundwater sampling is to provide data that are representative of actual aquifer conditions. Because standing water in a well casing may not be representative of aquifer conditions, that standing water and other near-well groundwater is typically purged (evacuated) from the well prior to sampling. The water level in the well is measured prior to, and frequently during, purging and sampling to determine the amount of standing water, location of the water with respect to the well screen, and drawdown and recovery rates. Water quality parameters such as pH, temperature, specific conductance, oxidation-reduction potential (ORP), dissolved oxygen (DO), and turbidity are typically monitored throughout purging to help determine when standing, stagnant water has been removed from the well and fresher aquifer water is available for sampling.

Groundwater wells are typically purged and sampled using a manual bailer or pumps such as a submersible pump, bladder pump, or peristaltic pump. In some cases, low-flow purging and sampling procedures will be specified when it is necessary to collect samples under conditions that are most reflective of ambient flow conditions and with as little hydraulic stress as possible at the well-aquifer interface. If dedicated or disposable equipment is not used, purging and sampling equipment will be decontaminated before use at a groundwater well location.

4 Cautions

4.1 Sampling

Cautions related to health and safety are discussed in Section 8.

Standard measures, such as the use of disposable gloves, should be used to avoid cross-contamination of samples between sample locations.

4.2 Special Considerations for Sampling for PFASs

When collecting samples for analysis of per- and polyfluoroalkyl substances (PFASs), it should be noted that common consumer products and commonly used environmental sampling equipment contain PFASs or PFAS derivatives that have the potential to cross-contaminate the samples, resulting in potential false positives for the PFAS analytes. Table 4-1 lists some common items and materials used during field efforts and sample collection that could contain PFASs, and acceptable non-PFAS substitutes to use. (Note: "PFAS" is the currently recognized term by the United States Environmental Protection Agency [EPA], the Centers for Disease Control and Prevention, and others for the class of chemical compounds addressed herein. PFASs might also be referred to as perfluorinated compounds [PFCs], although PFCs are a subset of PFASs.)

Table 4-1 Item and Material Guidance for Sampling for PFASs

Item/Material Type	Items/Materials to Avoid	Allowable Items/Materials
Pumps, tubing, connectors, and samplers	PTFE, Teflon™, and other fluoropolymer-containing materials[1] (including thread seal tapes and pastes); LDPE HydraSleeves	Peristaltic pump or stainless steel submersible pump HDPE or silicone tubing (LDPE[2] as a last resort) HDPE HydraSleeves Acetate items
Decontamination agents	Decon 90® (contains fluoro-surfactants); water from unknown sources	Alconox® or Liquinox® soap; PFAS-free water
Sample containers and packaging supplies	LDPE[2] or glass[3] bottles; PTFE-lined or Teflon™-lined caps; chemical ice packs (Blue Ice®), aluminum foil	Laboratory-provided, HDPE, or polypropylene[4] sample bottles; unlined HDPE or polypropylene[4] screw caps; regular ice made from PFAS-free water and contained in plastic (polyethylene) bags; standard Coleman® coolers are HDPE
Field documentation	Waterproof/treated paper or field books; plastic clipboards; Sharpies®; markers; adhesive paper products (such as Post-it® notes)	Plain paper; Masonite or metal clipboard; pens
Clothing, boots	Clothing or boots made of or with Gore-Tex™ or other synthetic water-resistant, waterproof, or stain-resistant materials; fabric softener-treated clothing; new clothing; Tyvek® material	Synthetic or cotton material; previously laundered clothing (preferably previously washed greater than six times) without the use of fabric softeners; polyurethane or PVC safety boots; powderless nitrile gloves; polyurethane or wax-coated rain gear
Personal care products	Cosmetics; moisturizers; hand cream; dental floss; most sunscreens; most insect repellants; and other related products	Avoid most personal care products the day of sampling; use PFAS-free or natural sunscreens and insect repellents (DEET is OK)

Table 4-1 Item and Material Guidance for Sampling for PFASs

Item/Material Type	Items/Materials to Avoid	Allowable Items/Materials
Food	Pre-packaged food; fast food wrappers and containers; candy wrappers; aluminum foil	Home-prepared foods (consumed only in a designated rest area); bottled water or hydration drinks

1 In cases where Teflon™-containing materials are unavoidable, ensure that adequate purging is performed prior to sampling (e.g., in-well pumps) and that rinsate blanks are collected prior to sampling.
2 Although LDPE is allowed by some agencies during sample collection, it is not recommended that samples be stored in LDPE sample containers.
3 Glass is to be avoided due to potential analyte loss from PFAS adsorption on the glass, not due to potential cross-contamination from glass.
4 Some laboratories recommend HDPE only and do not support the use of polypropylene bottles. Polypropylene bottles are allowed by EPA Method 537, for instance, because the method contains steps to recover PFASs that might have adsorbed to the inside of the container. Not all analytical methods, however, contain such steps.

Key:
DEET = N,N-Diethyl-m-toluamide
HDPE = High-density polyethylene
LDPE = Low-density polyethylene
PFAS = Polyfluoroalkyl substance
PTFE = Polytetrafluoroethylene (Teflon™)
PVC = Polyvinyl chloride

In addition to following the item/material guidance in Table 4-1, the following guidance should be followed to the extent practicable when sampling for PFASs:

- Wash hands before the sampling effort, even though gloves will be worn, to prevent the inadvertent transfer of PFASs to sampling supplies;
- Collect the samples for PFAS analysis prior to collecting samples for other parameters;
- Filter water samples with non-glass and non-PFAS-containing filters (glass fibers can potentially adsorb PFASs);
- Keep sampling supplies for PFAS sampling separate from other sampling supplies;
- Keep samples collected for PFAS analysis separate from other samples; and
- Include field blanks (such as trip blanks and/or equipment blanks) in the sampling protocol to check for potential cross-contamination from PFASs from non-field sources during sample transport and handling, as well as from equipment used during sampling.

5 Equipment and Supplies

The following is a general list of equipment and supplies. A detailed list of equipment and supplies will be prepared based on the project planning documents. In general, the use of dedicated or disposable equipment is preferred, to reduce the potential for cross-contamination between sampling locations, but equipment may be reused after thorough decontamination between sample locations.

- Water level indicator (e.g., electric sounder, steel tape, transducer, reflection sounder, airline, etc.) capable of measuring to 0.01-foot accuracy.

- Oil/water interface indicator.
- Keys or combinations for well cap locks.
- Organic vapor analyzer (e.g., photoionization detector).
- Specific purging/sampling equipment as applicable:
  - Bailers:
    - Reusable or disposable bailers of appropriate size and construction material.
    - Nylon or polypropylene line, enough to dedicate to each well.
    - Aluminum foil (to wrap clean bailers if not using disposable bailers).
  - Submersible Pump:
    - Submersible pump, preferably constructed of stainless steel or Teflon™.
    - Flow controller as applicable.
    - Safety cable (e.g., nylon or polypropylene line).
    - Flow meter with gate valve.
  - Bladder Pump:
    - Non-gas-contact bladder pump, preferably constructed of stainless steel or Teflon™.
    - Flow controller as applicable.
    - Spare bladders, typically polyethylene or Teflon™.
    - Compressor or compressed gas.
  - Suction Pump (Peristaltic Pump):
    - Suction pump.
    - Silastic (silicone) tubing of appropriate size and length for use in pump.
    - Flow meter with gate valve.
  - Low-Flow Purging/Sampling:
    - Pump (see above for options).
    - Transparent flow-through cell.
- Water discharge tubing for use with pumps, enough to dedicate to each well, and connectors (hose barbs, connectors, nipples, ferrules, etc.).
- Multi-parameter water quality measurement instrument suitable for measuring pH, temperature, specific conductance, ORP, and DO. If low-flow procedures and a flow-through cell are used, the water quality probes and flow-through cell may come together as a set.
- Turbidity meter.
- Water quality measurement calibration standards.
- Power for pumps: generator, gasoline, battery, and power cables.
- Chargers for any battery-operated equipment.
- Timepiece (preferably with a stopwatch function).
- Calculator.
- 5-gallon buckets (graduated), for purge water.

- Tools (pipe wrenches, wire strippers, electrical tape, tubing connectors, Teflon™ tape, box cutters, scissors, sharp knife, etc.).
- Associated equipment and supplies (e.g., meter stick or tape measure, aluminum foil, plastic sheeting, disposable gloves, sample containers, sample preservatives, field logbook, sampling log or field data sheets, sample custody and documentation supplies, decontamination supplies, sample packing/shipping supplies, safety supplies, and waste handling supplies).

6 Procedure

6.1 General Purging and Sampling Considerations

Groundwater sampling methods and equipment will be specified in project planning documents and will have been selected based on factors such as:

- Analytes of interest;
- Analytical volumes needed;
- The need for portable vs. dedicated equipment;
- Characteristics of the well being sampled, such as type, diameter, and depth to water;
- The need and availability of a power source for a sampling pump;
- Ease of decontamination;
- Project-specific regulations and requirements; and
- Cost.

In general, purging and sampling equipment must be constructed of materials that cannot interfere with the parameters being analyzed for. For example, some sample collection devices have parts constructed of plastic or rubber that cannot be used for sampling for volatile organic compounds (VOCs) and extractable organic parameters. Samplers constructed of glass, stainless steel, polyvinyl chloride (PVC), polytetrafluoroethylene (PTFE), or Teflon™ typically should be used, depending on the types of analyses to be performed (e.g., samples to be analyzed for metals should not be collected in metallic containers). Submersible and bladder pumps, which are inserted into the well, ideally should be constructed of stainless steel or Teflon™, and pumps ideally should have an adjustable and variable flow rate.

The water discharge tubing used with pumps should preferably be Teflon™ or Teflon™-lined polyethylene tubing when sampling is to include VOCs, semivolatile organic compounds (SVOCs), pesticides, polychlorinated biphenyls (PCBs), and certain inorganics. If tubing constructed of other materials is used, adequate information must be provided to show that the materials do not leach contaminants or cause interference to the analytical procedures to be used. PVC, polypropylene, or polyethylene tubing typically is acceptable when collecting samples for metal and other inorganics analyses.

The use of pumps, tubing, and equipment dedicated to an individual well is ideal when possible. Non-dedicated and non-disposable purging and sampling equipment requires decontamination prior to each sample location. When non-dedicated or non-disposable groundwater purging and sampling equipment is used, purging and sampling should be conducted moving from least contaminated well to most contaminated well. As well, decontamination of non-dedicated and non-disposable equipment will be minimized if purging and sampling are completed for an individual well before moving to the next well.

Power sources such as gas-powered generators must be positioned downwind of the well during purging and sampling to prevent contamination of the well or sampled groundwater with chemical constituents in gasoline. Gas-powered equipment and containers of spare fuel should not be stored near supplies used to purge and sample wells.

Plastic sheeting is typically placed on the ground around the well to provide a clean place to stage and use purging and sampling equipment.

In addition to using a field logbook, groundwater purging and sampling are often documented on standardized forms such as a sampling log or field data sheets, which may be project-specific. Standardized forms are also available in many state and federal guidance documents.

6.2 Well Observations and Sampling Preparation

6.2.1 Water Quality Meter Calibration

1. Calibrate the multi-parameter water quality meter and turbidity meter on a daily basis, before use, in accordance with manufacturers' instructions and project planning documents. If the calibration results are out of range, repeat the calibration so that acceptable results are obtained or remove the instrument from service and obtain a replacement.
2. In some cases, an additional mid-day calibration is advised, especially if readings are observed to drift during the day or otherwise be unreliable or suspect.

6.2.2 Monitoring Wells

1. Start at the least-contaminated well.
2. Note the location of the well, date, and time in the field logbook or sampling log.
3. Remove the locking well cap.
4. Remove the well cap covering the well riser. Listen for indications of pressure or vacuum when opening the well riser cap.
5. If required, test the headspace in the well interior casing for the presence of organic vapors using an organic vapor analyzer or equivalent.
6. Measure water level (depth to water) and total depth of the well using appropriate reference points and procedural steps in E & E SOP GEO 4.15, Measuring Water Level and Well Depth. If possible, measure water levels in neighboring wells before any individual well is disturbed by purging and sampling, which could affect certain neighboring wells.
7. If free-phase product is expected in the well, measure depth to product and depth to water with an oil/water interface meter.
8. Measure the diameter of the well and calculate the volume of water in the well as follows:

$$V = \pi r^2 h$$

Where:

V	=	Static well volume
π	=	Mathematical constant, 3.14159
r	=	Inside radius of well casing
h	=	Height of water in well (depth of well – depth to water)

Ensure that the units of all measures are the same (e.g., feet). Other volume measurements may be derived from cubic feet using the following conversions:

1 cubic foot = 7.48052 gallons,
28.3168 liters,
0.02832 cubic meter, and
1,728 cubic inches.

A commonly used alternative short-cut version of the same equation is:

$$V = Tr^2(0.163)$$

Where:

V	=	Static well volume, in gallons
T	=	Height of water in well, in feet (depth of well – depth to water)
r	=	Inside radius of well casing, in inches
0.163	=	Conversion constant for converting casing radius in inches to feet, and converting cubic feet to gallons

9. Determine the required volume of groundwater to be removed from the well, e.g., three well volumes or as indicated in the project planning documents.

6.2.3 Plumbed Well Systems

1. Visually assess the well system, from the well to the nearest tap.
2. Large-volume well systems (e.g., industrial and public supply wells) operate at high pressure and care must be taken when opening a large-diameter tap. Most large-volume well systems have a small-diameter tap near the well head to reduce pressure for sample collection.
3. Plan to purge/sample from as close to the well head as possible, before water treatment or softening systems, if present.
4. Avoid removing installed pumping systems to purge/sample the well directly because this may disturb the well, loosen rust, or cause other changes or damage.
5. Remove any filters, aerators, screens, washers, or hoses from the faucet prior to purging/sampling, with the permission of the well owner, and document any plumbing features that could affect the water sample.

6.3 Purging

6.3.1 Purging Considerations

Groundwater wells are typically purged prior to sampling to ensure that the sampled groundwater is representative of actual aquifer conditions. The amount of purging performed on a well prior to sample collection depends on the intent of the monitoring program, constituents to be analyzed, hydrogeologic conditions, and produced water management requirements. Programs in which overall quality determinations of water resources are involved may require long purging periods to obtain a sample that is representative of the groundwater.

Traditionally, three to five well casing volumes of water are removed. For sites with deep wells or many wells, this can generate a large volume of groundwater that will require proper handling and disposal if potentially contaminated. In addition, the amount of time to purge multiple casing volumes can be significant for sites with deep wells or many wells.

Monitoring for defining a contaminant plume requires a representative sample of a small volume of the aquifer. These circumstances require that the well be pumped enough to remove the stagnant water, but not enough to induce flow from other areas.

Non-representative samples can result from excessive pumping of a well. For example, excessive pumping can cause stratification of certain contaminants in the groundwater formation, or dilute or increase contaminant concentrations from what is normal.

Water quality parameters are typically measured and recorded at regular intervals during purging. The data may be used to compute water table or aquifer transmissivity and other hydraulic characteristics, as well as determine or confirm when water quality has stabilized and purging can be considered to be complete. In some cases, wells may simply be purged of a specified number of well volumes without confirmation of water quality stability.

Low-flow purging focuses on pumping a well from the well screen at a flow rate below the recharge capacity of the formation. The specific rate of pumping is generally aquifer-dependent and typically less than 500 milliliters per minute (ml/min). By purging at low-flow rates, only the groundwater that enters through the well screen is theoretically purged from the well. Because stagnant water located above the pump intake in the well casing is not drawn into the pump, the full casing volume (or multiple casing volumes) would not have to be purged from the well prior to sampling. The low-flow purging approach can reduce the volume of water generated during purging and the time spent performing the task.

6.3.2 Water Quality Measurements

Water quality parameters are measured during purging to determine when water quality has stabilized and the water available for sampling is from the formation. The parameters are generally considered to have stabilized, and purging is considered to be complete, when at least three successive measurements are within specified guideline values. Some common stability criteria are:

- **pH**: +/- 0.1 standard unit;
- **Temperature**: +/- 3 percent (%);
- **Specific Conductance**: +/- 3%;
- **Oxidation-Reduction Potential (ORP)**: +/-10 millivolts (mV);
- **Dissolved Oxygen (DO)**: +/- 10% for values greater than 0.5 milligrams per liter (mg/L); if three successive DO measurements are less than 0.5 mg/L, consider the parameter stabilized; and
- **Turbidity**: +/- 10% for values greater than 5 nephelometric turbidity units (NTUs); if three successive turbidity measurements are less than 5 NTU, consider the parameter stabilized.

In many cases, if all parameters other than turbidity have stabilized and turbidity is ≤50 NTUs, purging is considered complete and groundwater samples may be collected. If all parameters other than turbidity have stabilized and turbidity does not expeditiously reduce to ≤50 NTUs, purging is typically considered to be complete, and separate filtered and unfiltered samples may be required for metals and other analyses.

Water quality will be measured and recorded at pre-determined intervals specified in project planning documents. A typical interval is one-quarter of a well volume.

Project-specific requirements for water quality stability may be different from the above and will be followed.

6.3.3 Purging Wells Using Various Equipment

Each of the procedures below assumes that purging will be conducted until stable and acceptable water quality parameter values are achieved; information such as water level, pumping rate, drawdown rate, and water quality measurements is recorded in the field logbook or sampling log; and the proper purge volume is removed in accordance with project planning documents. These steps are not repeated below.

6.3.3.1 Bailer

1. Attach the bailer line to the bailer and lower the bailer slowly (trying not to agitate the water) until it is completely submerged.
2. Pull the bailer out of the well, ensuring that the line falls onto the plastic sheeting.
3. Empty the bailer into a graduated 5-gallon bucket.
4. Repeat until the required purge volume has been removed.
5. When the 5-gallon bucket is full, empty it into a 55-gallon drum or otherwise discharge the contents of the bucket as specified in project planning documents.

6.3.3.2 Submersible Pump

1. Assemble the pump, water discharge tubing, power source, and safety cable.
2. Lower the pump and assembly into the well to a point at least a few feet below the water level and above the bottom of the well. The midpoint is often used. Measure the new initial water level.
3. Begin purging at a low pumping rate, and increase the rate until water discharge occurs. Using a flow meter or a bucket and a stopwatch, determine the flow rate and calculate the time required to remove the required volume of water from the well.
4. Collect the purge water in graduated 5-gallon buckets, in 55-gallon drums, or as indicated in the project planning documents.
5. Lower the pump by stages until it is just above the screen, and continue to purge until the required volume of water has been removed from the well. Measure the water level as necessary to monitor drawdown rate and well recovery. In cases where the well will not yield water at a sufficient recharge rate, pump the well dry and allow it to recover.

6.3.3.3 Bladder Pump

1. Assemble the pump, water discharge tubing, compressor/control box, and power source.

2. Adjust the flow rate as needed to allow smooth intake and discharge cycles.
3. Lower the pump and assembly into the well to a point at least a few feet below the water level and above the bottom of the well. The midpoint is often used. Measure the new initial water level.
4. Refer to the remaining procedural steps for a submersible pump (see above).

6.3.3.4 Suction Pump (Peristaltic Pump)

1. Assemble the pump, tubing, and power source.
2. Lower the sample tubing into the well to a point at least a few feet below the water level and above the bottom of the well. The midpoint is often used. The pump stays outside of the well.
3. Refer to the remaining procedural steps for a submersible pump (see above).

6.3.3.5 Low-Flow Purging

The objectives of low-flow purging and sampling are to collect samples under conditions that are representative of ambient flow conditions in the subsurface and with as little hydraulic stress as possible at the well-aquifer interface. Some key steps related to low-flow purging are included below. Refer to EPA SOP EQASOP-GW 001, Low Stress (Low Flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells, for the complete procedure.

1. Assemble the pump, tubing, flow-through cell, and power source. Wells with low recharge rates may require the use of pumps that can attain low pumping rates, such as bladder or peristaltic pumps. Be advised that EPA and other agencies may not favor the use of a peristaltic pump when collecting sample that will be analyzed for pH and volatile constituents, because use of a peristaltic pump may cause pH modifications or degassing of the sample.
2. Lower the pump and assembly into the well to a suitable pump intake depth (often based on the location of the well screen), which also ideally should be at least a few feet above the bottom of the well. Measure the new initial water level.
3. Begin purging at a low pumping rate, and increase the rate until water discharge occurs. Collect the purge water into graduated 5-gallon buckets. An initial flow rate of a maximum of 100 to 500 mL/min is typical. Adjust the flow rate until there is little or no water level drawdown. Measure water level as necessary to monitor drawdown rate and well recovery. If the minimal drawdown that can be achieved exceeds 0.3 feet but remains stable, continue purging. Purge volume calculations should use the stabilized drawdown value, not initial drawdown.
4. If the initial water level is above the top of the well screen, do not allow the water level to drop below the top of the well screen.
5. Measure water quality parameters using the flow-through cell at key points during purging, such as at the beginning of purging, after the water level has stabilized, and periodically during purging until water quality stability is observed. Measure turbidity with a separate instrument that is either connected to the water discharge tubing through a connection separate from the flow-through cell or by using a standalone turbidity meter. Measure the parameters at a frequency approximately equal to the rate at which water in the flow-through cell is fully exchanged.

6.3.4 Purging Plumbed Wells

1. Small-volume well systems (e.g., domestic and livestock wells) typically have a 25-to-100-gallon pressure tank connected directly to the well. Consider clearing the volume of the pressure tank to purge the well.
2. Plan to purge from as close to the well head as possible, before water treatment systems, if present.
3. Wells that have been producing sufficiently to clear three to five times the well volume within the last 24 hours may not require extensive purging prior to sampling. Because this may not be known, and the casing volume also may not be known, plumbed wells are typically "purged" by opening the faucet or spigot nearest the well for approximately 10 to 15 minutes prior to sampling to allow for a fresh water sample to be collected.
4. Measure the purging flow rate by the time it takes to fill a container with a known volume (e.g., a graduated 5-gallon bucket).
5. Measure water quality parameters per the project planning documents. Purging is considered complete when the water quality parameters have stabilized.
6. Collect the purge water in the graduated bucket. Discharge the contents of the bucket as specified in project planning documents.
7. Record information such as flow rate, water quality measurements, and purge volume in the field logbook or sampling log.

6.4 Sampling

6.4.1 Sampling Considerations

Some steps in common to groundwater sampling regardless of the equipment used are as follows:

- Ensure that the well has adequately recharged after purging.
- Collect samples for VOCs, sulfide, and similar analyses as soon as possible in the sampling sequence and in a way that minimizes disturbance of the water, in order to minimize VOC loss. Sample retrieval systems generally viewed as suitable for the valid collection of samples for VOC analysis include bailers, submersible pumps, and bladder pumps. When collecting samples for the analysis of VOCs, do the following:
  - If the samples are required to be preserved, use pre-preserved volatile organic analysis (VOA) vials.
  - Open the VOA vial and set the cap in a clean place.
  - If using a bailer, deploy and retrieve the bailer as gently as possible. If using a pump, reduce the pumping rate as much as possible, e.g., to approximately 100 mL/min.
  - Fill the vial to the top until a convex meniscus forms on the top of the water. Do not overfill the vial.
  - Place the cap directly over the top of the vial and screw down firmly. Do not overtighten and break the cap.

  - Invert the vial and tap gently. If an air bubble appears, discard the sample and re-collect it. The sample must not contain trapped air.
  - Place collected samples on their sides in a cooler chilled to 4±2°C pending sample management and transport to the analytical laboratory.
- Filter samples as required by the project planning documents. Filtering is commonly performed when testing for metals in the groundwater, in which case both an unfiltered and filtered sample are collected to analyze total metals and dissolved metals, respectively. When pumps are used to sample, filtration is often performed at the time of sampling using a 0.45-micrometer (µm) (same as micron) cartridge filter installed in-line with the sampling system. The filter is attached to the end of the water discharge tubing prior to discharge into the sample containers. When using an in-line filter, the pumping rate should be reduced somewhat to accommodate the resistance of the filter, thereby preventing damage to the filter or to pump parts such as bladders. If not filtered in-line, samples are filtered following collection, using a 0.45-µm barrel filter or vacuum filter and a powered vacuum pump, hand pump, or similar. The sample is poured from the sample container into the chamber atop the filter, vacuum-pumped through the filter, and directed back to the sample bottle.
- Use pre-preserved sample containers or preserve samples as soon as possible after sample collection and filtration. Pre-preserved sample containers typically cannot be used for samples that are not filtered in-line during sample collection. Verify and document proper preservation in the field by pouring a small amount of the sample into the container lid or other clean container and measuring pH using a test strip (the test strip should not be inserted directly into the sample container).
- Place samples requiring cooling to 4±2°C on ice immediately following collection.
- Collect applicable quality control samples as outlined in project planning documents (also see Section 7).
- Record sampling information in the field logbook or sampling log.
- Complete a chain-of-custody form and handle and pack samples in accordance with project planning documents and E & E SOP ENV 3.16, Sample Handling, Packing, and Shipping.
- Non-dedicated and non-disposable sampling equipment requires decontamination prior to each sample location.

6.4.2 Sampling Wells Using Various Equipment

Each of the procedures below assumes that the well was recently purged and the necessary equipment is already at the well location (see Section 6.3.3). As well, the steps in Section 6.4.1 that are common to all procedures are not repeated below.

6.4.2.1 Bailer

1. Attach a bailer line to the bailer. If a bailer was used for purging, the same bailer and line may be used for sampling.
2. Lower the bailer slowly and gently into the well, taking care not to shake the well casing or splash the bailer into the water. Lower the bailer to different points adjacent to the well screen to ensure that a representative water sample is collected.

3. Slowly and gently retrieve the bailer from the well, minimizing contact with the well riser.
4. Carefully pour the water into individual sample containers or insert a stopcock valve into the bottom of the bailer to more cleanly direct the water into the sample containers.
5. After collecting all samples from the well, either dispose of, decontaminate, or dedicate the bailer to that well to ensure no cross-contamination between wells or samples.

6.4.2.2 Submersible Pump

1. Ensure that the pump and assembly are positioned in the well at a point at least a few feet below the water level and above the bottom of the well. A point just above the screened interval is often used.
2. Attach a gate valve to the discharge line, and adjust the flow rate to the minimum that will allow groundwater to come to the surface. If no gate valve is available, discharge the sample into a clean glass jar and fill the sample containers from the jar. Increase the flow rate as long as rapid well drawdown is not occurring and volatile constituents are not being collected. Measure water level as necessary to monitor drawdown rate and well recovery.
3. After collecting all samples from the well, remove the pump and assembly and properly decontaminate it prior to use in the next well. Do not reuse the tubing in another well. If dedicated to a particular well, tubing may be left in place for future sampling events.

6.4.2.3 Bladder Pump

1. Ensure that the pump and assembly are positioned in the well at a point at least a few feet below the water level and above the bottom of the well. A point just above the screened interval is often used.
2. Increase the cycle time and reduce the pressure to the minimum that will allow groundwater to come to the surface. Increase the flow rate as long as rapid well drawdown is not occurring and volatile constituents are not being collected. Measure water level as necessary to monitor drawdown rate and well recovery.
3. After collecting all samples from the well, remove the pump and tubing from the well and properly decontaminate the pump prior to use in the next well. Do not reuse the tubing and bladder in another well. If dedicated to a particular well, the bladder and tubing may be retained for future sampling events.

6.4.2.4 Suction Pump (Peristaltic Pump)

1. Ensure that the tubing is positioned in the well at a point at least a few feet below the water level and above the bottom of the well. A point just above the screened interval is often used.
2. Attach a gate valve to the discharge line if the suction pump discharge rate cannot be controlled. If no gate valve is available, discharge the sample into a clean glass jar and fill the sample containers from the jar. Increase the flow rate as long as rapid well drawdown is not occurring and volatile constituents are not being collected. Measure water level as necessary to monitor drawdown rate and well recovery.
3. After collecting all samples from the well, remove the tubing from the well. Do not reuse the tubing in another well. If dedicated to a particular well, tubing may be left in place for future sampling events.

6.4.2.5 Low-Flow Sampling

Some key steps related to low-flow sampling are included below. Refer to EPA SOP EQASOP-GW 001, Low Stress (Low Flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells, for the complete procedure.

1. Ensure that the pump and assembly are positioned in the well at a suitable pump intake depth (often based on the location of the well screen), which also should ideally be at least a few feet above the bottom of the well.
2. Disconnect the water discharge tubing from the flow-through cell. Discharge sample directly into the sample containers without passing the water through the flow-through cell. Adjust the flow rate to the minimum that will allow groundwater to come to the surface. Increase the flow rate with discretion as long as rapid well drawdown is not occurring and volatile constituents are not being collected. Measure water level as necessary to monitor drawdown rate and well recovery. One of the objectives of low-flow sampling is collect samples under conditions that are representative of ambient flow conditions in the subsurface. Do not allow the water level to drop below the top of the well screen.
3. After collecting all samples from the well, remove the pump and assembly from the well and properly decontaminate the pump prior to use in the next well. Do not reuse the tubing in another well. If dedicated to a particular well, tubing may be left in place for future sampling events.

6.4.3 Sampling Plumbed Wells

1. Following purging, remove any diversion hoses and similar items from the sampling port or tap and run the water briefly to clear any immediate contaminants.
2. Adjust the flow rate to a smooth flowing water stream, without splashing, for sample collection. This will minimize spikes or dips in flow pressure when sampling, which may dislodge material in the system. This step is especially important during sample collection for VOC analysis.
3. Attempt to collect water before it is directed through an in-line filter, water heater, water softener, or other treatment system. If determining how well the filter or treatment system is working is an additional goal of the project, collect additional samples after these systems.
4. Collect the water into individual sample containers.
5. After collecting all samples from the well, either dispose of or decontaminate sampling supplies, before reuse at another location, to ensure no cross-contamination between samples.

7 Quality Assurance/Quality Control

The program/project manager should identify personnel for the field team who have knowledge, training and experience in the groundwater sampling to be conducted. One member of the field team should be designated as the lead for groundwater sampling and will be responsible, with support from other field personnel, for implementing the procedures in this SOP. The program/project manager should also identify additional personnel, if necessary, to complete associated procedures (e.g., field logbook documentation, equipment decontamination, sample shipment, and waste disposal).

Prior to initiating field work, the project planning documents (e.g., work plan, sampling and analysis plan, quality assurance project plan, and site-specific health and safety plan [SHASP]) will be reviewed by field personnel to understand the sampling procedures that have been specified to result in groundwater samples that will meet project DQOs. Project planning documents will define the quality assurance/quality control (QA/QC) procedures necessary to meet project DQOs, including the sampling protocol for QC samples such as trip blanks, equipment rinsate blanks (to assess the effectiveness of field decontamination methods for non-dedicated and non-disposable equipment, or to test non-inert field equipment for the potential to leach contaminants into the samples), field duplicates, and other types of field and analytical QC samples. Field duplicates are typically collected from at least one location and treated as separate samples, blind to the laboratory. Certain field blanks should be processed at the site location to account for ambient and other site-specific conditions.

Collecting representative groundwater samples is an important quality consideration. Techniques to maximize the collection of samples that are representative of the aquifer or formation of interest are included in the procedures in Section 6 and include first purging the well of the required volume of standing, stagnant water; measuring water quality during purging to monitor stability; and the use of low-flow purging/sampling procedures if prescribed.

8 Health and Safety

Prior to entering the field, all field personnel will acknowledge in writing that they have read and understand the SHASP, which will be in compliance with the Corporate Health and Safety Program.

Unique hazards associated with collecting samples from groundwater wells can include:

- The use of gas-powered generators or electrical sources to provide power for sampling pumps: Gas-powered equipment will be fueled only when it is off and cool to the touch. Batteries, generators, and other sources of electrical power will be handled safely in accordance with the SHASP.

- The potential for contacting groundwater contaminated with site contaminants such as chemical, radioactive, and/or pathogenic biological material: The SHASP will provide instruction for safe handling of contaminated site materials.

- The use of sample preservatives either in pre-preserved sample containers or as added by the field team during sample management: The field team will wear the personal protective equipment specified by the SHASP, handle samples with care, and collect and process such samples in a well-ventilated area.

9 Special Project Requirements

Project-specific requirements will be included with the project planning documents.

10 References

American Society for Testing and Material (ASTM). 2013. Standard Guide for Sampling Ground-Water Monitoring Wells. D4448-01. ASTM International. West Conshohocken, Pennsylvania.

__________. 2012. Standard Guide for Purging Methods for Wells Used for Groundwater Quality Investigations. D6452-99. ASTM International. West Conshohocken, Pennsylvania.

New Hampshire Department of Environmental Services. 2016. Sampling for Per- and Polyfluoroalkyl Substances/Perfluorinated Chemicals (PFASs/PFCs) at Contaminated Sites. November 22, 2016. Concord, New Hampshire.

United States Department of Defense. 2013. *DoD Environmental Field Sampling Handbook.* Revision 1.0. April 2013.

United States Department of the Navy. 2015. Navy Drinking Water Sampling Policy for Perfluorochemicals Perfluorooctane Sulfonate and Perfluorooctanoic Acid. September 14, 2015. Office of the Chief of Naval Operations. N45 Ser/15U132432. Washington, DC.

United States Environmental Protection Agency (EPA). 1986. *RCRA Ground-Water Monitoring Technical Enforcement Guidance Document*. EPA/530/SW-86/055. Office of Solid Waste and Emergency Response. OSWER-9950,1. September 1986.

__________. 2010. Low Stress (Low Flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells. EQASOP-GW 001. EPA Region 1. July 30, 1996. Revised January 19, 2010. North Chelmsford, Massachusetts.

United States Geological Survey (USGS). 2015. *National Field Manual for the Collection of Water-Quality Data*. Chapter A4, Collection of Water Samples. Version 2.0. Chapter revised September 2006.

END OF SOP

ecology and environment, inc.

STANDARD OPERATING PROCEDURE

AQUATIC SEDIMENT SAMPLING

SOP NUMBER: ENV 3.8

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1 Scope and Application

This Standard Operating Procedure (SOP) describes the procedures utilized by E & E samplers for collecting representative sediment samples from beneath aquatic environments. The purpose of sediment sampling may range from simple reconnaissance to complex sampling programs. This SOP can be followed for all routine sample collection activities which may include: visual or other observations, in situ or ex situ field measurements (monitoring), or sample collection for biological, chemical, geological, radiological or physical analysis. Site-specific sampling procedures vary depending on the data quality objectives (DQOs) identified in program/project planning documents.

E & E routinely utilizes three types of sediment collection procedures, grab sampling, hand sampling, and coring. Sediment coring can be done by hand or by a contracted driller or vibracore company. For the purposes of this SOP, sediments are those mineral and organic materials situated beneath an aqueous layer. The water may be static, as in lakes, ponds, and impoundments; or flowing, as in rivers and streams.

Procedures for collecting soil samples for volatile organic compound (VOC) analyses are presented in the E & E VOC Soil and Sediment Sampling SOP ENV 25.

Procedures for sample handling are defined in E & E Environmental Sample Handling, Packaging and Shipping SOP ENV 3.16. Site-specific sample handling procedures are dependent on the project DQOs.

Procedures for equipment decontamination are defined in E & E Sampling Equipment Decontamination SOP ENV 3.15. Site-specific equipment decontamination procedures are dependent on the project DQOs.

This aquatic sediment sampling SOP is intended for use by personnel who have knowledge, training and experience in the field sediment sampling activities being conducted.

2 Definitions and Acronyms

cm	centimeters
DQO	data quality objectives
E & E	Ecology and Environment, Inc.
SOP	Standard Operating Procedure

3 Procedure Summary

Hand sampling is generally utilized to collect shallow sediment samples from along freshwater and marine shorelines or wetlands. Grab sampling, as routinely performed by E & E personnel, is conducted by using small vessels/floating platforms or stationary structures (e.g., bridges) above water to collect samples. Corers may be used to collect surface and shallow subsurface sediment along freshwater or marine shorelines, wetlands, or from floating platforms or stationary structures.

Hand sampling is utilized for aquatic surface sediment collection from wetlands; shallow lakes/ponds, shallow, low velocity streams/rivers; and marine intertidal zones. Pre-cleaned spoons, trowels, or other types of scoops are used to collect shallow (usually less than 10 centimeters [cm] deep) sediment samples. Sediment is collected manually from hand dug excavations. The depth interval of sediment collection is identified in the project planning documents.

A modified Van Veen, Ponar, Ekman or equivalent dredge is used for grab aquatic sediment sampling. Pre-cleaned dredges are used to mechanically collect the grab shallow surface sediment samples. Aliquots of sediment are collected by hand from within the body of the dredge. The depth interval of sediment collection is defined based on the type of dredge selected and is usually about 15 cm. The depth of penetration will depend on the type of sediment. The selection of the appropriate dredge should be identified in the project planning documents. In deeper waters, dredges can be used can be deployed from a boat or floating platform using a wench. This work is typically contracted.

Pre-cleaned hand corers or augers are used for shore-based core sample collection. The core tube/auger is advanced into the sediment to the pre-determined depth identified in the project planning documents. For small vessels/floating platforms or above water stationary structures a pre-cleaned gravity corer is used. As with the hand corers/augers, the depth of sediment penetration into the sediment, together with sample handling procedures, is identified in the project planning documents. In some cases, corers may include a liner on the interior of the core tube. Sediment cores may be sectioned to provide vertical profiles of sediment characteristics.

Volatile organic and sulfide samples are collected immediately after sample retrieval, regardless of the sampling procedure used. If multiple samples are required to provide the sample volume identified in the project planning documents, then samples must be thoroughly homogenized prior to collection of aliquots for testing.

4 Cautions

This SOP is applicable to routine E & E aquatic sediment sampling and is limited to relatively shallow sediment sampling depths. Hand sampling is generally limited to the upper 10 cm of sediment. Grab sampling may extend to about 15 cm below the sediment surface. Corers used in this SOP are generally effective only to a maximum depth of 100 cm below the sediment surface. The depth of sample collection will be limited if bottom sediment is sandy, clayey or rocky.

Sampling for some projects, such as dredging activities, usually requires deeper sediment sample collection and more sophisticated equipment (e.g., box corers or vibracorers). These are not activities typically contracted to a driller or vibracore operator and sample collection procedures using such equipment should be described in project planning documents. Sample sectioning and sub-sampling procedures described for hand core samples also are applicable to cores collected by a contractor.

Van Veen and Ponar grab samplers are designed for use in soft sediments. Other types of sampling devices may be required for use in clayey, sandy or rocky environments. Corers may work better than grabs in clayey or sandy substrates. Bottom dredges (not routinely used by E & E) may be required for sampling rocky substrates.

Because the sampling devices specified within this SOP provide limited sample volumes, multiple samples may be required to meet project DQOs. Sample compositing and homogenization should be addressed in the project planning documents. Sample aliquots for volatile organics, sulfide, or similar analytes should be collected as soon as possible after collection and prior to homogenization. Field personnel must maintain an awareness of the sediment sample volume collected versus the volume required to meet program/project DQOs.

Maintaining sample integrity requires selecting a sediment sampler that meets the project DQOs. Carefully following procedures should minimize the disruption of the sediment structure and subsequent changes in physiochemical and biological characteristics.

In flowing water, sediment samples should be collected moving from downstream to upstream. At sites with known or suspected contamination, samples should be collected moving from least contaminated area to most contaminated area.

Re-use of equipment may be unavoidable given size and cost. Decontamination should be matched to DQOs.

Experience has shown that real-world conditions (e.g., variable bottom conditions such as the presence of rocks or wood waste) may lead to unacceptable sediment sample recoveries and multiple attempts to collect sediment samples will be required at some locations.

Standard measures, such as the use of disposable gloves, that meet project DQOs, should be used to avoid cross contamination of samples.

As with all intrusive sampling work, project planning should address the potential for encountering subsurface "utilities" and the measures to be taken to avoid problems in the field.

5 Equipment and Supplies

The equipment and supplies required for field work depend on the program/project DQOs. The following is a general list of equipment and supplies. A detailed list of equipment and supplies should be prepared based on the project planning documents. In general, the use of dedicated or disposal equipment is preferred but equipment may be re-used after thorough decontamination between sample locations (refer to E & E Sampling Equipment Decontamination SOP ENV 3.15).

- Stainless-steel or Teflon™ spoons, trowels, or scoops. Other construction material may be acceptable depending upon the program/project planning documents and DQOs;
- Stainless-steel mixing bowls. Other bowl construction material may be acceptable depending upon the program/project planning documents and DQOs;
- Ekman grab(s);
- Modified Van Veen or Ponar grab sampler(s);
- Hand-driven auger(s), split core sampler(s), and multistage core sampler(s);
- Liners and/or catchers for augers or core samplers as specified in the project planning documents;
- Gravity corer(s) with weights, cutting edges, core catchers, end caps;
- Pipe cutter(s), stainless steel knives(s);
- Winch with hydrowire (power supply, e.g., generator if necessary). A hand operated winch may be used;
- Nylon line;
- Siphon (short length of Teflon or inert tubing);
- Core extruder;
- Connectors (e.g., Brummell hooks or shackles); and

- Ancillary equipment and supplies (e.g., meter stick or tape measure, aluminum foil, plastic sheeting, disposable gloves).

Supporting equipment and supplies also may be required to address the following:

- Field logbooks and supplies (Refer to project planning documents and the E & E Field Activity Logbooks SOP DOC 2.1 for details)
- Decontamination equipment and supplies (Refer to project planning documents and E & E Sampling Equipment Decontamination SOP ENV 3.15for details)
- Sample containers, preservatives, and shipping equipment and supplies (Refer to project planning documents and the E & E Environmental Sample Handling, Packaging and Shipping SOP ENV 3.16 for details)
- Waste handling supplies (Refer to project planning documents and E & E Handling Investigation-Derived Wastes SOP ENV 3.26 for details)

6 Procedures

E & E staff will use the following procedures for completing sediment sampling:

- Review relevant project planning documents, e.g., work plan, sampling and analysis plan, quality assurance project plan, health and safety plan, etc.
- Select the sampling procedure(s) that meet project DQOs.
- Refer to the E & E Field Activity Logbooks SOP DOC 2.1 for guidance on the types of information that should be recorded for each sample.
- Refer to the E & E Environmental Sample Handling, Packaging and Shipping SOP ENV 3.16 for guidance on how samples should be labeled, packaged, and shipped.

6.1 Hand Sediment Sampling

The following procedures are used for collecting sediment samples using hand tools. Wetlands, lakes/ponds, low-flow streams, and (with a tide that meets project DQOs) marine intertidal sediment samples may be collected by hand.

- Excavate shallow sediment with pre-cleaned spoons, trowels, or scoops.
- Minimize sediment disturbance.
- Identify sample collection intervals in the project planning documents. In general, the maximum depth of sample collection is 10 cm or less, although deeper sampling may be possible if the matrix is sufficiently stable for an excavation to remain open.
- Sampling device components that come into contact with the sediment samples should be constructed of stainless steel or Teflon™. Other materials may be appropriate if they meet project DQOs.
- Collect sufficient sample volume to meet the DQOs identified in the project planning documents
- Place aliquots to be analyzed for volatile organic analytes and/or sulfides directly into sample containers (i.e., prior to homogenation).
- Empty hand-collected samples into a pre-cleaned stainless steel bowl (or other type as specified in the project planning documents)

- If multiple hand collected samples are necessary to collect adequate sample volume, they should all be combined in the bowl prior to homogenization
- Homogenize the sample(s) as thoroughly as possible
- Transfer sample aliquots to appropriate sample containers and preserve as required in the project planning documents.
- Return unused sediment to the excavation when sampling is complete.

6.2 Grab Sediment Sampling

The following procedures are used for collecting sediment samples using a stainless steel Ekman dredge. Other Ekman construction materials may be appropriate if they meet project DQOs.

- Clean the Ekman grab prior to use.
- Open and lock the grab jaws
- Slowly lower the grab into the sediment
- Using whatever trip mechanism is associated with the grab, close the jaws.
- Retrieve the grab
- Empty the grab into a stainless steel bowl (or other type as specified in the project planning documents)
- Immediately collect volatile organic analyte and sulfide samples.
- If multiple Ekman grabs are necessary to collect adequate sample volume, they should all be combined in the bowl prior to homogenization
- Homogenize the sample as thoroughly as possible
- Transfer sample aliquots to appropriate sample containers and preserve as required in the project planning documents.
- Return unused sediment to the water when sampling is complete if allowed in the project planning documents.

The following procedures are used for collecting sediment samples using a grab sampling device such as a Ponar grab sampler.

- Grab sampling may be conducted from small vessels/floating platforms or stationary structures (e.g., bridges) above water. Refer to project planning documents for guidance related to sampling from small vessels.
- A pre-cleaned, modified 0.1-m^2 stainless steel Van Veen grab sampler is the preferred grab sampler for routine sediment collection.
- Ponar grab samplers are similar in design and operation to Van Veen samplers and may also be used. The maximum depth of sediment penetration that can be expected is about 15 cm, less in clayey, sandy or rocky environments. Van Veen and Ponar grabs may not be the most appropriate sampling devices for such matrices.
- Open and lock the grab jaws
- Remove the safety pin only after the grab is clear of the sampling platform

- Slowly lower the grab using a power winch-hydrowire, or by hand line to avoid a pressure wave
- The speed of decent should be about 1-foot per second within 1 meter from the bottom
- Once the grab reaches the bottom, the sampler will be “tripped”.
- Raise the grab slowly to allow proper jaw closure.
- Retrieve the grab. Do not exceed a 4-foot per second ascent speed to avoid disturbing the sample.
- Secure the grab on the sampling platform
- Open the upper sample access door(s) and evaluate the sample for acceptability
- The following criteria must be met for the sample to be acceptable
    - Sampler jaws should be closed (no rocks, sticks, or other materials should be trapped in the jaws since this would allow for sample washout from the grab)
    - Sampler must not be overfilled (overfilling could result in sample loss)
    - Overlying water is present (indicating sample integrity)
    - Sediment surface appears relatively undisturbed
    - The sediment surface should be even and roughly parallel to the top of the grab
    - Desired sample depth was achieved (ideally at least 1 cm of sediment should remain at the bottom of the sampler after the upper layer(s) have ben sampled)
- Siphon off overlying water (turbid water may be allowed to settle for a short period)
- Immediately collect volatile organic analyte and sulfide samples.
- Depending on the project DQOs, the entire sample may be transferred to a stainless-steel mixing bowl for homogenization and collection of sample aliquots.
- The sediment within grab also may be subsampled. Avoid taking sediment that has come in direct contact with the grab sampler.
- Pre-cleaned stainless steel or Teflon™ spoons, spatulas, or other scoops may be used to collect sediment from within the grab. Other scoop construction materials may be appropriate if they meet project DQOs.
- Place sediment into stainless steel mixing bowl (or other type as specified in the project planning documents)
- If multiple Van Veen grabs (or subsections from within multiple grabs) are necessary to collect adequate sample volume, they should all be combined in the bowl prior to homogenization
- Homogenize the sample as thoroughly as possible
- Transfer sample aliquots to appropriate sample containers and preserve as required in the project planning documents.
- Return unused sediment to the water when sampling is complete if allowed in the project planning documents.

6.3 Core Sediment Sampling

The following procedures are used for collecting sediment samples using a sediment hand core. The subsampling and sectioning procedure also is applicable to core samples collected by a contractor with vibracore. Specific procedures for collection of vibracore samples by a contractor should be included in the project planning documents.

Manual core sediment sampling may be conducted in wetlands, lakes/ponds, low-flow streams, and with a tide that meets project DQOs, the marine intertidal zone. Mechanical core sediment sampling also may be conducted from small vessels/floating platforms or stationary structures (e.g., bridges) above water. Refer to project planning documents for guidance related to sampling from small vessels. Core sampling is recommended if accurate resolution of sample depths is a DQO

There are a variety of manual sediment core sampling devices available for collecting virtually undisturbed sediment core samples. Augers, split core samplers, and multistage core samplers may be used with or without liners that are used to avoid contact between the sediment and the corer. While there are many types of mechanical coring devices, E & E routinely uses only gravity corers. Gravity corers may or may not include a liner.

The following procedures are used for collecting sediment samples using a coring device.

- Pre-clean the coring equipment. See E & E Sampling Equipment Decontamination SOP ENV 3.15 for decontamination procedures.
- Before deployment, visually inspect the sediment retainer (core catcher) to verify the seal should be sufficient to prevent loss of core sediment.
- If hand coring drive the pre-cleaned manual corer into the sediment and retrieve by hand. Hand coring will generally be limited to 2-inch diameter - 1 meter long samples.
- If using a winch from a sampling platform modify the procedure as follows:
    - Adjust the depth of penetration by adding or removing weights from the top of the corer.
    - Slowly lower the corer using a power winch to prevent the core tube from swinging. The corer should enter the bottom vertically.
    - The corer should be allowed to free-fall from 5 to 10 meters above the bottom
    - Once the corer has penetrated the sediment (based on visual changes in wire strain), the winch should be braked.
    - Use the winch to extract the corer (Considerable strain on the hydrowire can occur when a core tube is embedded in sediment. Use a steady continuous pull to lift the coring device). Do not exceed a 4-foot per second ascent speed to avoid disturbing the sample.
- Bring the corer out of the water and place onto the shore or sampling platform.
- Note if there is sample leakage at the cutter end.
- Sediment cores should be capped and stored upright if not sampled immediately. In general though cores should be split as soon as possible following collection.
- After allowing the surface sediment to settle, siphon off the surface water from the top of the core tube.

- Evaluate compaction (core length versus depth of penetration [based on sediment traces on the outside of the core tube]).
- The following criteria must be met for the sample to be acceptable.
  - Core catcher should be closed (no rocks, sticks, or other materials should be trapped in the catcher)
  - Core tube must not be overfilled (overfilling could result in sample loss)
  - Overlying water is present (indicating sample integrity)
  - Desired sample depth was achieved
- Sediment cores should be extruded or split as soon as possible following collection.
  - Decant water from the top of core barrel or drill a small opening above the sediment line to allow the surface water to drain.
  - Place core barrel or liner on clean surface
  - Carefully remove end caps or catchers
  - For transverse sectioning, beginning at the sediment surface, measure and mark the sample sections on the outside of the liner
    - Cut the liner with a manual pipe cutter or core liner and core with a decontaminated saw blade into marked sections.
    - Extrude the sediment from the cut segments of the liner. If necessary use a plunger cover with aluminum foil to aid in extruding the core.
    - For some geotechnical sampling the sediment may need to remain in the core liner and be cap and sealed.
    - Empty the core segment into a stainless steel bowl (or other type as specified in the project planning documents).
    - Record observations of the sediment types.
    - Immediately collect volatile organic analyte and sulfide samples.
  - For longitudinal sectioning, open the split tube or use a knife to cut the liner and expose the upper half of the sediment cylinder.
    - Beginning at the sediment surface, measure and mark the sample sections using a tape measure set aside the core.
    - Record observations of the sediment types.
    - Immediately collect volatile organic analyte and sulfide samples.
    - Scope the core segment into a stainless steel bowl (or other type as specified in the project planning documents).
- If multiple core segments are necessary to collect adequate sample volume, they should all be combined in the bowl prior to homogenization.
- Homogenize the sample as thoroughly as possible.
- Decant any excess water.   Sediment samples should be have greater than 30% solids and greater than 50% is preferred.

- Transfer sample aliquots to appropriate sample containers and preserve as required in the project planning documents.
- Return unused sediment to the water when sampling is complete if allowed in the project planning documents.

In very shallow water and soft sediment, the coring procedure can be modified to use only the core liner as follows. This procedure is only recommended for composite samples of the entire sediment depth.

- Drive the core liner into an undisturbed sediment area by hand.
- Once the liner is driven into the sediment, surface water is added to the top of the liner to create suction.
- Pull the core liner out of the sediment and place in the stainless steel bowl.
- Measure the sediment length and gently decant the water from the top of liner while holding the liner over the bowl.
- Once the suction is release the sediment should extrude into the bowl.
- Homogenize and sample as described above.

7 Quality Assurance/Quality Control

Prior to initiating field work, the project planning documents should be reviewed by field personnel to identify sampling procedure(s) that will most likely provide sediment samples that meet project DQOs.

The program/project manager should identify personnel for the field team who have knowledge, training and experience in the field sediment sampling activities being conducted. One member of the field team should be designated as the lead for sediment sampling and will be responsible, with support from other field personnel, for implementing the procedures in this SOP. The program/project manager should also identify additional personnel, if necessary, to complete ancillary procedures (e.g., field logbook documentation, equipment decontamination, sample shipment, and waste disposal).

The sediment sampling lead should prepare a detailed equipment checklist before entering the field and verify that sufficient and appropriate equipment and supplies are taken into the field.

Guidelines for accepting a sediment grab or core are noted within the sampling procedures. Unacceptable samples should be discarded.

Volatile organic analyte and sulfide samples should always be collected prior to homogenization.

Quality assurance/quality control samples (e.g., co-located samples) are collected according to the site quality assurance project plan. Field duplicates are collected from one location and treated as separate samples. Field duplicates are typically collected after the samples have been homogenized. Collocated samples are generally collected from nearby locations and are collected as completely separate samples.

In cases where multiple hand-collected samples; grabs; or cores are required to generate an adequate sample volume, homogenization is important. Field personnel should collect sample aliquots only after mixing has produced sediment with textural and color homogeneity.

In flowing water, sediment samples should be collected moving from downstream to upstream. At sites with known or suspected contamination, samples should be collected moving from least contaminated area to most contaminated area.

8 Health and Safety

Prior to entering the field, all field personnel should formally acknowledge that they have read and understand the project specific health and safety plan.

Hazards associated with wetlands work should be clear (e.g., engulfment and snakes) and proper precautions noted.

Ekman, Van Veen, and Ponar sampling apparatus are inherently dangerous pieces of heavy equipment which a high "pinch" potential. Care should be taken at all times when handling such equipment, not just during sample collection.

Grab samplers and coring devices are difficult to handle on small vessel decks and floating platforms. Care should be taken whenever handing heavy equipment. Be sure sampling devices are well-secured when not in active use.

Hazardous preservatives (e.g., acids, solvents, and formalin) should be properly handled and stored.

Work aboard small vessels and floating platforms should conform to good safe boating practices, coast guard (or other competent authority) guidance/regulations, and the boat operators standard operating procedures.

9 Special Project Requirements

Project or program-specific requirements that modify this procedure should be entered in this section and included with the project planning documents.

10 References

The following list sources of technical information on sediment sampling.

American Society for Testing and Materials, 1993, ASTM Standards on Aquatic Toxicology and Hazard Evaluation, Philadelphia, PA, ASTM Publication Code Number (PCN): 03-547093-16.

British Columbia Field Sampling Manual for Continuous Monitoring and the Collection of Air, Air-Emission, Water, Wastewater, Soil, Sediment, and Biological Samples, 2003 Edition, Prepared and published by: Water, Air and Climate Change Branch Ministry of Water, Land and Air Protection Province of British Columbia, January 2003

Burton, G. Allen, 1992, Sediment Toxicity Assessment, Chelsea, MI.

Collection and Preparation of Bottom Sediment samples for Analysis of Radionuclides and Trace Elements, IAEA-TECDOC-1360, International Atomic Energy Agency, July 2003

Commonwealth of Virginia, Department of Environmental Quality, November 2010, Standard Operating Procedures Manual for the Department of Environmental Quality Water Monitoring and Assessment Program, Revision No. 18.

Comprehensive Everglades Restoration Plan, 2009 Quality Assurance Systems Requirements (QASR) manual. http://www.evergladesplan.org/pm/program_docs/qasr.aspx

Great Lakes National Program Office, 1985, Methods Manual for Bottom Sediment Sample Collection, United States Environmental Protection Agency, Chicago, Illinois, EPA-905/5-85-004.

Handbook for Sediment Quality Assessment, Commonwealth Scientific and Industrial Research OrganiSation (CSIRO), 2005

Manual for Collection, Storage and Manipulation of Sediments for Chemical and Toxicological Analyses: Technical Manual, U.S. EPA, Office of Water, EPA-823-B-01-002, October 2001

Municipal Environmental Research Laboratory, 1980, Samplers and Sampling Procedures for Hazardous Waste Streams, United States Environmental Protection Agency, Cincinnati, Ohio EPA-600/280-018.

National Coastal Condition Assessment Field Operations Manual, U.S. EPA, Office of Water, EPA-841-R-09-003, April 23, 2010

Navy Environmental Compliance Sampling and Field Testing Procedures Manual, NAVSEA T0300-AZ-PRO-010

Pacific Northwest Laboratories, 1987, Guidance for Sampling of and Analyzing for Organic Contaminants in Sediments, United States Environmental Protection Agency, Criteria and Standards Division, Richland, Washington.

QA/QC Guidance for Sampling and Analysis of Sediments, Water, and Tissues for Dredged Material Evaluations Chemical Evaluations, U.S. EPA, Office of Water, EPA-823-B-95-001, April 1995

Recommended Guidelines for Sampling Marine Sediment, Water Column, and Tissue in Puget Sound, prepared by Puget Sound Water Quality Action Team for U.S. EPA, Region 10, April 1997

State of Ohio Environmental Protection Agency, November 2001, Sediment Sampling Guide and Methodologies

Texas Commission on Environmental Quality, October 2008, Surface Quality Monitoring Procedures, Volume 1, RG-415

United Nations Environment Programme, Mediterranean Action Plan, Manual on sediment Sampling and Analysis, UNEP(DEPI)/MED WG.321/Inf.4, 7 November 2007

United States Department of Commerce, National Technical Information Service, 1985, Sediment Sampling Quality Assurance User's Guide, Nevada University, Las Vegas, NV.

END OF SOP

ecology and environment, inc.

STANDARD OPERATING PROCEDURE

SURFACE WATER SAMPLING

SOP NUMBER: ENV 3.12

REVISION DATE: 6/30/2017 **SCHEDULED REVIEW DATE: 6/30/2022**

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1 Scope and Application

This Standard Operating Procedure (SOP) describes the procedures used by E & E for collecting representative aqueous samples from surface water bodies, such as streams, rivers, lakes, ponds, lagoons, and surface impoundments, both at the surface and at various depths in the water column. This SOP addresses routine sample collection activities consisting of sample collection for off-site laboratory analysis of chemical, biological, radiological, or physical parameters and field measurement of water quality parameters. Specific sampling procedures may vary depending on the data quality objectives (DQOs) identified in project planning documents. This SOP may be adapted for the collection of non-aqueous samples.

E & E routinely uses surface water collection procedures that vary depending on whether surface or near-surface samples are needed or samples need to be collected at discrete depths. Surface water samples can be collected as grab or composite samples, and composite sample collection is often automated. Surface water samples can be collected by hand from a small boat or the shoreline in shallower locations, or by a contracted survey company for deeper waters. Surface water bodies may be static, as in lakes, ponds, and impoundments, or flowing, as in rivers and streams. Surface water samples also may be collected from pipes or outfalls.

This surface water sampling SOP is intended for use by personnel who have knowledge, training, and experience in the field sampling activities being conducted.

Other E & E SOPs that would typically also apply to surface water sampling include the following:

- DOC 2.1, Field Activity Logbooks;
- ENV 3.15, Sampling and Field Equipment Decontamination;
- ENV 3.16, Environmental Sample Handling, Packaging, and Shipping; and
- ENV 3.26, Handling Investigation-Derived Wastes.

2 Definitions and Acronyms

DQO	Data quality objective
E & E	Ecology and Environment, Inc.
HDPE	High-density polyethylene
LDPE	Low-density polyethylene
NPDES	National Pollutant Discharge Elimination System
PFAS	Per- or polyfluoroalkyl substance
PFC	Perfluorinated compound
PTFE	Polytetrafluoroethylene (or Teflon™)
PVC	Polyvinyl chloride
QA	Quality assurance
QC	Quality control
SOP	Standard operating procedure

VOC Volatile organic compound

3 Procedure Summary

Sampling situations vary widely and, therefore, no universal sampling procedure will apply. A sampling plan must be completed before any sampling operation is attempted. The sampling plan should include objectives of the study, the number and type of samples required to meet these objectives, and procedures to collect the samples based on site characteristics. A general discussion of sampling considerations is included in this SOP.

Grab sampling of aqueous liquids from surface water sources can be accomplished near the surface using manual sample collection procedures or at depth using different types of samplers. Aqueous samples may be composited over time or based on flow using manual or automated techniques (compositing is often required to meet certain regulatory permit requirements). A general discussion of compositing methods is provided in this SOP, but specific procedures should be determined based on site-specific DQOs.

These sampling techniques will allow for the collection of representative samples from the majority of surface water types encountered.

4 Cautions

4.1 Sampling

Because many of the sampling devices discussed in this SOP provide limited sample volumes, multiple samples or sample aliquots may be required to meet project DQOs. Specific requirements for sample compositing and homogenization will be addressed in the project planning documents.

Standard measures, such as the use of disposable gloves, should be used to avoid cross-contamination of samples between sample locations.

4.2 Special Considerations for Sampling for PFASs

When collecting samples for analysis of per- and polyfluoroalkyl substances (PFASs), it should be noted that common consumer products and commonly used environmental sampling equipment contain PFASs or PFAS derivatives that have the potential to cross-contaminate the samples, resulting in potential false positives for the PFAS analytes. Table 4-1 lists some common items and materials used during field efforts and sample collection that could contain PFASs, and acceptable non-PFAS substitutes to use. (Note: “PFAS” is the currently recognized term by EPA, the Centers for Disease Control and Prevention, and others for the class of chemical compounds addressed herein. PFASs might also be referred to as perfluorinated compounds [PFCs], although PFCs are a subset of PFASs.)

Table 4-1 Item and Material Guidance for Sampling for PFASs

Item/Material Type	Items/Materials to Avoid	Allowable Items/Materials
Pumps, tubing, connectors, and samplers	PTFE, Teflon®, and other fluoropolymer-containing materials[1] (including thread seal tapes and pastes); LDPE HydraSleeves	Peristaltic pump or stainless steel submersible pump HDPE or silicone tubing (LDPE[2] as a last resort) HDPE HydraSleeves Acetate items
Decontamination agents	Decon 90® (contains fluoro-surfactants); water from unknown sources	Alconox® or Liquinox® soap; PFAS-free water
Sample containers and packaging supplies	LDPE[2] or glass[3] bottles; PTFE-lined or Teflon®-lined caps; chemical ice packs (Blue Ice®), aluminum foil	Laboratory-provided, HDPE, or polypropylene[4] sample bottles; unlined HDPE or polypropylene[4] screw caps; regular ice made from PFAS-free water and contained in plastic (polyethylene) bags; standard Coleman® coolers are HDPE
Field documentation	Waterproof/treated paper or field books; plastic clipboards; Sharpies®; markers; adhesive paper products (such as Post-it® notes)	Plain paper; Masonite or metal clipboard; pens
Clothing, boots	Clothing or boots made of or with Gore-Tex™ or other synthetic water-resistant, waterproof, or stain-resistant materials; fabric softener-treated clothing; new clothing; Tyvek® material	Synthetic or cotton material; previously laundered clothing (preferably previously washed greater than six times) without the use of fabric softeners; polyurethane or polyvinyl chloride (PVC) safety boots; powderless nitrile gloves; polyurethane or wax-coated rain gear
Personal care products	Cosmetics; moisturizers; hand cream; dental floss; most sunscreens; most insect repellants; and other related products	Avoid most personal care products the day of sampling; use PFAS-free or natural sunscreens and insect repellents (DEET is OK)
Food	Pre-packaged food; fast food wrappers and containers; candy wrappers; aluminum foil	Home-prepared foods (consumed only in a designated rest area); bottled water or hydration drinks

1 In cases where Teflon-containing materials are unavoidable, ensure that adequate purging is performed prior to sampling (e.g., in-well pumps) and that rinsate blanks are collected prior to sampling.

2 Although LDPE is allowed by some agencies during sample collection, it is not recommended that samples be stored in LDPE sample containers.

3 Glass is to be avoided due to potential analyte loss from PFAS adsorption on the glass, not due to potential cross-contamination from glass.

4 Some laboratories recommend HDPE only and do not support the use of polypropylene bottles. Polypropylene bottles are allowed by EPA Method 537, for instance, because the method contains steps to recover PFASs that might have adsorbed to the inside of the container. Not all analytical methods, however, contain such steps.

Table 4-1 Item and Material Guidance for Sampling for PFASs

Item/Material Type	Items/Materials to Avoid	Allowable Items/Materials

Key:

DEET = N,N-Diethyl-m-toluamide
HDPE = High-density polyethylene
LDPE = Low-density polyethylene
PFAS = Polyfluoroalkyl substance
PTFE = Polytetrafluoroethylene (Teflon™)
PVC = Polyvinyl chloride

In addition to following the item/material guidance in Table 4-1, the following guidance should be followed to the extent practicable when sampling for PFASs:

- Wash hands before the sampling effort, even though gloves will be worn, to prevent the inadvertent transfer of PFASs to sampling supplies;
- Collect the samples for PFAS analysis prior to collecting samples for other parameters;
- Filter water samples with non-glass and non-PFAS-containing filters (glass fibers can potentially adsorb PFASs);
- Keep sampling supplies for PFAS sampling separate from other sampling supplies;
- Keep samples collected for PFAS analysis separate from other samples; and
- Include field blanks (such as trip blanks and/or equipment blanks) in the sampling protocol to check for potential cross-contamination from PFASs from non-field sources during sample transport and handling, as well as from equipment used during sampling.

5 Equipment and Supplies

The following is a general list of equipment and supplies. A detailed list of equipment and supplies will be prepared based on the specific project planning documents. In general, the use of dedicated or disposable equipment is preferred, to reduce the potential for cross-contamination between sampling locations, but equipment may be reused after thorough decontamination between sample locations.

- Sampling equipment needed for collecting surface water samples, as specified in the work plan, may include:
  - Certified clean, unpreserved sample containers,
  - Dip sampler,
  - Kemmerer, Niskin, Van Dorn, or similar sample collector,
  - Bacon bomb,
  - Double check valve bailer,
  - Peristaltic pump with polytetrafluoroethylene (PTFE or Teflon™) tubing,
  - Automated composite sampler, and
  - Multi-analyte water quality meter with programmable data logger (for field-measured water quality parameters);
- Nylon rope or steel cable, for raising and lowering sampler line and messengers;

- Survey stakes, flags, or buoys and anchors; and
- Ancillary equipment and supplies (e.g., meter stick or tape measure, aluminum foil, plastic sheeting, disposable gloves, sample preservatives, field logbook, sample custody and documentation supplies, decontamination supplies, sample packaging/shipping supplies, safety supplies, and waste handling supplies).

6 Procedure

6.1 General Sampling Considerations

In order to collect a representative sample, the hydrology and morphology of a stream or impoundment should be determined prior to sampling. This will aid in determining the presence of phases or layers in lagoons or impoundments, flow patterns in streams, and appropriate sample locations and depths.

Generally, the deciding factors in the selection of a sampling device for surface water sampling are:

- Depth and flow of surface water body;
- Location from which the sample will be collected; and
- Depth at which the sample is to be collected.

The sampling device must be constructed of materials that cannot interfere with the parameters being analyzed for. For example, some sample collection devices have parts constructed of plastic or rubber that cannot be used for sampling for volatile organic compounds (VOCs) and extractable organic parameters. Samplers constructed of glass, stainless steel, polyvinyl chloride (PVC), PTFE, or Teflon™ should be used, depending on the types of analyses to be performed (e.g., samples to be analyzed for metals should not be collected in metallic containers).

In flowing water, surface water samples should be collected moving from downstream to upstream to prevent affecting the samples by the act of sampling. Similarly, sampling equipment and personnel should be positioned downstream of the sample location. If using motorized water craft, ensure that the sample location is upstream of the craft and the motor is downwind, downstream, and away from the sample. If sediment samples are collocated with surface water samples, the surface water samples should be collected first to avoid substrate cross-contamination.

At sites with known or suspected contamination, samples should be collected moving from least contaminated area to most contaminated area.

Non-dedicated sample collectors require decontamination prior to each sample collection.

Samples for VOCs, sulfide, or similar analyses should be collected as soon as possible in the sampling sequence and prior to homogenization.

Sample preservation should be performed as soon as possible after sample collection and preparation (compositing, homogenization, other preparation) and verified in the field (via pH testing and/or documentation) prior to shipping samples to the laboratory.

Sampling of outfalls for regulatory programs such as National Pollutant Discharge Elimination System (NPDES) permits, or state equivalents, should follow the specific requirements for that program. This SOP provides only general guidance on the outfall sampling.

For any analytical parameters for which the samples are required to be filtered prior to sample analysis, the filtering should be performed in the field, prior to sample preservation, using one 0.45-micrometer (µm) membrane filter per sample. It may be necessary to use a local laboratory for specialty parameters with very short holding times.

6.2 Manual Sample Collection

6.2.1 Direct Method

For streams, rivers, lakes, and other surface waters, the direct method may be used to collect grab water samples within the first 12 inches from the surface. This method is not to be used for sampling lagoons or other impoundments where contact with contaminants is a concern.

Access the sampling location by appropriate means (wading or boat). For shallow stream locations, collect the sample under the water surface, pointing the sample container upstream. The container must also be upstream of the collector. Avoid disturbing the substrate. For lakes and other impoundments, collect the sample under the water surface, avoiding surface debris and the boat wake.

Samples can be collected directly into the sample container or in a sample container connected to a pole, as follows:

- Using an unpreserved container, remove the lid, invert the sample jar, and lower the container beneath the surface (if surface debris or film is present, the container lid can be removed once the container is underwater).
- Tilt the container in the direction of water flow, allow the container to fill, and then quickly return the container to the surface.
- Discard a small portion of sample to allow for expansion and add the correct preservative, if required. Invert the container to mix.
- Check preservation by pouring a small portion of sample into the lid or another clean container. Adjust pH with additional preservative if necessary.
- Secure the cap, label, and immediately cool.

If sample containers are pre-preserved, then use the intermediate sampler method below.

6.2.2 Intermediate Sampler

A grab sample also can be collected using an intermediate container such as a clean, unpreserved sample container or bucket. Non-dedicated intermediate containers should first be rinsed with surface water and the water discarded downstream of the location. The intermediate container should be filled by following the direct sampling method. Once the intermediate container is filled, minimize agitation and then carefully fill the sample containers.

A dip sampler is useful for situations in which a sample is to be recovered from an outfall pipe, such as through a storm sewer grating, or along a lagoon bank where direct accessibility is limited. The long handle on such a device allows access from a discrete location. The procedure is as follows:

- Assemble the device in accordance with the manufacturer's instructions.
- Extend the device to the sample location, rinse with site water, and collect the sample.

- Retrieve the sampler and fill the sample containers, leaving a little headspace for samples being submitted for the analysis of non-volatile analytes.

Preserve samples as noted in Section 6.2.1.

6.3 Sample Collection at Depth

6.3.1 Kemmerer, Niskin, and Van Dorn-Type Samplers

Kemmerer, Niskin, Van Dorn, or similar sample collection devices are used when samples at a discrete depth are required. They also may be used where site access is from an elevated position, such as a boat, bridge, or pier. Sampling procedures are as follows:

- Use a properly decontaminated sample collector. If not dedicated or new, rinse with site water from downstream of the sample location.
- Set the sampling device so that the sampling end pieces are pulled away from the sampling tube, allowing the water to pass through the tube.
- Measure the depth of the water column to verify that sample can be collected at the specified water depth. Mark the line incrementally to the appropriate sample depth.
- Slowly lower the preset sampling device to the predetermined depth. Avoid bottom disturbance.
- When the sample collector is at the required depth, trigger the sampler closing device either by messenger weight or electrical signal. Some sample collectors may be set to close by a pressure or temperature switch.
- Retrieve the sampler slowly.
- Transfer the sample to the sample container.

Preserve samples as noted in Section 6.2.1.

6.3.2 Bacon Bomb Sampler

A bacon bomb sampler has a check valve that is opened and closed by a plunger at the bottom of the sampler or with a separate trigger line. It is often used to sample tanks and non-aqueous liquid substances. This type of sampler also may be used in situations similar to those discussed for other discrete depth samplers. Sampling procedures are as follows:

- Mark the lead line the same as the other depth samplers.
- For non-bottom samples, lower the bacon bomb sampler carefully to the desired depth, allowing the line for the trigger to remain slack at all times. When the desired depth is reached, pull the trigger line until taut, and then release the trigger line and retrieve the sampler slowly.
- For bottom samples, lower the bacon bomb sampler to the desired depth and allow the plunger to open the valve and fill the sampler; then retrieve the sampler slowly.
- Transfer the sample to the sample container.

Preserve samples as noted in Section 6.2.1.

6.3.3 Double Check Valve Bailers

Bailers with an upper and lower check valve can be lowered through the water column and water will continually be displaced through the bailer until the desired depth is reached, at which point the bailer is retrieved. This type of sampler may be used if the data requirements do not necessitate a sample from a strictly discrete interval of the water column. Sampling procedures are as follows:

- Use a properly decontaminated sample collector. If not dedicated or new, rinse with site water from downstream of the sample location.
- Measure the depth of the water column to verify that sample can be collected at the specified water depth. Mark the line incrementally to the appropriate sample depth.
- Slowly lower the bailer to the predetermined depth. Water is displaced through the body of the bailer. The degree of displacement depends on the check valve ball movement to allow water to flow freely through the bailer body. Avoid bottom disturbance.
- Retrieve the sampler slowly. Upon retrieval, the two check valves will seat, preventing water from escaping or entering the bailer.
- Transfer the sample to the sample container.

Preserve samples as noted in Section 6.2.1.

6.3.4 Pump and Tubing

Samples can be collected at the surface and at depth using a pump and tubing appropriate to the analytical parameters and sample depth. A peristaltic pump with PTFE or Teflon™ tubing would be used in most situations. Sampling procedures are as follows:

- Assemble the pump, tubing, and power source.
- Attach the tubing to a pole or rod that is marked with the required sample depth.
- If the pump method is being used to collect grab samples, then the tubing should be lowered at least 6 inches below the surface.
- Lower the rod or tubing carefully to the desired depth.
- Pump surface water through the tubing to thoroughly flush the system prior to collecting samples (use at least at 3 tubing volumes if possible).
- Set the pumping rate to allow the sample container to fill without splashing or overfilling.
- Fill the sample container without touching the tubing to the container, and leaving a little headspace for samples being submitted for the analysis of non-volatile analytes.

Preserve samples as noted in Section 6.2.1.

6.4 Composite Sample Collection

Time-weighted or flow proportion sample compositing may be specified when samples are required to be representative of certain site conditions or to meet permit conditions. Composite sample collection is not considered a routine procedure because of the variables introduced by site-specific conditions, equipment choices, and regulatory requirements; therefore, specific procedures are not included herein. The procedures and rationale for composite sampling of surface water will be specified in the project planning documents. Special consideration for the collection of sample for the analysis of VOCs and water quality parameters with short holding times need to be part of the planning documents.

In general, sample aliquots contributing to a composite sample can be collected manually or with an automatic sampler. Automatic samplers are often used when a location is to be sampled at frequent intervals or when a continuous sample is required over a long time period, and are often used for outfall or discharge sample collection. Composite samplers can be used to collect time composite or flow samples. Appropriate equipment and tubing will depend on the specified analytes. Flow measurements are typically required for composite sample collection. The most common flow measurement devices are flumes or weirs in which flow is calculated based on depth through a known area using a specific geometric relationship.

6.5 Field Measurement of Water Quality Parameters

Water quality parameters (such as temperature, depth, dissolved oxygen, pH, total dissolved solids, specific conductance, turbidity, salinity, oxidation reduction potential, and others) may need to be measured in the field as specified in the project planning documents. These parameters can be measured as a grab sample, using a multi-analyte sensor probe immersed directly into the water, or as a continuous measurement by connecting a pump to a flow-through cell containing a sensor probe. The multi-analyte sensor probe is connected to a water quality meter/data logger. Field personnel should be familiar with the instruments and their operational manuals. Steps to consider for the use of these instruments are:

- Calibrate the instrument used to measure water quality parameters in accordance with the instruments' manufacturer recommendations by following the calibration procedures specified in the instruction manual.
- Measure water quality parameters from the same location and depth as the sample collected for laboratory analysis.
- Collect field measurements in-situ by deploying the multi-analyte sensor probe to the desired sample location or by connecting to a flow-through cell.
- Allow a one- to two-minute equilibration period following deployment of the multi-analyte sensor probe before collecting readings.
- Record the measurements in the field logbook and/or initialize the data logger.

7 Quality Assurance/Quality Control

The program/project manager should identify personnel for the field team who have knowledge, training, and experience in the surface water sampling to be conducted. One member of the field team should be designated as the lead for surface water sampling and will be responsible, with support from other field personnel, for implementing the procedures in this SOP. The program/project manager should also identify additional personnel, as necessary, to complete ancillary procedures (e.g., field logbook documentation, equipment decontamination, sample shipment, and waste disposal).

Prior to initiating field work, the project planning documents (e.g., work plan, sampling and analysis plan, quality assurance project plan, and site-specific health and safety plan) will be reviewed by field personnel to understand the sampling procedures that have been specified to result in surface water samples that will meet project DQOs. Project planning documents will define the quality assurance/quality control (QA/QC) procedures necessary to meet project DQOs, including the sampling protocol for QC samples such as trip blanks, equipment rinsate blanks (to assess the effectiveness of field decontamination methods for non-dedicated and non-disposable equipment), field duplicates, and other types of field and analytical QC samples. Field duplicates are typically collected from at least one location and treated as separate samples, blind to the laboratory. Field duplicates are typically prepared after the samples have been homogenized. Field blanks should be processed at the site location to account for atmospheric site conditions.

Collecting representative samples for surface water is an important quality consideration. Many conditions such as flow, depth, biological impacts, and rainfall impacts need to be considered in establishing and following the sampling protocol. Surface water quality regulatory criteria are often very low values that are difficult to achieve with routine analytical procedures.

8 Health and Safety

Prior to entering the field, all field personnel will acknowledge in writing that they have read and understand the site-specific health and safety plan, which will be in compliance with the Corporate Health and Safety Program.

Unique hazards associated with collecting samples from surface water bodies could include working on boats, leaning off piers or embankments, wading into flowing waters, waterborne biological hazards (e.g., alligators, snakes), engulfment, and drowning.

When sampling lagoons or surface impoundments that contain known or suspected hazardous substances, adequate precautions must be taken to ensure the safety of sampling personnel. The sampling team member collecting the sample should not get too close to the edge of the impoundment, where bank failure may cause him/her to lose their balance. The person performing the sampling should be on a lifeline and wearing adequate protective equipment.

Work aboard small vessels and floating platforms should conform to safe boating practices, U.S. Coast Guard (or other competent authority) guidance/regulations, and the boat operator's safe practices.

9 Special Project Requirements

Project-specific requirements will be included with the project planning documents.

10 References

Virginia Department of Environmental Quality. 2017. *Standard Operating Procedures Manual for the Department of Environmental Quality Water Quality Monitoring*. Revision No. 20. June 5, 2017. Richmond, Virginia. Available at: http://www.deq.virginia.gov/Portals/0/DEQ/Water/WaterQualityMonitoring/2017_WQM_SOP.pdf

New Hampshire Department of Environmental Services. 2016. Sampling for Per- and Polyfluoroalkyl Substances/Perfluorinated Chemicals (PFASs/PFCs) at Contaminated Sites. November 22, 12016. Concord, New Hampshire.

United States Army Corps of Engineers Jacksonville District and South Florida Water Management District. Dated by chapter. *Quality Assurance Systems Requirements (QASR) Manual for the Comprehensive Everglades Restoration Plan*. Most chapters dated between 2007 and 2012. Available at: https://evergladesrestoration.gov/content/qaot/QASR_Manual.pdf

United States Department of the Navy. 2015. Navy Drinking Water Sampling Policy for Perfluorochemicals Perfluorooctane Sulfonate and Perfluorooctanoic Acid. September 14, 2015. Office of the Chief of Naval Operations. N45 Ser/15U132432. Washington, DC.

United States Environmental Protection Agency. 1992. *NPDES Storm Water Sampling Guidance Document*. EPA 833-B-92-001. July 1992. Washington, DC.

United States Geological Survey. 2015, *National Field Manual for the Collection of Water-Quality Data.* Techniques of Water-Resources Investigations. Book 9, Handbooks for Water-Resources Investigations. Compiled October 2015. Available at: https://water.usgs.gov/owq/FieldManual/compiled/NFM_complete.pdf

END OF SOP

STANDARD OPERATING PROCEDURE

SURFACE AND SHALLOW SUBSURFACE SOIL SAMPLING

SOP NUMBER: ENV 3.13

REVISION DATE: 5/31/2020 **SCHEDULED REVIEW DATE: 5/31/2025**

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1 Scope and Application

This Standard Operating Procedure (SOP) describes the procedures used by E & E for collecting representative surface and shallow subsurface environmental soil samples. Surface soils are generally classified as soils between the ground surface and 6 to 12 inches below ground surface. The definition of the depth of a surface soil sample is dependent on project data quality objectives (DQOs), which are driven by regulatory, risk-based, and other considerations. Shallow subsurface soils may be considered to extend from approximately 12 inches below ground surface to 2 or 3 feet below ground surface. The purpose of soil sampling may range from simple reconnaissance to complex sampling programs. This SOP addresses sample collection typically performed for off-site laboratory analysis of chemical, biological, geological, radiological, or physical parameters. Specific sampling procedures may vary depending on the DQOs identified in project planning documents.

E & E routinely uses three basic types of surface and shallow subsurface soil sample collection methods: hand implement, hand auger, and hand coring. In general, the sampling addressed by this SOP is considered to be non-heavy equipment or "hand sampling," and is performed within about four feet below ground surface. Procedures for collecting deeper subsurface soil samples (using backhoes, drill rigs, and direct push equipment) are provided in E & E SOP GEO 4.7, Borehole Installation and Subsurface Soil Sampling.

This soil sampling SOP is intended for use by personnel who have knowledge, training, and experience in the field sampling activities being conducted.

Other E & E SOPs that would typically also apply to surface and shallow subsurface soil sampling include the following:

- DOC 2.1, Field Activity Logbooks;
- ENV 3.15, Sampling and Field Equipment Decontamination;
- ENV 3.16, Environmental Sample Handling, Packing, and Shipping;
- ENV 3.25, Collecting Soil and Sediment Samples for VOC Analysis (contains specific sample containerization procedures not included in SOP ENV 3.13 herein); and
- ENV 3.26, Handling Investigation-Derived Wastes.

2 Definitions and Acronyms

DQO	Data quality objective
E & E	Ecology and Environment, Inc.
EPA	(United States) Environmental Protection Agency
HDPE	High-density polyethylene
LDPE	Low-density polyethylene
PFAS	Per- or polyfluoroalkyl substance
PFC	Perfluorinated compound
PTFE	Polytetrafluoroethylene (or Teflon™)
PVC	Polyvinyl chloride

QA	Quality assurance
QC	Quality control
SHASP	Site-specific health and safety plan
SOP	Standard operating procedure
VOC	Volatile organic compound

3 Procedure Summary

Spoons, trowels, or other types of hand implements are typically used to collect surface soil samples that are less than 6 to 12 inches deep. Hand-operated equipment such as bucket augers or core samplers are typically used for collecting relatively intact shallow subsurface (usually no deeper than approximately 4 feet) soil samples. The bucket auger or corer barrel is advanced into the soil to the pre-determined depth identified in the project planning documents. In some cases, corers may include a liner on the interior of the core barrel. Soil cores may be sectioned to provide vertical profiles of soil characteristics. Soil samples also may be collected directly from the auger when a continuous flight (screw) auger is used, although such soil will be somewhat disturbed by the sampling method. Reusable (i.e., non-disposable) sample collection implements and equipment are pre-cleaned prior to use and decontaminated between samples.

Surface soil aliquots are combined as necessary, homogenized, and placed in appropriate sample containers. The sample area is restored to its pre-sampling condition to the extent practicable, including filling the sampling hole with replacement soil or grout and restoring ground cover.

4 Cautions

4.1 Sampling

Cautions related to health and safety are discussed in Section 8.

Standard measures, such as the use of disposable gloves, should be used to avoid cross-contamination of samples between sample locations.

The decontamination of reusable sampling devices will generate one or more waste streams, some of which could be potentially hazardous waste. Generated wastes will be handled in accordance with E & E SOP ENV 3.26, Handling Investigation-Derived Wastes, as well as project planning documents.

4.2 Special Considerations for Sampling for PFASs

When collecting samples for analysis of per- and polyfluoroalkyl substances (PFASs), it should be noted that common consumer products and commonly used environmental sampling equipment contain PFASs or PFAS derivatives that have the potential to cross-contaminate the samples, resulting in potential false positives for the PFAS analytes. Table 4-1 lists some common items and materials used during field efforts and sample collection that could contain PFASs, and acceptable non-PFAS substitutes to use. (Note: "PFAS" is the currently recognized term by the United States Environmental Protection Agency (EPA), the Centers for Disease Control and Prevention, and others for the class of chemical compounds addressed herein. PFASs might also be referred to as perfluorinated compounds [PFCs], although PFCs are a subset of PFASs.)

Table 4-1 Item and Material Guidance for Sampling for PFASs

Item/Material Type	Items/Materials to Avoid	Allowable Items/Materials
Pumps, tubing, connectors, and samplers	PTFE, Teflon®, and other fluoropolymer-containing materials[1] (including thread seal tapes and pastes); LDPE HydraSleeves	Peristaltic pump or stainless-steel submersible pump; HDPE or silicone tubing (LDPE[2] as a last resort); HDPE HydraSleeves; Acetate items;
Decontamination agents	Decon 90® (contains fluoro-surfactants); water from unknown sources	Alconox® or Liquinox® soap; PFAS-free water
Sample containers and packaging supplies	LDPE[2] or glass[3] bottles; PTFE-lined or Teflon®-lined caps; chemical ice packs (Blue Ice®), aluminum foil	Laboratory-provided polypropylene[4] or HDPE sample bottles; unlined HDPE or polypropylene[4] screw caps; regular ice made from PFAS-free water and contained in plastic (polyethylene) bags; standard Coleman® coolers are HDPE
Field documentation	Waterproof/treated paper or field books; plastic clipboards; Sharpies®; markers; adhesive paper products (such as Post-it® notes)	Plain paper; Masonite or metal clipboard; pens
Clothing, boots	Clothing or boots made of or with Gore-Tex™ or other synthetic water-resistant, waterproof, or stain-resistant materials; fabric softener-treated clothing; new clothing; Tyvek® material	Synthetic or cotton material; previously laundered clothing (preferably previously washed greater than six times) without the use of fabric softeners; polyurethane or PVC safety boots; powderless nitrile gloves; polyurethane or wax-coated rain gear
Personal care products	Cosmetics; moisturizers; hand cream; dental floss; most sunscreens; most insect repellants; and other related products	Avoid most personal care products the day of sampling; use PFAS-free or natural sunscreens and insect repellents (DEET is OK)
Food	Pre-packaged food; fast food wrappers and containers; candy wrappers; aluminum foil	Home-prepared foods (consumed only in a designated rest area); bottled water or hydration drinks

1 In cases where Teflon-containing materials are unavoidable, ensure that adequate purging is performed prior to sampling (e.g., in-well pumps) and that rinsate blanks are collected prior to sampling.

2 Although LDPE is allowed by some agencies during sample collection, it is not recommended that samples be stored in LDPE sample containers.

3 Glass is to be avoided due to potential analyte loss from PFAS adsorption on the glass, not due to potential cross-contamination from glass.

4 Some laboratories recommend HDPE only and do not support the use of polypropylene bottles. Polypropylene bottles are allowed by EPA Method 537, for instance, because the method contains steps to recover PFASs that might have adsorbed to the inside of the container. Not all analytical methods, however, contain such steps.

Key:

DEET = N,N-Diethyl-m-toluamide
HDPE = High-density polyethylene
LDPE = Low-density polyethylene

Table 4-1 Item and Material Guidance for Sampling for PFASs

Item/Material Type	Items/Materials to Avoid	Allowable Items/Materials

PFAS = Polyfluoroalkyl substance
PTFE = Polytetrafluoroethylene (Teflon™)
PVC = Polyvinyl chloride

In addition to following the item/material guidance in Table 4-1, the following guidance should be followed to the extent practicable when sampling for PFASs:

- Wash hands before the sampling effort, even though gloves will be worn, to prevent the inadvertent transfer of PFASs to sampling supplies;
- Collect the samples for PFAS analysis prior to collecting samples for other parameters;
- Filter water samples with non-glass and non-PFAS-containing filters (glass fibers can potentially adsorb PFASs);
- Keep sampling supplies for PFAS sampling separate from other sampling supplies;
- Keep samples collected for PFAS analysis separate from other samples; and
- Include field blanks (such as trip blanks and/or equipment blanks) in the sampling protocol to check for potential cross-contamination from PFASs from non-field sources during sample transport and handling, as well as from equipment used during sampling.

5 Equipment and Supplies

The following is a general list of equipment and supplies. A detailed list of equipment and supplies will be prepared based on the project planning documents. In general, the use of dedicated or disposable equipment is preferred, to reduce the potential for cross-contamination between sampling locations, but equipment may be reused after thorough decontamination between sample locations.

- Sampling equipment for collecting soil samples, as specified in the work plan, may include:
  - Stainless steel or Teflon™ spoons, trowels, or scoops (other material may be acceptable depending on the project planning documents and DQOs),
  - Stainless steel mixing bowls (other material may be acceptable depending on the project planning documents and DQOs),
  - Hand-driven bucket auger, continuous flight auger, powered auger, split core sampler, single-stage core sampler, or multistage core sampler,
  - Auger extensions,
  - Rubber mallet or T-bar to help drive hand auger,
  - Spade, shovel, and/or pickaxe,
  - Liners or catchers for augers or core samplers as specified in project planning documents,
  - Pipe cutter, stainless steel knife, or power saw to cut liners,
  - Plastic sheeting;
- Clean replacement top, garden soil, or grout to fill in excavations or holes created during sampling;

- Survey stakes or flags to mark locations; and
- Supporting equipment and supplies, e.g., meter stick or tape measure, aluminum foil, disposable gloves, sample containers, sample preservatives, field logbook, sample custody and documentation supplies, decontamination supplies, sample packaging/shipping supplies, safety supplies, and waste handling supplies.

6 Procedure

6.1 General Sampling Considerations

To collect a representative sample, the type of soil and general geological conditions in the sampling area should be determined prior to sampling in order to determine the best type of sampling device. Evaluation factors in the selection of a sampling device for surface and shallow subsurface soil sampling include:

- Type of soil or fill;
- Location and depth from which the sample will be collected; and
- Volume of material needed for analytical testing (some sampling devices collect more soil than others).

As well, the sampling device must be constructed of materials that cannot interfere with the parameters being analyzed for. For example, some sample collection devices have parts constructed of plastic or rubber that cannot be used for sampling for VOCs and extractable organic parameters. Samplers constructed of glass, stainless steel, polyvinyl chloride (PVC), polytetrafluoroethylene (PTFE), or Teflon™ should be used, depending on the types of analyses to be performed.

At sites with known or suspected contamination, samples should be collected moving from least contaminated area to most contaminated area.

Reusable (i.e., non-disposable) sample collectors and sampling equipment require decontamination prior to and between collection for each discrete sample to prevent cross-contamination between samples.

If a powered auger is used, it should be positioned downwind of the sample location to the extent practicable to avoid contaminating the sample from exhaust fumes.

Samples for volatile organic compound (VOC), sulfide, or similar analyses should be collected and containerized as soon as possible in the sampling sequence and prior to homogenization or other sample disturbance, to the extent practicable. Specific procedures for containerizing soil samples for VOC analysis are provided in E & E SOP ENV 3.25, Collecting Soil and Sediment Samples for VOC Analysis.

Multiple sampling attempts may be required to yield sufficient soil sample volume for the analysis of all scheduled parameters for each sample. This will be affected by the sample recovery afforded by the sampling device used and by soil conditions (e.g., dry, rocky). Samples from multiple locations also may need to be collected and composited to provide a sample representative of a larger area. Sample homogenization and compositing will be addressed in the project planning documents.

Required sample preservation (e.g., cooling to 4°C) should be performed as soon as possible after sample collection and preparation (compositing, homogenization, or other preparation).

6.2 Soil Sampling with a Hand Implement

This type of sampling applies to the use of a hand scoop, trowel, spoon, or similar device to obtain surface soil samples, typically within a maximum of approximately 6 to 12 inches below ground surface.

1. Clear the area to be sampled of surface debris such as twigs, rocks, and litter.
2. Carefully remove any overlying sod or turf and set aside to be restored following sampling.
3. Use a sampling implement to carefully remove the top layer of soil to reach the desired sample depth.
4. Create a shallow soil excavation using the sampling implement (i.e., scoop, trowel, spoon, or similar). If a heavier tool is needed, use a shovel, spade, pickaxe, or similar.
5. Collect the sample from the shallow pit using the sampling implement. If a heavier tool was first used, use the sampling implement to first remove and discard the thin layer of soil from areas that came into contact with the shovel, spade, or pickaxe.
6. Collect samples for VOC or sulfide analysis directly into specialized sample containers (e.g., EnCore® sampler) prior to any required homogenization, disturbing the sample material as little as possible during collection.
7. Collect sufficient sample volume for the remaining analyses per the project planning documents. Place the sample volume into a stainless-steel bowl or equivalent.
8. Homogenize the sample as thoroughly as possible.
9. Transfer the sample to appropriate sample containers and preserve as required in the project planning documents.
10. Return unused soil to the excavation. If a lot of soil was removed during sampling, use clean replacement top soil or garden soil to fill in the excavation. Level the area and replace grass turf as necessary.

6.3 Soil Sampling with a Bucket Auger

This soil sampling method consists of the use of a bucket auger, a series of extensions, and a T-handle to obtain surface and shallow subsurface soil samples, typically within a maximum of approximately a few feet below ground surface. The dimensions of the bucket define the volume and depth interval of possible sample collection.

1. Attach the bucket auger bit to a drill rod extension, and attach T-handle to the drill rod.
2. Clear the area to be sampled of surface debris such as twigs, rocks, and litter.
3. Carefully remove any overlying sod or turf and set aside to be restored following sampling.
4. Begin augering, periodically removing and depositing accumulated soils onto a plastic sheet spread near the hole until the desired upper sampling depth is reached.
5. Decontaminate the bucket auger or replace it with a clean one, and resume augering for sample collection. After reaching the desired depth (no more than the maximum length of the auger bucket), carefully remove the auger from the boring.
6. Empty the bucket auger-collected sample into a stainless-steel bowl (or equivalent) or use a sampling implement to carefully subsample soil from within the bucket. (Due to

soil boring wall sloughing and the tendency of the bucket auger to scrape the soil boring walls during removal, soil from the top several inches of the bucket auger may need to be discarded prior to collection and homogenization.)

7. Collect samples for VOC or sulfide analysis directly into specialized sample containers (e.g., EnCore® sampler) prior to any required homogenization, disturbing the sample material as little as possible during collection.
8. If multiple bucket auger-collected samples are necessary to collect adequate sample volume, they should be combined in the bowl prior to homogenization. If necessary, auger a new borehole as close to the original as possible to collect additional volume, following the above steps.
9. Homogenize the sample as thoroughly as possible.
10. Transfer the sample to appropriate sample containers and preserve as required in the project planning documents.
11. If another sample is to be collected in the sample hole, but at a greater depth, decontaminate the auger bucket or attach a clean one and follow the steps above.
12. Return unused soil to the hole. If a lot of soil was removed during sampling, use clean replacement top soil or garden soil to fill in the hole. Level the area and replace grass turf as necessary.

6.4 Soil Sampling with a Continuous Flight Auger

This soil sampling method consists of the use of a continuous flight auger, a series of extensions, and a T-handle to obtain surface and shallow subsurface soil samples, typically within a maximum of approximately a few feet below ground surface. The dimensions of the continuous flight auger define the volume and depth interval of possible sample collection. When a continuous flight auger is used, the sample is collected directly off the flights. A continuous flight auger is useful when a composite of the soil column is desired or when a flighted auger would more successfully move through the soil to reach sample depth. (However, note that, if a composite sample is not desired, use of a flighted auger to obtain soil sample from a discrete depth would result in some mixing of soil from different depths when the flighted auger is advanced into and/or retrieved from the hole.) A powered auger may be part of the setup.

1. Attach the continuous flight auger to a drill rod extension, and attach T-handle to the drill rod.
2. Clear the area to be sampled of surface debris such as twigs, rocks, and litter.
3. Begin augering, periodically removing and depositing accumulated soils onto a plastic sheet spread near the hole until the desired upper sampling depth is reached.
4. Decontaminate the auger or replace it with a clean one, and resume augering for sample collection. After reaching the desired depth (no more than the maximum length of the auger), carefully remove the auger from the boring.
5. Place the auger-collected sample into a stainless-steel bowl (or equivalent) or use a sampling implement to carefully subsample soil from the auger flights.
6. Collect samples for VOC or sulfide analysis directly into specialized sample containers (e.g., EnCore® sampler) prior to any required homogenization, disturbing the sample material as little as possible during collection.

7. If multiple auger flight-collected samples are necessary to collect adequate sample volume, they should be combined in the bowl prior to homogenization.
8. Homogenize the sample as thoroughly as possible.
9. Transfer the sample to appropriate sample containers and preserve as required in the project planning documents.
10. If another sample is to be collected in the sample hole, but at a greater depth, decontaminate the auger or attach a clean one and follow the steps above.
11. Return unused soil to the hole. If a lot of soil was removed during sampling, use clean replacement top soil or garden soil to fill in the hole. In some cases, the boring might need to be grouted with bentonite. Level the area and replace grass turf as necessary.

6.5 Soil Sampling with a Soil Core Sampler

This soil sampling method consists of the use of a core barrel (with liners and liner caps, as appropriate), caps, core tips, and slide hammer. The dimensions of the core barrel define the volume and depth interval of possible sample collection. Core sampling is recommended if accurate resolution of sample depths and/or vertical sample profile characteristics are needed. Hand coring will generally result in samples that are 2 inches in diameter and up to 4 feet long.

A variety of manual soil core sampling devices is available for collecting undisturbed soil core samples. Split core, single core, and multistage core samplers may be used with or without liners, which are used to avoid contact between the soil and the corer, minimize the need for frequent decontamination between samples, and help maintain the integrity of the cored sample when it is removed from the sampler.

1. Assemble the soil core sampler based on manufacturer instructions and project planning document requirements (e.g., using a liner and/or catcher as needed).
2. Clear the area to be sampled of surface debris such as twigs, rocks, and litter.
3. Using the slide hammer, sledge hammer, or pounding sleeve, drive the corer into the soil until the desired upper sampling depth is reached.
4. Carefully retrieve the corer from the boring.
5. Decontaminate the core barrel and shoe, replace them with clean ones, or use a new liner, and resume coring for sample collection.
6. Following collection, extrude or split the soil core as soon as possible:
   a. Place core barrel or liner on clean surface.
   b. Carefully remove end caps and/or catchers.
   c. Evaluate compaction (core length versus depth of penetration).
   d. For transverse sectioning, beginning at the soil surface, measure and mark the sample sections on the outside of the liner:
      i. Cut the liner with a manual pipe cutter or core liner and core with a saw blade into marked sections.
      ii. Extrude the soil from the cut segments of the liner. If necessary, use a plunger cover with aluminum foil to aid in extruding the core.
      iii. Empty the core segment into a stainless-steel bowl (or equivalent).

iv. Record observations of the soil types.

v. Collect samples for VOC or sulfide analysis directly into specialized sample containers (e.g., EnCore® sampler) prior to any required homogenization, disturbing the sample material as little as possible during collection.

e. For longitudinal sectioning, open the split tube or use a knife to cut the liner and expose the soil cylinder:

i. Beginning at the soil surface, measure and mark the sample sections using a tape measure.

ii. Record observations of the soil types.

iii. Collect samples for VOC or sulfide analysis directly into specialized sample containers (e.g., EnCore® sampler) prior to any required homogenization, disturbing the sample material as little as possible during collection.

iv. Scope the core segment into a stainless-steel bowl (or equivalent).

7. If multiple core segments are necessary to collect adequate sample volume, they should be combined in the bowl prior to homogenization.
8. Homogenize the sample as thoroughly as possible.
9. Transfer the sample to appropriate sample containers and preserve as required in the project planning documents.
10. Return unused soil to the boring. If a lot of soil was removed during sampling, use clean replacement top soil or garden soil to fill in the boring. Level the area and replace grass turf as necessary.

7 Quality Assurance/Quality Control

The project manager should identify personnel for the field team who have knowledge, training, and experience in the soil sampling to be conducted. One member of the field team should be designated as the lead for soil sampling and will be responsible, with support from other field personnel, for implementing the procedures in this SOP. The project manager should also identify additional personnel, if necessary, to complete ancillary procedures, e.g., field logbook documentation, equipment decontamination, sample shipment, and waste disposal.

Prior to initiating field work, the project planning documents (e.g., work plan, sampling and analysis plan, quality assurance project plan, and site-specific health and safety plan [SHASP]) will be reviewed by field personnel to understand the sampling procedures that have been specified to result in surface and shallow subsurface soil samples that will meet project DQOs. Project planning documents will define the quality assurance/quality control (QA/QC) procedures necessary to meet project DQOs, including the sampling protocol for QC samples such as trip blanks, equipment rinsate blanks (to assess the effectiveness of field decontamination methods for non-dedicated and non-disposable equipment), field duplicates, and other types of field and analytical QC samples. Field duplicates are typically collected from at least one location and treated as separate samples, blind to the laboratory. Field duplicates are typically prepared after the sample has been homogenized. Certain field blanks should be processed at the site location to account for ambient and other site-specific conditions.

Collecting representative samples of soil is an important quality consideration. Most soil representing a discrete sample location (and depth) will be required to be homogenized following collection and prior to containerization in the various sample bottles representing the suite of required analyses for that sample.

8 Health and Safety

Prior to entering the field, all field personnel will acknowledge in writing that they have read and understand the SHASP, which will be in compliance with the E & E Corporate Health and Safety Program.

Unique hazards associated with collecting surface and shallow subsurface soil samples primarily consist of the following:

- The potential presence of underground utilities such as gas and electric lines that could be hazardous if damaged. Prior to any subsurface work, the field team should verify that underground utilities have been located and marked as necessary.
- The pinch potential associated with use of sampling devices such as augers and sample corers. Sampling apparatus should be handled carefully and in accordance with manufacturers' recommendations.
- The potential for contamination of surface and subsurface soil with site contaminants such as chemical, radioactive, and/or pathogenic biological material. The SHASP will provide instruction for safe handling of contaminated site soils.

9 Special Project Requirements

Project-specific requirements will be included with the project planning documents.

10 References

United States Department of Defense (DoD). 2013. *DoD Environmental Field Sampling Handbook*. Revision 1.0. April 2013.

United States Environmental Protection Agency (EPA). 1980. *Samplers and Sampling Procedures for Hazardous Waste Streams*. EPA-600/2-80-018. January 1980. Municipal Environmental Research Laboratory. Cincinnati, Ohio.

__________. 1984. *Characterization of Hazardous Waste Sites – A Methods Manual: Volume II. Available Sampling Methods*, *Second Edition.* December 1984. EPA-600/4-84-076. Environmental Monitoring Systems Laboratory. Las Vegas, Nevada.

__________. 1985. *Characterization of Hazardous Waste Sites – A Methods Manual: Volume I – Site Investigations*. Section 7, Field Investigations. April 1985. EPA/600/4-84/075. Environmental Monitoring Systems Laboratory. Las Vegas, Nevada.

__________. 1989a. *Methods for Evaluating the Attainment of Cleanup Standards. Volume I: Soils and Solid Media*. EPA 230/02-89-042. February 1989. Office of Policy, Planning, and Evaluation. Washington, DC.

__________. 1989b. *Soil Sampling Quality Assurance User's Guide. Second Edition*. EPA/600/8-89/046. March 1989. Environmental Monitoring Systems Laboratory. Las Vegas, Nevada.

___________. 1991. *Removal Program Representative Sampling Guidance. Volume I – Soil*. Publication 9360-4-10. PB92-963408. November 1991. Office of Emergency and Remedial Response. Washington, DC.

___________. 2000. Soil Sampling. EPA Environmental Response Team. Standard Operating Procedures. SOP number 2012. February 18, 2000.

___________. 2001. *Environmental Investigations Standard Operating Procedures and Quality Assurance Manual*. EPA Region 4. November 2001. Athens, Georgia.

___________, 2014. Soil Sampling. Operating Procedure Number SESDPROC-300-R3. August 2014. EPA Region 4. Science and Ecosystem Support Division. Athens, Georgia.

END OF SOP

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STANDARD OPERATING PROCEDURE

SAMPLING AND FIELD EQUIPMENT DECONTAMINATION

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1 Scope and Application

This Standard Operating Procedure (SOP) describes the procedures used by E & E for decontaminating sampling and other field equipment to 1) minimize sample cross-contamination and 2) promote health and safety by preventing the transfer of site contaminants to other locations. This SOP is applicable to the decontamination of equipment that will be re-used in the field and equipment that will be returned to a rental vendor, subcontractor (e.g., drilling equipment), warehouse, or other facility prior to re-use.

Project-specific data quality objectives (DQOs) dictate the scope and goals of the field investigation, including the sampling design, which further dictate the types of sampling and other field equipment needed for a project. Project planning documents will identify the site-specific decontamination procedures. This SOP applies to equipment routinely used for:

- Water sampling (e.g., buckets, bailers, pump, and tubing);
- Flow/water depth measuring (e.g., velocity meters, stream gauges, and depth sounders);
- Soil and sediment sampling (e.g., corers, augers, trowels, shovels, scoops, direct-push samplers, homogenization buckets, and mixing tools);
- Field and sampling support (e.g., tapes/rulers/meter sticks, tools); and
- Ambient monitoring and sampling (e.g. dust monitors, vapor monitors, air samplers, radiation monitors).

Decontamination of reusable sampling equipment can be time-consuming and costly and may require additional sampling and analyses to verify the effectiveness of decontamination procedures (e.g., rinsate blanks) and/or determine the content of generated decontamination waters. The use of dedicated or clean disposable equipment (e.g., Teflon or plastic bailers for groundwater sampling, aluminum bowls for soil homogenization) is typically preferred, when practicable (assuming that the disposable equipment does not eventually have to be handled as a hazardous waste).

This SOP does not address decontamination of protective clothing or personnel, which will be addressed in the site-specific health and safety plan (SHASP) developed for the fieldwork. This SOP also does not address decontamination for biohazards, reactive or explosive materials, or prolonged exposure to a contaminant; or decontamination necessary to result in ultra-clean sampling equipment required for the investigation and analysis of very low levels of certain environmental contaminants.

This SOP is intended for use by personnel who have knowledge, training, and experience in the field activities being conducted and who understand the importance of decontamination in meeting project-specific DQOs.

2 Definitions and Acronyms

ASTM	American Society for Testing and Materials
CFR	Code of Federal Regulations
Deionized water	Purified water produced by filtration through deionizing columns or other similar means, which removes charged particles and mineral ions

Distilled water	Purified water produced by distillation, which removes minerals, salts, particulates, and certain other impurities
DQO	Data quality objective
E & E	Ecology and Environment, Inc.
EPA	(U.S.) Environmental Protection Agency
Potable water	Water from a treated municipal or industrial drinking water distribution system
QA	Quality assurance
QC	Quality control
SHASP	Site-specific health and safety plan
SOP	Standard operating procedure

3 Procedure Summary

Equipment decontamination procedures vary depending on the DQOs identified in the project planning documents. These planning documents will identify the types and levels of contamination anticipated, specify appropriate decontamination procedures and supplies, and address the handling of investigation-derived waste.

A typical hazardous waste site will have a specific location for decontamination activities in an area designated as the contamination reduction zone.

Several different procedures are presented for the decontamination of equipment. In general, equipment that is in direct contact with collected samples will be washed with a detergent solution followed by a series of rinses with decontamination agents and water. Equipment that is not in direct contact with material that is sampled will be washed or wiped clean and rinsed with water. These procedure can be expanded to include additional or alternate wash/rinse steps designed to remove specific target analytes/compounds, if required by site-specific work plans or as directed by a particular client.

4 Cautions

The decontamination of field and sampling equipment will generate one or more waste streams, some of which could be potentially hazardous waste. All wastes will be handled in accordance with E & E SOP ENV 3.26, Handling Investigation-Derived Wastes, as well as project planning documents.

Decontamination agents, including water, detergents, acids, and solvents, can be potentially damaging to some equipment and instrumentation. Care should be taken to ensure that the decontamination process is compatible with the equipment/materials being decontaminated.

Decontamination agents, including waters, detergents, acids, and solvents, must be stored in their original containers or in clearly marked secondary containers onto which information from the original label has been transferred. The secondary labeling should include reagent name, source, date opened/transferred, and expiration date, as well as any applicable hazardous labels, and should be consistent with the Occupational Safety and Health Administration Hazard Communication standard in 29 Code of Federal Regulations (CFR) 1200.

5 Equipment and Supplies

Project planning documents will provide direction on specific decontamination equipment and supplies. The following equipment and supplies are commonly used for the routine decontamination of sampling and field equipment for a broad-scale field sampling program:

- Galvanized steel or similar wash basins;
- Plastic buckets (5-gallon);
- Long-handled brushes;
- Spray/squeeze bottles;
- Non-phosphate detergent (e.g., Alconox™ or Liquinox™);
- Pesticide-grade (or equivalent) organic solvents (e.g., methanol, hexane, or other) as specified in the planning documents;
- Ten percent, by volume in deionized water, nitric acid (ultrapure) (used when metals are a target field analyte);
- Potable water;
- Deionized water (e.g., American Society for Testing and Materials [ASTM] Type II);
- Organic-free water;
- Plastic sheeting for ground cover;
- Paper towels;
- Aluminum foil;
- Trash bags;
- Waste collection drums (if required);
- Protective clothing appropriate for conducting decontamination (including safety glasses or splash shield, splash apron, and nitrile or neoprene gloves); and
- Decontamination verification supplies (e.g., samples bottles for equipment rinsate blank collection, wipes for wipe sampling).

6 Procedure

6.1 General Decontamination Considerations

To minimize decontamination, E & E personnel should follow best practices to minimize contamination of equipment and cross-contamination of cleaned equipment. Measures to minimize contamination include:

- Designate an exclusion zone that isolates areas of contamination from clean areas of the site. Between the exclusion zone and support zone, a contamination reduction zone should be established, within which decontamination activities will be conducted;
- Employ work practices that minimize contact with hazardous or toxic substances (e.g., avoid areas of obvious contamination, avoid touching potentially contaminated materials);

- Use plastic to cover certain parts of monitoring and sampling equipment;
- Use disposable protective apparel and disposable sampling equipment;
- Keep contaminated and uncontaminated equipment and supplies segregated from each other;
- Ensure that decontamination wastes and other investigation-derived wastes are appropriately contained and containerized;
- Use disposable towels to clean the outer surfaces of sample bottles after sample collection; and
- Enclose sources of contamination in plastic sheeting or other barriers.

Because some practices to minimize decontamination can result in more waste to manage (e.g., using disposable sampling implements), it is important to balance decontamination and waste management plans and procedures. The proper balance will be driven by the field investigation tasks and the nature of the contaminants on site.

Potable water, which can be used for certain decontamination steps, can be obtained from a municipal or treated water system. The use of an untreated water supply is not an acceptable substitute for potable water.

The use of distilled, deionized, or ultrapure water is typically acceptable for decontamination of sampling equipment provided that the water has been verified by laboratory analysis to be analyte-free. Analyte-free water is commonly available from commercial vendors and sometimes can be obtained from the project analytical laboratory. Distilled or deionized water available from local grocery stores and pharmacies is generally not acceptable for final decontamination rinses. Analyte-free water that has been stored in unsealed containers or stored at a contaminated site for a prolonged time period also should not be used for final decontamination rinses because the water could have absorbed atmospheric contaminants over time.

The use of solvent rinses (e.g., hexane, methanol, acetone, nitric acid) as part of a decontamination protocol must balance the goals of the decontamination (i.e., to effectively remove the site contaminant as well as other contaminants with the potential to cross-contaminate the investigative samples) with the potential detriment of introducing a contaminant similar to that being investigated (e.g., using hexane as a decontamination solvent would not be advised if hexane is a site contaminant of interest).

6.2 Decontamination Procedure for Equipment in Direct Contact with Sample

Routine decontamination steps for equipment that directly contacts samples are described below.

1. Physically remove gross contamination from equipment by abrasive scraping and/or brushing.
2. Wash equipment with non-phosphate detergent (e.g., Alconox™ or Liquinox™) in potable water.
3. Rinse equipment with potable water.
4. Rinse equipment with deionized water.
5. Decontamination step if sampling/analyzing for metals:

   a. If specified in project planning documents, rinse with 10% nitric acid solution. Nitric acid solution is made from reagent grade nitric acid and deionized water. If equipment is comprised of low-carbon steel, then a 1% nitric acid solution would typically be used.
   b. Rinse equipment with deionized water (a water rinse should always follow an acid rinse).
6. Decontamination step if sampling/analyzing for high levels of organic constituents:
   a. If specified in project planning documents, rinse with specified organic solvent. In general, use a methanol rinse to dissolve and remove soluble (polar) organic contaminants for high-concentration samples, and use a hexane rinse to dissolve and remove waste lubricating oils, tars, and bunker fuels (non-polar organics) for high-concentration samples.
   b. Rinse equipment with deionized, organic-free water,
7. Air dry the equipment.
8. If a rinsate blank sample is specified in project planning documents for verification of decontamination effectiveness, the sample should be collected from sampling equipment at this step.
9. Air dry the equipment again if necessary.
10. Wrap decontaminated equipment in aluminum foil or plastic if the equipment will not be used immediately. Determine the best material to wrap equipment with based on the site contaminants of interest (e.g., the use of plastic would be minimized if sampling for volatile and extractable organics).
11. Containerize decontamination wastes that require testing and/or regulated disposal. Dispose of all wastes in conformance with applicable regulations as defined in the project planning documents.

6.3 Decontamination Procedure for Pumps and Water Quality Meters

Pumps and meters with internal parts that come into direct contact with samples often cannot be thoroughly or directly decontaminated. Consult the manufacturer's guidelines before decontaminating such equipment, to safeguard against damaging it. General decontamination steps are described below.

1. Physically remove visible contamination from equipment by brushing the outside of the equipment or wiping with a dry or damp paper towel.
2. Rinse with or pump acceptable decontamination agents through the equipment.
3. Rinse with or pump potable water through the equipment.
4. Rinse with or pump deionized water through the equipment..
5. Air dry the equipment.
6. If exterior surfaces have not been in direct contact with sample, follow the decontamination procedure described in Section 6.4.
7. If a rinsate blank sample is specified in project planning documents for verification of decontamination effectiveness, the sample should be collected from the equipment at this step.

8. Air dry the equipment again if necessary.
9. Wrap decontamined equipment in aluminum foil or plastic if the equipment will not be used immediately. Determine the best material to wrap equipment with based on the site contaminants (e.g., the use of plastic would be minimized if sampling for volatile and extractable organics).
10. Containerize decontamination wastes that require testing and/or regulated disposal. Dispose of all wastes in conformance with applicable regulations as defined in the project planning documents.

6.4 Decontamination Procedure for Equipment Not in Direct Contact with Sample

Field equipment that does not come into direct contact with samples may be potentially contaminated by exposure to contaminants in dust, by inadvertent contact with contaminated materials, or otherwise. Such equipment could include ambient and air monitoring instruments, tools, generators, computers, and other reusable supplies. In this case, the goal of the decontamination is to remove the site contaminant for health and safety reasons; potential cross-contamination of samples caused by improper decontamination is not a concern. Because this type of equipment often cannot be thorough or directly decontaminated with standard decontamination agents or methods, consideration should be given to discarding the equipment if there is any question regarding whether the decontamination described below is adequate. Consult the manufacturer's guidelines before decontaminating such equipment, to safeguard against damaging it. General decontamination steps are described below.

1. If equipment has tubing or other removable or disposable components (such as with air monitors), they should be removed if practicable and handled separately from the rest of the equipment. It may be possible to thoroughly decontaminate separate parts using the steps in Sections 6.2 or 6.3, or discard them as contaminated waste.
2. Physically remove visible contamination from the outside of the equipment by brushing it or wiping with a dry or damp paper towel.
3. Wash any watertight parts with detergent and water as described in Sections 6.2 and 6.3.
4. Air dry the equipment.
5. Use canned air to dust off computer keyboards and other electronics.
6. Containerize decontamination wastes that require testing and/or regulated disposal. Dispose of all wastes in conformance with applicable regulations as defined in the project planning documents.

6.5 Decontamination Procedure for Heavy Equipment

For heavy equipment such as drill rigs, excavators, loaders, and direct-push technology samplers, a decontamination pad should be established by the subcontractor. Decontamination of heavy sampling equipment (e.g., augers, split spoon samplers) typically includes a steam cleaning and/or high-pressure water wash step after gross contamination is removed by detergent and brushing. Equipment should be final-rinsed and air dried. If a wipe or rinsate sample is specified in project planning documents for verification of decontamination effectiveness, the sample should be collected from equipment after these steps.

6.6 Decontamination Procedure for Equipment at a Radiation Site

For equipment used at sites where radioactive materials are contaminants of concern, the decontamination steps are similar to those described in Sections 6.2 through 6.5, with a few special considerations. Radiation contamination monitoring is used to help locate contamination and guide the success of the decontamination process. The liberal use of water as a decontamination agent is often minimized, where practicable, because of the expense that can be incurred with disposing of radioactively contaminated decontamination water. Containerized decontamination wastes must be evaluated for radioactive content and disposed of appropriately depending on their content. Specific requirements will be included in the project planning documents.

7 Quality Assurance/Quality Control

Prior to inititating fieldwork, the project planning documents (e.g., work plan, sampling and analysis plan, quality assurance project plan, and SHASP) will be reviewed by field personnel to understand the equipment decontamination procedures that have been specified to meet project DQOs. The project planning documents will define the quality assurance/quality control (QA/QC) procedures necessary to meet project DQOs, including the collection of equipment rinsate blanks and similar QC samples intended to evaluate the effectiveness of decontamination. An equipment rinsate blank typically consists of passing analyte-free water through or over a fully decontaminated sampling device, collecting that water, and analyzing it to assess whether the specified decontamination steps thoroughly removed contaminants of interest and confirm that samples are not being cross-contaminated from unclean equipment.

In cases where it is not feasible to pass water through or over a sampling device or piece of equipment, a wipe sample can be used. A wipe sample typically consists of an analyte-free absorbent material like paper, cloth, glass fiber material, or filter paper that is wiped over the decontaminated surface and analyzed to evaluate the effectiveness of decontamination.

8 Health and Safety

Prior to entering the field, all field personnel will acknowledge in writing that they have read and understand the SHASP, which will be in compliance with the Corporate Health and Safety Program.

Unique hazards associated with decontamination activities include the use of hazardous decontamination agents, the use of steam or high-pressure water cleaning systems, working around heavy equipment (pinch or crush potential), and the generation of potentially hazardous wastes.

Exposure to hazardous decontamination agents is controlled by practices such as contamination avoidance, the use of appropriate personal protective equipment, and proper handling and storage of the agents and wastes, as specified in the SHASP and other project planning documents.

Safety Data Sheets should be available on site for all hazardous decontamination agents, in accordance with the requirements of 29 CFR 1200, Hazard Communication.

Decontamination procedures that employ steam or high-pressure water systems must be performed following equipment manufacturer's operating and safety guidelines. Care must be taken when working around and decontaminating heavy equipment, especially equipment that is in motion while entering/exiting the contamination reduction zone or while being cleaned (e.g., when ensuring that all parts of the equipment are decontaminated).

9 Special Project Requirements

Project-specific requirements will be included in the project planning documents.

10 References

American Socity for Testing and Materials. 2015. Standard Practice for Decontamination of Field Equipment Used at Waste Sites. ASTM D5088-15a. West Conshohocken, Pennsylvania.

United States Department of Defense. 2013. *DoD Environmental Field Sampling Handbook.* Revision 1.0. April 2013.

United States Environmental Protection Agency (EPA). Sampling Equipment Decontamination. SOP# 2006, REV.# 0.0. August 11, 1994. Environmental Response Team.

___________. 2015. Field Equipment Cleaning and Decontamination. SESDPROC-205-R3. December 18, 2015. EPA Region 4. Athens, Georgia.

END OF SOP

STANDARD OPERATING PROCEDURE

SAMPLE HANDLING, PACKING, AND SHIPPING

SOP NUMBER: ENV 3.16

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1 Scope and Application

This Standard Operating Procedure (SOP) describes the handling, packing[1], marking, labeling, and shipping procedures routinely used by E & E field personnel to ship samples from the field to off-site laboratories. Shipping includes transport by air, motor vehicle, or rail.

Samples collected of the following matrices typically would be classified as nonhazardous samples (commonly called "environmental samples"):

- Drinking water, groundwater, and surface water;
- Soil and sediment;
- Air;
- Treated municipal and industrial effluent; or
- Biological specimens (e.g., non-pathogenic plant or animal tissue).

Samples collected from drums, storage tanks, impoundments, and lagoons; from known or suspected contaminated areas; and of leachate may potentially need to be classified as hazardous samples.

This SOP does not address sample collection, which is addressed in other E & E SOPs, and assumes that properly collected, filtered (as applicable), preserved, and labeled samples are presented for shipment.

This SOP also does not address the specific procedures for packing, marking, labeling, documenting, and shipping hazardous samples as United States Department of Transportation (DOT) hazardous materials or International Air Transport Association (IATA) dangerous goods, and directs the reader to E & E's Hazardous Materials/Dangerous Goods Shipping Manual for those steps. The project planning documents (e.g., work plan, sampling and analysis plan, quality assurance project plan, and site-specific health and safety plan (SHASP) will address the types and degrees of contamination anticipated and also might address certain handling and shipping procedures.

This SOP is intended for use by personnel who have knowledge, training, and experience in the procedures described herein.

E & E SOP DOC 2.1, Field Activity Logbooks, also would typically apply to sample handling, packing, and shipping.

2 Definitions and Acronyms

APHIS	Animal and Plant Health Inspection Service
°C	degrees Celsius
CLP	Contract Laboratory Program
COC	Chain of custody

[1] Although some common vernacular might be to "package" samples, the term "pack" samples is used in this SOP: 1) for alignment with the reference SOPs used to develop this SOP, and 2) to prevent confusion with the definitions in hazmat transport regulations for "packaging," which is the receptacle used to contain a hazardous material, and "package," which is the packaging plus its contents.

DOT	(United States) Department of Transportation
DQO	Data quality objective
EPA	(United States) Environmental Protection Agency
IATA	International Air Transport Association
QA/QC	Quality assurance/quality control
RHTC	Regional Hazmat Transportation Coordinator
SHASP	Site-specific health and safety plan
SOP	Standard operating procedure
USDA	United States Department of Agriculture
VOA	Volatile organic analysis

3 Procedure Summary

Properly preserved, containerized, and labeled samples provided by field personnel are maintained under secure custody during sample handling, packing, and shipping. Samples presented for shipment are sealed in plastic bags and secured in a plastic-lined cooler. Double-bagged ice is added to the cooler for samples requiring cold preservation. A chain-of-custody (COC) form is completed in full, carefully cross-checked with the samples in the cooler, and enclosed in the cooler. Shipping papers are completed and attached to the cooler, which is custody-sealed and taped closed. The E & E project manager and designated analytical laboratory are notified daily of impending shipments.

4 Cautions

Cautions related to health and safety are discussed in Section 8.

In order to ship hazardous samples, E & E personnel must have received training consistent with the requirements in Title 49 of the Code of Federal Regulations Part 172 (49 CFR 172) Subpart H. If the samples will be shipped by air, E & E personnel also must have received training consistent with Section 1.5 of the IATA Dangerous Goods Regulations. E & E provides this training to applicable employees. The training includes instruction in the use of E & E's on-line Hazardous Materials/Dangerous Goods Shipping Manual and the role of E & E Regional Hazmat Transportation Coordinators (RHTCs), who provide technical support for hazardous sample shipping. This SOP does not specifically address the requirements to properly pack and ship samples that are a hazardous material/dangerous good.

Soil samples from foreign countries, United States (U.S.) territories (i.e., Puerto Rico, U.S. Virgin Islands, and North Mariana Islands), Hawaii, and certain parts of the U.S. fall under federal quarantine as authorized under 7 CFR 301 and are regulated by the U.S. Department of Agriculture (USDA), Animal and Plant Health Inspection Service (APHIS). Some areas in the U.S. also are under state or local agricultural quarantine. Soils from these regulated areas may contain bacteria, viruses, fungi, nematodes, invertebrates, or seeds of undesirable plant species that could be harmful to U.S. agriculture or natural resources. The movement of these soils within the continental U.S. is regulated under 7 CFR 330.300, which may impose additional special handling, packing, and shipping requirements. Although the general packing for environmental samples likely will suffice, APHIS may have additional requirements, such as for the use of specialized electronic barcoded shipping labels. The project team should refer to the

USDA APHIS and analytical laboratory requirements before handling, packing, and shipping such samples.

International shipping requirements will apply to samples shipped to or from foreign countries and are not addressed by this SOP.

5 Equipment and Supplies

Project planning documents will provide direction on specific equipment and supplies. The following equipment and supplies are commonly used to handle, pack, and ship samples that are presented for shipment:

- Filtered (as necessary), preserved, containerized, and labeled samples, prepared by the field team;
- Coolers, custody seals, and COC documentation forms (typically provided by the laboratory);
- Electrical tape, clear tape, duct tape, and fiber-reinforced packing tape (strapping tape);
- Resealable plastic bags, typically 1-gallon and 2-gallon sizes; freezer-style is preferable because they are thicker;
- Large plastic bags or drum liners, to line coolers;
- Shock-absorbing packing material (e.g., foam block, bubble wrap);
- Packaged ice (commercially available, typically in sizes such as 7-pound and 20-pound bags); and
- Shipping documentation, consisting of an air waybill (air transport) or bill of lading (ground transport).

6 Procedure

6.1 Prior to Field Activity

The following activities are performed prior to field mobilization.

1. Team personnel will assemble and stage equipment and supplies needed to handle, pack, and ship samples;
2. Temperature blanks (typically tap water-filled 40-milliliter volatile organic analysis [VOA] vials or other containers specified in the sampling and analysis plan) will be prepared for use in the field;
3. The project manager or designee will determine the best mode of transportation and verify available locations and pickup/delivery schedules; and
4. The project manager or designee will coordinate with the assigned analytical laboratory regarding schedule and availability to receive and log in the shipped samples. Laboratory receipt of samples on a weekend or holiday will require additional coordination with the laboratory.

6.2 Sample Custody

Collected samples must be either in the custody of responsible personnel or sealed and secured if samples are being stored or transported. Samples are considered to be secure if they are in a locked area with controlled access or when being transported by approved field personnel, a commercial carrier (such as FedEx or UPS), or an approved courier.

A COC form is used to document who has custody of a sample, when, and any exchange of sample custody between the field, shipper/transporter, and laboratory. The COC form also documents sample information and analysis requirements. The final signed COC form becomes the permanent record for sample collection, requested analyses, and custody for each collected sample.

A custody seal is a specialized adhesive label or tape that is used to seal sample containers and the shipment packaging, which for samples is typically a cooler. Custody seals must be affixed such that the seal will be visibly broken if the containers or cooler are opened or tampered with. An intact custody seal means that the samples and their shipping container have not been accessed during storage or shipping. When the laboratory logs in the samples, they will report the condition of the custody seals on the COC or otherwise in the laboratory analytical report.

6.3 Determining Whether Samples are Hazardous

Trained and competent field personnel (see Section 4) will determine if the samples could be considered to contain hazardous materials (dangerous goods) according to U.S. DOT and/or IATA regulations. If so, the samples will be packed, marked, labeled, documented, and shipped in accordance with those regulations. E & E's online Hazardous Materials/Dangerous Goods Shipping Manual provides guidance concerning shipping hazardous samples, and E & E's RHTCs should be consulted during the process.

Types of samples that likely would be classified as hazardous materials/dangerous goods include:

- Samples collected from waste lagoons, drums, tanks, heavily stained soils, and groundwater contaminated with a non-aqueous phase liquid;
- Known or suspected polychlorinated biphenyl- or dioxin-containing samples;
- Samples preserved with methanol, such as from using a Terra Core™ kit (although such samples can be shipped as an excepted quantity of hazardous material, which has some less rigorous shipping requirements); and
- Some biological specimen samples, such as those known or suspected to contain an infectious agent.

Water samples preserved with acids or bases typically will not be considered hazardous materials/dangerous goods. (The containers of acid or base preservatives themselves would be a hazardous material/dangerous good.)

6.4 Environmental Sample Packing

It is E & E's intent to pack samples securely to prevent damage and leakage during shipment. This is to prevent the loss of samples and the expenditure of funds to re-obtain the samples or for potential emergency response to a leaking package or spill. Liquid samples are particularly vulnerable. Even if a package is classified and transported as a nonhazardous material, transporters (carriers) are not able to know the difference between a package leaking distilled water and a package leaking a hazardous chemical and may react to a spill in an emergency fashion, potentially causing expense to E & E or its clients for the cleanup of the sample material. Therefore, samples are packed in plastic bags with the use of shock-absorbent/cushioning material to help prevent leaking of samples both inside and outside the transport package.

Environmental samples will be packed securely whether the samples are shipped via commercial carrier or courier. Environmental samples are usually shipped in 80-quart, solid outer-shell plastic or metal coolers, although other size coolers may be used if they meet project needs. Disposable, pressed Styrofoam™ coolers must not be used to store or ship samples.

Initial Steps

1. Remove non-applicable labels from the cooler.
2. Seal the cooler drain hole with duct tape or equivalent both inside and outside the cooler to prevent leakage.
3. Assemble the containerized samples that will be shipped in the cooler.
4. Ensure that the sample containers are clean, dry, and labeled (wipe container with a paper towel if the container is not clean or dry).
5. Verify that sample container caps/lids are tight.
6. Apply a custody seal over the cap/lid and then secure the custody seal and cap/lid to the container using fiber-reinforced tape, electrical tape, or equivalent. Do not obscure the sample label with the custody seal or tape.
7. Ensure that each container is fully documented on the COC form. COC forms may be completed electronically or by hand depending on project requirements. E.g., EPA Contract Laboratory Program (CLP) sampling/analysis may require electronically generated and completed COC forms.
8. Place each sample container into a resealable plastic bag.
9. Place at least 1 inch of inert shock-absorbent material (e.g., bubble wrap) in the bottom of the cooler.
10. Line the cooler with a heavy-duty plastic trash bag or drum liner.
11. For samples requiring cold preservation:
    a. Maintain the samples on ice during sample handling and packing.
    b. Fill resealable plastic bags with ice and enclose each bag in a second resealable plastic bag such that the ice is double-bagged. These bags of ice will be needed for the cooler.

Securing Sample Containers in the Cooler

1. The sample containers themselves will typically be secured inside the cooler using one of the following methods intended to prevent container damage or breakage.
    a. Pre-cut foam block insert:
        i. Place the foam block insert (with holes cut for the sample containers) inside the plastic bag.
        ii. Place the containers upright in the holes in the foam block.

b. Bubble wrap or equivalent:

    i. Surround each sample container (including the bottom) with bubble wrap, taping the wrap securely around the container; or place the container in a bubble bag. (Some personnel opt to surround the sample container with bubble wrap before placing the sample container in its resealable bag.)

    ii. Place the containers upright in the plastic bag.

    iii. Fill void spaces with additional bubble wrap or other shock absorbent.

c. Loose material that provides shock absorption and liquid absorption (e.g., small animal bedding material made from recycled paper/wood waste):

    i. Place at least 1 inch of the absorbent material in the bottom of the plastic bag lining the cooler.

    ii. Place each sample container upright inside the plastic bag, maintaining about 3 inches between containers.

    iii. Fill the void spaces around the containers with absorbent to at least half the height of the largest container.

2. For liquid samples packed by methods 1a or 1b above, void spaces in the plastic-lined cooler additionally can be filled with non-combustible, absorbent packing material to absorb any sample liquid should breakage or leakage occur and breach the plastic bags containing the individual samples. Vermiculite or light-weight cat litter should not be used for this purpose because they are dusty, staticky, and difficult to remove from the sample containers and cooler. The animal bedding material described in method 1c above is a suitable material for this purpose, as is cellulose wadding and super-absorbent packets. The use of liquid absorbent is not strictly required, and the consequences of sample container leakage are largely mitigated by following the other steps in this section (e.g., the use of multiple layers of plastic bags).

3. If the samples require cold preservation, fill void spaces with double-bagged ice. The ice should be sufficient to maintain the temperature of the samples to about 4 degrees Celsius (°C), ±2 °C, and also not freeze the samples. Additional ice likely will be needed in warmer climates, during warmer times of the year, and if the samples will not be immediately checked in by the laboratory (such as during weekends or holidays). Samples that do not arrive at the laboratory at the proper temperature might need to be re-collected if analysis of those samples would result in qualified data. Analysis of improperly preserved samples and/or re-collection of samples will result in additional expense to E & E and its client that is far greater than shipping the additional sample coolers that might be needed to accommodate a sufficient quantity of ice.

4. Place a temperature blank inside a resealable plastic bag and place the blank inside the cooler.

5. Close and seal the plastic bag lining the cooler and affix a custody seal. This custody seal is an additional layer of custody security in case the cooler is opened and inspected by the U.S. Transportation Security Administration or by customs for international shipments, or the outer custody seals on the cooler fail.

Final Steps

1. Complete and sign the COC form, maintain the required copies, place it in a resealable plastic bag or pouch, and tape the bag/pouch to the inside of the cooler lid.

2. Close the cooler. Place custody seals in two locations along the top of the cooler such that the cooler cannot be opened without breaking the seals. Do not place the custody seals on the hinged side of the cooler lid.
3. Secure the cooler with strapping tape or equivalent over the hinges, over the custody seals, and and around the entire cooler.

6.5 Marking, Labeling, and Shipping

Marking, labeling, and shipping will be performed in accordance with the requirements of the carrier (e.g., Federal Express) or courier that will be used.

Each cooler of environmental (nonhazardous) samples will be marked with an address label showing the name and address of the sender and recipient. “This Side Up” labels will be applied to at least two sides of the cooler.

Shipping documentation will consist of an airbill for air transport or a bill of lading for ground transport, which will be affixed to the lid of the cooler. A hazardous materials/dangerous goods shipper’s declaration is not used when shipping environmental (nonhazardous) samples.

The field team will notify the E & E project manager and the recipient laboratory daily of impending shipments. The E & E project manager will notify E & E’s client if required. The field team or project manager will follow up daily using shipper tracking numbers and review of laboratory log-in documentation to ensure that each shipment of samples has been received as scheduled and logged in immediately upon receipt, and that samples requiring cold preservation have been placed in cold storage upon receipt at the laboratory.

7 Quality Assurance/Quality Control

The program/project manager will identify personnel for the field team who have knowledge, training, and experience in the sample handling, packing, and shipping activities to be conducted.

Prior to initiating field work, the project planning documents (e.g., work plan, sampling and analysis plan, quality assurance project plan, SHASP) will be reviewed by team personnel to understand the procedures that have been specified to result in samples that will meet project data quality objectives (DQOs). Project planning documents will define the quality assurance/quality control (QA/QC) procedures necessary to meet project DQOs. QA/QC steps important to sample handling, packing, and shipping have been incorporated into the procedures in Section 6 and include steps such as the following:

- Maintaining samples under secure custody;
- Completely and accurately filling out COC forms and diligently checking the samples in the cooler against the samples listed on the COC form;
- Using sufficient ice to maintain appropriate sample temperatures during the shipping of samples requiring cold preservation;
- Coordinating with the recipient laboratory regarding scheduled sample shipments; and
- Following up with the laboratory to ensure that samples have been received as scheduled and logged in, and that samples requiring cold preservation have been placed in cold storage upon receipt at the laboratory.

8 Health and Safety

Prior to entering the field, personnel will acknowledge in writing that they have read and understand the SHASP, which will be in compliance with the Corporate Health and Safety Program.

Unique hazards associated with sample handling, packing, and shipping include handling containerized samples that have been preserved with acids, bases, or other chemicals, and the ergonomic hazards of lifting heavy coolers of samples. Exposure to these hazards will be controlled by following the SHASP and the hazard control measures and safe work practices it prescribes, such as wearing gloves and using safe lifting practices.

9 Special Project Requirements

Project-specific requirements will be included with the project planning documents. Programs such as the EPA CLP may have additional, specific proceedures for handling, packing, and shipping samples.

10 References

United States Environmental Protection Agency (EPA). 2014. *Sampler's Guide. Contract Laboratory Program Guidance for Field Samplers.* OSWER 9200.2-147. EPA-540-R-014-013. Office of Superfund Remediation and Technology Innovation. October 2014.

__________. 2015. Packing, Marking, Labeling and Shipping of Environmental and Waste Samples. SESDPROC-2009-R3. EPA Region 4. Science and Ecosystem Support division. February 4, 2015. Athens, Georgia.

__________. 2015. Sample Packing and Shipping. Scientific Engineering, Response and Analytical Services (SERAS) SOP Number 2004. Revision 1.0. June 25, 2015. Edison, New Jersey.

END OF SOP

STANDARD OPERATING PROCEDURE

COLLECTING SOIL AND SEDIMENT SAMPLES FOR VOC ANALYSIS

SOP NUMBER: ENV 3.25

REVISION DATE: 7/30/2018 **SCHEDULED REVIEW DATE: 7/30/2023**

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1 Scope and Application

This Standard Operating Procedure (SOP) describes the procedures used by E & E for collecting and containerizing soil and sediment samples for off-site analysis of volatile organic compounds (VOCs) in accordance with United States Environmental Protection Agency (EPA) SW-846 Methods 5035, 5035A, or similar. These collection procedures are designed to minimize disturbance of the sample and loss of VOCs. The purpose of soil and/or sediment sampling may range from simple reconnaissance to complex sampling programs. Specific sampling procedures may vary depending on the data quality objectives (DQOs) identified in project planning documents. Both low-concentration and high-concentration VOC sampling procedures are provided herein.

This SOP does not address the procedures to initially obtain the soil or sediment material, which would be collected using hand implements, augers, corers, or heavy equipment such as split-spoon samplers. This SOP addresses only the specific methods to properly collect and containerize the subsample (or aliquot) being submitted for VOC analysis.

This SOP is intended for use by personnel who have knowledge, training, and experience in the field sampling activities being conducted.

Other E & E SOPs that would typically also apply to the collection of soil and sediment samples for VOC analysis include the following:

- DOC 2.1, Field Activity Logbooks;
- ENV 3.8, Aquatic Sediment Sampling;
- ENV 3.13, Surface and Shallow Subsurface Soil Sampling;
- ENV 3.15, Sampling and Field Equipment Decontamination;
- ENV 3.16, Environmental Sample Handling, Packing, and Shipping;
- ENV 3.26, Handling Investigation-Derived Wastes; and
- GEO 4.7, Borehole Installation and Subsurface Soil Sampling.

2 Definitions and Acronyms

°C	Degrees Celsius
DI	Deionized
DQO	Data quality objective
E & E	Ecology and Environment, Inc.
EPA	(United States) Environmental Protection Agency
g	gram
µg/kg	micrograms per kilogram (parts per billion)
mL	milliliter
$NaHSO_4$	Sodium bisulfate
QA	Quality assurance
QC	Quality control

SHASP	Site-specific health and safety plan
SOP	Standard operating procedure
VOA	Volatile organic analysis
VOC	Volatile organic compound

3 Procedure Summary

The subsample or aliquot of a soil or sediment sample that is submitted for analysis of VOCs is collected using specialized methods and containers designed to minimize disturbance of the sample and loss of VOCs. Project planning documents will specify methods appropriate for the low and/or high concentrations of VOCs anticipated to be in the samples. The methods and containers typically consist of specialized samplers such as Terra Core™ samplers, En Core™ samplers, or equivalent; sample preparation or preservation solutions such as deionized (DI) water, sodium bisulfate ($NaHSO_4$), or methanol; and volatile organic analysis (VOA) vials or jars.

4 Cautions

Cautions related to health and safety are discussed in Section 8.

Standard measures, such as the use of disposable gloves, should be used to avoid cross-contamination of samples between sample locations.

The quantities of methanol and $NaHSO_4$ used as preservatives in some of the sampling methods are likely considered to be hazardous materials (as defined by the United States Department of Transportation) or dangerous goods (as defined by the International Air Transport Association), and therefore will require transportation in accordance with proper regulations. An E & E hazardous materials shipping specialist and E & E's Hazardous Materials Shipping Manual should be consulted for guidance.

5 Equipment and Supplies

The following is a general list of equipment and supplies that applies to the sampling methods discussed in Section 6. A detailed list of equipment and supplies will be prepared based on the project planning documents.

- Terra Core™ or En Core™ samplers or equivalent;
- Laboratory-provided or vendor-provided pre-preserved VOA sample vials (typically pre-weighed, labeled, with preparation solution, preservative, stir bars, and other analysis-specific components);
- 40-milliliter (mL) VOA vials;
- 2- or 4-ounce Teflon-lined, septum-sealed VOA jars;
- Plastic 5-mL disposable syringes, where the barrel outside diameter is less than the sample vial neck inside diameter, or sample coring devices supplied by the laboratory;
- Cutting tool (for syringes if not pre-cut);
- If samples are weighed in the field, then:
  - Portable analytical balance (range 0 to 100 grams [g]) and capable of weighing to ±0.01 g,

  - Calibration weight set (1 to 50 g), and
  - Weighing dishes (disposable);

- Specialized quality control samples provided by the project laboratory, e.g., purified-grade sea sand trip blanks or field blanks; and
- Supporting equipment and supplies, e.g., disposable gloves, field logbook, sample custody and documentation supplies, decontamination supplies, sample packaging/shipping supplies, safety supplies, and waste handling supplies.

6 Procedure

6.1 General Sampling Considerations

The E & E project manager will coordinate with qualified project laboratories and vendors to ensure that the correct sampling procedures and equipment are used in accordance with project DQOs, project planning documents, and laboratory requirements. VOC sample vial size, type, and style may vary by laboratory.

The sampling method specified in the project planning documents takes into account whether low-concentration VOCs (generally in the range of approximately 0.5 to 200 micrograms per kilogram [µg/kg]) or high-concentration VOCs (greater than approximately 200 µg/kg) are anticipated. Collection methods suitable for the analysis of both low and high concentrations of VOCs are used if the VOC concentrations are unknown.

Soil and sediment samples collected for VOC analysis might be able to be collected directly from the enviroment, but most often are collected by subsampling the soil/sediment initially collected using some type of sampling equipment (e.g., hand implements, augers, corers, or split spoons). Soil and sediment samples collected and prepared for VOC analysis are collected as soon as possible after the soil or sediment material is initially collected and before any homogenization of that material.

Dedicated laboratory- or vendor-supplied equipment such as Terra Core™ or En Core™ (or equivalent) sampling tools do not require decontamination prior to use and prevent sample cross-contamination. Other field equipment used to collect soil/sediment samples for VOC analysis should be cleaned/decontaminated or disposed of between sampling locations to prevent cross-contamination between samples. Chemical solvents should not be used as decontamination agents because they could result in false positive VOC results for the collected sample if the solvents are not rinsed off well enough.

If not otherwise specified by the project planning documents, a separate and additional sample for percent moisture determination should be obtained for each sample location by filling a standard 40-mL VOA vial or a 2- or 4-ounce jar with the same material being submitted for VOC analysis.

6.2 Low-Concentration Vial Sampling (DI Water or Preservative)

This procedure is the most common one used to collect a soil or sediment sample for the analysis of low concentrations of VOCs. The procedure uses laboratory-provided VOA vials containing either 5 mL of DI water or a small amount of $NaHSO_4$ preservative ($NaHSO_4$ slightly acidifies the sample and reduces biological activity) and a sample collection/coring (e.g.,Terra Core™) device. For most sampling under this procedure, E & E typically uses vials containing DI water.

Typically, the laboratory or vendor provides pre-weighed unpreserved (DI water) or preserved ($NaHSO_4$) VOA vials, and sample weights are estimated based on sample volumes defined by the coring device volume. Sample weights will vary depending on the soil/sediment sample density. If sample weights are too low, analytical detection limits may be affected and more accurate determination of sample weights may be required, as per Step 1, although Step 1 is seldom required.

1. **Calculate the sample volume required for sample collection (optional)**

   If the laboratory does not provide pre-weighed vials or if the project DQOs require accurate determination of sample weight and volume, then a portable balance and work station are set up in the field. The following steps are followed to weigh the vials and determine an appropriate sample weight.

   a. Calibrate the analytical balance daily before use. Check the balance with four weights ranging from 1 to 50 g. Record readings against expected values in the logbook. Readings must be within ± 0.01 g of the expected value or the balance must be checked and recalibrated.

   b. To determine or verify a laboratory- or vendor-provided VOA vial weight, place the sample vial with DI water or $NaHSO_4$, cap, stirring bar, etc. on the balance. If the vial weight is not within ± 0.1 g of the laboratory-reported or acceptable weight, do not use the vial.

   c. Prepare a sample corer by cutting the tip off of a 5-mL plastic syringe or use the sample corer provided by the laboratory. The diameter of the syringe barrel needs to be less than the diameter of the sample vial.

   d. Determine the sample volume necessary to provide a 4.5 to 5.5 g sample.

   e. Collect approximately 5 g of sample using the syringe barrel or Terra Core™ sampler.

   f. Extrue the sample onto a tared weighing dish and weigh it. If the sample weight is between 4.5 and 5.5 g, then proceed to Step 2. If the sample weight is outside of the range of 4.5 to 5.5 g, dispose of the weighing dish and sample. Adjust the sample volume, recollect, and reweigh a sample expected to be within the required range. Once the correct sample volume has been determined, proceed to Step 2.

2. **Sample Collection**

   a. Confirm that a sample vial weight has been provided by the laboratory or vendor or otherwise determined, such as via Step 1.

   b. Inspect the sample vials and verify that the sample stir bar is present and that water or solution levels are consistent. If it appears that water or solution is lost from the vial, do not use it.

   c. Prepare a sample corer by cutting the tip off of a 5-mL plastic syringe or use the sample corer (e.g., Terra Core™) provided by the laboratory. The diameter of the syringe barrel needs to be less than the diameter of the sample vial.

   d. Collect the calculated or desired sample volume by driving the coring device into a representative section of the soil or sediment material.

   e. Carefully extrude the soil/sediment into the sample vial taking care not to lose any water or solution from the vial. If water or solution is inadvertently pushed out of the vial, then discard the vial and re-collect the sample.

f. Wipe the exterior of the sample vial and cap. Ensure that no soil is on the vial top and that a tight seal is formed when capping the vial.

g. Soil/sediment samples that contain carbonate material may effervesce on contact with $NaHSO_4$. After capping the vial, check the sample and solution. If there is significant effervescence, discard the sample and use a vial containing DI water. Note the amount of effervescence in the field logbook and any decisions made to retain the use of $NaHSO_4$ vials or switch to DI water vials. The amount of effervescence for retained samples will be reviewed during data validation because effervescence can lead to vial overpressure and potential loss of VOCs during sampling. Allow any discarded effervescing vials to vent slightly prior to disposal to prevent the vial from breaking.

h. For each sample, collect into additional vials using the same coring device and from the same area of the material. The number of vials per sample will be determined with the laboratory, but at least two to three vials are typically collected.

i. Place the vials for the same sample into one sealable plastic bag. A custody seal can be applied to the bag closure instead of each vial.

j. If a percent moisture determination sample has not yet been collected, collect and place one separate standard percent moisture determination soil/sediment aliquot into a 40-mL VOA vial or a 2- or 4-ounce jar. Place the sample in a sealable plastic bag.

k. Place the soil samples on ice (4±2°C). Lay the vials on their side so that the septum remains wet on the inside, thereby preventing vapor leaks around it in case any bubbles form. As well, if the sample is later frozen by the laboratory, being on its side allows water to expand into the flexible septum rather than break the vial.

If the sample is extruded into DI water, the vial may be cooled to 4±2°C for no more than 48 hours, after which the sample must be analyzed or frozen to < -7°C by the laboratory. The holding time between collection and analysis in this case is typically 14 days, if frozen. The holding time between collection and analysis for samples preserved with $NaHSO_4$ is typically 14 days.

6.3 High-Concentration Vial Sampling (Methanol-Preserved)

This procedure can be used to collect a soil or sediment sample for the analysis of high concentrations of VOCs. Collection and analysis of samples for high concentrations of VOCs is typically conducted in addition to that for low concentrations of VOcs in cases where VOC concentrations are unknown or high VOC concentrations are expected. Analytical detection limits for high-concentration sampling and analysis may be elevated by several orders of magnitude above low-concentration detection limits. Methanol is used in this procedure as both a preservative and analytical extraction solution.

Collect the sample as follows:

1. Use the steps in Section 6.2 Step 1 if needed to determine the sample volume to be collected, to verify laboratory- or vendor-provided vial weights, or if pre-weighed VOA vials are not provided.
2. Use a sample vial with methanol, cap, stirring bar, etc. The methanol will be analyzed directly on the instrument for very high-concentration samples.

3. Prepare a sample corer by cutting the tip off of a 5-mL plastic syringe or use the sample corer (e.g., Terra Core™) provided by the laboratory. The diameter of the syringe barrel needs to be less than the diameter of the sample vial.
4. Collect the calculated or desired sample volume (same as the low-concentration aliquot) by driving the coring device into a representative section of the soil or sediment material.
5. Carefully extrude the soil/sediment into the sample vial.
6. Wipe the exterior of the sample vial and cap. Ensure that no soil is on the vial top and that a tight seal is formed when capping the vial.
7. For each sample, collect into a second vial using the same coring device and from the same area of the material.
8. Place the vials for the same sample into one sealable plastic bag. A custody seal can be applied to the bag closure instead of each vial.
9. If a percent moisture determination sample has not yet been collected, collect and place one separate standard percent moisture determination soil/sediment aliquot into a 40-mL VOA vial or a 2- or 4-ounce jar. Place the sample in a sealable plastic bag.
10. Place the soil samples on ice (4±2°C). Lay the vials on their side so that the septum remains wet on the inside, thereby preventing vapor leaks around it in case any bubbles form.

The holding time between collection and analysis for vial samples preserved with methanol is typically 14 days.

6.4 Low- or High-Concentration Vial Sampling (Unpreserved)

This procedure can be used to collect a soil or sediment sample for the analysis of low or high concentrations of VOCs using no preservation or preparation solution (i.e., no DI water or chemical preservative) in the field. The soil or sediment is extruded into a pre-weighed and unpreserved vial. The laboratory will add the appropriate amount of extraction solution to the sample as required for low-concentration analysis (DI water) or high-concentration analysis (methanol).

Collect the sample as follows:

1. Use the steps in Section 6.2 Step 1 if needed to determine the sample volume to be collected, to verify laboratory- or vendor-provided vial weights, or if pre-weighed VOA vials are not provided.
2. Use a sample vial, cap, stirring bar, etc.
3. Prepare a sample corer by cutting the tip off of a 5-mL plastic syringe or use the sample corer (e.g., Terra Core™) provided by the laboratory. The diameter of the syringe barrel needs to be less than the diameter of the sample vial.
4. Collect the calculated or desired sample volume by driving the coring device into a representative section of the soil or sediment material.
5. Carefully extrude the soil/sediment into the sample vial.
6. Wipe the exterior of the sample vial and cap. Ensure that no soil is on the vial top and that a tight seal is formed when capping the vial.

7. For each sample, collect into two more vials using the same coring device and from the same area of the material.
8. Place the vials for the same sample into one sealable plastic bag. A custody seal can be applied to the bag closure instead of each vial.
9. If a percent moisture determination sample has not yet been collected, collect and place one separate standard percent moisture determination soil/sediment aliquot into a 40-mL VOA vial or a 2- or 4-ounce jar. Place the sample in a sealable plastic bag.
10. Place the soil samples on ice (4±2ºC).

The vial may be cooled to 4±2ºC for no more than 48 hours, after which the sample must be analyzed or frozen to < -7°C by the laboratory. The holding time between collection and analysis for this type of VOC sample collection is typically 14 days, if frozen.

6.5 High-Concentration Bulk Sampling (Unpreserved)

This procedure can be used to collect a soil or sediment sample for the analysis of high concentrations of VOCs. Collection and analysis of samples for high concentrations of VOCs is typically conducted in addition to that for low concentrations of VOCs in cases where VOC concentrations are unknown or high VOC concentrations are expected. Analytical detection limits for high-concentration sampling and analysis may be elevated by several orders of magnitude above low-concentration detection limits.

Collect the sample as follows:

1. Completely fill a septum-sealed 2- or 4-ounce VOA sample container with soil or sediment, leaving as little headspace as possible.
2. For each sample, fill a second container using the same implement and from the same area of the material. This additional quantity is most needed if only high-concentration samples are being collected under the sampling program.
3. Apply a custody seal to each sample container and place each in a sealable plastic bag.
4. If a percent moisture determination sample has not yet been collected, collect and place one separate standard percent moisture determination soil/sediment aliquot into a 40-mL VOA vial or a 2- or 4-ounce jar. Place the sample in a sealable plastic bag.
5. Place the soil samples on ice (4±2ºC).

The holding time between collection and analysis for bulk soil or sediment samples is typically 14 days. These samples should not be frozen.

6.6 En Core™ Sampling

The En Core™ sampler can be used to collect a soil or sediment sample for the analysis of low or high concentrations of VOCs. The En Core™ sampler consists of a sampler unit, T-handle, and cap. The collected sample is not required to be chemically preserved in the field. The En Core™ sampler works best in cohesive granular materials and may not be appropriate for sample collection of some matrices (e.g., dry sands).

Collect the sample as follows:

1. Remove the sampler from the sealed foil package.
2. Insert the sampler in the T-handle, turn, and allow the locking arm to click into place.

3. Place the sampler over the soil sample. The view hole should be open.
4. Push down until you see a gasket in the view hole. Twist the sampler and remove it from surrounding soil.
5. Check that the sampler is full of soil. Place the cap over the sample unit and lock it into place.
6. Release the locking arm and remove the sampler unit from the T-handle.
7. Label the sampler unit with the sticker located on the foil pouch.
8. Return the labeled sampler unit to the foil pouch and seal it.
9. For each sample, collect into two additional sampler units from the same area of the material.
10. If a percent moisture determination sample has not yet been collected, collect and place one separate standard percent moisture determination soil/sediment aliquot into a 40-mL VOA vial or a 2- or 4-ounce jar.
11. Place the samples on ice (4±2°C). (The pouched samples may be frozen prior to shipping, although this is seldom feasible in the field.)
12. Decontaminate the T-handle between unique sample locations.

The holding time between collection and analysis for samples collected using an En Core™ (or equivalent) sampling device is typically 48 hours.

7 Quality Assurance/Quality Control

The project manager should identify personnel for the field team who have knowledge, training and experience in the soil/sediment sampling activities to be conducted. One member of the field team should be designated as the lead for soil/sediment sampling conducted for VOC analysis and will be responsible, with support from other field personnel, for implementing the procedures in this SOP. The project manager should also identify additional personnel, if necessary, to complete ancillary procedures, e.g., field logbook documentation, equipment decontamination, sample shipment, and waste disposal.

Prior to initiating field work, the project planning documents (e.g., work plan, sampling and analysis plan, quality assurance project plan, and site-specific health and safety plan [SHASP]) will be reviewed by field personnel to understand the sampling procedures that have been specified to result in soil/sediment samples and VOC data that meet project DQOs. Project planning documents will define the quality assurance/quality control (QA/QC) procedures necessary to meet project DQOs, including the sampling protocol for QC samples such as trip blanks, equipment rinsate blanks (to assess the effectiveness of field decontamination methods for non-dedicated and non-disposable equipment), field duplicates, and other types of field and analytical QC samples. Trip blank samples for soil and sediment VOC analyses are typically prepared by the project laboratory using pre-cleaned sea sand in appropriate vials and/or samplers. For other types of field blanks prepared in the field, pre-cleaned sea sand provided by the project laboratory can be used, following the same sample collection procedures in this SOP. Field duplicates are typically collected from at least one location and treated as separate samples, blind to the laboratory. Certain field blanks should be processed at the site location to account for ambient and other site-specific conditions.

The E & E project manager will coordinate with qualified project laboratories and vendors to ensure that the correct procedures and equipment for collecting samples for VOC analysis are used in accordance with project DQOs and planning documents.

The use of different procedures to collect soil/sediment samples for VOCs within the same project (or between projects) can affect the comparability of the VOC data if samples collected by different procedures are evaluated together.

The small size of the samples collected and analyzed by the procedures addressed in this SOP can inherently limit the representativeness of the sample data when compared to larger, homogenized samples. If the collocated sample portions collected for each sample do not appear to be homogeneous, the field sampler should attempt to sample one type of material to the extent practicable and note this in the field logbook. Because field duplicate samples for VOC analysis also are collocated, and are not homogenized replicates, some degree of field variability is inherently added that may result in less precision between field duplicate sample results than is seen when homogenized samples are analyzed as field duplicates.

8 Health and Safety

Prior to entering the field, all field personnel will acknowledge in writing that they have read and understand the SHASP, which will be in compliance with the E & E Corporate Health and Safety Program.

Unique hazards associated with collecting soil and sediment samples for VOC analysis consist of:

- The use and presence of chemical preservatives such as $NaHSO_4$ and methanol in pre-preserved sample containers. The field team will wear the personal protective equipment specified by the SHASP, handle the sample containers with care, and collect and process such samples in a well-ventilated area.
- The potential for contamination of soil and sediment with site contaminants such as chemical, radioactive, and/or pathogenic biological material. The SHASP will provide instruction for safe handling of contaminated site soils and sediment.

9 Special Project Requirements

Project-specific requirements will be included with the project planning documents.

10 References

United States Department of Defense (DoD). 2013. *DoD Environmental Field Sampling Handbook*. Revision 1.0. April 2013.

United States Environmental Protection Agency (EPA). 1984. *Characterization of Hazardous Waste Sites – A Methods Manual: Volume II. Available Sampling Methods*, *Second Edition.* December 1984. EPA-600/4-84-076. Environmental Monitoring Systems Laboratory. Las Vegas, Nevada.

__________. 1985. *Characterization of Hazardous Waste Sites – A Methods Manual: Volume I – Site Investigations*. Section 7, Field Investigations. April 1985. EPA/600/4-84/075. Environmental Monitoring Systems Laboratory. Las Vegas, Nevada.

__________. 1991. *Removal Program Representative Sampling Guidance. Volume I – Soil*. Publication 9360-4-10. PB92-963408. November 1991. Office of Emergency and Remedial Response. Washington, DC.

__________. 2000. Soil Sampling. EPA Environmental Response Team. Standard Operating Procedures. SOP number 2012. February 18, 2000.

__________. 2001. *Environmental Investigations Standard Operating Procedures and Quality Assurance Manual*. EPA Region 4. November 2001. Athens, Georgia.

__________. 2014a. *Sampler's Guide. Contract Laboratory Program Guidance for Field Samplers.* OSWER 9200.2-147. EPA-540-R-014-013. Office of Superfund Remediation and Technology Innovation. October 2014. Washington, DC.

__________, 2014b. Soil Sampling. Operating Procedure Number SESDPROC-300-R3. August 2014. EPA Region 4. Science and Ecosystem Support Division. Athens, Georgia.

__________. 2014c (or latest available update). *Test Methods for Evaluating Solid Waste*: *Physical/Chemical Methods*. SW-846. Methods 5035 and 5035A, Closed-system Purge-and-Trap and Extraction for Volatile Organics in Soil and Waste Samples.

END OF SOP

STANDARD OPERATING PROCEDURE

HANDLING INVESTIGATION-DERIVED WASTES

SOP NUMBER: ENV 3.26

REVISION DATE: 6/30/2017 **SCHEDULED REVIEW DATE: 6/30/2022**

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1 Scope and Application

This Standard Operating Procedure (SOP) describes the procedures used by E & E for handling investigation-derived waste (IDW). Procedures for handling non-hazardous and hazardous categories of IDW are provided. IDW commonly includes:

- Cuttings from drilling (e.g., soil, sediment);
- Rotary drilling fluids (e.g., muds or solutions);
- Groundwater obtained through well development or well purging;
- Spent decontamination/cleaning fluids (e.g., solvents, wash water);
- Used personal protective equipment (PPE) (e.g., protective suits, gloves);
- Disposable equipment and materials (e.g., sampling equipment, containers); and
- Used packing and shipping materials.

This SOP provides references to certain federal regulatory standards for hazardous waste management and does not address state or local regulatory standards or requirements. The contents of regulatory standards for characterizing and transporting hazardous waste are outside the scope of this SOP. Users of this SOP are required to comply with applicable regulations.

This SOP does not apply to IDW associated with explosive, radioactive, mixed (hazardous and radioactive), or pathogenic wastes or to projects outside of the United States.

The IDW expected to be generated during an investigation and the procedures to manage it should be identified in project planning documents.

This SOP for handling IDW is intended for use by personnel who have knowledge, training, and experience in field activities that generate IDW and how that IDW is handled.

2 Definitions and Acronyms

CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CWA	Clean Water Act
DOT	(U.S.) Department of Transportation
E & E	Ecology and Environment, Inc.
EPA	(U.S.) Environmental Protection Agency
Hazardous waste	Discarded material that is dangerous or potentially harmful to human health or the environment. Hazardous waste can be solid, semisolid, liquid, or contained gaseous material. EPA defines hazardous waste under RCRA as waste that exhibits specific hazardous characteristics, is a listed hazardous waste under the statute, or otherwise meets the definition. For the purposes of this SOP, hazardous waste also will include wastes that contain hazardous constituents regulated under CERCLA, TSCA, CWA, and similar regulations.

IDW	Investigation-derived waste, specifically as pertaining to solid or liquid wastes resulting from E & E field activities
Non-hazardous waste	For the purposes of this SOP, non-hazardous waste means traditional garbage or refuse and does not include wastes that meet the RCRA definition of a hazardous waste; wastes that contain hazardous constituents regulated under CERCLA, TSCA, CWA, and similar regulations; or regulated non-hazardous waste such as industrial waste
PPE	Personal protective equipment
RCRA	Resource Conservation and Recovery Act
SHASP	Site-specific health and safety plan
SOP	Standard operating procedure
TDU	Treatment/disposal unit
TSCA	Toxic Substances Control Act
TSD	Treatment, storage, and disposal

3 Procedure Summary

The IDW procedures identified in the project planning documents will vary depending on the site contaminants, site conditions, sampling procedures, and applicable regulatory requirements. Non-hazardous and hazardous wastes will be handled separately. IDW management requires pre-investigation planning, on-site IDW waste minimization, IDW waste segregation, and specific IDW handling and disposal depending on the type of IDW that is generated.

4 Cautions

Cautions related to health and safety are discussed in Section 8.

The U.S. Environmental Protection Agency's (EPA's) Resource Conservation and Recovery Act (RCRA) defines hazardous waste and imposes limitations and restrictions on its storage, transport, and disposal. Hazardous wastes may require separate sampling and analysis to determine proper IDW disposition. Because sampling and analysis of wastes can be time-consuming and expensive, best professional judgment combined with knowledge of historical site activities and existing site processes/raw material/waste stream information should be the first source of data in the characterization IDW.

Because hazardous waste transporters move regulated wastes on public roads, highways, rails, and waterways, the EPA and the U.S. Department of Transportation (DOT) jointly developed the hazardous waste transporter regulations, which are found in Title 40 Part 263 of the U.S. Code of Federal Regulations (40 CFR 263). Certain DOT regulations in 49 CFR Parts 100 to 185 also are applicable to the off-site transportation of hazardous IDW.

Other regulations also may apply to IDW handling, including those of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Toxic Substances Control Act (TSCA), Clean Water Act (CWA), and state, local, and tribal entities.

5 Equipment and Supplies

Equipment needed for handling IDW typically includes:

- Fifty-five-gallon drums;
- Five-gallon buckets;
- Labels for drums and buckets;
- Wrench and hammer to secure drum lids;
- Lumber, plastic sheeting, and plywood for creating a temporary storage area;
- Trash bags;
- Sample containers;
- Indelible ink pen/permanent marker for labeling drums/containers;
- Manifests/shipping documents;
- Plastic trash bags; and
- PPE.

6 Procedure

6.1 Planning

Prior to site investigation activities, E & E project personnel will develop appropriate project planning documents (e.g., work plan, sampling and analysis plan, quality assurance project plan, and site-specific health and safety plan [SHASP]), which collectively will address the types of IDW expected to be generated and how that IDW will be managed. Prior to field activities, E & E and subcontractor field personnel are required to review and understand site-specific procedures established for handling IDW.

6.2 Waste Minimization

The generation of IDW should be minimized to reduce the need for handling, storage, and disposal that may result in substantial additional costs yet provide little or no reduction in site risks. Waste minimization will be initiated during site planning by identifying and eliminating site activities that may generate IDW or identifying methods to reduce the generation of IDW. Methods and techniques that will contribute to eliminating or reducing IDW include:

- Replace solvent-based cleaners with aqueous-based cleaners for decontamination of equipment;
- Eliminate solvent use when possible;
- Avoid the generation of excess decontamination liquid (e.g., use less water);
- Limit traffic between clean and hot zones;
- Limit field team contact with site contaminants;
- Minimize the use of disposable equipment and materials;
- Use non-disposable equipment/materials that can effectively be decontaminated and reused;
- Use non-intrusive or minimally intrusive investigation methods and sampling techniques that generate little waste (e.g., direct-push samplers);

- Avoid co-mingling hazardous and non-hazardous wastes;
- Recycle clean and non-hazardous traditional recyclables such as cardboard, paper, metal, and beverage containers; and
- Collect only the amount of sample that is needed.

6.3 Management of Non-hazardous IDW

For the purposes of this SOP, non-hazardous IDW means traditional garbage or refuse and does not include wastes that meet the RCRA definition of a hazardous waste; wastes that contain hazardous constituents regulated under CERCLA, TSCA, CWA, and similar regulations; or regulated non-hazardous waste such as industrial waste.

For non-hazardous IDW comprised of uncontaminated or decontaminated PPE, disposable equipment/materials, paper towels, and other wastes that are known to be non-hazardous, the following procedures are typically employed:

- Render the IDW unusable (e.g., by cutting or tearing the material).
- Double-bag the IDW in plastic bags.
- If the investigation is at an active facility, request permission from the owner/operator to dispose of the non-hazardous waste in the facility's operational trash and recycling receptacles/dumpsters.
- If the investigation is not at an active facility, arrange with the client for the non-hazardous IDW to be disposed of at a permitted municipal solid waste disposal facility.

For non-hazardous IDW comprised of site media like soil cuttings, drilling mud, purge or development water, and decontamination wash water that are known to be non-hazardous, the following procedures are typically employed:

- Spread soil/sediment cuttings around the well or borehole or place the cuttings back in the borehole or excavation.
- Pour groundwater from potable water wells and monitoring wells onto the ground in locations where no environmental impacts are anticipated.
- Pour decontamination water (which may contain low levels of non-phosphate detergents) onto the ground in locations where no environmental impacts are anticipated.
- Pour decontamination water down a sanitary sewer if available and allowed.

Record in the field logbook the methods used to handle, containerize, and dispose of non-hazardous IDW.

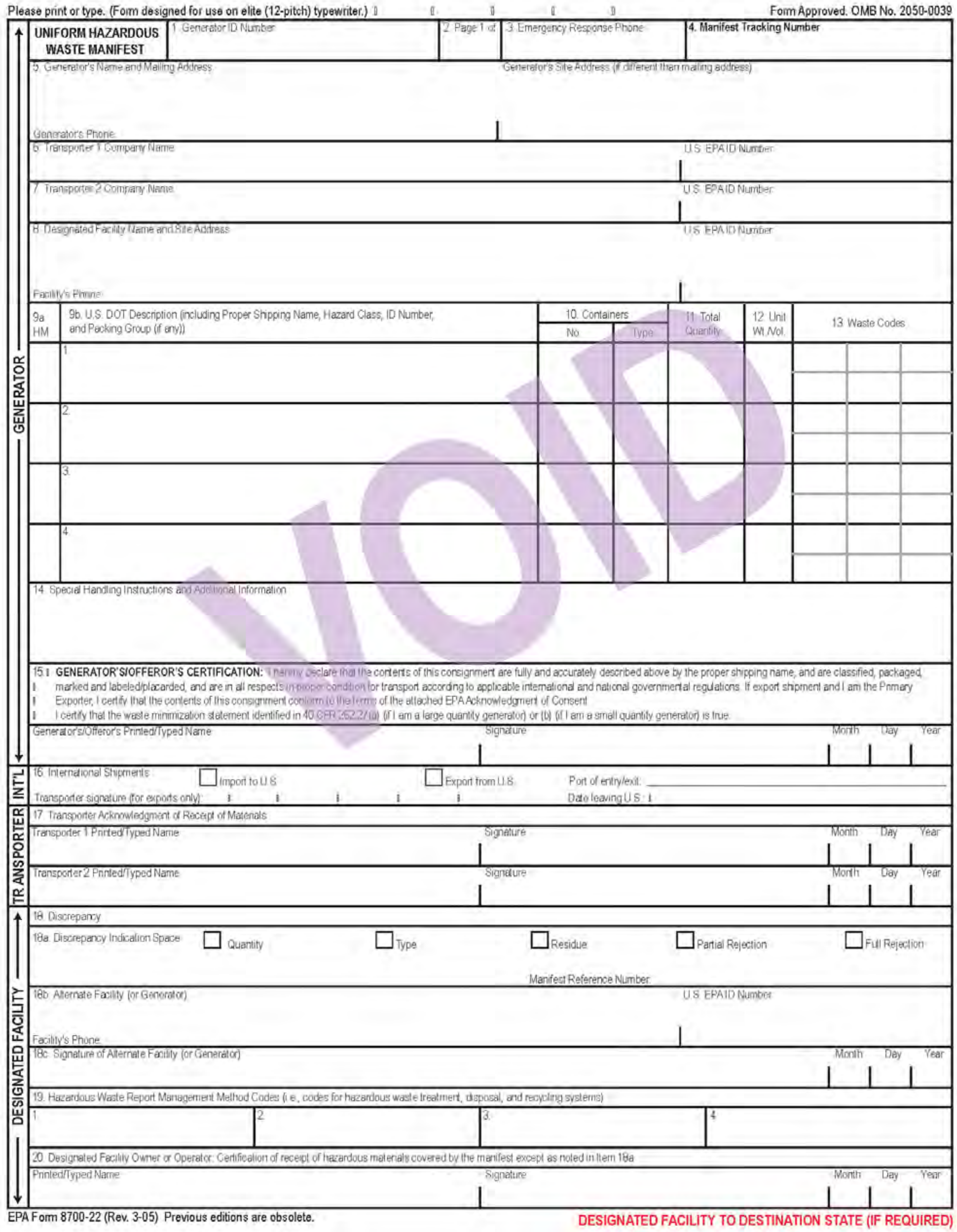
6.4 Management of Hazardous IDW

For the purposes of this SOP, hazardous waste means waste meeting the RCRA definition (e.g., waste that exhibits specific hazardous characteristics, is a listed hazardous waste under the statute, or otherwise meets the definition) or waste that contains hazardous constituents regulated under CERCLA (hazardous substances), TSCA (lead, asbestos), CWA, and similar regulations.

The RCRA regulations address the requirements for the handling, storage, transport, disposal, and tracking of hazardous waste. Hazardous IDW containing CERCLA-defined hazardous substances, TSCA-regulated toxic constituents, and other regulated substances similarly must also be handled, stored, transported, disposed, and tracked in accordance with associated regulations.

For hazardous IDW, the following procedures are typically employed:

- Make reasonable efforts to characterize the hazardous IDW. Use available knowledge of historical site activities and existing site processes/raw material/waste stream information, site monitoring, and/or sample analysis data to characterize wastes. Project planning documents will provide the procedures required for sampling/analysis of wastes necessary for waste characterization.
- Containerize hazardous IDW in accordance with regulations.
- Store hazardous IDW in accordance with regulations, with consideration for secure storage and EPA 90-day interim storage rules. For active sites, it may be possible to store hazardous IDW in the facility's designated area.
- Complete any required hazardous waste labels using indelible ink and apply the labels to the waste containers. The labels will typically require generator identification information (the client, never E & E), the date the waste was first accumulated, and the accompanying waste manifest number.
- Complete, or assist others with completion of, the Uniform Hazardous Waste Manifest (see Figure 6-1).
- For sites with an operational treatment/disposal unit (TDU), it may be possible to dispose of hazardous wastes in the on-site TDU, with client approval.
- If off-site disposal of hazardous IDW is required, coordinate with the client to ensure that the hazardous IDW is transported by an approved hazardous waste transporter and disposed of at a permitted treatment, storage, and disposal (TSD) facility, and that the transporter and TSD facility have passed compliance verification. E & E can assist clients with these arrangements but does not take responsibility for hazardous waste transport and ultimate treatment, storage, and disposal. E & E also is not allowed, per E & E legal instructions, to be identified as the hazardous waste generator or to sign hazardous waste shipping manifests. If E & E subcontracts hazardous waste transport and disposal for a project to a qualified subcontractor, E & E still is not identified as the generator, does not sign hazardous waste manifests, and coordinates with the subcontractor and client to ensure that the transporter and TSD facility have passed compliance verification.
- If off-site disposal of hazardous IDW is required, verify that waste container labels comply with EPA and DOT regulations and the requirements of the receiving TSD facility.
- Record in the field logbook the methods used to characterize, handle, containerize, store, dispose of, and track hazardous IDW.



Please print or type. (Form designed for use on elite (12-pitch) typewriter.) Form Approved. OMB No. 2050-0039

UNIFORM HAZARDOUS WASTE MANIFEST | 1. Generator ID Number | 2. Page 1 of | 3. Emergency Response Phone | 4. Manifest Tracking Number

GENERATOR

5. Generator's Name and Mailing Address | Generator's Site Address (if different than mailing address)

Generator's Phone:

6. Transporter 1 Company Name | U.S. EPA ID Number

7. Transporter 2 Company Name | U.S. EPA ID Number

8. Designated Facility Name and Site Address | U.S. EPA ID Number

Facility's Phone:

9a. HM	9b. U.S. DOT Description (including Proper Shipping Name, Hazard Class, ID Number, and Packing Group (if any))	10. Containers No.	10. Containers Type	11. Total Quantity	12. Unit Wt./Vol.	13. Waste Codes
	1.					
	2.					
	3.					
	4.					

14. Special Handling Instructions and Additional Information

15. GENERATOR'S/OFFEROR'S CERTIFICATION: I hereby declare that the contents of this consignment are fully and accurately described above by the proper shipping name, and are classified, packaged, marked and labeled/placarded, and are in all respects in proper condition for transport according to applicable international and national governmental regulations. If export shipment and I am the Primary Exporter, I certify that the contents of this consignment conform to the terms of the attached EPA Acknowledgment of Consent.
I certify that the waste minimization statement identified in 40 CFR 262.27(a) (if I am a large quantity generator) or (b) (if I am a small quantity generator) is true.

Generator's/Offeror's Printed/Typed Name | Signature | Month Day Year

INT'L

16. International Shipments: Import to U.S. | Export from U.S. | Port of entry/exit:
Transporter signature (for exports only): | Date leaving U.S.:

TRANSPORTER

17. Transporter Acknowledgment of Receipt of Materials
Transporter 1 Printed/Typed Name | Signature | Month Day Year
Transporter 2 Printed/Typed Name | Signature | Month Day Year

DESIGNATED FACILITY

18. Discrepancy
18a. Discrepancy Indication Space: Quantity | Type | Residue | Partial Rejection | Full Rejection
Manifest Reference Number:

18b. Alternate Facility (or Generator) | U.S. EPA ID Number
Facility's Phone:

18c. Signature of Alternate Facility (or Generator) | Month Day Year

19. Hazardous Waste Report Management Method Codes (i.e., codes for hazardous waste treatment, disposal, and recycling systems)
1. | 2. | 3. | 4.

20. Designated Facility Owner or Operator: Certification of receipt of hazardous materials covered by the manifest except as noted in Item 18a
Printed/Typed Name | Signature | Month Day Year

EPA Form 8700-22 (Rev. 3-05) Previous editions are obsolete.

DESIGNATED FACILITY TO DESTINATION STATE (IF REQUIRED)

VOID

Figure 6-1 Uniform Hazardous Waste Manifest

In cases where an E & E subcontractor (e.g., driller) produces hazardous IDW, the subcontractor may take responsibility for proper containerization, characterization, labeling, storage, transport, disposal, and tracking of the wastes if authorized under the subcontract. The E & E subcontracting documentation should include relevant subcontractor SOPs for these activities and specify the documentation to be provided to E & E before, during, and after IDW disposal, The E & E project manager or field team leader should verify that subcontractor IDW handling complies with applicable or relevant and appropriate requirements as well as subcontracting requirements. The E & E project manager also should verify that the subcontractor's proposed transporter and TSD facility have passed compliance verification. When a subcontractor is used, the subcontractor and pricing will be identified in the resultant task order.

7 Quality Assurance/Quality Control

The program/project manager will identify personnel for the field team who have knowledge, training, and experience in the handling and management of IDW in accordance with applicable regulations. The field team leader or designee is the lead for IDW handling and will be responsible, with support from other field personnel, for implementing the procedures in this SOP.

The field team leader will verify that IDW handling, storage, transport, disposal, and tracking information is recorded in the field logbook.

The field team leader and project manager will verify that handling and management of both non-hazardous and hazardous waste comply with DOT and other applicable regulations.

8 Health and Safety

IDW associated with explosive, radioactive, mixed (hazardous and radioactive), or pathogenic wastes, and IDW that poses specific toxicity or other safety (e.g., extreme flammability) concerns, are not specifically addressed by this SOP and must be addressed in project planning documents, including the SHASP.

If heavy drums or containers of IDW need to be moved, appropriate mechanical devices such as drum-handling equipment or the equivalent will be used. Prior to moving a drum, it should be visually inspected for labeling to verify the contents, signs of deterioration, signs that it is under pressure (bulging or swelling), or leaking. If the drum shows signs of deterioration, being under pressure, or leaking, it will not be moved until a safe procedure is determined in conjunction with the project manager and site safety officer.

Appropriate PPE will be worn when handling IDW, as specified in the SHASP.

9 Special Project Requirements

Additional project- and site-specific requirements for IDW handling will be included in the project planning documents.

10 References

Scientific, Engineering, Response and Analytical Services (SERAS). 2015. Investigation-Derived Waste Management. SERAS SOP 2049, Rev 0.1. October 5, 2015. Prepared for EPA Emergency Response Team activities. Edison, New Jersey.

United States Environmental Protection Agency (EPA). 1992. Guide to Management of Investigation-Derived Wastes. April 1992. Publication 9345.3-03FS. NTIS: PB92-963353INX. Office of Solid Waste and Emergency Response.

__________. 2014. Management of Investigation Derived Waste. Operating Procedure Number SESDPROC-202-R3. July 3, 2014. EPA Region 4. Athens, Georgia.

END OF SOP

ecology and environment, inc.

STANDARD OPERATING PROCEDURE

PROCEDURE FOR ROUTINE GPS OPERATION

SOP NUMBER: ENV 3.27 SOP STATUS: Final

REVISION DATE: 6/14/2012 **SCHEDULED REVIEW DATE: 6/14/2013**

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1 Scope and Application

This Standard Operating Procedure (SOP) describes the procedures utilized by E & E GIS Department and samplers relating to the use of GPS (Global Positioning System) handheld receivers. The GPS is a satellite-based positioning system operated by the U.S. Department of Defense (DOD). A constellation of operational NAVSTAR satellites orbit the earth every 12 hours, providing worldwide, all-weather, 24-hour time and position information. The handheld GPS receivers enable field teams to collect accurate location information in the field associated with sample collection, visual or other observations, field measurements (monitoring) or survey of physical or biological features.

Because GPS instruments and data standards are routinely updated, this SOP incorporates links to E & E and external websites by reference.

This SOP is intended for use by personnel who have knowledge, training and experience in the GPS operation activities being conducted.

2 Definitions and Acronyms

DOP	Dilution of Precision
DQO	Data Quality Objectives
E & E	Ecology and Environment, Inc.
EPA	Environmental Protection Agency
Field	Locations (sites) outside the controlled environment of an office or laboratory.
Field Observation	The qualitative and/or quantitative remarks/statements regarding sensory inputs noted in the field.
Field Measurement	The quantitative determination of physical, chemical, biological, geological or radiological properties of a matrix by measurements made in the field.
Field Sampling	The process of obtaining a representative portion of an environmental matrix suitable for laboratory or field measurement or analysis.
GIS	Geographic Information System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
ID	Identification
PDOP	Positional (3D) Dilution of Precision
POC	Point of Contact
QA	Quality assurance
QC	Quality control
SOP	Standard operating procedure

3 Procedure Summary

GPS handheld receivers are used by E & E personnel to collect data that can be integrated into a GIS. Handheld GPS units serve as mobile platforms for data collection. The data collected can be directly integrated into a GIS and used to store, manage, analyze, map and present a variety of geographical and environmental variables. Additionally, the data collected in the field can serve as a work product that can be delivered to the client.

Several factors need to be considered when selecting the type of GPS receiver for a specific task or application: accuracy requirements, occupation time permitted, and local environment conditions (forest cover, terrain characteristics, etc.) should be taken into account. Depending on one's specific requirements, Survey Grade or Mapping Grade GPS applications can be deployed.

The majority of E & E field work is done with mapping grade GPS units. These types of GPS receivers collect mapping / GIS data with an emphasis on efficiency, rather than accuracy. Data collection time ranges from 1 – 30 seconds per location, depending on local atmospheric and geographic conditions, and number of visible satellites. Coordinate and attribute information are captured simultaneously and stored in a GIS compatible format. The two most commonly used models are the Trimble GeoXH and Trimble Geo6000 Series ©. Both these models utilize the global navigation satellite system (GNSS) to collect positions and deliver sub-meter accuracy. Using an external antenna or post-processing software can increase the accuracy down to the centimeter level. Depending on the project requirements, the GPS unit can be used to either record new data points or navigate to previously recorded locations.

Survey Grade receivers place a higher emphasis on accuracy, but data capture time is significantly increased (45 - 60 minutes per location).

The E & E GIS Department is responsible for the ordering and set-up of GPS units. This is done through the Control Point intranet website (http://gps.ene.com/Default.aspx). The website automates the ordering process, serves as a data management system to track orders and also provides resources for software, proper usage and helpful tips. The majority of GPS units are rented from a preferred vendor, GeoPlane Services (http://www.geoplane.com). The website ordering process is the main communication tool between E & E and GeoPlane (Vendor).

Field personnel access the website to order the rental GPS unit. The GIS Department *GPS Team* (see member list) is notified via e-mail and the GIS project point of contact (POC) is assigned. The POC ensures that the requested background data, imagery, and data collection forms are combined into a mobile software application that is transferred onto the GPS unit. The GPS team is responsible for ensuring the field personnel know how to operate the GPS unit and understand the data collection protocols. When the GPS unit is returned the GPS team retrieves the field data off the GPS unit and returns the rental. The data is post-processed if necessary and then stored on the GIS server for future data mapping and analysis.

Prior to field activity, the program/project manager identifies field personnel; designates a field team leader; and team members responsible for GPS operation in the field activities. GPS operators must have received training in GPS operation. Prior to entering the field, the individual responsible for GPS operation coordinates with the GIS department and project manager to determine how the GPS unit should be set-up. The GPS unit may serve as the primary mechanism to document visual or other observations, field measurements (including instrument/equipment calibrations), or sample collection information associated with location information.

4 Cautions

GPS receivers are sensitive instruments that are used to capture project-specific measurement data. Care should be used in handling and storing the unit. In addition to completing the electronic GPS forms, one team member should record the same pertinent data on hard copy data sheets or logbooks. The level of duplication will depend on the project data quality objectives (DQOs). At the end of each survey day or as soon as possible, the field team will check all data sheets for completeness and accuracy against the electronic data. Field teams back-up electronic data in duplicate locations (e.g. laptop, CDs/DVDs, etc.) until the final files are transferred to E & E secure servers.

5 Equipment and Supplies

The following is a list of GPS equipment we routinely use on projects.

- Geo XH 2008
- Geo XH 6000 Series
- Trimble Yuma (tablet)
- External Zephyr Antenna
- External Patch Antenna
- External Battery Pack (Geo XT and Geo XH 2008 series only)

5.1 Software

ESRI ArcPad is the most commonly used software on mapping grade GPS receivers. ArcPad is a mobile field mapping and data collection software that allows for capturing, editing and displaying geographic information. ArcPad is customizable and compatible with the GIS software used by the E & E GIS Department. Another supported but less used software is Terrasync by Trimble.

6 Procedure

E & E maintains an internal website that provides information on the GPS equipment, training, and operation (http://gps.ene.com/Default.aspx). The website provides a link to current pricing and manufacturer websites and GPS checklists and the site is incorporated into this SOP by reference. An overview of the GPS operation procedure is provided below. In addition, E & E staff should refer to the E & E Field Activity Logbooks SOP DOC 2.1 for guidance on the types of information that should be recorded in addition to the electronic data in the GPS unit and field data collection forms.

6.1 Field Data Collection Preparation

Field personnel should contact the E & E GIS Department for guidance on: GPS equipment, Mobile ArcPad application development and any training that may be required. Table 1 describes the general work flow of Mobile Data Collection preparation methods. The GIS Department can also provide training on the Trimble GPS Receivers, mobile data collection forms, and project-specific data work-flows.

Table 1 GPS Work Flow

Step	Description
1	Determine Field-Schedule and Data Collection Requirements
2	Database Design / Data Collection Strategy
3	Mobile Application Development
4	Mobile Application Quality Assurance and Testing
5	End-User Training
6	Mobile Application Deployment/Data Collection
7	Data Quality Control/Quality Assurance
8	Data Upload and Post-Processing Repeat Data QA/QC

GIS personnel and field team personnel should review relevant project planning documents, e.g., work plan, sampling and analysis plan, quality assurance project plan, health and safety plan, etc. The data collection strategy and GPS equipment should be chosen to meet project DQOs. The project planning documents should clearly define the requirements for accuracy of the positional data both horizontal and vertical, the datum for reporting, and any metadata standards. Many federal and state agencies have specific GPS standards and GIS data reporting requirements that must be followed. In the absence of project-specific requirements, the project team can consult EPA National Geospatial Data Policy for guidance (http://www.epa.gov/geospatial/docs/National_Geospatial_Data_Policy.pdf).

Most projects for the federal government require metadata describing geospatial data be produced in accordance with the FGDC Content Standard for Digital Geospatial Metadata (http://www.fgdc.gov/metadata/geospatial-metadata-standards).

6.2 GPS Accuracy

The suite of GPS handheld units typically rented by E & E can provide different accuracy as follows:

- Trimble GeoXT Handheld Series: Submeter horizontal accuracy (good for most projects).
- Trimble GeoXH Handheld Series: Subfoot horizontal accuracy (good for most projects) – most often rented GPS receiver
- Trimble Yuma Tablet: a tablet GPS Receiver that allows the user to store a greater amount of data. Runs a full version of Windows. 5 meter horizontal accuracy.
- External Zephyr Antenna: this is an antenna that you can use in conjunction with any of the above listed handheld receivers to improve your accuracy to ~8 inches when using with GeoXT/XH Handheld Series. When using with Yuma, improve accuracy to ~2 meters.

Although manufacture specifications may indicate a level of accuracy, there are numerous factors that can affect the accuracy obtained from the receiver (see Table 2). When highly accurate positional data are required (i.eless than sub-foot) a licensed surveyor should be used.

Table 2 Factors and Ways to Maximize Accuracy

Factor	Description	To Maximize Accuracy
Number of visible satellites	The accuracy of your data increases with the number of satellites being used to calculate the position.	You need at least four satellites to calculate an accurate 3-dimensional position. Trimble data collection software only logs GPS positions when four or more satellites are visible. Tracking more satellites can help to lower DOP values.
Multipath	Multipath is when GPS satellite signals are reflected off nearby objects, such as buildings or cars, causing an erroneous signal to be received by the GPS antenna. This can cause errors of several meters.	To reduce multipath, collect data in an open environment away from large reflective surfaces and with a clear view of the sky. In high multipath environments, record velocity data and use velocity filtering when post-processing the data.
Weak satellite signals	Signal-to-Noise Ratio (SNR) is a measure of the strength of the satellite signal relative to the background noise. Accuracy degrades as the signal strength decreases. Weak signals may be caused by signals coming through vegetation, multipath signals, or low satellite elevation.	Set your GPS application to ignore satellites with a weak SNR. Trimble recommends a minimum SNR setting of 39 dBHz.

Table 2 Factors and Ways to Maximize Accuracy

Factor	Description	To Maximize Accuracy
Poor satellite geometry	Dilution of Precision (DOP) is a measure of the quality of GPS positions, based on the spread (geometry) of the satellites in the sky that are used to compute the positions. DOP can be expressed as a number of separate measurements. HDOP, VDOP, PDOP, and TDOP are respectively Horizontal, Vertical, Positional (3D), and Time Dilution of Precision. When satellites are widely spaced relative to each other, the PDOP value is lower, and position accuracy is greater. If the view of the sky is partially blocked, or if all of the satellites are in one area of the sky, the geometry and DOP may be poor.	Set your GPS application to ignore positions with a poor DOP value. You can choose to filter positions based on PDOP (Positional Dilution of Precision) or HDOP (Horizontal Dilution of Precision). PDOP is a measure of the horizontal and vertical quality of the GPS positions, whereas HDOP is just a measure of the horizontal precision (x and y coordinates). Select HDOP rather than PDOP if you want to ensure positions are accurate horizontally, and when vertical accuracy is less important. Trimble recommends a maximum PDOP setting of 6, or a maximum HDOP setting of 4.
Satellite elevation	When a satellite is low on the horizon, satellite signals must travel farther through the atmosphere. This results in a lower signal strength and delayed reception by the GPS receiver, which can cause errors in calculating the position.	Set the elevation field in your data collection software to ignore satellites that are low in the sky. Trimble recommends a minimum elevation setting of 15°.
Occupation time at a point	Occupation time is the time spent at a point logging GPS positions.	For point features, remain at the feature and log a number of GPS positions to obtain an averaged position. When collecting line and area features, collect them using averaged vertices.

Source: Trimble Getting Started Guide, GeoExplorer 2005 Series V1.10, April 2007

6.3 GPS Data Collection

Field personnel should follow the GPS data checklist and equipment instructions provided on the E & E GPS website. To ensure maximum positional accuracy, the PDOP will be used by the field teams to determine the quality of GPS positions, based on the spread (geometry) of the satellites in the sky that are used to compute the positions. A PDOP setting of ≤ 6, or a HDOP setting of ≤ 4 is recommended; anything larger will likely result in greater positional inaccuracy.

The window of satellite availability is planned through the U.S. Coast Guard and the Department of Homeland Security. Field Team members should consult with Trimble's Planning Software to determine visibility for GPS, GLONASS, IGSO and geostationary satellites. Trimble Planning software is included in the GPSCorrect install, and can be accessed from the GPSCorrect window on the Trimble GPS receiver. Data collection during times of poor PDOP signals should be avoided.

E & E's default Data Collection Settings to ensure accurate GPS data is set as follows:

- A minimum of four visible satellites are available
- Position Dilution of Precision (PDOP) <= 6
- Satellite elevation >= 15° above the horizon
- Acceptable signal-to-noise ratio (SNR) Mask - 39 dBHz.
- 10 GPS points will be collected at each location; the locational average of these points will be captured.

The GIS Department (GPS Team member) will verify that your Trimble Handheld GPS Receiver will be set-up to collect data that meets these requirements. Field personnel should verify that the GPS is functioning properly before collecting data. Other settings may be used based on project-specific requirements.

To provide additional assurance of data accuracy and reproducibility, the field team will capture GPS data points at three known, fixed structures within the project area during each field day. At least one point will be captured *before* the collection of any other data. The other point(s) may be collected when encountered during normal daily field activities. If none are encountered, the field team will drive to the nearest acceptable location to capture the needed points. The locations used each day will be recorded in the field notebook. It is acceptable to use up to two areas (e.g., southwest corner and southeast corner) on one bridge or structure; this will be decided based on field conditions (e.g., traffic, obstructions, etc.) and will be recorded as part of the data identification and in the field notebook.

Field personnel should QA/QC field data on a nightly basis. Although data loss is rare with the newer GPS units, it is advised that a nightly data back-up is performed. E & E field personnel can use the provided ArcPad data entry forms, installed on their laptops, to back-up or edit their data. Use of other GIS programs can result in corrupted data/data loss, and should be avoided. The GPS unit can be used to QA/QC field data and data can be back-up to a secure data memory card.

6.4 Data Transfer and Post-processing

E & E will transfer datasets when the field crews return to the office. The data are usually collected in a local datum. Datasets are differentially corrected using Trimble software and assessed for accuracy. Real-time data collection is utilized when available. This process involves both the field crew and the GIS analysts that are assigned to the project. Data points that may be erroneous or outliers will be checked and may be eliminated from the survey. To ensure spatial data validation, E & E uses high resolution 1-foot ground pixel orthophotography and the field crew notes to check GIS data after transferred to the computer. Daily checks of fixed locations will be used to verify accuracy on a daily basis.

Datasets collected will be mapped and analyzed for both spatial and non-spatial statistics. Generally, GIS analysts will assess the lows and highs of various parameters and distances accompanying the data. Spatial analysis will be carried out using ArcGIS desktop software.

Trimble GPS Receivers collect data in WGS 84 datum. Data will be delivered with coordinates in the original WGS84 coordinate system unless otherwise specific in the project planning documents. ESRI ArcPad software records data in shapefiles that can be referenced to any supported projection coordinate system and datum, and accurately transforms incoming GPS coordinates to the defined projection. The E & E GIS department selects an appropriate coordinate system based on the spatial extent of the survey, and local coordinate system options. Commonly implemented coordinate systems:

- State Plane Coordinate System (SPCS)
- Universal Transverse Mercator (UTM)

7 Quality Assurance/Quality Control

Compliance with/or deviation from the work plan, sampling and analysis plan, quality assurance project plan, or other project or program plans should be recorded together with authorization for any deviations.

Prior to entering the field, the individual responsible for GPS activities should identify daily check points, assess satellite availability and any obstructions that may limit accuracy. If possible, field team should bring a detailed aerial or topographic map with pre-determined coordinates to verify field locations. If it is important to know accuracy of the GPS data to know a standard then it may be necessary to use an established benchmark (see http://www.ngs.noaa.gov/).

The field coordinator will ensure that all paper form based information is scanned or photocopied and maintained with GPS data. The field coordinator will also provide quality assurance/quality control for spatial and attribute consistency performed by the field teams. All hard copy data will be organized into files according to the date collected. The GIS analyst will verify that spatial accuracy meets project requirements and that feature attributes have been entered in fully and accurately. If errors are noticed, measures will be taken to reconcile them with field team assistance as soon as possible. After QA checks are complete, the files will be saved for GIS processing.

8 Special Project Requirements

EPA Great Lakes National Program Office (GLNPO) has a specific data collection for GPS data. Locational Data Checklist and Metadata Recording Form and GPS Daily Check form. These forms will be completed for projects associated with Great Lakes based on the current version available. The forms will be included with the project planning documents.

9 References

The following list sources of sources information on GPS data collection.

http://gis.ny.gov/coordinationprogram/workgroups/wg_1/related/standards/documents/GPS_Guidelines_FINAL.pdf

http://www.state.nj.us/dep/gis/gpsoutstand.html

END OF SOP

Title:	**SOIL VAPOR INTRUSION INVESTIGATION**
Category:	ENV 3.30
Revised:	November 2006

STANDARD OPERATING PROCEDURE

Soil Vapor Intrusion Investigation in New York State

ecology and environment, inc.
368 Pleasant View Drive / Lancaster, New York 14086 / (716) 684-8060

TITLE:	**SOIL VAPOR INTRUSION INVESTIGATION**		
CATEGORY:	ENV 3.30	**REVISED:**	November 2006

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1. Introduction

This Standard Operating Procedure (SOP) describes procedures for sample collection and evaluation for a soil vapor intrusion investigation in the State of New York. It incorporates guidance provided by the New York State Department of Health (NYSDOH) on the general steps and strategies that should be applied when conducting a soil vapor intrusion investigation. This SOP may be applied in other states; however, New York State guidance includes some specific procedures and excludes use of vapor intrusion modeling and collection of some samples that may be applicable elsewhere. Therefore, this SOP **must** be confirmed and discussed with the appropriate regulatory agencies, even in New York State, prior to the investigation start date, to verify that it has been accepted by the reviewing agency. This SOP must be used in combination with an appropriate analytical method (e.g., USEPA TO-15).

2. Scope

Included in this SOP are the sample collection procedures for the following sample media:

1. Subsurface Soil Vapor Samples (collected outdoors, typically at foundation level directly from the soil);
2. Sub-slab Vapor Samples (collected beneath a structure's slab);
3. Indoor Air Samples (collected from ambient air within a structure); and
4. Outdoor Air Samples (collected from ambient air outside of a structure).

The purpose of this investigation is to identify soil vapor intrusion pathways and determine if any migrating contaminant vapors have the potential to adversely impact humans that are exposed to these vapors. It is recommended that this investigation be conducted during the heating season because it is the period where the greatest impact is anticipated - when a building's heating system is in operation typically causing a pressure gradient into the building and vapors may be drawn into the building. Heating season dates will vary with locale, but is generally defined by NYSDOH as November 15 through March 31.

3. Equipment

The survey will be performed using the equipment listed below.

- Hammer drill;
- Hand auger or post digger;
- Vacuum with high efficiency particulate air (HEPA) filtration for dust and debris cleanup;
- Dustpan and brush;
- ½-inch bottle brush;
- Drill bits, 1-inch diameter x 6 inches long (typical, minimum usable length);
- Drill bits, ½-inch diameter x 12 inches long (typical, minimum usable length);
- Building power source, generator, or batteries for hammer drill;
- Bentonite (fine granular or powder);
- Glass beads or coarse sand;
- Water;
- Inert laboratory- or food-grade-quality tubing (e.g., polyethylene, Teflon-lined polyethylene, or stainless steel), typically ¼- to ⅜-inch ID;
- Organic vapor monitor that reads in the parts per billion range (e.g., ppbRAE) <*to be used only when product inventories or indoor air sampling are conducted*>;
- Enclosure such as a small bucket (5-gallon, typical) and three, ⅜-inch holes with rubber grommets (typical) <*for leak detection testing during soil vapor sampling only*>;
- Helium (ultra-pure, when possible) gas tank < *for leak detection testing during soil vapor sampling only*>
- Portable helium detector < *for leak detection testing during soil vapor sampling only*>
- Syringe without needle (100-cc volume, typical);

- Tedlar bag for vapor purge collection <*for use only during sub-slab vapor sampling when indoor air sampling will be conducted concurrently*>;

- Adjustable wrench and screwdriver/nutdriver;

- Hydraulic cement and mixing tools; and

- Digital camera.

Samples are collected using canisters with vacuum gauges and flow controllers. The sampling equipment is provided by a laboratory certified to perform EPA Method TO-14 or TO-15 by New York State Department of Health (NYSDOH) Environmental Laboratory Approval Program (ELAP). NYSDOH ELAP will certify the sampling canister preparation procedure and equipment. Canisters may be 1-liter (L) or 1.4-L "Mini-Cans" or 6-L Summa canisters. The choice of canister depends on the sampling conditions and laboratory availability. Canisters must be certified clean (in accordance with EPA Method TO-15) and under a vacuum pressure of no more than -25 inches of mercury (in Hg). Batch cleaning is acceptable as long as the cleaning process is certified by NYSDOH. Flow controllers must be set for the appropriate collection period (1- or 24-hour, typical) (flow rate dependent upon size of canister). Flow controllers must maintain a constant flow over the sampling period. Note the method description below:

> "With a critical orifice flow restrictor, there will be a decrease in the flow rate as the pressure approaches atmospheric. However, with a mass flow controller, the subatmospheric sampling system can maintain a constant flow rate from full vacuum to within about 7 kPa [kilopascals] (1.0 psi [pound per square inch) or less below ambient pressure."

The laboratory must be notified at least two weeks in advance of sampling to ensure the canisters are available. The laboratory should provide enough canisters for one week of sampling with an extra 10% to account for added samples (e.g. multiple sub-slab samples in one structure) and regulator/canister failures (e.g., sampling rate incorrect, initial canister pressure too high).

4. Multimedia Sampling Procedures

4.1 Soil Vapor Samples

4.1.1 Selection of Sampling Locations

1. **To evaluate the potential for current on-site or off-site exposures, collect soil vapor samples:**

   - In the vicinity of a building's foundation at a point located between the building and the contaminant source or along the site's perimeter. <*For buildings with no surrounding surface confining layer (e.g., pavement or sidewalk), samples should* *be located in native or undisturbed soils away from fill material surrounding the building (approximately 10 feet away from the building) to avoid sampling in an area that may be influenced by the building's operations. For example, operation of HVAC systems, fireplaces, or mechanical equipment (e.g., clothes dryers or exhaust fans/vents) in a building may exacerbate the infiltration of outdoor air into the vadose zone adjacent to the building. As a result, soil vapor samples collected in uncovered areas adjacent to the building may not be representative*>; and

- At a depth of approximately 8 feet below grade or comparable to the depth of foundation footings (determined on a building-specific or site-specific basis). <*In areas where the groundwater table is less than 6 feet below grade, collect soil vapor samples at least 1 foot above the water table but no shallower than 4 feet below grade*>.

2. **To evaluate the potential for future exposures if development on a known or suspected contaminated area on-site or off-site is possible, collect soil vapor samples:**

   - In areas with either known or suspected subsurface sources of volatile chemicals, where elevated readings were obtained with field equipment during previous investigations, or where volatile organic compound contamination is reported to be present in the upper groundwater. <*If information is limited for the area, collect soil vapor samples in a grid pattern across the area at an appropriate spacing interval relative to the size of the area*>; and

   - At multiple depths from the suspected subsurface source (no deeper than 1 foot above the water table), or former source, to a depth comparable to the expected depth of foundation footings.

3. **To evaluate the potential for off-site vapor contamination, collect soil vapor samples:**

   - Along the site's perimeter or in areas of potential subsurface sources of vapor contamination (e.g., a groundwater source that has migrated off-site); and

   - At a depth comparable to the depth of foundation footings (determined on a site-specific basis). <*In areas where the groundwater table is less than 6 feet below grade, collect soil vapor samples at least one foot above the water table but no shallower than 4 feet below grade* >.

4. **To evaluate on-site and off-site preferential migration pathways in areas with low permeability soils, collect soil vapor samples:**

   - Along preferential soil vapor flow paths, such as sewer lines, utility corridors, trenches, pipelines, and other subsurface structures that are likely to be bedded with higher permeability materials; and

   - At depths corresponding to these subsurface features (depends on site-specific conditions).

5. **To characterize on-site or off-site contamination in the vadose zone, collect soil vapor samples:**

   - In areas with either known or suspected subsurface sources of volatile chemicals, where elevated readings were obtained with field equipment (eg; PID) during previous investigations, or where volatile chemical contamination is reported to be present in the upper groundwater; and

   - At appropriate depths associated with these areas (depends on site-specific conditions).

6. **To investigate the influence of contaminated groundwater or soil on soil vapor and to characterize the vertical profile of contamination, collect soil vapor samples:**

   - From clusters of soil vapor probes at varying depths in the vadose zone (no deeper than 1 foot above the water table) and preferably in conjunction with the collection of groundwater or soil samples.

4.1.2 Preparation

For **permanent soil vapor sampling probes**, the following sampling preparation procedure is to be followed:

- Create a hole in the soil of at least 1-inch diameter using direct push or an auger to the desired sampling depth (typically 8 feet below grade).

- Insert rigid tubing (e.g., stainless steel) of the appropriate size (typically ⅛- to ¼-inch inner diameter) into the constructed soil probe hole, keeping the bottom of the tubing at least 6 inches off the bottom of the hole and extend it to the surface. Alternatively, install a soil gas implant such as that manufactured by Geoprobe Systems. The Geoprobe Soil Gas Implant consists of double-woven stainless steel screen available in 6-, 14-, and 21-inch lengths. The implant is installed through the bore after the Geoprobe rods have been driven to depth. Flexible tubing (e.g., polyethylene or Teflon-lined polyethylene) is connected to the top of the implant and extended to the surface. Cap the tubing at the surface.

- Place porous backfill material (e.g., glass beads or coarse sand) into soil probe hole around the tubing/implant to create a sampling zone of 1 to 2 feet in length.

- Place a minimum of 6 to 12 linear inches of granular bentonite above the glass beads/sand pack and hydrate with potable water.

- Mix and install at least 3 linear feet of grout (Portland cement with 5% bentonite by weight or a premixed non-shrinking grout) in the annular space around the tubing to prevent direct infiltration of air from the surface. Backfill the remainder of the hole with clean material. For multiple probe depths in one borehole, the annular space should be grouted with bentonite between the probes to create discrete sampling zones.

- Install a protective casing around the top of the probe tubing and grout (e.g., concrete) in place.

For **temporary soil vapor sampling probes**, the installation procedures are identical to those described above with the following exceptions:

- A system such as the Geoprobe Post-Run Tubing (PRT) System may be used to eliminate the need for soil vapor implants, porous backfill, bentonite, and grout. Instead, soil vapor samples are collected using flexible tubing connected directly to a fitting at the bottom of the direct push rods after they have been advanced to depth and withdrawn approximately 6 inches. Soil vapor is drawn in from the open space beneath the rods.

- The interface between the rods and the soil must be sealed at the surface by excavating a small (1 to 3 inches deep) hole around the rods and packing it with hydrated bentonite, forming a slight mound at the surface.

- Direct-push rods and associated tooling must be decontaminated between locations.

4.1.3 Purging and Pre-Sample Testing

Prior to completing probe construction or attempting sample collection, the sample probe should be tested to determine if it will yield vapor for sampling (this is particularly important at sites with low permeability soils). Connect a syringe to the sample tubing and attempt to draw vapor into the syringe several times, sealing the sample tubing between draws. If a vacuum pressure is generated, the syringe plunger will be drawn back in when released and vapor sample collection will not proceed. Alternatively, the pump of an organic vapor or helium detector may be used by connecting the inlet of the operating device to the sample tubing and observing the ability of the pump to operate without creating a vacuum and stopping.

To purge ambient air from the sample tubing and to ensure that representative samples are being collected that are not affected by ambient air, the following steps should be followed:

- Connect the helium detector to the sample tubing to obtain “background” helium concentrations (helium is unlikely to be present in the subsurface at a detectable concentration; however, water vapor and certain organic vapors can interfere with the helium detector yielding a false detection).

- Place the bucket over the sample tube, gasket side down, and slip the sample tube through one of the predrilled holes. Insert a tube from the helium tank through another of the predrilled holes with the tubing outlet just above the ground surface (bottom of the inverted bucket). If a good seal cannot be obtained between the bucket gasket and the ground surface, place a hydrated bentonite seal around the bucket.

- Connect the helium detector to a test port installed near the base of the bucket and release helium into the bucket. The target concentration within the bucket is at least 25% helium.

- Disconnect the helium detector and plug the sample port. Connect the helium detector to the sample tube and measure the helium concentration in the soil vapor. Purge approximately 3 volumes of the tubing using the helium detector (approximately 10 milliliters [ml] per foot for ¼-inch inner diameter tubing).

- If the purge vapor is greater than 1% helium above background, reseal the probe hole with bentonite and repeat the purge/helium test process again. If after two successive attempts, the sample tube penetration cannot be thoroughly sealed, move to a new location or eliminate the soil vapor sample.

- Disconnect the helium detector from the sample tubing and reconnect to the test port in the bucket to ensure that helium was maintained with the test chamber throughout the duration of the test.

- Remove the bucket and helium supply when purging is complete.

- Begin sample collection.

4.1.4 Sample Collection

Soil vapor samples will be collected in specially prepared canisters equipped with a flow controller pre-set for a 1-hour sampling duration. For preparation of the canister and collection of the sample, the following procedure is to be followed:

- Place canister on a stable surface (ground) adjacent to the sample tube.

- Record the canister’s serial number on the chain of custody (COC) and field notebook/sample form.

- Assign sample identification on canister ID tag and record on COC and field notebook/sample form.

- Samples should be assigned an ID according to the following convention:

  SID-###-SC/Q

  - SID - Three letter code identifying the site (note that private property information such as street address must not be used in the sample identifier);
  - ### - Sequential location number (note that all samples from a single structure should have the same location ID for grouping of sample types by location ID);
  - SC – Sub-code identifying type of sample (note that additional numeric characters may be added for multiple samples of one type in a single structure);
  - Q - Quality control sample code such as D for duplicate.

  - The matrix codes are as follows:
    - BA - Indoor Air from Basement or Crawlspace
    - FA - Indoor Air, First Floor (not basement)
    - OA - Outdoor Air
    - SS - Sub-slab Vapor
    - SV - Soil vapor
    - TB - Trip Blank

- Remove plug from canister fitting, if equipped.

- Connect the sample tubing to the pressure gauge/flow controller.

- Install pressure gauge/metering valve on canister valve fitting if not already installed. *<For compression fittings [e.g., Swagelok], ensure the ferrule is properly seated, tighten the nut by hand, and complete tightening the nut ¼-turn with a wrench.>*

- Open and close the canister valve, if so equipped. *<Some flow controllers do not include valves and sample collection is initiated immediately when the controller is connected to the canister. In this case, it is important to ensure that the sample tubing is properly connected to the flow controller prior to connecting the flow controller to the sample canister.>*

- Record gauge pressure; vacuum gauge pressure must read -25 in Hg or less or the canister cannot be used without verification from the laboratory that the canister did not leak during transport (i.e., the laboratory should supply the vacuum pressure for the canister when it was measured prior to shipment).

- Open canister valve to initiate sample collection. Observe the gauge pressure after approximately 1 to 2 minutes. The pressures should increase by approximately 1 in Hg per 2 minutes. If the pressure increases too rapidly, there may be a leak in the system and sample collection should be terminated. Identify the leak and recollect the sample using a new cylinder and flow controller.

- Take digital photograph of canister setup and surrounding area.
- Record the start time on COC and in the field notebook/sample form.

Procedure for termination of sample collection:

- Close the canister valve.
- Record the stop time on COC and in the field notebook/sample form. The date of the stop time will be considered the date of sampling for QC purposes.
- Record the final gauge pressure; vacuum gauge pressure should read between approximately -5 and 0 in Hg.
- Disconnect the sample tubing and pressure gauge/flow controller from canister, if applicable.
- Install plug on canister inlet fitting <*and on sample tubing for permanent probes*>.
- Place the sample container in the original box.
- For temporary sampling locations, remove the sample tubing and rods and backfill the hole with clean material.
- Fill in the sample collection log with the appropriate information; including, sample identification, date and time of sample collection, sampling depth, identity of samplers, sampling methods and devices, purge volumes, volume of soil vapor extracted, canisters used, the vacuum before and after samples collected, apparent moisture content (dry, moist, saturated, etc.) of the sampling zone, and log each sample on the COC form.
- All canisters will be returned at the completion of the field sampling to the laboratory by overnight shipment or courier. No work or shipment of samples will be expected on weekends or holidays, without prior notice.

4.2 Sub-slab Vapor Samples

4.2.1 Selection of Sampling Locations

To evaluate the potential for current human exposure within a building, collect sub-slab vapor samples:

- In structures with a concrete slab or other flooring from a central location away from foundation footings and within the soil or aggregate immediately below the basement slab or slab-on-grade. <*The number of sub-slab vapor samples required in a building depends upon the number of slabs (e.g., multiple slabs-on-grade in a large ware-*

house) and foundation types (e.g., combined basement and slab-on-grade in a residence). At least one sub-slab sample should be collected from each representative area. In structures within partial slabs or utility pads, collect the sub-slab vapor sample from beneath the pad>.

- In structures with dirt floors (basement or crawlspaces), sub-slab samples are not collected but indoor air samples in the basement or crawlspace will be collected.

4.2.2 Preparation

For the sub-slab vapor sampling, the following sampling preparation procedure is to be followed for concrete basement/floor slabs:

- Drill a ½-inch diameter hole (or appropriate size for the sample tubing to be used) completely through the concrete floor slab using an electric rotary hammer drill and masonry bit; brush the concrete dust away from the hole. Record the approximate thickness of the slab.

- Drill a 1-inch diameter hole (nominal diameter) 1 to 2 inches into the concrete floor centered on the ½-inch hole. <*The 1-inch diameter hole may be drilled first at the discretion of the field team leader*>.

- Sweep excess concrete dust away from the drill hole and clean the hole with a ½-inch bottle brush.

- Insert flexible tubing through the hole with the bottom no more than 2 inches below the bottom of the slab.

- Mix a paste of bentonite and water. Place the bentonite paste at the bottom of the 1-inch diameter drill hole around the tubing and form a small mound over the area to seal the interface between the tubing and the concrete.

- Concrete dust can be cleaned up with a vacuum equipped with a HEPA filter only after the sample tubing is properly sealed and sample collection has begun.

4.2.3 Purging and Pre-Sample Testing

To purge ambient air from the sample tubing and to ensure that representative samples are being collected from beneath the slab, the following steps should be followed:

- Attach the syringe to the sample tubing and withdraw approximately 3 volumes of the sample tubing (approximately 10-ml per foot for ¼-inch inner diameter tubing). <*Note the difficulty with which the air is withdrawn; if it is very difficult to withdraw the purge volume, then the sample tube may be plugged at the bottom and should be reinstalled and repurged. If indoor air sampling is to be conducted, then the purged vapor should be discharged outside to prevent cross-contamination (either cap the syringe or discharge to a Tedlar bag and empty the Tedlar bag outside). Prior to* *discharge, measure the organic vapor concentration of the purged air using a photoionization detector (PID) and record the reading. A PID may be used to purged the sample tubing; however, the exhaust must be captured for discharge outside if in-door air sampling is planned>.*

- Begin sample collection.

4.2.4 Sample Collection

For preparation of the canister and collection of the sub-slab vapor sample, the procedure described in Section 4.1.4 is to be followed with the following exceptions:

- Flow controllers must be set for a **24-hour** collection period.
- Upon initiation of sample collection, the pressure should not appear to change in a short period. If the pressure increases too rapidly, there may be a leak in the system and sample collection should be terminated. Identify the leak and recollect the sample using a new cylinder and flow controller.
- When possible, return to the sample location after approximately 1 hour to verify that sample collection is progressing (the gauge pressure should increase by approximately 1 in Hg per hour).

4.3 Indoor Air Samples

4.3.1 Selection of Sampling Locations

To characterize contaminant concentration trends and potential exposures within a building, collect indoor air samples

- From the crawlspace area;
- From the basement (where vapor infiltration is suspected or in a central location) at a height approximately 3 feet above the floor to represent a height at which occupants normally are seated and/or sleep;
- From the lowest level living space (in centrally-located, high-use areas) at a height approximately 3 feet above the floor to represent a height at which occupants normally are seated and/or sleep; and
- If in a commercial setting (e.g., a strip mall), from multiple tenant spaces at a height approximately 3 feet above the floor to represent a height at which occupants normally are seated.

4.3.2 Preparation

- Conduct a pre-sampling inspection prior to each sampling event to identify conditions that may affect or interfere with the proposed testing including the type of structure, floor layout, physical conditions, and airflows of the building(s) being studied. *<Many State health departments provide reporting forms for this information. For example, in New York State use the NYS Department of Health Indoor Air Quality Questionnaire and Building Inventory form. This form is attached for reference and may be modified for use outside of New York.>*

- Conduct a product inventory to identify potential air sampling interference by characterizing the occurrence and use of chemicals and products throughout the building, keeping in mind the goal of the investigation and site-specific contaminants of concern. <*For example, it is not necessary to provide detailed information for each individual container of like items. However it is necessary to indicate that "20 bottles of perfume" or "12 cans of latex paint" were present with containers in good condition*>.

- Take inventory of each room on the floor of the building being tested and on lower floors, if possible. <*This is important because even products stored in another area of a building can affect the air of the room being tested. For example, when testing for a petroleum spill, all indoor sources of petroleum hydrocarbons should be scrutinized. These can include household and commercial products containing volatile organic compounds (VOCs), petroleum products including fuel from gasoline-operated equipment, unvented space heaters and heating oil tanks, storage and/or recent use of petroleum-based finishes and paints or products containing petroleum distillates. This information should be detailed on the Product Inventory Form*>.

- Draw plot sketches of the building interior (crawlspace, basement, and/or first floor) that includes sample locations, possible indoor air pollution sources, floor types, footings that create separate foundation sections, and vapor intrusion pathways into the building (cracks, utility penetrations, sumps, etc.).

- If the inventory identifies indoor sources of air contamination that may interfere with the objectives of the investigation, the following measures should be implemented:

- Remove products or eliminate activities that may result in the release of volatile chemicals from the indoor environment prior to testing.

- Make sure all containers storing volatile chemicals are tightly sealed.

- Ventilate building by operating the building's heating ventilation and air conditioning (HVAC) system to maximize outside air intake or open windows/doors and operate exhaust fans if the building has no HVAC system.

- Note any measures taken to control indoor air interferences on the building inspection form.

- Do not begin sample collection for at least 24 hours after implementing these measures.

FOR 24 HOURS PRIOR TO SAMPLING, ALL REASONABLE MEASURES SHOULD BE TAKEN TO AVOID:

- Opening any windows, fireplace dampers, openings, or vents;
- Operating ventilation fans unless special arrangements are made;
- Smoking in the house;
- Painting;
- Using wood stoves, fireplaces or other auxiliary heating equipment (e.g., kerosene heaters);
- Operating or storing automobiles in an attached garage;
- Allowing containers of gasoline or oil to remain within the house, except for fuel oil tanks;
- Cleaning, waxing, or polishing furniture or floors with petroleum- or oil-based products;
- Using air fresheners or odor eliminators;
- Engaging in any hobbies that use materials containing volatile organic chemicals;
- Using cosmetics, including hairspray, nail polish, nail polish removers, perfume/cologne, etc.;
- Applying pesticides; and
- Storing recently dry-cleaned clothing and materials.

4.3.3 Purging and Pre-Sample Testing

- Use portable vapor monitoring equipment readings (e.g., PIDs for VOCs, Mercury Vapor Analyzer for mercury) to evaluate potential sources of chemical products stored in the building. Due to the low detection limits typically achieved for air sampling, a PID capable of measuring VOCs in the parts-per-billion (ppb) range is recommended. However, the ionization potential of the chemicals of interest must be considered when selecting a PID.
- Take inventory of products stored in buildings **every time** air is tested. <*If available, chemical ingredients of interest should be recorded for each product. If the ingredi-*

ents are not listed on the label, record the product's exact and full name, and the manufacturer's name, address and phone number, if available. In some cases, Material Safety Data Sheets may be useful for identifying confounding sources.>

4.3.4 Sample Collection

For preparation of the canister and collection of the indoor air sample, the procedure described in Section 4.2.4 is to be followed with the following exceptions:

- The canister may be placed on a stable surface approximately 3 feet above the floor or it may be placed on the floor with flexible sample tubing extended from the canister to a collection height of approximately 3 feet.

4.4 Outdoor Air Samples

4.4.1 Selection of Sampling Locations

To characterize "background" contaminant concentrations in ambient air, collect outdoor air samples from a representative upwind location:

- Whenever indoor air sampling is being conducted;
- Away from wind obstructions (e.g., trees or bushes); and
- At a height above the ground to represent breathing zones (3 to 5 feet).

A representative sample is one that is not biased toward obvious sources of volatile chemicals (e.g., automobiles, lawn mowers, oil storage tanks, gasoline stations, industrial facilities, etc.). Outdoor ambient air samples should be collected at the rate of one per day in the vicinity of indoor air sample locations.

4.4.2 Preparation

The following actions should be taken to document conditions during outdoor air sampling and ultimately to aid in the interpretation of the sampling results:

- Draw a plot sketch of the sampling area that includes sample locations, buildings and other nearby structures, possible sources of outdoor air pollution (industries, gas stations, repair shops, etc.), and wind direction.
- Record weather (e.g., precipitation, temperature, and barometric pressure); and
- Record any pertinent observations, such as odors, readings from field instrumentation, and significant activities in the vicinity (e.g., operation of heavy equipment or dry cleaners).

4.4.3 Purging and Pre-Sample Testing

None.

4.4.4 Sample Collection

For preparation of the canister and collection of the outdoor air sample, the procedure described in Section 4.3.4 is to be followed.

5. Quality Assurance

5.1 Quality Assurance/Quality Control Samples

Field quality control (QC) samples may include duplicates and trip blanks, as determined on a site-specific basis. Duplicate samples provide insight as to the homogeneity of the sample matrix and establish a degree of confidence that the sample represents site conditions. The relative percent difference between the concentrations in the original and duplicate samples measure the overall precision of the field sampling and analytical method. Field duplicates must be collected at a rate that satisfies the data quality objectives of the program and can be project specific. In the absence of project-specific requirements, collect duplicates at the rate of one duplicate per 20 original samples (5%).

Trip blanks are collected to establish that the transport of sample canisters to and from the field does not result in the contamination of the sample from external sources. Trip blanks consist of an unopened, precleaned, certified canister shipped from the laboratory with the sample collection canisters, stored on site with the sample collection canisters, and returned to the laboratory unopened. Typically, trip blanks are submitted for analysis with each sample shipment. However, the applicability of trip blanks must be determined on a site-specific basis since they are not required by the analytical method (typically TO-15). It is not possible to mimic round-trip shipping conditions with a single trip blank since sample canisters are shipped from the lab under vacuum pressure and are returned to the lab at or close to ambient pressure.

Field QC sample results must be assessed during data review.

5.2 Sample Analysis

All air and vapor samples will be analyzed using USEPA Method TO-15 or another approved method suitable to meet the data quality objectives of the project. Analyses must be performed by a laboratory certified for the particular analysis in the State or Federal program in which the project is being conducted. In New York State, laboratories must be certified by the NYSDOH ELAP. The analyte list must be selected to comply with the data quality objectives of the project. For example, chlorinated solvents may be selected for drycleaner sites and aromatic/petroleum hydrocarbons may be selected for fuel spill sites. Reporting limits should be approximately 1 microgram per cubic meter ($\mu g/m^3$) for all compounds, unless otherwise specified to meet data quality objectives. For example, in New York State, a reporting limit of 0.25 $\mu g/m^3$ must be met for trichloroethene in indoor and outdoor air samples.

6. Health and Safety

The type of personnel protective equipment (PPE) to be used during sampling is outlined in the site-specific Health and Safety Plan (HASP) and is contaminant specific. The HASP should be reviewed with specific emphasis placed on the safety procedures to be followed. Standard safe operating practices should be followed, such as minimizing contact with potential contaminants in both the vapor phase and liquid matrix through the use of respirators and protective clothing during soil vapor sampling. Typically, exposure to contaminants is minimal during sub-slab vapor, indoor air, and outdoor air sampling and PPE is not required; however, this must be determined on a site- and location-specific basis.

7. References

New York State Department of Health, February 2005, *Guidance for Evaluating Soil Vapor Intrusion in the State of New York*, Public Comment Draft.

United States Environmental Protection Agency, November 2002, *OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance)*, EPA530-D-02-004.

CONFIDENTIAL

OSR – 3
(EEEPC Revision 2)

NEW YORK STATE DEPARTMENT OF HEALTH
INDOOR AIR QUALITY QUESTIONNAIRE AND BUILDING INVENTORY
CENTER FOR ENVIRONMENTAL HEALTH

This form must be completed for each residence involved in indoor air testing.

Preparer's Name ________________________________ Date/Time Prepared ________________

Preparer's Affiliation ____________________________ Phone No.________________________

Purpose of Investigation____

Property Address:____

Location/Sample ID:____

1. OCCUPANT: Interviewed: Y / N

Last Name: ________________________ First Name: ________________________

Address: ____

County: ________________

Home Phone: ___________________ Office Phone: ___________________

Number of Occupants/persons at this location _______ Age of Occupants ______________________

2. OWNER OR LANDLORD: (Check if same as occupant ___) **Interviewed: Y / N**

Last Name: ________________________First Name: __________________________

Address: ____

County: ________________

Home Phone: ___________________ Office Phone: ___________________

3. BUILDING CHARACTERISTICS -Type of Building: (Circle appropriate response)

Residential	School	Commercial / Multi-use
Industrial	Church	Municipal / Government
Other (Describe): _______________________		

If the property is residential, type? (Circle appropriate response)

Ranch	2-Family	3-Family
Raised Ranch	Split Level	Colonial
Cape Cod	Contemporary	Mobile Home
Duplex	Apartment House	Townhouses/Condos
Modular	Log Home	Other:_______________

If multiple units, how many? ________

If the property is commercial, type?

Business Type(s) ____

Does it include residences (i.e., multi-use)? Y / N If yes, how many? ______

Other Building Characteristics:

Number of floors______ Approx. building age______

Is the building insulated? Y / N How air tight? Tight / Average / Not Tight

4. AIRFLOW

Qualitatively describe:

Airflow between floors

____

____

____

Airflow near source

____

____

____

Outdoor air infiltration

____

____

____

Infiltration into air ducts

____

____

____

5. BASEMENT AND CONSTRUCTION CHARACTERISTICS (Circle all that apply)

a. Above grade construction:	wood frame	concrete	stone	brick	other _________
b. Basement type:	full	crawlspace	slab	other _________	
c. Basement floor:	concrete	dirt	stone	other _________	
d. Basement floor:	uncovered	covered	covered with ________________		
e. Concrete floor:	unsealed	sealed	sealed with _________________		
f. Foundation walls:	poured	block	stone	other _________	
g. Foundation walls:	unsealed	sealed	sealed with _________________		
h. The basement is:	wet	damp	dry	moldy	
i. The basement is:	finished	unfinished	partially finished		
j. Sump present?	Y / N				
k. Water in sump?	Y / N / NA				
l. Sump covered/sealed?	Y / N / NA				
m. Floor drains present?	Y / N / NA				
n. Perimeter trench drains present?	Y / N / NA				
o. Indoor cisterns/drywell?	Y / N / NA				
p. Laundry chute to 1st or 2nd Floors?	Y / N / NA				

Basement/Lowest level depth below grade: ________(feet)

Identify and describe potential soil vapor entry points and approximate size (e.g., floor cracks, utility ports, floor drains, wall cracks, weeps, or indoor wells)

____

____

____

Other Comments: ____

____

6. HEATING, VENTING and AIR CONDITIONING (Circle all that apply) Type of heating system(s) used in this building: (circle all that apply – note primary)

Hot air circulation	Heat pump	Hot water baseboard	
Space Heaters	Stream radiation	Radiant floor	
Electric baseboard	Wood stove	Outdoor wood boiler	Other ___________

Approximate age of heating system(s): _____________________

The primary type of fuel used is:

Natural Gas	Fuel Oil	Kerosene
Electric	Propane	Solar
Wood	Coal	

Domestic hot water tank fueled by: ____________________________

Fuel oil storage location/condition/size, if applicable:__________________________________

Boiler/furnace located in: Basement Outdoors Main Floor Other ______________________

Storage wood or coal: Basement Outdoors Main Floor Other ___________________

Fireplace(s) located in: Basement Main Floor Other _______________

Air conditioning: Central Air Window units Open Windows None

Dehumidification: Stand alone unit Located on central air system

Are there air distribution ducts present? Y / N

Describe the supply and cold air return ductwork, and its condition where visible, including whether there is a cold air return and the tightness of duct joints. Indicate the locations on the floor plan diagram.

____

____

____

____

7. OCCUPANCY Is basement/lowest level occupied? Full-time Occasionally Seldom Almost Never

Level	**General Use of Each Floor (e.g., family room, bedroom, laundry, workshop, storage)**
Basement	____
1st Floor	____
2nd Floor	____
3rd Floor	____
4th Floor	____

8. FACTORS THAT MAY INFLUENCE INDOOR AIR QUALITY

a. **Is there an attached garage?** Y / N

b. **Does the garage have a separate heating unit?** Y / N / NA

c. **Are petroleum-powered machines or vehicles stored in the garage** (e.g., lawnmower, atv, car, boat) Y / N / NA
Please specify_________________________

d. **Has the building ever had a fire?** Y / N When?________________________

e. **Is a kerosene or unvented gas space heater present?** Y / N Where? ______________________

f. Is there a workshop or hobby/craft area? Y / N Where & Type? _______________________

g. Is there smoking in the building? Y / N How frequently? _______________________

h. Have cleaning products been used recently? Y / N When & Type? _______________________

i. Have cosmetic products been used recently? Y / N When & Type? _______________________

j. Has painting/staining been done in the last 6 months? Y / N Where & When? _______________________

k. Is there new carpet, drapes or other textiles? Y / N Where & When? _______________________

l. Have air fresheners been used recently? Y / N When & Type? _______________________

m. Is there a kitchen exhaust fan? Y / N If yes, where vented? ___________________

n. Is there a bathroom exhaust fan? ☐ Basement ☐ First floor Y / N If yes, where vented? ___________________

o. Is there a clothes dryer? ☐ Gas ☐ Electric Y / N If yes, is it vented outside? Y / N

p. Has there been a pesticide application? Y / N When & Type? _______________________

q. Basement windows? Type: Casement Awning Glass block Condition: _______________________

r. Are there exterior doors in the basement (e.g. "Bilco") Y / N / NA

Are there odors in the building? Y / N
If yes, please describe: ____

Do any of the building occupants use solvents at work? Y / N (e.g., chemical manufacturing or laboratory, auto mechanic or auto body shop, painting, fuel oil delivery, boiler mechanic, pesticide application, cosmetologist

If yes, what types of solvents are used? ____

If yes, are their clothes washed at work? Y / N

Do any of the building occupants regularly use or work at a dry-cleaning service? (Circle appropriate response)

Yes, use dry-cleaning regularly (weekly) No

Yes, use dry-cleaning infrequently (monthly or less) Unknown

Yes, work at a dry-cleaning service

Is there a radon mitigation system for the building/structure? Y / N Date of Installation: _______________

Is the system active or passive? Active/Passive

9. WATER AND SEWAGE

Water Supply:	Public Water	Drilled Well	Driven Well	Dug Well	Other: _______
Sewage Disposal:	Public Sewer	Septic Tank	Leach Field	Dry Well	Other: _______

11. OTHER ENVIRONMENTAL HAZARDS OBSERVED

Note factors that may impact vapor mitigation system installation or other construction activities:

A. Asbestos: Yes No Suspected

1. Location & Estimated Quantity: ____

   ____

2. General Condition: Good Fair Poor

3. Other Comments: ____

   ____

B: Lead Paint: Yes No Suspected

1. Location & Estimated Quantity: ____

   ____

2. General Condition: Good Fair Poor

3. Other Comments: ____

   ____

12. Photographs

Photograph the basement and first floor of the building including possible air sampling locations and/or possible indoor air pollution sources. Include photo ID, compass direction, date, and subject.

Photo ID:	**Direction:**	**Date/Time:**
Subject:		

Photo ID:	**Direction:**	**Date/Time:**
Subject:		

Photo ID:	**Direction:**	**Date/Time:**
Subject:		

13. FLOOR PLANS

Draw a plan view sketch of the basement and first floor of the building. Indicate air sampling locations, possible indoor air pollution sources and PID meter readings. If the building does not have a basement, please note. **Include compass orientation or reference to street or front of house.**

Basement:

First Floor:

14. OUTDOOR PLOT

Draw a sketch of the area surrounding the building being sampled. If applicable, provide information on spill locations, potential air contamination sources (industries, gas stations, repair shops, landfills, etc.), outdoor air sampling location(s) and PID meter readings.

Also indicate compass direction, wind direction and speed during sampling, the locations of the well and septic system, if applicable, and a qualifying statement to help locate the site on a topographic map.

15. PRODUCT INVENTORY FORM

Page ___ of ___

Make & Model of field instrument used: ____________________________________

List specific products found in the residence that have the potential to affect indoor air quality.

Location	Product Description	Size (units)	Condition *	Chemical Ingredients	Field Instrument Reading (units)	Photo Y / N **

* Describe the condition of the product containers as **Unopened (UO), Used (U),** or **Deteriorated (D)**

** Photographs of the **front and back** of product containers can replace the handwritten list of chemical ingredients. However, the photographs must be of good quality and ingredient labels must be legible.

ecology and environment engineering, p.c.
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Tel: 716/684-8060, Fax: 716/684-0844

Soil Vapor Intrusion/Indoor Air Sampling Data Collection Form

Site Name:	Project No.:

Sample Location Information

Location ID/Description:		
Address:	**City:**	**State:**

Sampler Names (Print):

Building Inspection & Inventory Performed? ☐ Yes ☐ No

Organic Vapor Meter Used: ☐ PID ☐ FID Model:

		Sub-slab Vapor	Basement Air	First-floor Air	Outdoor Air			
Sample ID								
Canister No.								
Regulator No.								
Duration (hours)								
Start	Date							
	Time							
	Pressure							
End	Date							
	Time							
	Pressure							
Quality Control								
OVM (ppb)								
Analysis Method								

Laboratory:	**Date Shipped to Lab:**
Associated Trip Blank Sample ID:	
Comments:	

Key:
FID = flame-ionization detector
OVM = organic vapor meter
PID = photo-ionization detector
ppb = parts per billion
Pressure measured in inches of mercury, gauge (in Hg)

Implants Operation

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Attaching polyethylene tubing to the sampling implant.

Sampling Implants – Operation

Installation Instructions for Soil Gas Implants

1. Drive probe rods to the desired depth using a Point Holder (AT-13B) and an Implant Anchor/Drive Point (PR-14). DO NOT disengage the drive point when depth has been reached.

2. Attach appropriate tubing to the implant **(Figure 1)**. If tubing is pre-cut, allow it to be approximately 48 in. (1219 mm) longer than the required depth of the implant. Cover or plug the open end of the tubing.

3. Remove pull cap and lower the implant and tubing down inside the diameter of the probe rods until the implant hits the top of the Anchor/Drive Point. Note the length of the tubing to assure that proper depth has been reached.

4. Rotate tubing counterclockwise while exerting a gentle downward force to engage the PRT threads **(Figure 2)**. Pull up on the tubing lightly to test the connection. DO NOT cut excess tubing.

5. Position a Probe Rod Pull Plate or Manual Probe Rod Jack on the top probe rod. Exert downward pressure on the tubing while pulling the probe rods up. Pull up about 12 in. (305 mm).

6. If using 1/4-in. (6,4 mm) O.D. tubing or smaller, thread the excess tubing through the Implant Funnel and position it over the top probe rod. If using larger tubing, it may not be possible to install the glass beads.

Figure 1. Attaching tubing to the sampling implant.

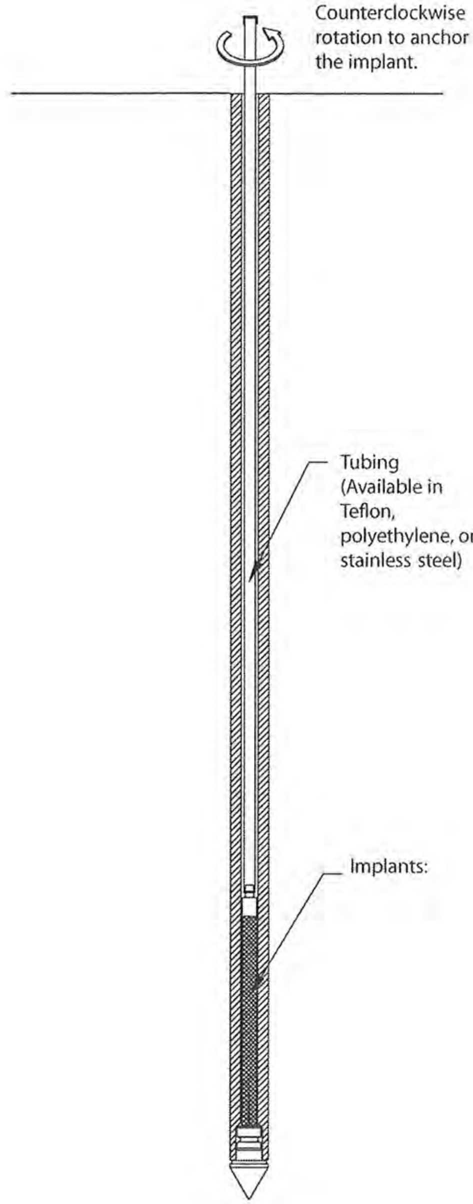


Figure 2. Once depth is achieved, the selected implant and tubing are inserted through the rods. The tubing is rotated to lock the implant into the drive point.

7. Pour glass beads down the inside diameter of the probe rods around the outside of the tubing. Use the tubing to "stir" the glass beads into place around the implant. Do not lift up on tubing. It should take less than 150 mL of glass beads to fill the space around the implant.

   NOTE: Backfilling through the rods with glass beads or glass beads/bentonite mixes can only be performed in the Vadose Zone, not below the water table.

8. Lift up an additional 18 to 24 in. (457 to 610 mm) and pour the bentonite seal mixture into place as in Step 7. The volume to be filled is about 154 mL per foot. It may be necessary to "chase" the seal mixture with distilled water to initiate the seal.

9. Pull the remaining rods out of the hole as in Step 5. Backfilling with sackcrete (cement/sand) or bentonite/sand may be done while removing the rods **(Figure 4)**. If the PR-14 Implant Anchor is used, the tubing may be cut flush with the top probe rod and a regular pull cap may be used to remove the remaining probe rods after Step 8.

10. After the probe rods have been removed, cut the tubing at the surface, attach a connector or plug, and mark the location with a pin flag or stake. The point is ready for sampling now.

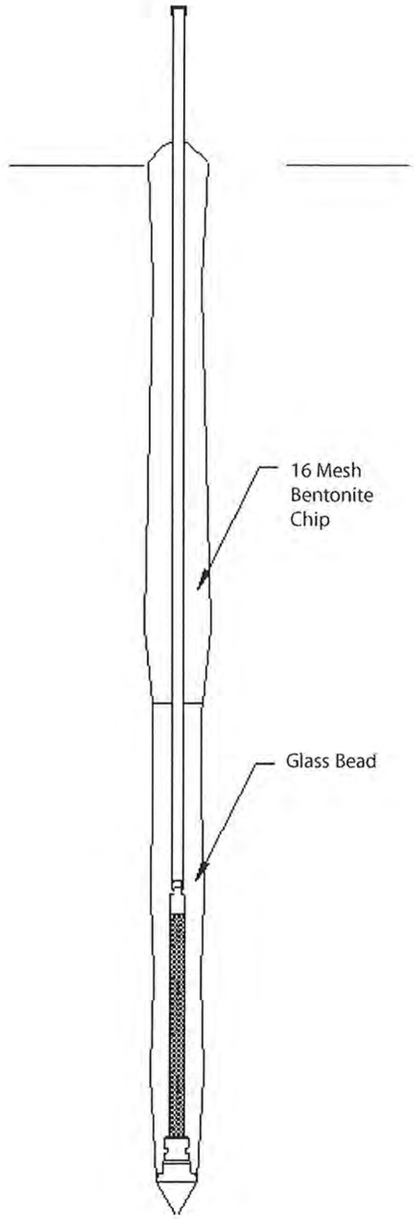
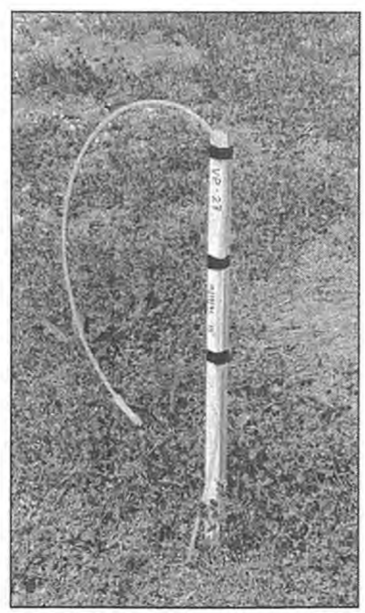


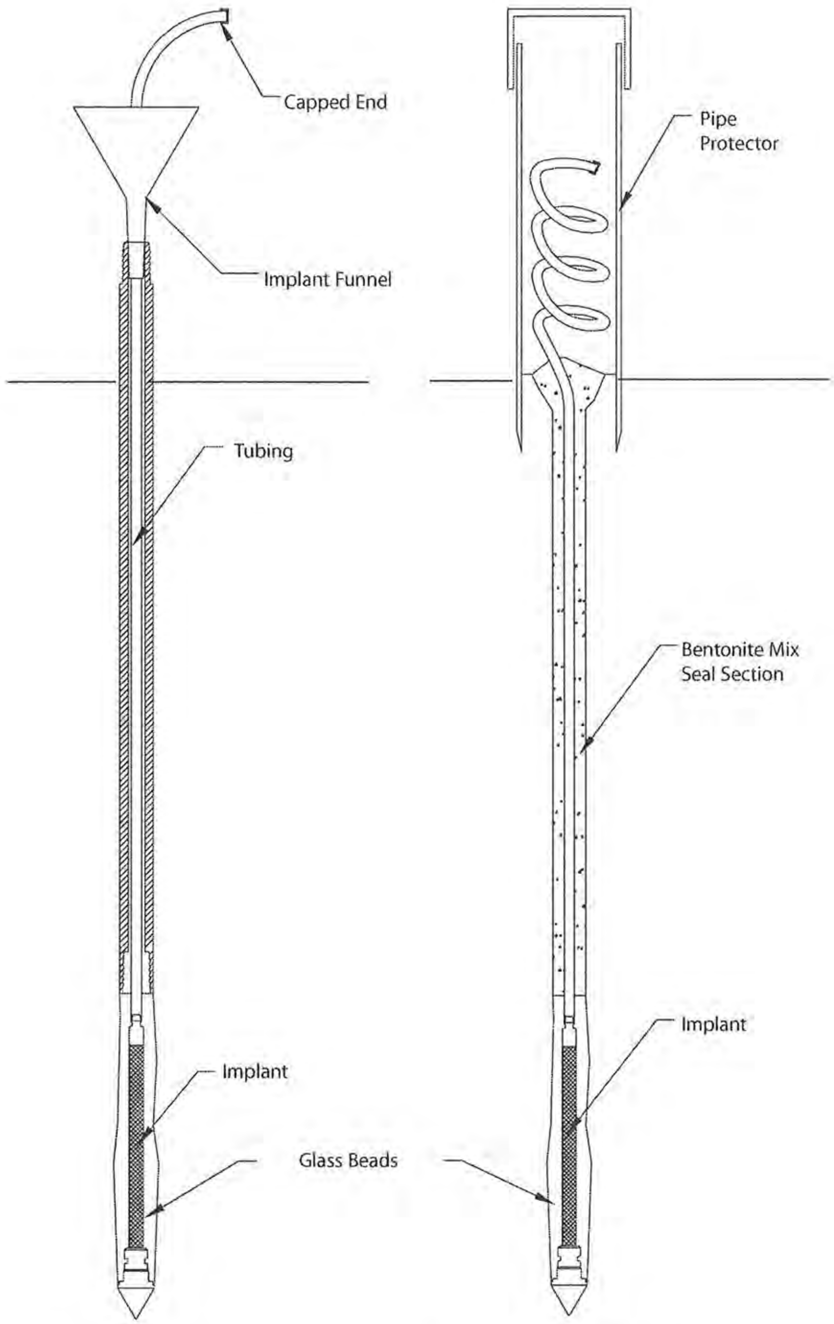
Figure 4. After the implant has been secured, the rods are removed and the annulus backfilled as appropriate.

Figure 3. Glass Beads create a permeable layer around vapor sample implants.



A vapor implant location.

Sampling Implants – Operation



Backfill materials include glass beads and bentonite sealants.

Example of completed permanent soil gas monitoring point.

Soil Gas Sampling – PRT System Operation

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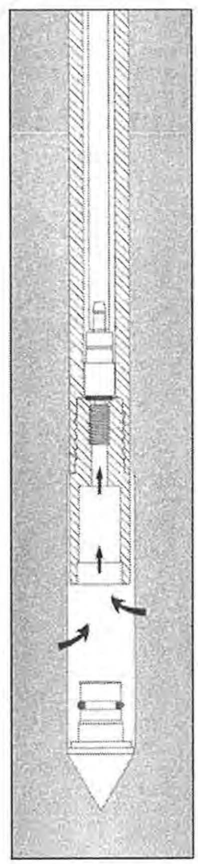


Soil Gas Sampling using the Post-Run Tubing (PRT) System.

Soil Gas Sampling — PRT System Operation

Basics

Using the Post-Run Tubing System, one can drive probe rods to the desired sampling depth, then insert and seal an internal tubing for soil gas sampling. The usual Geoprobe probe rods and driving accessories and the following tools are required:

- PRT Expendable Point Holder
- PRT Adapter
- Selected PRT Tubing

Preparation

1. Clean all parts prior to use. Install O-rings on the PRT Expendable Point Holder and the PRT adapter.

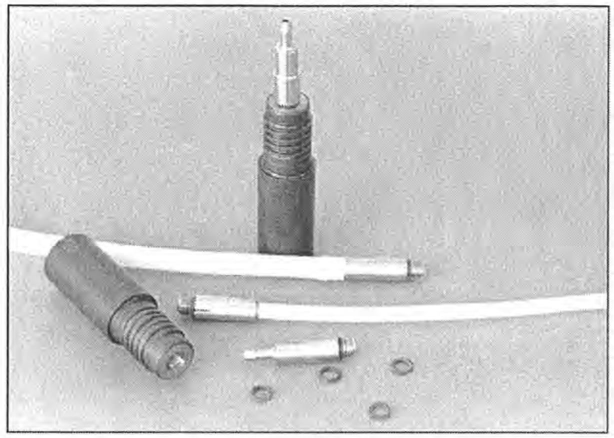
2. Inspect the probe rods and clear them of all obstructions.

3. TEST FIT the adapter with the PRT fitting on the expendable point holder to assure that the threads are compatible and fit together smoothly.

   NOTE: PRT fittings are left-hand threaded.

4. Push the adapter into the end of the selected tubing. Tape may be used on the outside of the adapter and tubing to prevent the tubing from spinning freely around the adapter during connection – especially when using Teflon tubing **(Figure 1)**.

   REMEMBER: The sample will not contact the outside of the tubing or adapter.



PRT SYSTEM PARTS
PRT Expendable Point Holder, PRT Adapters, Tubing, and O-rings.

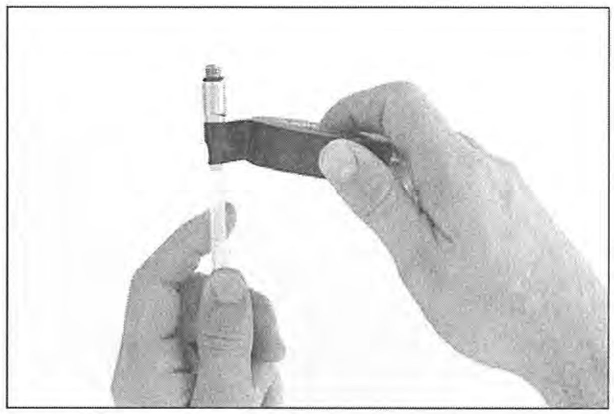


Figure 1. Securing adapter to tubing with tape. NOTE: Tape does not contact soil gas sample.

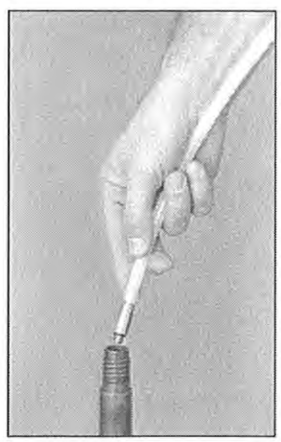


Figure 2. Insertion of tubing and PRT adapter.

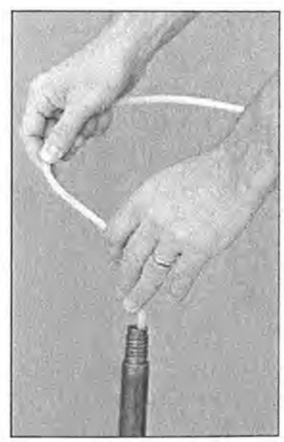
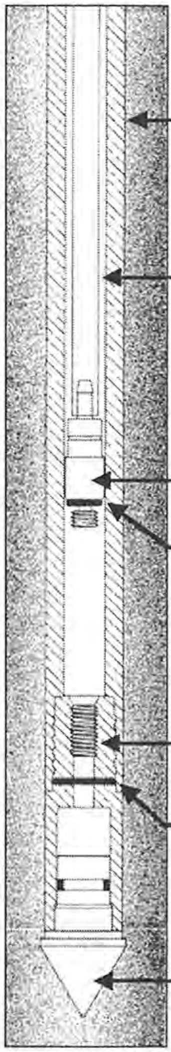


Figure 3. Engaging threads by rotating tubing.



A cross section of probe rods driven to depth and then retracted to allow for soil gas sampling. The PRT adapter and tubing are now fed through the rods and rotated to form a vacuum-tight connection at the point holder. The result is a continuous run of tubing from the sample level to the surface.

Probing

Drive the PRT tip configuration into the ground. Connect probe rods as necessary to reach the desired depth. After depth has been reached, disengage the expendable point by pulling up on the probe rods. Remove the pull cap from the top probe rod, and position the Geoprobe unit to allow room to work.

Connection

1. Insert the adapter end of the tubing down the inside diameter of the probe rods **(Figure 2)**.

2. Feed the tubing down the rod bore until it hits bottom on the expendable point holder. Allow about 2 ft. (610 mm) of tubing to extend out of the hole before cutting it.

3. Grasp the excess tubing and apply some downward pressure while turning it in a counterclockwise motion to engage the adapter threads with the expendable point holder **(Figure 3)**.

4. Pull up lightly on the tubing to test engagement of the threads. (Failure of adapter to thread could mean that intrusion of soil may have occurred during driving of probe rods or disengagement of drive point.)

Sampling

1. Connect the outer end of the tubing to the Silicone Tubing Adapter and vacuum hose (or other sampling apparatus).

2. Follow the appropriate sampling procedure for collecting a soil gas sample **(Figure 1)**.

Removal

1. After collecting a sample, disconnect the tubing from the vacuum hose or sampling system.

2. Pull up firmly on the tubing until it releases from the adapter at the bottom of the hole. (Taped tubing requires a stronger pull.)

3. Remove the tubing from the probe rods. Dispose of polyethylene tubing or decontaminate Teflon tubing as protocol dictates.

4. Retrieve the probe rods from the ground and recover the expendable point holder with the attached PRT adapter.

5. Inspect the O-ring at the base of the PRT adapter to verify that proper sealing was achieved during sampling. The O-ring should be compressed. This seal can be tested by capping the open end of the point holder applying vacuum to the PRT adapter.

6. Prepare for the next sample.

Figure 1. Taking a soil gas sample for direct injection into a GC with the PRT system.

ecology and environment, inc.

STANDARD OPERATING PROCEDURE

DRUM AND CONTAINER HANDLING AND SAMPLING

SOP NUMBER: ENV 3.31

REVISION DATE: 11/30/2017 **SCHEDULED REVIEW DATE: 11/30/2022**

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1 Scope and Application

This standard operating procedure (SOP) describes procedures used by Ecology and Environment, Inc. (E & E) for collecting samples from drums, tanks, vaults, and smaller containers in order to identify and characterize the material or waste for handling, management, transportation, and/or disposition. These procedures apply to drums, containers, tanks, and vaults such as those for which the contents are completely unknown and could contain hazardous materials or waste; drums containing purge water from groundwater well sampling; drums containing water resulting from decontamination activities; drums containing waste drill cuttings; lab pack drums and their contents; and miscellaneous small containers. Tanks and vaults containing hazardous substances will be handled in a manner similar to that for drums and containers, taking into consideration the size and orientation of the tank or vault. Specific handling and sampling procedures may vary depending on the data quality objectives (DQOs) identified in project planning documents. Procedures in this SOP are designed to meet the requirements of Occupational Safety and Health Administration (OSHA) Hazardous Waste Operations and Emergency Response regulations in Title 29 of the Code of Federal Regulations, Part 1910.120 (29 CFR 1910.120). Elements of these procedures are based on paragraph (j) of the standard, entitled Handling Drums and Containers (29 CFR 1910.120[j]).

This SOP does not include the sampling of containers or cylinders known to contain compressed gases.

Because the investigation of unknown drums and containers is one of the more hazardous activities that E & E conducts, this SOP addresses more health and safety-related information than is normally addressed in a procedural SOP. This SOP is intended for use by personnel who have knowledge, training, and experience in the drum and container sampling activities being conducted.

Other E & E SOPs that also would typically apply to drum and container sampling include the following:

- DOC 2.1, Field Activity Logbooks;
- ENV 3.2, Site Entry Procedures for Potentially Contaminated Sites;
- ENV 3.15, Sampling and Field Equipment Decontamination;
- ENV 3.16, Environmental Sample Handling, Packaging, and Shipping; and
- ENV 3.26, Handling Investigation-Derived Wastes.

2 Definitions and Acronyms

Bung	A threaded cap used to seal bung holes in a drum head or lid
Chine	A ridge in a metal drum
COLIWASA	Composite liquid waste sampler
DQO	Data quality objective
DOT	(United States) Department of Transportation
E & E	Ecology and Environment, Inc.
EPA	(United States) Environmental Protection Agency

NIOSH	National Institute for Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
PVC	Polyvinyl chloride
QA	Quality assurance
QC	Quality control
SHASP	Site-specific health and safety plan
SOP	Standard operating procedure

3 Procedure Summary

Prior to sampling, drums and containers will be safely inspected, inventoried, staged if necessary, and opened. Drums and containers are usually opened manually but can be opened remotely using specialized tools and equipment as necessary to ensure the health and safety of personnel. Drum and container sampling involves the selection and use of appropriate, often specialized, sampling devices.

4 Cautions

Cautions related to health and safety are discussed in Section 8, Health and Safety, and in certain procedural steps in Section 6, Procedure.

Drums and containers used for any site clean-up or investigation waste will be handled, transported, labeled, and disposed of according to appropriate United States Department of Transportation (DOT), OSHA, and United States Environmental Protection Agency (EPA) regulatory requirements.

5 Equipment and Supplies

Project planning documents will provide direction on specific equipment and supplies for handling and sampling drums and containers. In general, the use of dedicated or disposable equipment is preferred, to reduce the potential for cross-contamination between sampling locations, but equipment may be reused after thorough decontamination between sample locations. The following are standard equipment and supplies for sampling drums and containers:

- Drum/container marking and labeling supplies (e.g., paint, paint markers, tags, labels, bands);
- Vapor and temperature monitoring devices;
- Grounding equipment;
- Sample data sheets (such as those in Appendix A);
- Heavy equipment (e.g., forklift, grappler) or carts to move drums;
- Drum opening devices;
- Small container opening tools (prying tools, pliers, screwdriver, cutter, etc);
- Drum and container sampling devices (discussed in Sections 6.6 and 6.7);
- Sample containers;

- Spill containment supplies; and
- Ancillary equipment and supplies (e.g., sample preservatives, camera, field logbook, sample custody and documentation supplies, decontamination supplies, sample packaging/shipping supplies, safety supplies, and waste handling supplies).

Specific types of drum opening devices are described below.

Bung Wrench

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

Drum Deheader

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

Hand Pick, Pickaxe, and Hand Spike

These tools are usually constructed of brass or a nonsparking alloy with a sharpened point that can penetrate the drum lid or head when the tool is swung. The hand picks or pickaxes that are most commonly used are commercially available, whereas the spikes are generally uniquely fabricated 4-foot-long poles with a pointed end.

Backhoe Spike

A means to open drums remotely is the use of a metal spike attached or welded to a backhoe bucket or similar equipment.

Hydraulic Devices

Hydraulic devices used to open drums remotely use hydraulic pressure to pierce through the wall of a drum. An example of such a device consists of a manually operated pump that pressurizes oil through a length of hydraulic line.

Pneumatic Devices

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

6 Procedure

6.1 General Considerations

The initial assessment made of the site and areas where drums and containers are located will help inform health and safety decisions. Procedures for site entry are discussed in SOP ENV 3.2, Site Entry Procedures for Potentially Contaminated Sites.

Because there is a potential for accidents or spills to occur during handling of any drum or container, they should only be handled if necessary and should be handled with caution. Until the contents of a drum or container are identified or characterized, field personnel should assume that an unlabeled or unmarked drum/container contains hazardous materials or waste. Prior to the movement of drums or containers, all workers exposed to the transfer operation shall be warned of the potential hazards associated with the contents of the drums or containers.

Small, non-drum containers that E & E encounters may contain used or expired chemicals or process chemical samples from laboratories, hospitals, and similar institutions. These small containers may have been filled and stored with inadequate consideration of chemical compatibility, and may be found in cabinets, on shelves, in boxes, or packed in lab pack drums. These small containers may contain shock-sensitive, explosive, highly volatile, highly corrosive, very toxic, exotic, or radioactive materials and should be considered hazardous until identified or characterized. Small containers also can pose unique handling challenges because they are often composed of materials such as glass, paper, fiber, plastic, or other materials not typically associated with sturdy waste or storage containers, and even can consist of inappropriate containers not designated for such use (e.g., food/beverage containers, plastic bags). The use of non-sturdy, incompatible, or inappropriate containers can lead to an increased likelihood of container rupture, breakage, or spillage during handling. A qualified chemist or chemically trained individual should therefore be part of the project team.

6.2 Drum/Container Inspection and Inventorying

Prior to any container moving, opening, and/or sampling, the drums/containers should be inspected, inventoried in place, and labeled. A description of each container (e.g., size, color, material of construction), its condition, labels, markings, and the location where it was found or stored will be recorded on a data sheet (see example in Appendix A). Drums and containers should be inspected for the following:

- Labels, markings, and other identifying information;
- Condition (age, corrosion, rust marks, punctures, bulges, and deformation). If available, a thermal imaging camera can be used to determine if the drum/container has contents and, in some cases, if they are reacting exothermically. Mark on the container the presumed level of material in the container;
- Temperature;
- Detection of vapors around container;
- Observation of leaks;

- Observation of surface staining; and
- Physical instability (e.g., stacked drums or drums on damaged pallets).

The inventorying step involves documenting the location of each drum/container and labeling or marking drums and containers with a unique identifier. To put the identifier on drums, use spray paint or paint makers (color-coded tags, labels, or bands also can be used, but are susceptible to being removed or lost from the drum). To put the identifier on small containers, use paint makers (paint pens), markers, labels, tags, or bands.

If a container is suspected to contain explosive or shock-sensitive material as determined by visual inspection, seek specialized assistance before further handling. If crystalline material is observed at the neck of any container, handle it as a shock-sensitive material because it may indicate the presence of picric acid. Note whether the label on the container lists chemicals that are known to form shock-sensitive explosives in certain conditions (see Appendix B). In some circumstances, it may be appropriate to use field-testing methods (e.g., peroxide test strips) to determine the presence of shock-sensitive crystals on containers. Drums and containers containing packaged laboratory wastes will be considered to contain shock-sensitive or explosive materials until they have been characterized. The practice of tapping the side of a drum/container to determine its contents is not always safe or effective and should not be used if the container is visibly over-pressurized or if shock-sensitive materials are suspected.

Drums or containers that cannot be inspected before being moved because of storage conditions (i.e., buried in the ground, stacked behind other drums, stacked several tiers high in a pile, etc.) will need to be moved to an accessible location and inspected prior to further handling. A ground-penetrating system or other type of detection system can be used to estimate the location and depth of buried drums and containers. Soil or material covering a buried drum should be removed with caution to prevent drum or container rupture.

6.3 Drum/Container Staging

Once the drums and smaller containers have been inspected and inventoried, and prior to staging, any immediate safety and spill hazards need to be addressed in accordance with the site-specific health and safety plan (SHASP) and work plan. For example, spill hazards typically can be eliminated by overpacking a damaged drum (i.e., placing it in a DOT-specified salvage drum), placing the drum in an area with adequate secondary containment of suitable volume, or transferring the contents to a new drum. Appropriate types and quantities of absorbent materials are required to be available to handle spilled drum and container contents. If it becomes necessary to transfer drum contents to a new container, appropriately rated devices constructed of compatible materials will be used. Drums that have been over-pressurized to the extent that the head is swollen above the level of the top chine (ridge) should not be moved (refer to Section 6.4.5 for measures to depressurize). After the immediate safety and spill hazards have been resolved, the containers can be staged as necessary for safety and better access for sampling.

Special consideration should be given to equipment used to move drums and containers. Equipment must not be a source of ignition of vapors emanating from leaking or ruptured drums and containers. Such equipment should be positioned upwind of the drums or containers, if possible; otherwise, manually operated equipment such as a pallet jack or drum cart should be used.

For staging to facilitate drum/container opening and sampling, the containers should be physically separated (if potential contents are known from drum type or existing labels) into the following categories: those containing liquids, those containing solids, lab packs, and those that are empty. This is done because the strategy for sampling and handling drums and containers in each of these categories will be different. Solids and sludges are typically contained in open-top drums and wide-mouth containers, whereas liquids are typically contained in closed-head drums with a bung hole (opening) in the lid and narrow-mouth containers. Closed-head drums may contain materials that have solidified over time, in which case the drum may need to be deheaded prior to sampling.

Drums/containers determined to contain explosive or shock-sensitive material should be evaluated to determine if they are safe to move. If so, they should be staged in a separate, isolated area if possible. Placement of explosive or shock-sensitive materials in diked and fenced areas will help minimize the hazard and the adverse effects of any premature detonation of explosives. Such drums/containers will not be directly handled by E & E personnel, as discussed in Section 8.

Where space allows, the staging area should be physically separated from other work areas such as the container opening area. Ideally, the staging area should be located far enough from the opening area to prevent a chain reaction if a drum/container should explode or catch fire when opening.

Drums are moved from the staging area to the opening area one at a time using appropriate equipment such as forklifts or skid steers equipped with drum grabbers or a barrel grappler. In a large-scale drum handling operation, drums may be moved to the drum opening area using a roller conveyer. Some drums and smaller containers can generally be moved with a cart or wagon.

For staging to facilitate preparation of containers for off-site transport and disposition, drums and containers should be segregated and staged by hazard class (e.g., corrosives, poisons/toxics, flammables, etc.). These staging areas will be kept to the minimum number necessary and must be provided with adequate access and egress routes. Bulking of wastes within a hazard class will take place only after waste streams are tested (i.e., hazard categorization) by a qualified individual, a bulking scheme has been established, and the bulking scheme has been tested on a bench scale.

6.4 Opening Drums

6.4.1 General Considerations

There are two basic types of drums: open-head (open-top) and closed-head. Open-head drums have a removable lid and are typically used to store solid materials. An open-head drum also could have bungs in its lid and be used to store liquid material. Closed-head drums have permanently sealed tops with threaded bung holes that can be sealed with threaded bungs, and are almost exclusively used to store liquid material. A closed-head drum could contain materials that have solidified or polymerized over time into solid or semi-solid material.

In order to sample either type of drum, the lid (for open-head drums) or bung (any open-head or closed-head drum with bungs) needs to be loosened, allowing pressure in the drum to equalize with ambient pressure, and then removed.

Closed-head drums can be opened manually if that can be performed safely. Closed-head drums should be opened remotely, at a safe distance, using specialized tools and equipment if the drum's contents are potentially explosive, shock-sensitive, reactive, or otherwise unstable. The choice of drum opening technique will depend on the number of drums to be opened, their contents, and their physical condition.

Metal drums not in direct contact with the earth should be grounded before opening using grounding wires, alligator clips, and a grounding rod or a metal structure.

Only personnel essential to the opening of drums/containers should be present in the work area. Generally, only non-sparking hand tools will be used to pierce drums and remove bungs. Only intrinsically safe monitoring instruments will be used near drums and containers. Personnel working immediately at or near drums being opened will be equipped with a face shield, at a minimum, to protect them from injury from direct sprays or accidental explosion. Personnel will not climb or stand on drums/containers for any reason. Appropriate equipment will be used to reach drums/containers in elevated positions (e.g., manlifts, excavators with drum grapplers).

For drums/containers for which there is a potential explosion hazard when opening, a suitable shield that does not interfere with the work operation should be placed between employees and those drums/containers. Controls for drum or container opening equipment, monitoring equipment, and fire suppression equipment should be located behind the explosion-resistant barrier. Such drums/containers will not be directly handled by E & E personnel, as discussed in Section 8.

E & E personnel will open lab packs only when necessary and then only by an individual knowledgeable in the inspection, classification, and segregation of the containers within the pack according to the hazards of the wastes. This individual will have available to them reference material (e.g., Merck Index, Hawley's Chemical Dictionary, National Institue for Occupational Safety and Health [NIOSH] Pocket Guide to Chemical Hazards) to help with this process.

6.4.2 Opening of Open-Head Drums

An open-head drum with bungs should be treated as a closed-head drum and opened through its bung holes unless it is known that the drum contains a solid material or contains a liquid of known and benign origin (such as purge water from groundwater well sampling or water from on-site decontamination activities). See Sections 6.4.3 and 6.4.4 for the opening of closed-head drums. Only as a last resort, or if the drum contains solids that cannot be sampled through the bung hole, should an open-head drum containing bungs be opened by removing the lid.

Open-head drums have a lid that is secured in place by either a lever-latch ring or bolt ring. Each type of lid ring fits around the drum lip and drum lid such that, when tightened, the drum and lid are secured together. The lever-latch ring has a leverage mechanism that is pulled and secured against the ring. The bolt ring has a bolt and nut that fasten and tighten the ring in place with a ratchet wrench.

To open the drum, loosen and open the lever-latch ring or bolt ring slowly and carefully, and remove it. Gently loosen the drum lid to allow pressure in the drum to equalize with ambient pressure. If the lid is rusted to the drum and requires additional loosening prior to removal, use non-sparking tools, such as a rubber mallet, to the extent practicable. Gently remove the drum lid.

6.4.3 Manual Opening of Closed-Head Drums

Manual opening of closed-headed drums with bung wrenches, deheaders, or other tools should be performed only with structurally sound drums that are known to contain material that is not shock-sensitive, reactive, or explosive.

6.4.3.1 Bung Wrench

The drum should be positioned upright with the bung up or, for a drum with bungs on the side, laid on its side with the bung plugs up. Using a non-sparking bung wrench, apply a wrenching motion that consists of a slow, steady pull across the drum. If the length of the bung wrench handle provides inadequate leverage for unscrewing the plug, affix an extension to the bung wrench handle to improve leverage.

6.4.3.2 Drum Deheading

There are various types of drum deheaders. Prior to using a drum deheader, personnel should read and follow the manufacturer's instructions and safety precautions.

Drums are opened with a drum deheader by first positioning the cutting edge just inside the top chine and then tightening the adjustment screw so that the deheader is held against the side of the drum. Moving the handle of the deheader up and down while sliding the deheader along the chine will enable the entire top to be rapidly cut off if so desired. If the top chine of a drum has been damaged or badly dented, it may not be possible to cut the entire top off. Because there is always the possibility that a drum may be under pressure, the initial cut should be made very slowly to allow for the gradual release of any built-up pressure. It might be necessary to employ a remote method (Section 6.4.4) prior to using the deheader. Self-propelled drum openers are available, which are either electrically or pneumatically driven, and can be used for quicker and more efficient deheading.

6.4.3.3 Hand Pick, Pickaxe, or Spike

When neither a bung wrench nor a drum deheader is suitable, then the drum can be opened by using a hand pick, pickaxe, or spike. Often, the drum lid or head must be hit with a great deal of force in order to penetrate it, and drums cannot be opened slowly with these tools. As a result, the potential for splash or spraying is greater than with other opening methods and appropriate safety measures must be taken. Therefore, this method of opening drums of liquid is the least recommended and may not be used without approval from the Regional Safety Coordinator. This method also may not be used unless the contents of the drum or container are known to contain material that is not shock-sensitive, reactive, or explosive. Some spikes have been modified by the addition of a circular splash plate near the penetrating end. This plate acts as a shield and reduces the amount of splash in the direction of the person using the spike. Even with this shield, good splash gear is essential.

The pick or spike should be decontaminated after each drum is opened to avoid cross-contamination and adverse chemical reaction from incompatible materials.

6.4.4 Remote Opening of Closed-Head Drums

Remotely operated drum opening tools are the safest available means of opening closed-head drums where the bungs are difficult to remove. Remote drum opening is slow, but provides a higher degree of safety compared to manual methods of opening.

6.4.4.1 Backhoe Spike

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

The spike should be decontaminated after each drum is opened to prevent cross-contamination. Although some splash or spray may occur when this method is used, the operator of the backhoe can be protected by mounting a shatter-resistant shield in front of the operator's cage. This, combined with the normal personal protection gear, should be sufficient to protect the operator.

6.4.4.2 Hydraulic Devices

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

6.4.4.3 Pneumatic Devices

Pneumatically operated devices using compressed air are available to remove drum bungs or to dehead drums remotely.

6.4.5 Opening Over-Pressurized Drums

A number of devices can be used to vent swollen drums. One effective method is a tube and spear device. A light aluminum tube (about 3 meters long) is positioned at the vapor space of the drum, and a rigid hooking device attached to the tube goes over the chine and holds the tube securely in place. The spear is inserted in the tube and positioned against the drum wall. A sharp blow on the end of the spear drives the sharpened tip through the drum, and the gas vents along the grooves. The venting should be done from behind a wall or barricade. Once the pressure has been relieved, the bung can be removed and the drum sampled.

As an alternative, a backhoe spike can be used to relieve drum pressure. This remote approach provides an added margin of safety when drum contents are suspected of being shock-sensitive, reactive, or explosive.

6.5 Opening Small Containers

Jars, jugs, flasks, canisters, and bottles typically have screw top lids or stoppers that can be removed by a gloved hand, pliers, or wrenches. Cans and buckets typically have lids that can be pried open with a flat-head screw driver, paint-can opener, or prying tool. Boxed, bulked, or bagged materials can be opened using the intended box top or bag opening. If sealed, the box or bag can be carefully cut to create an opening for a sampling tool.

Small containers suspected of containing an explosive, shock-sensitive, reactive, or unstable material, or that are bulging or otherwise suspected of being over-pressurized, should be opened remotely using methods similar to those described in Section 6.4.4 for drums.

Following sampling of small containers, care should be taken to seal any openings to prevent spillage during later handling. In cases where the original container is in poor condition or is unsealable, the contents can be transferred to a better container.

6.6 Drum Sampling

After the drum has been opened, preliminary monitoring of headspace gases should be performed using an explosimeter and organic vapor analyzer. Record the approximate depth of the container contents if possible prior to sample collection.

In some cases, it is difficult to observe the contents of sealed or partially sealed drums. A thermal imaging camera can provide some information about contents. Since some layering or stratification is likely in any solution left undisturbed over time, a sample must be taken that represents the entire depth of the container. A depth measurement and description of each layer (color, clarity, viscosity) should be noted.

When sampling a previously sealed drum, a check should be made for the presence of a bottom sludge. This is accomplished by measuring the depth to the apparent bottom, then comparing it to the known interior depth.

Record sampling efforts in the field logbook and/or on a sampling data sheet such as the example in Appendix A.

6.6.1 Glass Thief Sampler

A widely used implement for drum sampling is a glass tube often called a glass thief or drum thief (approximately 6- to 16-millimeter interior diameter x 48-inch length). This disposable tool is simple, cost-effective, and quick to use, and collects a sample without the need to decontaminate.

Procedure for Use

1. Insert the glass sample thief almost to the bottom of the drum or until a solid layer is encountered. About one foot of the glass tube should extend above the drum.
2. Allow the material in the drum to reach its natural level in the tube. In many instances, there may be a sludge layer at the bottom of the drum. Slow insertion of the sample tube into this layer and then a gradual withdrawal will allow the sludge to act as a bottom plug to maintain the fluid in the tube. The plug can be gently removed and placed into the sample container by using a stainless steel lab spoon.
3. Cap the top of the sampling tube with a tapered stopper or thumb, ensuring that liquid does not come into contact with the stopper.
4. Slowly withdraw the capped tube from the drum with one hand while wiping the sample tube with a disposable towel with the other hand.
5. Insert the uncapped end into the sample container. Do not spill liquid on the outside of the sample container. Release stopper and allow the glass thief to drain completely into the sample container.
6. Remove the glass tube from the sample container and break it into the drum. (Because disposal of the tube by breaking it into the drums may interfere with eventual plans for disposition of the drum and its contents, be sure to obtain approval for this step from the project manager.)
7. Cap the sample container tightly and place it in a carrier.
8. Replace the bung or place plastic over the drum.
9. Log the sample in the field logbook and/or sampling data sheet.

10. Perform hazard categorization or other field screening analyses if included in the project scope. Each layer of the drum should be screened because they might be different from one another.

11. Move the sample to the contamination reduction (decontamination) zone and package it for transport to the analytical laboratory, as necessary. Complete chain of custody records. If the sample is not to be submitted to an analytical laboratory following field screening, the containerized sample may be placed with the original drum or container for later disposal or entered into the site waste stream through some other mechanism. The project manager will determine the appropriate pathway.

6.6.2 COLIWASA

The Composite Liquid Waste Sampler (COLIWASA) is designed to permit representative sampling of multiphase materials from drums and other containers. It collects a sample from the full depth of a drum and maintains it in a transfer tube until delivery to the sample bottle. One configuration consists of a 152-centimeter by 4-centimeter inner diameter section of tubing with a neoprene stopper at one end attached by a rod running the length of the tube to a locking mechanism at the other end. Manipulation of the locking mechanism opens and closes the sampler by raising and lowering the neoprene stopper.

The drawback associated with using a COLIWASA is cost. A COLIWASA is more expensive to purchase than a glass thief and also is difficult to effectively decontaminate; therefore, it should be disposed of after use, which increases equipment supply and waste management costs. Its best application is for instances where a true representation of a multiphase material is necessary.

Procedure for Use

1. Put the sampler in the open position by placing the stopper rod handle in the T-position and pushing the rod down until the handle sits against the sampler’s locking block.

2. Slowly lower the sampler into the drum. Lower the sampler at a rate that permits the levels of the liquid inside and outside the sampler tube to be about the same. If the level of the liquid in the sampler tube is lower than that outside the sampler, the sampling rate is too fast and may result in a less representative sample.

3. When the sampler stopper hits the bottom of the waste container, push the sampler tube downward against the stopper to close the sampler. Lock the sampler in the closed position by turning the T-handle until it is upright and one end rests tightly on the locking block.

4. Slowly withdraw the sampler from the drum with one hand while wiping the sampler tube with a disposable towel with the other hand.

5. Carefully discharge the sample into the sample container by slowly pulling the lower end of the T-handle away from the locking block while the lower end of the sampler is positioned in the sample container.

6. Cap the sample container tightly and place it in a carrier.

7. Replace the bung or place plastic over the drum.

8. Unscrew the T-handle of the sampler and disengage the locking block. Clean or dispose of the sampler as applicable.

9. Log the sample in the field logbook and/or sampling data sheet.

10. Perform hazard categorization or other field screening analyses if included in the project scope.
11. Move the sample to the contamination reduction (decontamination) zone and package it for transport to the analytical laboratory, as necessary. Complete chain of custody records. If the sample is not to be submitted to an analytical laboratory following field screening, the containerized sample may be placed with the original drum or container for later disposal or entered into the site waste stream through some other mechanism. The project manager will determine the appropriate pathway.

6.6.3 Syringe-Type Device

A syringe-type sampling device is typically used for sampling high-viscosity liquid materials and sludge. The device will have either a valve tip for liquids or a coring tip for sludge.

Procedure for Use with Liquids

1. Put the sampler in the piston-down position.
2. Ensure that the valve tip is pulled down to the open position.
3. Slowly lower the sampler into the liquid material.
4. As the sampler is being lowered, the sampler's piston is pulled up to collect the sample.
5. Once the sample is collected, close the valve tip by pushing the valve tip up using the bottom or side of the drum.
6. Slowly withdraw the sampler from the drum with one hand while wiping the sampler tube with a disposable towel with the other hand.
7. Discharge the sampler's contents into the sample container by opening the valve tip and pushing down on the sampler's piston.
8. Cap the sample container tightly and place it in a carrier.
9. Replace the bung or place plastic over the drum.
10. Clean or dispose of the sampler as applicable.
11. Log the sample in the field logbook and/or sampling data sheet.
12. Perform hazard categorization or other field screening analyses if included in the project scope.
13. Move the sample to the contamination reduction (decontamination) zone and package it for transport to the analytical laboratory, as necessary. Complete chain of custody records. If the sample is not to be submitted to an analytical laboratory following field screening, the containerized sample may be placed with the original drum or container for later disposal or entered into the site waste stream through some other mechanism. The project manager will determine the appropriate pathway.

Procedure for Use with Sludge

1. Put the sampler in the piston-down position.
2. Push the sampler body into the sludge.
3. As the sampler is being pushed into the sludge, the sampler's piston is pushed up to collect the sample.

4. Slowly withdraw the sampler from the drum with one hand while wiping the sampler tube with a disposable towel with the other hand.
5. Discharge the sampler's contents into the sample container by pushing down on the sampler's piston.
6. Continue sample collection in accordance with steps 8 through 13 above for liquids.

6.6.4 Plunger-Type Device

The drawback associated with using a plunger-type sampler is cost. Such a device is more expensive to purchase than other types of drum samplers and also is difficult to effectively decontaminate; therefore, it should be disposed of after use, which increases equipment supply and waste management costs.

Procedure for Use

1. Put the sampler in the open position.
2. Connect the sample container to the head section of the sampler.
3. Slowly lower the sampler into the liquid. Lower the sampler at a rate that permits the levels of the liquid inside and outside the sampler tube to be about the same. If the level of the liquid in the sampler tube is lower than that outside the sampler, the sampling rate is too fast and may result in a less representative sample.
4. When the sampler's plunger hits the bottom of the drum, engage the plunger by pulling the sampler rod upward, which will put the sampler in the closed position.
5. Without removing the sampler from the drum, pull the plunger rod upward, filling the sample container.
6. Slowly withdraw the sampler from the drum with one hand while wiping the sampler tube with a disposable towel with the other hand.
7. Prior to removing the sample container from the sampler, allow sufficient time for all of the sample to flow into the sample container.
8. Cap the sample container tightly and place it in a carrier.
9. Replace the bung or place plastic over the drum.
10. Clean or dispose of the sampler as applicable.
11. Log the sample in the field logbook and/or sampling data sheet.
12. Perform hazard categorization or other field screening analyses if included in the project scope.
13. Move the sample to the contamination reduction (decontamination) zone and package it for transport to the analytical laboratory, as necessary. Complete chain of custody records. If the sample is not to be submitted to an analytical laboratory following field screening, the containerized sample may be placed with the original drum or container for later disposal or entered into the site waste stream through some other mechanism. The project manager will determine the appropriate pathway.

6.6.5 Bailer

A bailer can be used to sample homogeneous and non-viscous liquids in a drum, such as purge water from groundwater well sampling or water resulting from on-site decontamination activities.

A bailer is particularly useful when a large volume of sample is needed. Reusable bailers, which are higher quality and intended to be decontaminated or dedicated to a particular drum, typically would not be used to sample drums/containers for the purposes of characterization and removal from a site. Instead, inexpensive, single-use bailers would more commonly be used, to avoid the need to decontaminate.

Procedure for Use

1. Make sure the bailer is in the open position.
2. Slowly lower the bailer into the drum. Lower the bailer at a rate that permits the levels of the liquid inside and outside the bailer to be about the same. If the level of the liquid in the bailer is lower than that outside the bailer, the sampling rate is too fast and may result in a less representative sample.
3. When the bailer hits the bottom of the waste container, pull the bailer up, at which point the ball stopper should close the bailer.
4. Slowly withdraw the bailer from the drum with one hand while wiping the outside of the bailer with a disposable towel with the other hand.
5. Carefully discharge the bailer’s content into the sample container by using the tube that inserts into the bottom of the bailer.
6. Cap the sample container tightly and place it in a carrier.
7. Replace the bung or place plastic over the drum.
8. Clean or dispose of the bailer as applicable.
9. Log the sample in the field logbook and/or sampling data sheet.
10. Perform hazard categorization or other field screening analyses if included in the project scope.
11. Move the sample to the contamination reduction (decontamination) zone and package it for transport to the analytical laboratory, as necessary. Complete chain of custody records. If the sample is not to be submitted to an analytical laboratory following field screening, the containerized sample may be placed with the original drum or container for later disposal or entered into the site waste stream through some other mechanism. The project manager will determine the appropriate pathway.

6.6.6 Coring Device

A coring device can be used to sample solids in drums, such as solid waste materials or drill cuttings. The sampler consists of a coring device, extension attachments, and T-handle.

Procedure for Use

1. Assemble the sampling equipment.
2. Insert the sampling device to the bottom of the drum. The extensions and the T-handle should extend above the drum.
3. Rotate the sampling device to cut a core of material.
4. Slowly withdraw the sampling device so that as much sample material as possible is retained within it.

5. Transfer the sample to the sample container. A stainless steel spoon or scoop may be used as necessary. If the sample must be composited and/or homogenized, transfer the sample instead to an interim vessel such as a stainless steel bowl.
6. Return the sampling device to the drum and collect material from different areas within the drum to ensure a representative sample. Transfer the additional sample to the sample container or compositing/homogenizing vessel.
7. Composite/homogenize the sample as applicable and transfer it to the sample container.
8. Cap the sample container tightly and place it in a carrier.
9. Replace the drum lid or place plastic over the drum.
10. Clean or dispose of the sampler as applicable.
11. Log the sample in the field logbook and/or sampling data sheet.
12. Perform hazard categorization or other field screening analyses if included in the project scope.
13. Move the sample to the contamination reduction (decontamination) zone and package it for transport to the analytical laboratory, as necessary. Complete chain of custody records. If the sample is not to be submitted to an analytical laboratory following field screening, the containerized sample may be placed with the original drum or container for later disposal or entered into the site waste stream through some other mechanism. The project manager will determine the appropriate pathway.

6.7 Small Container Sampling

Liquids can be poured directly into a sample container or the sample can be transferred with a pipette and bulb or similar device. Solid materials can be poured directly into a sample container or the sample can be transferred with a scoop, trowel, or spoon. Following sample collection, perform the following:

1. Clean or dispose of the sampler as applicable.
2. Replace the cap or lid of the small container or place plastic over it.
3. Log the sample in the field logbook and/or sampling data sheet.
4. Perform hazard categorization or other field screening analyses if included in the project scope.
5. Move the sample to the contamination reduction (decontamination) zone and package it for transport to the analytical laboratory, as necessary. Complete chain of custody records. If the sample is not to be submitted to an analytical laboratory following field screening, the containerized sample may be placed with the original material container for later disposal or entered into the site waste stream through some other mechanism. The project manager will determine the appropriate pathway.

7 Quality Assurance/Quality Control

The program/project manager should identify personnel for the field team who have knowledge, training, and experience in the drum/container sampling activities to be conducted. The program/project manager should also identify additional personnel, as necessary, to complete ancillary procedures, e.g., field logbook documentation, equipment decontamination, sample shipment, and waste disposal.

Prior to initiating field work, the project planning documents (e.g., work plan, sampling and analysis plan, quality assurance project plan, health and safety plan) will be reviewed by field personnel to understand the procedures that have been specified to result in samples that will meet project DQOs. Project planning documents will define the quality assurance/quality control (QA/QC) procedures necessary to meet project DQOs, including the sampling protocol for QC samples such as trip blanks, field duplicates, equipment rinsate blanks, and other types of field and analytical QC samples. Because the contents of drums and similar types of containers could be non-homogeneous, field duplicates and other types of collocated samples will need to be collected in a way that ensures that the sample pairs are as similar to each other as possible.

8 Health and Safety

Sampling of drums and containers will be performed in accordance with a sampling procedure that is part of, or referenced by, the SHASP. Prior to entering the field, all field personnel will acknowledge in writing that they have read and understand the SHASP. Certain safety procedures inherent to steps in this SOP have been incorporated into those steps in Section 6.

Opening sealed drums and other containers with unknown contents is one of the more hazardous activities that E & E conducts. Unique hazards associated with opening drums and containers with unknown contents include the potential for the release of explosive, pressurized, or hazardous materials and wastes. Unique hazards associated with inventorying, handling, staging, and sampling drums and containers include the potential for exposure to hazardous materials or wastes; crush and pinch hazards from handling heavy objects (a 55-gallon drum containing just water weighs over 450 pounds); and spills due to accidents, inadequate containerization or storage, and material degradation.

Minimum health and safety requirements will likely consist of personal protective equipment and monitoring instrumentation. Employing proper drum opening techniques and equipment, as described in this SOP, will help to safeguard personnel. The use of remote opening and sampling equipment is recommended when applicable. Spill response supplies such as salvage drums, absorbent materials, and berm material should be available during any container handling or sampling operation. When airline respirator systems are used, air lines and connections will be protected from contact with contaminants and positioned where they will not be physically damaged by operations. Fire extinguishers will be available to handle a potential incipient fire.

Drums or containers suspected of containing explosive, shock-sensitive, highly toxic, exotic, or radioactive materials should not be handled, opened, or sampled until their hazard has been assessed; this can include consulting the Regional Safety Coordinator and soliciting expert advice. Containers suspected of containing explosive or shock-sensitive material will not be directly handled by E & E personnel. Should others on site become involved with these containers, E & E personnel will be evacuated from the area. E & E's site safety officer will verify that material handling equipment for these containers is provided, including explosion containment devices or protective shields to protect equipment operators from exploding containers, and that an audible signal is established to inform site personnel of the commencement and completion of container handling activities. E & E or other site command personnel will maintain continuous communications with the personnel conducting explosive or shock-sensitive material handling.

Drums/containers may not be opened using the hand pick/pick axe/spike method without the approval of the Regional Safety Coordinator.

Some drum types have distinct hazards:

- Polyethylene or polyvinyl chloride (PVC)-lined drum – Often contains strong acids or bases. If the lining is punctured, the substance can quickly corrode the steel, resulting in a leak or spill.
- Exotic metal drum (e.g., aluminum, nickel, stainless steel, or other atypical drum metal) – An expensive drum that usually contains an extremely dangerous material.
- Single-walled drums used as a pressure vessel – This type of drum has fittings for both product filling and placement of an inert gas, such as nitrogen. May contain reactive, flammable, or explosive substance.
- Laboratory pack – Used for disposal of used or expired chemicals and process samples from laboratories, hospitals, universities, and similar institutions. Individual containers within the lab pack are often not packed in absorbent material. They may contain incompatible materials, radioisotopes, shock-sensitive, highly volatile, highly corrosive, or very toxic exotic chemicals. Laboratory packs can be an ignition source for fires.

E & E personnel shall not enter a tank or vault without special approval of the Corporate Health and Safety Director in conjunction with E & E SOP HS 5.1, Confined Space Entry. Entry procedures will be described in the SHASP, where applicable.

9 Special Project Requirements

Project-specific requirements will be included with the project planning documents.

10 References

American Society for Testing and Materials (ASTM) International. 2011. Standard Guide for Sampling of Drums and Similar Containers by Field Personnel. ASTM D6063-11.

__________. 2013. Standard Practice for Sampling Single or Multilayered Liquids, With or Without Solids, in Drums or Similar Containers. ASTM D5743-97(2013).

__________. 2014. Standard Practice for Sampling Unconsolidated Solids in Drums or Similar Containers. ASTM D5680-14.

__________. 2016a. Standard Practice for Sampling Consolidated Solids in Drums or Similar Containers. ASTM D5679-16.

__________, 2016b. Standard Guide for Selection of Sampling Equipment for Waste and Contaminated Media Data Collection Activities. ASTM D6232-16.

National Institute for Occupational Safety and Health (NIOSH), Occupational Safety and Health Administration (OSHA), U.S. Coast Guard (USCG), and U.S. Environmental Protection Agency (EPA). 1985. *Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities.* U.S. Department of Health and Human Services. October 1985.

National Research Council (NRC). 2011. *Prudent Practices in the Laboratory. Handling and Management of Chemical Hazards*. Committee on Prudent Practices in the Laboratory. National Academies Press.

United States Environmental Protection Agency (EPA). 1985. *Guidance Document for Cleanup of Surface Tank and Drum Sites.* OSWER Directive 9380.0-3. May 1985.

__________. 1986. *Drum Handling Practices at Hazardous Waste Sites.* EPA/600/2-86/013. PB86-165362. January 1986.

__________. 1994. Drum Sampling. SOP# 2009. Revision # 0.0. November 16, 1994.

__________. 2002. *RCRA Waste Sampling Draft Technical Guidance; Planning, Implementation and Assessment*. EPA530-D-02-002. August 2002.

__________. 2013. Waste Sampling. Operating Procedure Number SESDPROC-302-R2. Region 4. Athens, Georgia.

Appendix A. Drum/Container Data Sheet Project ID: Click here to enter text.

Sample ID#: Click here to enter text. Date Sampled: Click here to enter text.

Drum/Container ID#: Click here to enter text. Time Sampled: Click here to enter text.

Original Grid Location: Click here to enter text. Staging Location: Click here to enter text.

Sampler's Name: Click here to enter text.

Drum/Container Condition and Construction Material: Click here to enter text.

Drum/Container Size: Click here to enter text. Opening Type: Click here to enter text.

Physical Appearance of Drum/Container: Click here to enter text.

Bung Present: Click here to enter text. Drum Leaking: Click here to enter text.

Photograph Taken: Click here to enter text. Photo ID#: Click here to enter text.

Multiple Phases: Click here to enter text.

Estimated Liquid and Solid Quantities: Click here to enter text.

Color of Materials: Click here to enter text. Odor: Click here to enter text.

VOC Screening Results: Click here to enter text. pH: Click here to enter text.

Radiation Screening Results: Click here to enter text.

Compatibility: Click here to enter text. Hazard: Click here to enter text.

Field Analytical Data: Click here to enter text.

Fixed Laboratory Data: Click here to enter text. Date of Analysis: Click here to enter text.

Waste ID: Click here to enter text.

Treatment Disposal Recommendations: Click here to enter text.

Approval

Lab: Click here to enter text. Date: Click here to enter text.

Site Manager: Click here to enter text. Date: Click here to enter text.

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Appendix B. Chemicals That Can Form Peroxides* Project ID: Click here to enter text.

Class A: Chemicals that form explosive levels of peroxides without concentration.

- Isopropyl ether
- Butadiene
- Chlorobutadiene (chloroprene)
- Potassium amide
- Potassium metal
- Sodium amide (sodamide)
- Tetrafluoroethylene
- Divinyl acetylene
- Vinylidene chloride

Class B: Chemicals that are a peroxide hazard on concentration (distillation/evaporation). A test for peroxide should be performed if concentration is intended or suspected.

- Acetal
- Cumene
- Cyclohexene
- Cyclooctene
- Cyclopentene
- Diaacetylene
- Dicyclopentadiene
- Diethylene glycol dimethyl ether (diglyme)
- Diethyl ether
- Dioxane (p-dioxane)
- Ethylene glycol dimethyl ether (glyme)
- Furan
- Methyl acetylene
- Methyl cyclopentane
- Methyl-isobutyl ketone
- Tetrahydrofuran
- Tetrahydronaphthalene
- Vinyl ethers

Class C: Unsaturated monomers that may autopolymerize as a result of peroxide accumulation if inhibitors have been removed or are depleted.

- Acrylic acid
- Butadiene
- Chlorotrifluoroethylene
- Ethyl acrylate
- Methyl methacrylate
- Styrene
- Vinyl acetate
- Vinyl chloride
- Vinyl pyridine

*These lists are illustrative, not comprehensive.

Types of compounds known to auto-oxidize to form peroxides:

- Ethers containing primary and secondary alkyl groups (never distill an ether before it has been shown to be free of peroxide),
- Compounds containing benzylic hydrogens,
- Compounds containing allylic hydrogens (C=C—CH),
- Compounds containing a tertiary C—H group (e.g., decalin and 2,5-dimethylhexane,
- Compounds containing conjugated, polyunsaturated alkenes and alkynes (e.g., 1,3-butadiene, vinyl acetylene), and
- Compounds containing secondary or tertiary C—H groups adjacent to an amide (e.g., 1-methyl-2-pyrrolidinone).

Source: National Research Council 2011.

End of Appendix B

END OF SOP

ecology and environment, inc.

STANDARD OPERATING PROCEDURE

UNMANNED AERIAL SYSTEM FLIGHT SAFETY PROTOCOL

SOP NUMBER: ENV 3.32

REVISION DATE: 12/21/2017 **SCHEDULED REVIEW DATE: 12/21/2018**

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1 Scope and Application

The purpose of this document is to provide legal requirements and internal procedures for the safe operation of an Unmanned Aerial System (UAS) in various environments and circumstances in which Ecology and Environment, Inc. (E & E) may be asked to perform professional services. This document should be considered E & E's Standard Operating Procedure (SOP). While not all instructions will apply to all scenarios, the application of good judgment and effective Crew Resource Management will reduce the risk of a flight incident and help ensure a safe flight experience for all personnel. E & E's Legal and Regulatory, Health and Safety, and IT-GIS Departments may be contacted with any questions or concerns.

This SOP is compliant with Federal Aviation Administration (FAA) regulations in Title 14 of the Code of Federal Regulations, Part 107 (14 CFR 107), Small Unmanned Aircraft Systems.

This SOP is intended for use by personnel who have knowledge, training, and experience in UAS flight operations. Any deviations must be approved by the E & E Corporate Health and Safety Director (CHSD) and Legal and Regulatory Department.

2 Definitions and Acronyms

AGL	Above ground level
CFR	Code of Federal Regulations
CHSD	Corporate Health and Safety Director
E & E	Ecology and Environment, Inc.
FAA	Federal Aviation Administration
GCS	Ground Control Station
GPS	Global positioning system
H&S	Health and safety
IMU	Inertial measurement unit
LED	Light-emitting diode
mph	Miles per hour
NOTAM	Notice to airmen
QA/QC	Quality assurance/quality control
PAC	Pilot at Controls
PIC	(Remote) Pilot in Command
SHASP	Site-specific health and safety plan
SOP	Standard operating procedure
TFR	Temporary flight restriction
UAS	Unmanned Aerial System
USB	Universal serial bus

VLOS	Visual line of sight
VMC	Visual meteorological condition
VO	Visual Observer

3 Personnel and Qualifications

3.1 Remote Pilot in Command (PIC)

The PIC is responsible for safety, equipment, and personnel directly engaged in UAS operations. In the instance of multiple flight operations, use of visual observers (VOs), and participation of multiple pilots at controls (PACs), the PIC maintains responsibility for flight planning, health and safety (H&S) compliance, data quality assurance/quality control (QA/QC), FAA reporting and compliance, and UAS personnel. The PIC has sole discretion over flight operations on-site.

The PIC is responsible for compliance with all procedures and requirements stated in FAA Part 107. Specifically, the PIC will take all actions, including reviewing weather, flight battery requirements, aircraft performance data, airspace regulations, and launch and recovery locations, before initiation of a flight. The PIC also will account for relevant site-specific conditions in the pre-flight procedures.

The PIC shall have the following minimum qualifications:

- FAA Part 107 License, small UAS rating;
- Hold a valid U.S. driver's license;
- 20/20 corrected vision;
- Working knowledge of this flight safety protocol SOP;
- Working knowledge of FAA Part 107 requirements;
- Familiarity with the UAS equipment itself, including:
  - Operation of sufficient flights to be familiar with all flight characteristics, including evasive and emergency maneuvers,
  - Familiarity with the latest revision of ground control software, where applicable,
  - Familiarity with acceptable field repair and maintenance procedures, and
  - Familiarity with emergency recovery procedures in failed link situations;
- Mastery of mission planning, pre-flight, and post-flight procedures; and
- Versed in emergency procedures and contingency operations.

The PIC may act as the PAC during a given flight or operation. The terms and practical application may be interchangeable in many circumstances.

3.2 Pilot at Controls (PAC)

The PAC is responsible for the equipment and flight plans associated with the UAS over which the PAC operates direct control. The PIC may act as the PAC during a given flight or operation. The terms and practical application may be interchangeable in many circumstances. However, in the instance of multiple flight operations, use of VOs, and participation of multiple PACs, the PAC is responsible only for the flight planning, H&S compliance, and data QA/QC directly associated with operation of a specific UAS. Each PAC will coordinate and comply with the commands of the PIC. The PAC shall have the following minimum qualifications:

- FAA Part 107 License, small UAS rating, where applicable[1];
- 20/20 corrected vision;
- Knowledge of this flight safety protocol SOP;
- Knowledge of FAA Part 107;
- Familiarity with UAS operations, including:
  - Operation of sufficient flights to be familiar with all flight characteristics, including evasive and emergency maneuvers,
  - Familiarity with the latest revision of ground control software, where applicable,
  - Familiarity with acceptable field repair and maintenance procedures, and
  - Familiarity with emergency recovery procedures in failed link situations;
- Familiarity with mission planning and preflight procedures; and
- Versed in emergency procedures and contingency operations.

3.3 Ground Crew

The Ground Crew shall understand the inherent risks of being in the vicinity of flight operations and must adhere to PIC instructions at all times.

3.4 Visual Observer (VO)

All operations must use a VO. The VO shall have the following minimum qualifications:

- Understand the inherent risks of being in the vicinity of flight operations;
- 20/20 corrected vision;
- Familiarity with this flight safety protocol SOP;
- Familiarity with FAA Part 107 requirements; and
- Familiarity with operation of their own aircraft, including:
  - Familiarity with the construction and configuration of each UAS, and
  - Familiarity with Ground Control Station (GCS) electronics and configuration.

4 Cautions

The following safety considerations must be considered when planning the use of a UAS for E & E projects. These safety considerations are not necessarily all-inclusive. Results of a preliminary inspection of the flight area should be used to help determine additional hazards that might be present. A site-specific health and safety plan (SHASP) is required to be developed for use of a UAS for a project (also see Section 8).

[1] The FAA allows for an unlicensed PAC if the ground control system or UAS controls permit dual pilots, thus allowing a licensed PIC or PAC to take control if necessary. If no such capability exists, the PAC must have an FAA Part 107 license.

The PIC is responsible for ensuring that UAS flights will be compliant with applicable FAA restrictions and regulations, and that property access to planned flight areas has been granted.

4.1 FAA-Mandated Operating Restrictions

The following restrictions are absolute and non-negotiable. All UAS operations are to proceed in accordance with the restrictions described below.

1. Access and Permission to Operate
    a. All activities must occur over access-controlled property, i.e., property where permission has been obtained by a person with legal authority to grant access.
    b. Permission must be obtained in writing prior to commencement of activities.
    c. Where the property over which UAS operations will occur is owned and/or controlled by the client, a signed scope of work authorizing UAS operations is sufficient access.
    d. Where the property over which UAS operations will occur is owned and/or controlled by the a third party, a written access agreement must be executed, authorizing UAS operations, prior to commencement of any flight activities.
    e. Contact the E & E Legal and Regulatory Department for review and negotiation assistance associated with all access agreements.
2. Proximity to Participating and Non-participating Persons
    a. UAS operations must be 500 feet or more from any non-participating person, without exception.
    b. UAS operations may occur near or over only those people directly participating in the operation of the UAS, i.e., the PIC, PAC, VO, and other consenting personnel directly participating in the activities.
    c. UAS operations may occur near, but not over, people participating in the intended purpose of the UAS operation.
3. Operational Parameters and Boundaries: The UAS may not be operated at a speed exceeding that which has been recommend by the aircraft manufacturer. In no event shall the airspeed exceed 87 knots or 100 miles per hour (mph).
4. Altitude and Line of Sight
    a. The UAS may not be operated at an altitude above 400 feet above ground level (AGL).
    b. The UAS must be operated within the unaided Visual Line of Sight (VLOS) of the PIC and the VO at all times.
    c. A UAS must give way to all manned aircraft.
    d. Exception to this rule: The UAS may be flown in excess of the 400-foot-AGL altitude limit while surveying a structure as long as the UAS remains within a 400-foot radius of said structure. Under this scenario, the UAS is allowed to fly up to 400 feet above the highest point of the structure as long as it does not enter controlled airspace without authorization. Class E airspace begins at either 700 feet AGL or 1200 feet AGL, depending on the area.

5. Use of VO
    a. All operations must use a VO and a minimum of two personnel.
    b. The VO must be able to communicate verbally with the PIC at all times. Radios are recommended.
6. Operating Documents
    a. This SOP, the FAA aircraft registration, the FAA pilot license, and applicable manufacturer instructions shall be accessible during UAS operations.
    b. Operations shall be performed in accordance with the requirements of this SOP, FAA Part 107, and manufacturer guidelines.
7. Maintenance
    a. A UAS that undergoes maintenance or alterations that affect operation or flight characteristics must undergo a functional test flight prior to further operations.
    b. Functional test flights must be conducted by the PIC with a VO.
    c. Functional test flights must be 500 feet from all participating and non-participating persons.
    d. Pre-flight inspections must be performed prior to every flight. If the inspection reveals a condition affecting safe operations, the UAS will be grounded until necessary maintenance has been performed.
    e. E & E will comply with all manufacturer safety bulletins.
    f. E & E will comply with all manufacturer maintenance, overhaul, replacement, inspection, and life-limit requirements.
    g. Consult the pre-flight checklist.
8. Time of Day and Weather Conditions
    a. UAS operations will not be conducted at night.
    b. UAS operations will be conducted under visual meteorological conditions (VMCs), i.e., conditions in which the PIC/PAC and VO have sufficient visibility to fly the UAS while maintaining visual separation from terrain and other aircraft.
    c. No UAS operations will take place in electrical storms.
    d. No UAS operations may take place 500 feet below or less than 2,000 feet horizontally from a cloud.
    e. No UAS operations may take place when visibility is less than 2 statute miles from the PIC.
9. Communication and Control Loss
    a. The UAS must be immediately (or as soon as is safe to do so) landed upon loss of global positioning system (GPS) signal.
    b. In the event that command or control links are lost, the UAS must follow a pre-determined route to either reestablish link or immediately land.

10. Batteries: Prior to launch, batteries must hold a charge sufficient for each intended flight plan, plus 5 minutes of flight time. No flights should be attempted with a battery below 50%.
11. Registration of UAS
    a. All UASs must be registered in accordance with 14 CFR 47 and 48.
    b. All UASs must have identification markings in accordance with 14 CFR 45, Subpart C, or 14 CFR 48.
12. FAA Reporting
    a. All incidents, accidents, and flight operations that transgress the allowed lateral and/or vertical boundaries must be reported to the FAA within 24 hours.
    b. Accidents and incidents must be reported to the National Transportation Safety Board in accordance with 49 CFR 830.5 (instructions at www.ntsb.gov).
    c. Any injury requiring a hospital visit (e.g., broken bone, stitches, head trauma) must be reported to the FAA within 10 days.
    d. Any damage where the cost to repair is over $500, not including the UAS itself, must be reported to the FAA.
13. Operations and Flight Planning
    a. Written flight plans must be drafted prior to UAS activities. The flight plan should consider any potential hazards, flight restrictions, weather conditions, notices to airmen (NOTAMs), and temporary flight restrictions (TFRs). It is the responsibility of the PIC to notify Air Traffic Control of the flight and request permission to enter controlled airspace (where applicable).
    b. Be sure to define primary and auxiliary launch and recovery sites. A minimum of two is required.
    c. Determine how best to transport the UAS in compliance with applicable air transportation regulations pertaining to lithium batteries if staff is flying to a site or equipment is shipped via air courier (e.g., FedEx, UPS).
    d. Inspect the UAS for damage prior to flight (refer to the pre-flight checklist).
    e. The flight path must be approved by the designated PIC.
    f. Obtain prior written consent to access all property over which the UAS will operate. This includes all public and private property. There are no exceptions to this requirement. Contact the E & E Legal and Regulatory Department regarding questions concerning access to any property.
    g. Attempt to obtain footage of only access-controlled areas.
    h. Alert adjacent landowners of the flight pattern to diminish concern.
    i. Avoid flying:
        - Within controlled airspace. Air Traffic Control approval is required prior to entering controlled airspace.
        - Above 400 feet AGL.
        - Over/within National Parks (drones are banned in National Parks).

- Over property for which no written consent to access has been obtained.
- Near people (500 feet).
- Near livestock.
- Near buildings.
- Within 100 feet of power lines.
- Near cell or microwave towers.
- in precipitation or fog.
- At night, dawn, or dusk.
- Over multi-lane divided highways.
- When conditions are windy (winds greater than 25 mph).
- Inclement weather, including snow, sleet, rain, and fog.

j. The UAS must remain in view (visual line of sight) of the PIC/PAC and the VO during the entire flight.

k. Ensure that there is adequate space for takeoff and landing. There should be adequate clearance (12-foot radius from launch point) surrounding the takeoff/landing area to allow gradual ascents/descents of the UAS.

l. Do not touch propellers while the UAS is powered on. Minimally, the PAC and VO must wear safety glasses during takeoffs and landings. Other persons in the vicinity of takeoffs and landings also should wear safety glasses.

m. In the unlikely event that a manned aircraft flies below 400 feet where the UAS is operating, the PAC will keep both the vehicle and manned aircraft in sight and will give way to the manned aircraft at all times.

4.2 General Hazards

Each potential hazard has its own unique circumstances that may affect the operation of the UAS, safety factors, and personnel involved. The PIC will consider the factors described below before authorizing launch of the UAS.

1. Weather: When possible, the PIC will contact the closest flight service station for weather in the immediate area of operations. In lieu of that source, local weather information may be obtained from the internet or observations on site. The PIC will have final determination of risk due to weather and authority over any launch of the aircraft.
2. Hazards to the Public: The PIC will make every effort to ensure that flight operations will not pose any undue risk to the public, client personnel, other contractors, or subcontractors. The PIC will have final determination of risk and authority over any/every launch. PACs will participate in risk assessment activities associated with their own aircraft.
3. Hazards to Property: The PIC will make every effort to ensure that flight operations will not pose any undue risk to any property in the area of UAS activities. The PIC will have final determination of risk to the property and authority over any/every launch. PACs will participate in risk assessment activities associated with their own aircraft.

4. Hazards to Personnel: The PIC will make every effort to ensure that flight operations will not pose any undue risk to any personnel. The PIC will have final determination of risk to personnel and authority over any/every launch. PACs will participate in risk assessment activities associated with their own aircraft.
5. Proximity to Controlled Airspace: Operations inside any controlled airspace will be performed with permission of, and in constant communication with, the controlling authority of the airspace. The PIC will have final determination of risk to the public and authority over any/every launch.

5 Equipment and Supplies

The following are typical equipment and supplies for operating a UAS:

- A complete UAS kit, consisting of:
  - Drone,
  - Remote controller,
  - iOS/Android device,
  - Drone batteries,
  - Battery charger,
  - Spare propellers,
  - SD cards, and
  - Drone registration card;
- Sunshades/visor for the phone/tablet; and
- Spare iOS/Android cables.

6 Procedure

6.1 Launch and Landing Site Selection

6.1.1 Launch Site Selection

Launch site selection will be driven by safety, first and foremost. The selection of launch sites will be based on consideration of:

1. Buffer zones: Adequate buffer zones of at least 50 feet between aircraft operations and non-essential personnel must be maintained. VOs will act as safety supervisors when not performing the duties of in-flight observer.
2. Environmental assessment: No launches shall occur until all environmental assessments have been considered. Personnel have final authority to abort any launch based on hazard to the environment, themselves, or other personnel in the area.
3. Departure over sparsely populated corridors: The PIC/PAC will make every effort to select a launch site that minimizes departures over populated areas. If flights over populated areas must take place, the PIC will plan each flight to minimize the time over areas of concern.

6.1.2 Landing Site Selection

The selection of landing sites will be based on consideration of:

1. Primary Landing Site: Typically, the primary landing will be the same as the launch site. The PAC has authority for any approaches to the primary site and may wave off any approach deemed unsafe. The PIC has final authority, including the authority to override any PAC determinations.
2. Alternate Landing Site: The PAC will designate at least one alternate landing site. In the event that a wave-off is not possible and the primary landing site is deemed unsafe, procedures to use the alternate site will be invoked.
3. Mission Abort Site: The PIC may optionally designate an abort site where the aircraft may be “dumped” in an emergency situation. The abort site will be so far removed as to provide absolute minimal risk should the aircraft be required to vacate airspace in an emergency. Should the PIC deem it necessary, the UAS may be flown to this site and inserted without regard to the safety of the aircraft or flight equipment.
4. Approaches over Populated Areas: The PIC/PAC will make every effort to select a landing site that minimizes approaches over populated areas.

6.2 Pre-Flight, In-Flight, and Post-Flight Procedures

6.2.1 Pre-Flight Procedures

Pre-flight activities are completed and verified by the PIC on an operations level and by the PAC, for his/her aircraft, before takeoff. Pre-flight activities are generally performed upon arrival at the location where the operation is to be performed. Pre-flight activities refer to all knowledge gathering, area assessment, and actions performed on the aircraft before takeoff. These include inspection of aircraft, assessment of the operating location, coordination with other crew members involved in the operation, and equipment checkouts. Some specific steps are described below.

1. Obtain General Flight Information: Prior to arriving on-site, check the weather forecast for the flight area. Ensure that forecasted weather meets flight safety requirements. Weather conditions can change quickly, therefore, on-site staff must maintain a continual weather assessment.
2. Perform a site safety assessment and prepare a SHASP prior to deploying the UAS, as specified in Sections 4 and 8.
3. Identify and confirm the identity of the PIC, PAC, and VO. The PIC may be the PAC, but a separate VO is required for each aircraft.
4. Perform a visual inspection of the aircraft:
    a. Check for cracks in the propellers and chassis.
    b. Look for excessive propeller wear. An excessively worn propeller may be cracked, have small pieces missing, or may have fatigued (the propeller blade appears to sag at the edges more than other blades). Very small, minor notches in the propeller blades are indicative of normal wear and tear.
    c. Inspect the landing gear, ensuring that it is tightly secured to the aircraft and free of cracks or other damage.
    d. Check all electrical connections (where applicable).
5. Check UAS battery power levels: Push the button on each battery one time, briefly. The four light-emitting diode (LED) charge indicator lights will light up to report the remaining

battery power. Each LED represents 25% of the total battery capacity. If the battery is below 50% (one solid LED and one blinking LED), the flight should not be attempted until the battery has been fully recharged.

6. Power on Remote Control: Remote control should have a green power light and four white battery indicator lights. Each of the smaller indicator lights represent 25% of the remote controller's battery capacity. If the battery level is below 75%, the flight should not be attempted until the controller has been fully recharged.
7. Power on and connect tablet/phone:
    a. Connect corresponding cable to the universal serial bus (USB) interface on the back of the controller.
    b. Once the phone or tablet is booted, open the DJI GO v4.0 app on the device.
8. Prepare UAS for flight:
    a. Insert the memory card to be used for the flight. It is recommended to ensure that there will be sufficient space free on the card for the flight imagery. If not, formatting the card prior to use is recommended.
    b. Remove the lens cap and gimbal clamp.
    c. Inspect the camera, verifying that the camera body, lens, and gimbal are intact and free from damage. Ensure that the camera is properly and securely attached to the UAS. Ensure that the gimbal is not obstructed and can move freely.
    d. Insert the battery until it clicks securely into the UAS.
9. Power on the UAS:
    a. Ensure that the flight control toggle switch on the remote control is set to "P."
    b. Push the power button once, then press and hold the power button on the battery until all four power LEDs light up, then release the button. The UAS should play a chime sound and blink its indicator lights (located underneath the propellers) red, yellow, and green.
    c. Set the UAS down on a level surface and allow it to acquire GPS satellites. This can take anywhere from 1 to 5 minutes. The Phantom must acquire at least six satellites before flight can be attempted. The rear indicator lights will blink solid green once it has acquired six GPS satellites. Once acquisition is complete, the UAS should acquire at least 12 satellites.
10. Assess System Status:
    a. The DJI Go app will provide telemetry information, including drone inertial measurement unit (IMU), gimbal, and compass status. Ensure that all systems are normal prior to flight.
    b. If errors are found, address according to the app recommendations and/or DJI user manual.
11. Position the UAS: The UAS must be a minimum of 12 feet from the PAC, facing away from staff.
12. Position the VO: The VO must be a minimum of 20 feet from the PAC but no more than 12 feet from the UAS. The UAS should be facing away from the VO.
13. Before energizing propellers, announce out loud – "All Clear – Contact."

14. Launch the aircraft.

6.2.2 In-Flight Procedures

1. Be mindful of FAA regulations and general safety guidelines regarding UAS flights.
2. Climb to a safe altitude away from potential hazards and check control systems.
   a. The recommended minimum altitude is 120 feet AGL, where applicable.
   b. The minimum Return to Home altitude should be 140 feet AGL.
3. Keep aircraft at a safe operating distance from people and buildings.
4. If the aircraft must be flown over buildings or people, maintain a safe altitude for recovery and make every effort to minimize exposure.
5. Continually scan the flight and ground areas for potential hazards.

6.2.3 Landing Procedures

1. Check the control systems and set the trims so that if necessary, an emergency abort landing can be made.
2. Scan the landing area for potential obstruction hazards and re-check weather conditions.
3. Announce out loud – "Preparing to land."
4. Always be prepared to go around.
5. Carefully land the aircraft away from obstructions and people.
6. Only use automated landing features once the UAS has safely returned to the landing zone and is hovering overhead.

6.2.4 Post-Flight Checks and Procedures

1. After landing the UAS and stopping the propellers, power off the UAS.
2. Remove the battery. Once the battery is removed, the PAC will audibly call out “Clear to approach aircraft” to indicate that the aircraft is now safe to handle.
3. Power off the remote control only after the battery has been removed from the UAS.
4. Re-attach the gimbal/lens clamp.
5. Remove the memory card and place it in the memory card storage container.
6. Inspect the UAS for any damage that may have occurred during flight or landing. It is common for the UAS to accumulate dirt, insect remains, or mud/grass bits and stains post-flight. In these instances, the UAS can be cleaned by wiping it down with a cleaning wipe. Do not clean the camera lens with anything other than a dry microfiber cloth.
7. Log the flight activity in the UAS logbook. Note flight times, which battery was used for which flight, and any flight anomalies.
8. Place the UAS, controller, phone/tablet, batteries and memory cards into the specified locations carved out in the case. Close the lid and latch it securely.

9. Upon return to base, recharge the UAS batteries, remote control, and phone/tablet to prepare for the next flight.

6.2.5 Field Repairs

After recovery of the aircraft, if an inspection should reveal any damage, the PIC may authorize the field repair of the aircraft. Field repairs can consist of two types, critical and non-critical.

Non-critical repairs are repairs made to the airframe or components that are not critical to the flight control or function of the aircraft for its assigned mission. Repairs of this nature are patches to covering, replacing fairings or cowlings, replacement of propellers, or repairs that enhance the mission payload.

Critical repairs are those repairs that directly affect the ability of the aircraft to perform its function and continue the mission. Typical repairs of this nature would be replacing a motor, the remote control, the camera/gimbal system, or a flight control servo. Typically, a critical repair should not be attempted on-site. If the UAS has warranty service remaining, contact the manufacturer for repair information or service. Once critical repairs are complete, a complete inspection and test flight of the aircraft is required before it can return to field duty.

6.3 Clearing the Scene

Personnel will leave as small an environmental footprint as possible. Personnel are to check the immediate area around the flight operations for any equipment, personal items, or trash and remove as appropriate.

6.4 Reporting

Two types of reports are required by the FAA for UAS operation: accident and incident. Each is accessible from the FAA UAS portal: www.faa.gov/uas.

6.4.1 Accident Reporting

An accident would include a technical malfunction, pilot error, or other flight complication resulting in damage or injury. Specific reporting procedures include:

1. Report an accident to the FAA within 10 days of any operation resulting in:
    - Injury requiring a hospital visit, or
    - Property damage exceeding $500 (not including the UAS).
2. Accident reports are due within 24 hours of the accident. Accident reporting is available via the FAA reporting portal: https://www.faa.gov/uas/report_accident/

6.4.2 Incident Reporting

Incidents involving unsafe flight operations by other non-E & E personnel must be reported to the FAA. Examples include:

- Unsafe and or unauthorized UAS activity;
- A flight incident involving a near-miss or collision of the UAS with manned aircraft; and
- A flight incident involving another UAS.

Refer to the graphic below for more information.

FAA Drone Incident Reporting

Document and provide the following information to FAA:

- Identity of operators and witnesses (name, contact information)
- Type of operation (hobby, commercial, public/governmental)
- Type of device(s) and registration information (number/certificate)
- Event location and incident details (date, time, place)
- Evidence collection (photos, video, device confiscation)

Contact your FAA LEAP agent or an FAA Operations Center for assistance.

FACILITY	STATES	PHONE NUMBER	EMAIL
Western ROC	AK, AZ, CA, CO, HI, ID, MT, NV, OR, UT, WA and WY	425-227-1999	9-WSA-OPSCTR@faa.gov
Central ROC	AR, IA, IL, IN, KS, LA, MI, MN, MO, ND, NE, NM, OH, OK, SD, TX and WI	817-222-5006	9-CSA-ROC@faa.gov
East ROC	AL, CT, FL, GA, KY, MA, ME, MS, NC, NH, PR, RI, SC, TN, VI and VT	404-305-5180	9-ESA-ROC@faa.gov
East ROC	DC, DE, MD, NJ, NY, PA, VA and WV	404-305-5150	9-ESA-ROC@faa.gov

7 Quality Assurance/Quality Control

Prior to initiating fieldwork, the project planning documents (e.g., work plan, SHASP) will be reviewed by field personnel. The program/project manager should identify personnel for the field team who have the knowledge, training, and experience required for this work.

The PIC should prepare a detailed equipment checklist before entering the field and verify that sufficient and appropriate equipment and supplies are taken into the field.

Instrumentation will be operated in accordance with operating instructions as supplied by the manufacturer unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to operation and they must be documented.

All deliverables will receive peer review prior to release.

8 Health and Safety

A SHASP will be prepared prior to all UAS operations. Prior to entering the field, all field personnel will acknowledge in writing that they have read and understand the SHASP, which will be in compliance with the Corporate Health and Safety Program.

9 Special Project Requirements

Project-specific requirements will be included with the project planning documents.

10 References

Federal Aviation Administration (FAA). 2016. Remote Pilot – Small Unmanned Aircraft Systems Study Guide. FAA-G-8082-22. August 2016. Flight Standards Service. Washington, DC.

END OF SOP

ecology and environment, inc.

STANDARD OPERATING PROCEDURE

BOREHOLE INSTALLATION AND SUBSURFACE SOIL SAMPLING METHODS

SOP NUMBER: GEO 4.7

REVISION DATE: 5/25/2012 **SCHEDULED REVIEW DATE: 5/26/2017**

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1 Scope and Application

This Standard Operating Procedure (SOP) describes the procedures utilized by E & E for collection of unconsolidated and consolidated subsurface samples from boreholes using a subcontract driller. Most subsurface investigations require the drilling of boreholes for one or more purposes: collection of soil samples for lithologic logging and laboratory testing; lithologic and hydrogeologic characterization using borehole geophysical logging; and installation of piezometers or monitoring wells. Drilling methods are selected based on availability and cost; suitability for the type of geologic materials at a site (unconsolidated or consolidated); and potential effects on sample integrity (influence by drilling fluids and potential for cross-contamination between aquifers). Site-specific drilling methods and sampling procedures also vary depending on the data quality objectives (DQOs) identified in program/project planning documents.

Procedures for collecting soil samples for volatile organic compound (VOC) analyses are presented in the E & E VOC Soil and Sediment Sampling SOP ENV 25.

Procedures for collecting surface and shallow subsurface soil sampling SOP are presented in the E & E Borehole Installation Methods SOP ENV 3.13.

Procedures for sample handling are defined in E & E Environmental Sample Handling, Packaging and Shipping SOP ENV 3.16. Site-specific sample handling procedures are dependent on the project DQOs.

Procedures for equipment decontamination are defined in E & E Sampling Equipment Decontamination SOP ENV 3.15. Site-specific equipment decontamination procedures are dependent on the project DQOs.

This is intended for use by personnel who have knowledge, training and experience in the field soil sampling activities being conducted.

2 Definitions and Acronyms

DQO	Data Quality Objective
E & E	Ecology and Environment, Inc.
HSA	hollow-stem auger
SHASP	Site Specific Health and Safety Plan
SOP	Standard Operating Procedure
VOC	Volatile Organic Compound

3 Procedure Summary

A wide variety of drilling methods have been developed that could be suitable for one or more of the purposes described above. Table 1 summarizes information on drilling methods.

Table 1 Summary Information on Drilling Methods

Drill Method	Casing/ Open Hole	Can Drill Fluids Affect Groundwater Quality?	Core Samples?
Hollow-Stem Auger	Open Hole	No	Possible
Direct-Push/Geoprobe®	Either	No	Yes
Open-Hole Rotary Methods			
Direct Air Rotary with Bit	Open Hole	Yes	Possible
Direct Air Rotary with Downhole Hammer	Open Hole	Yes	Possible
Direct Mud Rotary	Open Hole	Yes	Possible
Reverse Rotary (no casing)	Open Hole	Yes	Possible
Cable Tool	Either	No	Possible
Rotary Drill-Through Methods			
Rotary Casing Driver	Casing	Yes	Possible
Dual Rotary Advancement	Casing	Yes	Possible
Other Methods			
Reverse Dual Wall Rotary	Casing	Yes	Possible
Reverse Dual Wall Percussion	Casing	Yes	Possible
Hydraulic Percussion	Casing	Yes	Possible
Downhole Casing Advancers	Casing	Yes	Possible
Jet Percussion	Casing	Possible	Possible
Jetting	Open Hole	Possible	No
Solid-Stem Auger	Open Hole	No	Possible
Bucket Auger	Open Hole	No	Possible
Rotary Diamond	Open Hole	Possible	Yes
Directional Drilling	Either[a]	Possible	Possible[b]
Sonic Drilling	Either	Possible	Yes
Driven Wells	Either	No	No
Cone Penetration	Open Hole	No	Possible[c]

Notes:
[a] EC rig uses casing advancement; other methods may involve open-hole advancement.
[b] Sampling with a device resembling a split spoon may be possible with some directional rigs.
[c] Geoprobe has developed a core sampler for use with a cone penetration testing rig.

Subsurface soil samples are collected from boreholes for chemical and physical analysis and to aid in the definition and tracking of contaminants in the soil. The subsurface soil samples may be either composite or discrete, and either disturbed or undisturbed. The type of sample to be collected depends on the drilling technique and the purpose of the investigation.

4 Cautions

Cautions associated with borehole installation include decontamination procedures, depth control, and health and safety associated with heavy equipment use. All equipment that is brought on site must be clean prior to arrival and all downhole equipment must be decontaminated prior to drilling each boring location. This is an important factor to ensure that off-site contaminants are not introduced to the soils (and groundwater) being collected and that contaminants encountered at one site location are not spread throughout the site.

Depth control is also an important factor to ensure that exact soil horizons, formations, and zones of contamination identified during sampling are accurately documented and will allow for accurate placement of well materials. The oversight geologist should be familiar with the drilling methodology and independently verify measurements on a regular basis. This will identify any discrepancies between the oversight geologist and the drill rig operator.

As with any heavy equipment operation, proper personal protective equipment is essential. At a minimum, Level-D protection will be required for all drilling operations.

5 Equipment and Supplies

The equipment and supplies required for field work depend on the program/project DQOs. The following is a general list of equipment and supplies. A detailed list of equipment and supplies should be prepared based on the project planning documents. In general, the use of dedicated or disposal equipment is preferred but equipment may be re-used after thorough decontamination between sample locations (refer to E & E Sampling Equipment Decontamination SOP ENV 3.15).

- Stainless-steel or Teflon™ spoons, trowels, or scoops. Other construction material may be acceptable depending upon the program/project planning documents and DQOs
- Soil-coring equipment or augers acceptable depending upon the program/project planning documents and DQOs
- Sampler such as thin-walled tube sampler (e.g., shelby tube sampler), split-spoon sampler, continuous soil core sampler (e.g. Laskey), continuous-flight auger, or direct push soil corer (e.g., Macro-Core®).
- Stainless-steel mixing bowls. Other bowl construction material may be acceptable depending upon the program/project planning documents and DQOs
- Spade(s) and/or shovel(s)
- Liners and/or catchers for augers or core samplers as specified in the project planning documents
- Pipe cutter(s), stainless steel knives(s), or power saw to cut liners
- Survey stakes or flags to mark locations
- Ancillary equipment and supplies, e.g., meter stick or tape measure, aluminum foil, plastic sheeting, disposable gloves.

Supporting equipment and supplies also may be required to address the following:

- Field logbooks and supplies (Refer to project planning documents and the E & E Field Activity Logbooks SOP DOC 2.1 for details)
- Decontamination equipment and supplies (Refer to project planning documents and E & E Sampling Equipment Decontamination SOP ENV 3.15for details)
- Sample containers, preservatives, and shipping equipment and supplies (Refer to project planning documents and the E & E Environmental Sample Handling, Packaging and Shipping SOP ENV 3.16 for details)
- Waste handling supplies (Refer to project planning documents and E & E Handling Investigation-Derived Wastes SOP ENV 3.26 for details)

6 Procedure

The most accurate method for obtaining information on the characteristics of unconsolidated deposits is to collect representative samples of the soil at measured depths and at intervals that will provide a complete lithologic profile of the soils. E & E staff will use the following procedures for completing borehole installation and subsurface soil sampling:

- Review relevant project planning documents, e.g., work plan, sampling and analysis plan, quality assurance project plan, health and safety plan, etc.
- Select the sampling procedure(s) that meet project DQOs.
- Refer to the E & E Field Activity Logbooks SOP DOC 2.1 for guidance on the types of information that should be recorded for each sample.
- Refer to the E & E Environmental Sample Handling, Packaging and Shipping SOP ENV 3.16 for guidance on how samples should be labeled, packaged, and shipped.

6.1 Subsurface Soil Sampling Methods

6.1.1 Disturbed and Undisturbed Overburden Samples

Soil samples from unconsolidated deposits can be collected as disturbed or undisturbed soil samples. Disturbed soil samples are produced by the action of the hollow-stem auger (HSA) and are called drill cuttings. The components of an HSA are shown in Figure 1. Disturbed samples are not representative of the formations penetrated because of the possible sorting and grinding of the cuttings while being carried to the surface. In general, disturbed samples do not contain detailed lithologic information, and the depth that the soil is encountered is less precise.

Mildly disturbed to relatively undisturbed soil samples are collected in a variety of sampling devices, including the split spoon or split-barrel sampler (see Figure 2), and the continuous soil core sampler (see Figure 3). Sonic drilling also provides relatively undisturbed samples. Undisturbed soil samples are collected using the thin-walled tube sampler (see Figure 4).

The collection of undisturbed samples ensures the preservation of detailed lithologic information (such as the degree of consolidation, sorting, bedding, etc.) and a more accurate estimation of sample depth.

6.1.2 Composite and Discrete Overburden Samples

Composite samples are prepared from aliquots of discrete samples. They are useful for obtaining a representative sample from a subsurface interval for analytical purposes. However, composite samples are inadequate for lithologic purposes.

Discrete samples are obtained from a specific depth and are useful when detailed analytical information about the overburden soils is required. Analysis of discrete overburden soil samples provides the more accurate information on the depth of contamination than composite samples.

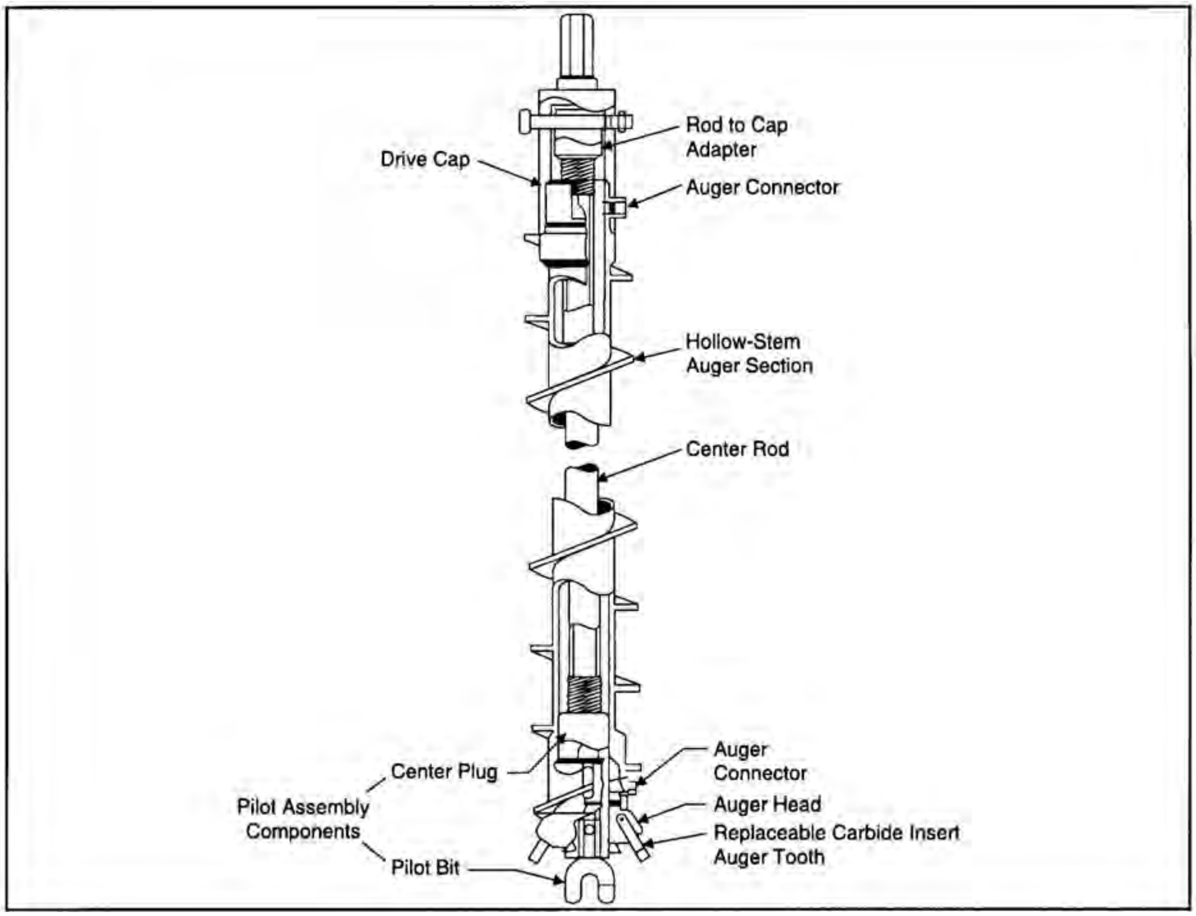

Figure 1 Typical Components of a Hollow-Stem Auger

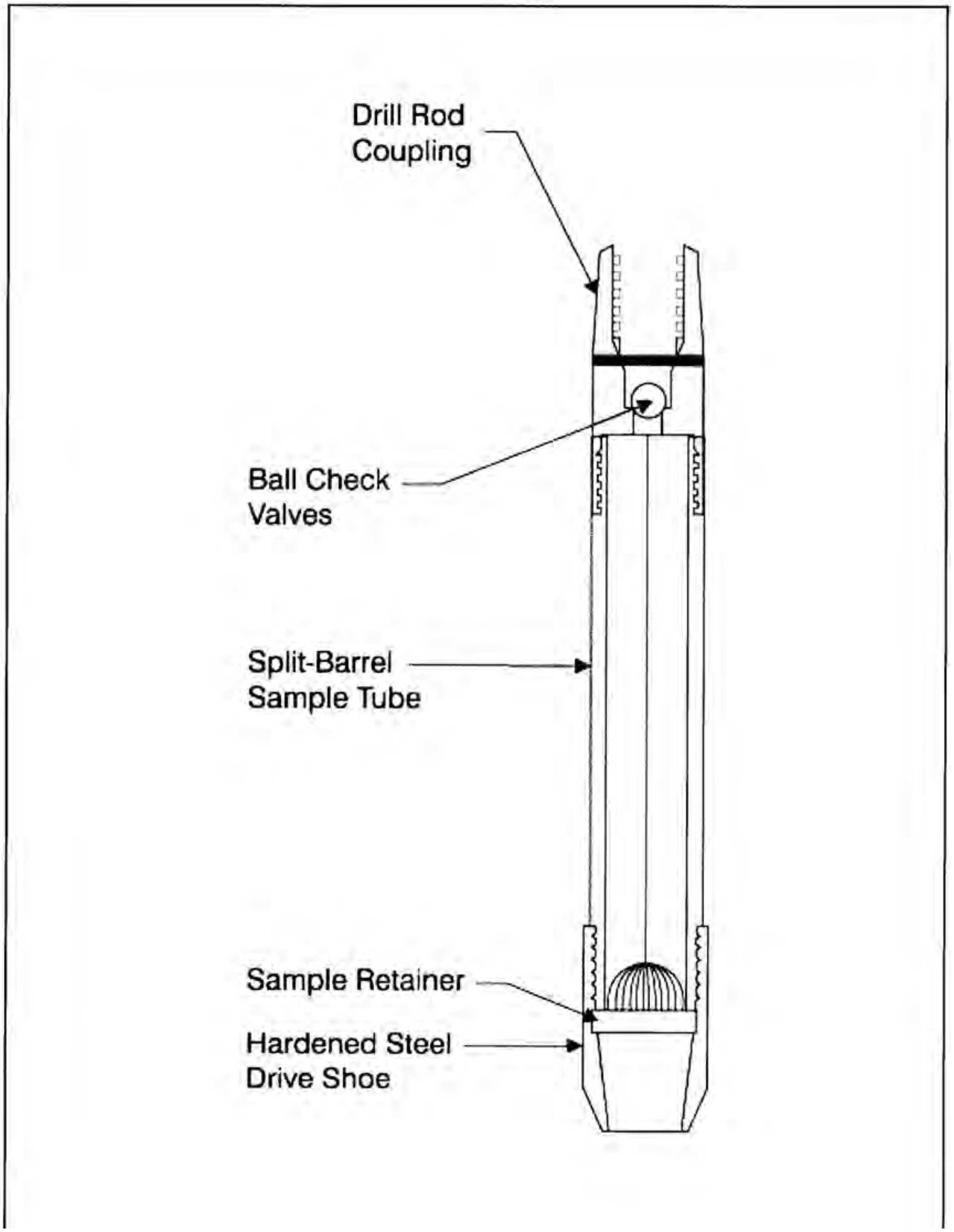

Figure 2 Split-Spoon or Split-Barrel Sampler

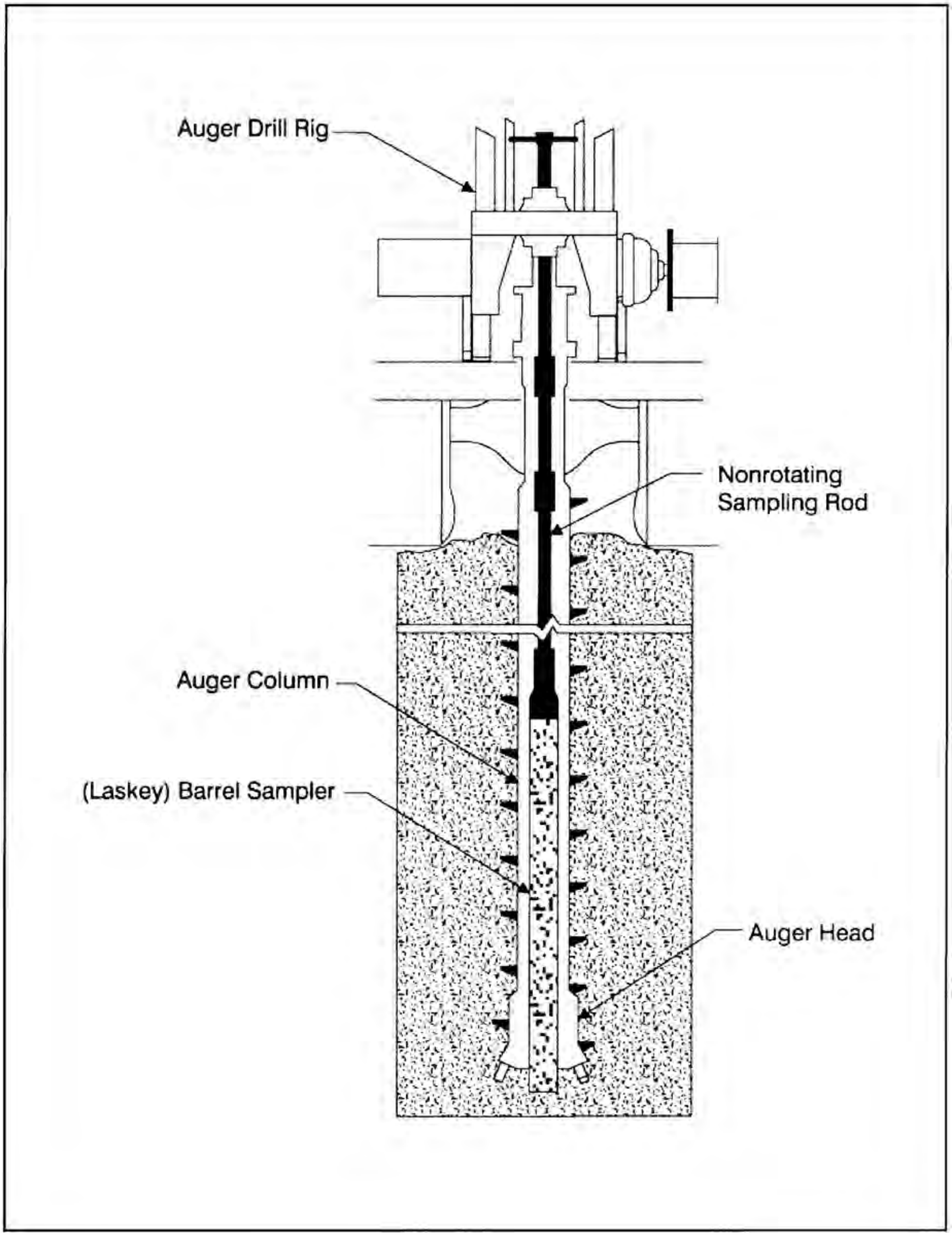

Figure 3 Continuous Sampling Tube System (Laskey)

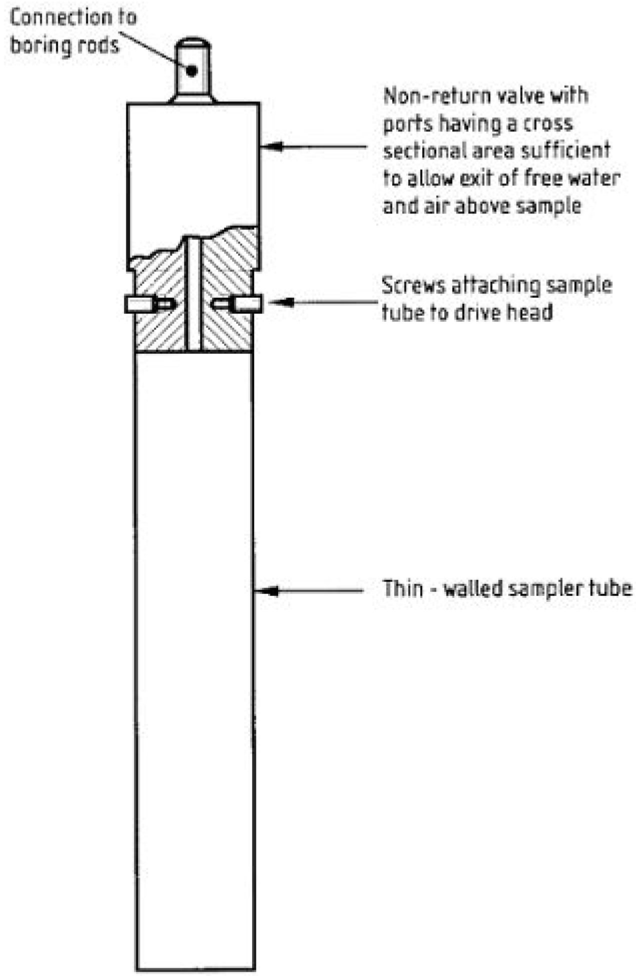

Figure 4 Shelby Tube Sampler

6.1.3 Environmental Sample Collection

Samples for environmental laboratory analysis can be collected from sampling devices described above and in Section 6.2.

1. Samplers should be decontaminated or dedicated for collection of environmental samples.
2. Samplers should be in a perpendicular position on the sample material.
3. Sampling methods should attempt to minimize compression of the sample.
4. Record the length of the tube used to penetrate the material being sampled and the number of blows required to obtain this depth.
5. Once the sample is collected record all length of sample and estimate sample recovery and compression. Project planning documents may indicate acceptability criteria for samples recovery and sample collection. The geologist will need to determine based on site conditions if poor recovery is due to sampling equipment or the geologic formation. The goal is obtain a sample for environmental analysis that is representative of subsurface soil at a specified depth interval and meet the project DQOs. If samples don't meet the DQOs then determine a course of action with the project manager.

6. Soil samples should be collection as soon as possible following extraction of the sampler.
    - Place sampler or liner on clean surface
    - Carefully remove any end caps and/or catchers
    - Evaluate record core length, geologic information, monitoring data, and any visual observations.
    - For transverse sectioning of liners, beginning at the soil surface, measure and mark the sample sections on the outside of the liner
        - Cut the liner with a manual pipe cutter or core liner and core with a decontaminated saw blade into marked sections.
        - Extrude the soil from the cut segments of the liner. If necessary use a plunger cover with aluminum foil to aid in extruding the core.
        - Empty the core segment into a stainless steel bowl (or other type as specified in the project planning documents).
        - Record observations of the soil types.
        - Immediately collect volatile organic analyte and sulfide samples.
    - For longitudinal sectioning of cores, open the split spoon or use a knife to cut the liner and expose the upper half of the soil cylinder.
        - Beginning at the soil surface, measure and mark the sample sections using a tape measure set aside the core.
        - Record observations of the soil types.
        - Immediately collect volatile organic analyte and sulfide samples.
        - Scope the core segment into a stainless steel bowl (or other type as specified in the project planning documents).
    - If multiple core segments are necessary to collect adequate sample volume, they should all be combined in the bowl prior to homogenization
    - Homogenize the sample as thoroughly as possible
    - Transfer sample aliquots to appropriate sample containers and preserve as required in the project planning documents.
7. Return unused soil to the boring or containerize as specific in the project planning documents,
8. Follow proper procedures for sample handling and transportation to the laboratory for analysis.

6.1.4 Geotechnical Sample Collection

Some sampling devices also may be used to collect information for geotechnical analysis such as soil density. Geotechnical sampling should strictly follow standards for sampling based on the type of test performed. This information should be documented in the project planning documents. Detailed procedures are not included here because standards are routinely updated and only the most current standard should be used. Spilt spoon sampling work should be performed in accordance with American Society for Testing and Materials (ASTM) ASTM

D1586 - 11 *Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils*. If thin-wall tube sampling is used for soil collection, then follow ASTM D1587 - 08 *Standard Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes.*

6.2 Borehole Installation

6.2.1 Inspection and Cleaning of Sampling Equipment

Proper cleaning of the drill rig, downhole equipment, and sampling equipment prior to arriving at the site and between drilling locations is necessary to minimize the potential introduction of contaminants into soil and groundwater samples. A rig should not be allowed to enter a site if the rig appears to be dirty (other than road dirt) from previous use at another site. While operating on site, the drill rig should be checked repeatedly for oil and hydraulic fluid leaks. These precautions are essential to ensure that trace contaminants from the drilling process are not introduced to the samples.

Before drilling begins at a site, and after each boring is completed, all the down-the-hole drill equipment, the rig, and other equipment (as necessary) should be steam cleaned, or cleaned using high-pressure hot water, and rinsed with pressurized potable water to minimize cross contamination. Special attention should be given to the threaded sections of the casings and drill rods. Additional cleaning may be necessary during the drilling of individual holes to minimize the carrying of contaminated materials from shallow to deeper strata by contaminated equipment (e.g., decontamination of split spoon samplers as associated drill rods).

Equipment with porous surfaces, such as rope, cloth hoses, and wooden blocks or tool handles cannot be thoroughly decontaminated. These should be disposed of properly at appropriate intervals. These intervals may be the duration of drilling at the site, between individual wells, or between stages of drilling a single well, depending upon characteristics of the tools, site contamination, and other considerations.

Cleaned equipment should not be handled with soiled gloves. Surgical gloves, new clean cotton work gloves, or other appropriate gloves should be used and disposed of when even slightly soiled. The use of new painted drill bits and tools should be avoided since paint chips can bias soil and groundwater samples.

Upon completion of drilling activities at a particular site, all drilling equipment should be steam cleaned or cleaned using high-pressure hot water to ensure that no contamination is transported off site.

6.2.2 Hollow-Stem Auger Drilling

An HSA column simultaneously rotates and axially advances using a mechanically or hydraulically powered drill rig. The hollow stem of the auger allows use of various methods for continuous or intermittent sampling of subsurface soils. Riser and screen for monitoring wells can be placed in the hollow stem when the desired depth has been reached, and filter pack and grouting emplaced as the auger is gradually withdrawn from the hole. Use of different diameter augers allows use of casings to isolate near-surface contamination and continuation of drilling with a smaller-diameter auger. HSA flights are manufactured in 5-foot lengths and have various inside diameters ranging from 2.25 inches to 10.25 inches.

If a split-barrel soil sampler is used to collect unconsolidated soil samples, a center plug of the same diameter as the HSAs and a section of drilling rod are placed inside the lead flight. The HSAs are advanced through the unconsolidated deposits to the first sampling interval, and the center plug is then removed from the HSAs. A precleaned split-barrel soil sampler is attached to the end of the drilling rod and lowered into the HSAs. A safety hammer is attached to the top of the drilling rod, and the split-barrel soil sampler driven into the undisturbed soil to a depth of 2 feet. The split-barrel soil sampler is retrieved and opened to remove the soil sample. The center plug is replaced in the HSAs, and another flight of HSAs is attached to the top of the flight already in the ground. The process is repeated until bedrock is encountered or the project depth is reached.

A continuous soil core sampler (i.e., Laskey) is used to collect 5-foot continuous soil core samples while the HSAs are turning. The Laskey soil sampler is used instead of a center plug in 4.25-inch HSAs, and the head of the sampler leads the HSAs by 2 to 6 inches. At the completion of a 5-foot run of HSAs, the Laskey soil sampler is recovered and opened in a manner similar to a split-barrel sampler. Following sample collection and decontamination of the Laskey soil sampler, the sampler is replaced inside the HSAs, and another flight of HSAs is attached to the top of the flight already in the ground.

A Shelby tube sampler is used to collect undisturbed overburden soil samples in a manner similar to a split-barrel soil sampler. Once the HSAs have reached the top of the interval to be sampled, the drilling rods holding the center plug are withdrawn from the HSAs, the Shelby tube is attached to the end of the drilling rod, and the Shelby tube is lowered into the HSAs. The Shelby tube is pushed out the bottom of the HSAs to the prescribed depth, and the tube is retrieved. The Shelby tube is not opened in the field, but is shipped to the laboratory. The process is repeated until bedrock is encountered or the project depth is reached.

6.2.3 Direct-Push/Geoprobe

Installation of boreholes using direct-push/Geoprobe® methods utilizes a hydraulically powered machine to drive rods into the subsurface with both static (downward push) and percussive (hammer) force. Rod widths generally vary from 1.25 inches to 4.25 inches in diameter. This method can be used for continuous or discrete soil sampling in unconsolidated formations only. This method of borehole installation is effective for achieving depths up to 60 feet below ground surface or less, although newer more powerful machines have recently been constructed that have achieved depths in excess of 200 feet below ground surface in certain formations (e.g., 8000 Series Geoprobe®).

There are two soil sampling methods commonly used, macro-core and dual tube. The macro-core sampler does not incorporate the use of casing and utilizes a center rod to hold the core barrel tip in place until the desired depth is reached. The center rod is removed at the desired depth so that soils are allowed to enter the core barrel while it is further driven into the subsurface. The entire assembly is removed to retrieve the soil core and the borehole may collapse at this time. Because the borehole can collapse in between sampling, there are some concerns with slough and cross contamination using this method. A plastic sleeve lines the length of the macro-core barrel to contain the soils and is used to remove the soils. The plastic sleeve should be replaced with a new sleeve for each soil core. This method can be used for continuous or discrete sampling and typically uses a 2.25-inch core barrel and yields a 1.25-inch soil core (other sizes available).

Dual-tube soil sampling utilizes one set of rods that are advanced as an outer casing. A set of inner rods are used to hold a 4- or 5-foot plastic sleeve in the tip of the casing/rod. After each 4- or 5-foot increment, the plastic sleeve is removed using the inner rods and replaced with a new liner before advancing further. Borehole advancement only continues when the soil core barrel is placed back into the borehole and mated with the leading rod of the casing. This method is generally used for continuous soil sampling although it can be utilized for discrete sampling using a center rod. The typical diameter of tooling using this set up is 4.25-inche casing with a 3-inch soil core. Because the casing remains in place, this method is effective for use in saturated formations and areas where cross contamination is of concern. Given the greater diameter of the tooling, this method typically is more limited in depths of penetration (Geoprobe® 2006).

6.2.4 Direct Mud Rotary

Direct mud rotary bore hole drilling is advanced through rapid rotation of a drill bit (Tri-cone) mounted upon the end of drill rods. The bit cuts and breaks the material at the bottom of the hole into small pieces (cuttings). The cuttings are removed by pumping drilling fluid (water, or water mixed with bentonite or other fluid enhancers) down through the drill rods and bit and up the annulus between the bore hole and the drill rods. The fluid is referred to as drilling mud. Drilling mud is recirculated through the use of a "mud tub" where cuttings are accumulated and drilling mud is pumped back down the drilling rods. The drilling fluid also serves to cool the drill bit and stabilize the bore-hole walls, to prevent the flow of fluids between the bore hole and surrounding earth materials, and to reduce cross contamination between aquifers. Direct mud rotary drilling offers a number of advantages; it is a fast and efficient means of drilling. Efficient rigs can produce several hundred feet of hole per day. The direct mud rotary method can reach to several thousand feet in depth and create hole diameters to greater than 48 inches. The method is adaptable to a wide range of geologic conditions. Only exceptionally large, poorly stabilized boulders, or karst (cavernous) conditions are unsuited for direct mud rotary drilling. Direct mud rotary rigs are widely available throughout the United States. Sediment sampling is broadly supported in direct mud rotary drilling: standard split-barrel and thin-wall sampling are available in poorly lithified materials while a broad range of coring apparatus' are supported for consolidated rock. Hydrologic conditions have little effect upon direct mud rotary drilling; operations are usually unhindered by the presence of ground water. Direct mud rotary drilling readily supports the telescoping of casings to successively smaller sizes to isolate drilled intervals and to protect lower geologic units from contamination by previously drilled, contaminated upper sediments.

The use of direct mud rotary drilling requires careful management of drilling fluids to prevent the buildup of drilling mud (mud cake) in permeable intervals, which can impact the quality of water samples collected from the monitoring well and inhibit flow to the well. A pH neutral bentonite should be used to prevent interference with water quality samples. Additionally, care has to be taken to ensure that organic compounds sometimes added to drilling fluids do not interfere with chemical analysis of water samples. To prevent this, drilling muds will only contain chemically inert substances and the use of petroleum products for fittings and pipe joints will be prohibited. Substitutes for petroleum grease such as vegetable-based oil and lubricants will be utilized.

Direct mud rotary drilling may sometimes be the best available alternative, especially for deep wells or wells completed into well lithified rocks. When direct mud rotary methods are used, hole diameters should be 3 to 5 inches larger than the outer diameter of the well casings to allow effective placement of filter and sealing materials. Two-inch diameter monitoring wells should therefore be installed within 5.5-inch diameter or larger holes.

6.2.5 Direct Air Rotary and Downhole Hammer

The basic rig setup for air rotary with a tri-cone or roller-cone bit is similar to direct mud rotary, except that the circulation medium is air rather than water or mud. Compressed air is circulated down through the drill rods to cool the bit and carry cuttings up the hole to the surface. A cyclone separator slows the air velocity and allows the cuttings to fall into a container. A down-the-hole hammer, which operates with a pounding action as it rotates, replaces the roller-cone bit.

6.2.6 Sonic Drilling

The sonic drill rig is similar to other drilling rigs in that it is a machine attached to a frame mounted on some type of vehicle. Sonic drilling is the application of high frequency vibration used in conjunction with down pressure and rotation to advance drilling tools through subsurface formations (see Figure 5). The use of high frequency vibration through the drilling tools causes the formation materials to vibrate at their natural frequencies allowing the drilling tool (casing) to advance by fracturing, shearing, or displacing formation material. Most sonic drilling is utilized for drilling in unconsolidated material. However, sonic drilling can also be used for drilling and sampling of rock formations.

During drilling, unconsolidated samples are collected using a sample (or core) barrel. Core barrels are either solid tubes or split barrels of various diameters and lengths generally sized to match the inside diameter of the drill casing being utilized. Typical core barrels are 10 to 20 feet in length and casing sizes range from 0.5 inches to 12 inches, although 4- to 6-inch casing is typical. The core barrel is fitted with a drill bit/cutting shoe, and the sampler is placed within the outer casing material and attached to the rig by drilling rods. As the borehole is advanced, formation material is collected within the core barrel.

Following the sampling run (typically 10 to 20 feet), the core barrel is extracted from the well casing. Formation material is then extracted from the core barrel. Typically, sample material is extracted into a plastic sleeve, which is separated into convenient lengths for logging. The process of sonic drilling and sample collection will cause the sample to be distorted due to vibration, but generally will be intact. In the case of rock drilling, the vibration may create mechanical fractures that can affect the structural analysis for permeability and thereby not reflect the true *in-situ* condition.

The advantages to using sonic drilling technology include reducing the amount of drill cutting generated, providing rapid formation penetration, and the recovery of a continuous core sample.

6.3 Borehole Abandonment

Borehole abandonment is necessary to eliminate potential physical hazards, prevent groundwater contamination, conserve aquifer yield and hydrostatic head, and prevent intermixing of surface water and subsurface water. After the necessary unconsolidated soil samples or consolidated core samples have been collected from the borehole, the HSAs are removed from the borehole and the HSA flights cleaned. A cement/bentonite grout should be tremied into the borehole to the surface. The grout should consist of potable water, bentonite powder, and Type I Portland cement, with 94 pounds of cement and 5 pounds of bentonite per 6.5 gallons of water.

Always determine whether there are applicable regulatory or programmatic specific borehole abandonment procedures or reporting requirements.

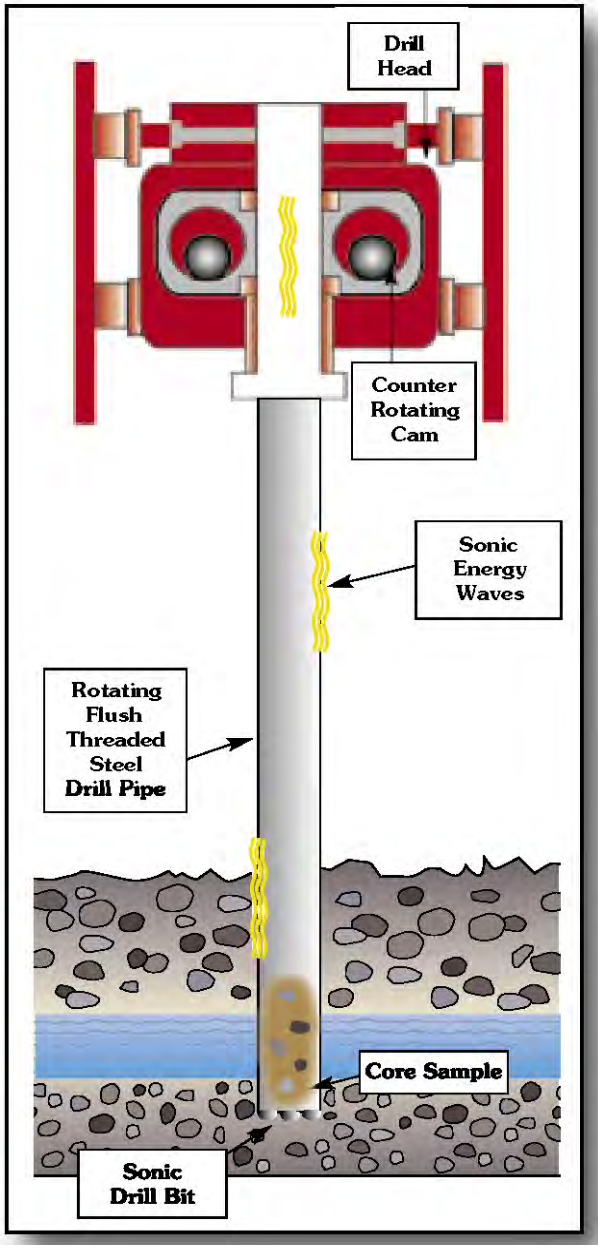

Figure 5 Typical Sonic Drilling Components

7 Quality Assurance/Quality Control

Prior to initiating field work, the project planning documents (e.g., work plan, sampling and analysis plan, quality assurance project plan, SHASP, *et al*) should be reviewed by field personnel to identify sampling procedure(s) that will most likely provide surface and shallow subsurface soil samples that meet project DQOs.

The program/project manager should identify personnel for the field team who have knowledge, training and experience in the borehole installation and subsurface soil sampling activities being conducted typically trained geologist. The geologist should document all borehole sampling and lithological information in E & E's geotechnical logbook. All project personnel, if necessary, can complete ancillary procedures, e.g., field logbook documentation, equipment decontamination, sample shipment, and waste disposal.

The lead geologist should prepare a detailed equipment checklist before entering the field and verify that sufficient and appropriate equipment and supplies are taken into the field.

Quality assurance/quality control samples (e.g., co-located samples) are collected according to the site quality assurance project plan. Field duplicates are collected from one location and treated as separate samples. Field duplicates are typically collected after the samples have been homogenized. Collocated samples are generally collected from nearby locations and are collected as completely separate samples. Rinsate blanks may be necessary to evaluate the effectiveness of field decontamination procedures (see E & E SOP Env 3.15).

In cases where multiple hand-collected scoop, auger or core samples are required to generate an adequate sample volume, homogenization is important. Field personnel should collect sample aliquots only after mixing has produced soil with textural and color homogeneity.

At sites with known or suspected contamination, samples should be collected moving from least to most contaminated areas.

8 Health and Safety

Prior to entering the field, all field personnel formally acknowledge that they have read and understand the project specific health and safety plan.

Augers and soil core sampling apparatus are inherently dangerous pieces of heavy equipment which a high “pinch” potential. Care should be taken at all times when handling such equipment, not just during sample collection.

Prior to any subsurface work, verify that underground utilities have been located and marked.

9 Special Project Requirements

Project or program-specific requirements that modify this procedure should be entered in this section and included with the project planning documents.

10 References

See E & E SOP Env 3.13 for additional sources of technical information on soil sampling.

Geoprobe®. 2006. Geoprobe® DT 325 Dual Tube Sampling System, Technical Bulletin NO. MK 3138, revised 1/2011.

END OF SOP

ecology and environment, inc.

STANDARD OPERATING PROCEDURE

GEOLOGIC LOGGING

SOP NUMBER: GEO 4.8

REVISION DATE: 5/31/2020 **SCHEDULED REVIEW DATE: 5/31/2025**

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1 Scope and Application

This Standard Operating Procedure (SOP) describes the procedures used by E & E for performing geologic logging and completing the geotechnical logbook in accordance with the data quality objectives (DQOs) prescribed for the project in planning documents. Geologic logging involves keeping detailed records during the drilling of boreholes, collection of subsurface samples, installation of monitoring wells and piezometers, and excavation of test pits; and entering in a standardized manner the geologic descriptions of the soil and rock materials observed and recovered. It is typically the responsibility of the field geologist to ensure that the proper information is collected and documented in the field. Correct and accurate documentation for drilling projects is important to maintain quality control and provide a legally defensible record for the project. This SOP does not discuss other subsurface activities such as sampling, borehole installation, and monitoring well installation.

This SOP is intended for use by personnel who have knowledge, training, and experience in performing geologic logging.

Other E & E SOPs that could also apply or are related to geologic logging activities include the following:

- DOC 2.1, Field Activity Logbooks;
- ENV 3.15, Sampling and Field Equipment Decontamination;
- ENV 3.26, Handling Investigation-Derived Wastes;
- GEO 4.7, Borehole Installation and Subsurface Soil Sampling;
- GEO 4.10, Monitoring Well Installation; and
- HS 5.3, Health and Safety on Drilling Rig Operations.

2 Definitions and Acronyms

ASTM	American Society for Testing and Materials
DQO	Data quality objective
E & E	Ecology and Environment, Inc.
m	meter
mm	millimeter
QA	Quality assurance
QC	Quality control
RQD	Rock quality designation
SHASP	Site-specific health and safety plan
SOP	Standard operating procedure
TOIC	Top of inner casing
USCS	Unified Soil Classification System

3 Procedure Summary

To perform geologic logging and complete the geotechnical logbook, a trained geologist observes and oversees the drilling being performed and makes and records detailed observations concerning the drilling method and lithology (general characteristics of soils/sediments and rocks) encountered. These observations follow standardized terms and descriptions. During geologic logging, rock cores from the borehole are arranged in core boxes, which can be labeled and stored for later reference as needed.

4 Cautions

Cautions related to health and safety are discussed in Section 8.

Geotechnical logbook entries must be a priority and not left to later. Contemporaneous documentation is important to achieve complete, accurate, and precise reporting.

Geotechnical logbooks become part of the permanent record for projects/programs; therefore, language used in logbooks should be objective and factual. Pertinent personal observations may be included but must be clearly identified as such.

The geotechnical logbook should focus on drilling and related subsurface investigation activities and typically does not function as the overall field logbook. However, the geotechnical logbook may contain other pertinent site information as appropriate.

Geotechnical logbooks are considered evidentiary files. As such, cross-outs should be simple and not obscure the original entry, cross-outs should be initialed, and applicable pages of the logbook should be signed and dated. Other procedures for logbook entries described in E & E SOP 2.1, Field Activity Logbooks, also may apply to geotechnical logbooks.

5 Equipment and Supplies

The following is a general list of equipment and supplies. A detailed list of equipment and supplies will be prepared based on the project planning documents.

- Geotechnical logbook (bound, with consecutively numbered pages);
- Indelible ink pens (preferably black);
- Ruler or tape measure;
- Camera;
- Cutting knife/spoon/spatula;
- A hand lens/magnifier is helpful, but not required;
- Supplemental soil/rock identification materials (e.g., American Geosciences Institute data sheets, Midwest Geosciences laminated field guides, Munsell soil color charts); and
- Supporting equipment and supplies, e.g., field logbook, personal protective equipment, decontamination supplies, safety supplies, and waste handling supplies.

6 Procedure

6.1 Completing the Geotechnical Logbook

6.1.1 Basic Information

Basic project, site, and team information is recorded on the front cover and inside title page of the geotechnical logbook. The next pages of the geotechnical logbook consist of blank logbook pages that can be used as needed for general project- and site-related information for the drilling effort.

When drilling boreholes, the field geologist will maintain a log that describes each borehole. The geotechnical logbook contains record space for each borehole to be drilled. The following basic information should be entered on the heading (top half) of each drilling log sheet (see Figure 1):

- Borehole/well identifier;
- Project name;
- Site location;
- Dates that drilling was started and finished;
- Drilling company;
- Driller’s name;
- E & E geologist's name and signature;
- Drill rig type;
- Drilling method;
- Bit and auger sizes;
- Depth of auger/split barrel sampler refusal;
- Total depth of borehole;
- Total depth of corehole (if applicable);
- Water level at time of completion measured from top of inside casing (TOIC); and
- A well location sketch.

6.1.2 Drilling and Lithology Information

Information concerning drilling of the borehole is entered next in the drilling log. Specific technical information about the unconsolidated material and rock encountered should be recorded on the bottom half of the drilling log sheet that continues on subsequent pages as needed (see Figure 1). The following technical information should be recorded regarding drilling:

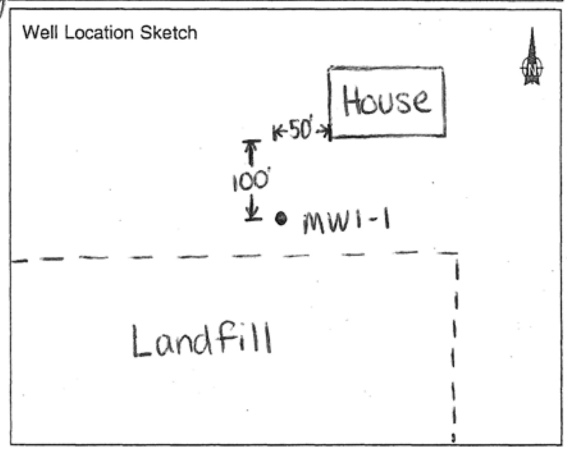
- Depth that sample was collected or encountered;
- Sample number;

DRILLING LOG FOR MWI-1

Project Name ABC Landfill RI
Site Location Midway, TN
Date Started/Finished 1/6/17 – 1/6/17
Drilling Company E & E Drilling & Testing
Driller's Name Clark Robinson
Geologist's Name Kelly Thompson
Geologist's Signature Kelly Thompson
Rig Type (s) DIEDRICH D50
Drilling Method (s) 4.25" HSA
Bit Size (s) ______ Auger Size (s) 8" O.D.
Auger/Split Spoon Refusal 24 ft
Total Depth of Borehole Is 24 ft
Total Depth of Corehole Is N/A

Water Level (TOIC)		
Date	Time	Level(Feet)
1/6/17	1640	16.25
1/8/17	0920	13.75
1/14/17	0830	13.86
1/14/17	1020	14.26

Well Location Sketch



Depth(Feet)	Sample Number	Blows on Sampler		Soil Components Rock Profile CL SL S GR	Penetration Times	Run Number	Core Recovery	RQD	Fracture Sketch	HNu/OVA (ppm)	Comments
0'-.5' Asphalt											
1–2	1	10 / 16	9 / 19	SL/S		1	N/A		NONE	Ø PPM	
3–4	2	7 / 10	8 / 9	SL/S		2	N/A		NONE	Ø PPM	
5–6	3	6 / 5	8 / 9	SL/S		3	N/A		NONE	Ø PPM	
7–8	4	4 / 23	11 / 10	SL/S		4	N/A		NONE	Ø PPM	
9–10	5	7 / 10	8 / 9	SL/S		5	N/A		NONE	Ø PPM	
11–12	6	6 / 26	9 / 32	S/GR		6	N/A		NONE	1 PPM	
13–14	7	12 / 34	24 / 48	S/GR		7	N/A		NONE	Ø PPM	
15											

Figure 1 Example First Page of Drilling Log

- For soil samples collected using conventional hollow-stem auger drilling and standard split-spoon sampling methods, the number of blow counts required to drive the split-barrel sampler 2 feet at 6-inch intervals;
- Description of soil components (see Section 6.2) and rock profile (see Section 6.3);
- Rock drilling penetration rates (times);
- Core run number;
- Soil/rock core recovery;
- Rock quality designation (see Section 6.3);
- Organic vapor readings; and
- Comments.

Additionally, a narrative description of the lithology of the overburden material and bedrock encountered is recorded on the facing pages of the drilling log sheets (see Figure 2). Sections 6.2 and 6.3 provide information on describing lithology.

6.1.3 Well Construction Information

When wells or piezometers are installed, a description of the materials used in the construction of the well, their depth intervals, the type of well installed (e.g., screened or open-hole well), and completion information will be recorded on the diagram on the top half of the second page of the drilling log sheet (see Figure 2).

6.1.4 Well Development Record

The proper development of monitoring wells will prevent the buildup of fine sediment in the well and provide groundwater samples that are representative of the native conditions of the aquifer. Wells should be developed according to E & E SOP GEO 4.11, Well Development. An example of a well development record in the geotechnical logbook is shown in Figure 3 (which consist of two parts).

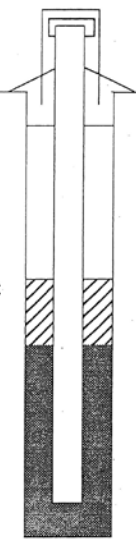
6.1.5 Investigation-Derived Waste Inventory

The drill cuttings, drilling fluids, development and purge water, and other wastes from subsurface drilling activities typically will be containerized and analyzed for proper disposal (discussed in other E & E SOPs). The geotechnical logbook provides an investigation-derived waste inventory sheet on which to record information about the containerized wastes, as shown in the example in Figure 4. The information that is tracked consists at a minimum of:

- The source of the waste (e.g., borehole or well identifier);
- Identification number for the drum or container;
- Date of generation;
- Contents;
- Approximate volume; and
- Location of the drum/container.

Investigation-derived waste should be handled and disposed of in accordance with E & E SOP ENV 3.26, Handling of Investigation-Derived Wastes.

SCREENED WELL



Lock Number IG031

Stick-up 2 ft

Inner Casing Material PVC

Inner Casing Inside Diameter 2 inches

GROUND SURFACE

Top of Grout 0 ft

Top of Seal at 10 ft

Top of Sand Pack 12 ft

Top of Screen at 14 ft

Bottom of Screen at 24 ft

Bottom of Hole at 24 ft

Bottom of Sandpack at 24'

Quantity of Material Used:

Bentonite Pellets 2 Buckets

Cement 4 Bags

Borehole Diameter 8 inches

Cement/ Bentonite ______

Grout ______

Screen Slot Size 0.010

Screen Type Continuous

☒ PVC 2"

☐ Stainless Steel ______

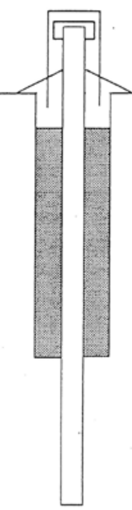
Pack Type/Size:

☒ Sand 00N

☐ Gravel ______

☐ Natural ______

OPEN-HOLE WELL



Stick-up ______ ft

Inner Casing Material ______

Inner Casing Inside Diameter ______ inches

Outer Casing Diameter ______ inches

Borehole Diameter ______ ft

Bedrock ______ ft

Bottom of Rock Socket/ Outer Casing ______ ft

Bottom of Inner Casing ______ ft

Corehole Diameter ______

Bottom of Corehole ______ ft

NOTE: See pages 136 and 137 for well construction diagrams

Depth-ft.	NARRATIVE LITHOLOGIC DESCRIPTION	Moisture Content: Dry	Moist	Wet
	8" Asphalt then fill - Black & Dry (cuttings)	●	○	○
1	↓	●	○	○
2–3	Fill Materials, Mainly Black Cinders, Some White Ash last 3"	●	○	○
3	↓	●	○	○
4–5	Brown Sandy-Silt Matrix about 50% Small large gravel, subangular	●	●	○
5	↓	●	●	○
6–7	Same as above	○	●	○
7	↓	○	●	○
8–9	Same as above	○	●	○
9	↓	○	●	○
10–11	Same as above with large gravel (< 2") Hoist, 1 PPM	○	●	○
11	↓	○	●	○
12–13	3" Rock & Ground Rock, Grey Sands	○	●	○
14		○	○	●
15		○	○	●

Figure 2 Example Well Construction/Lithologic Description Page of Drilling Log

WELL DEVELOPMENT RECORD

SITE ABC Landfill DATE 1/14/17

LOCATION Midway, TN WELL NO. MW1-1

MEASUREMENT OF WATER LEVEL AND WELL VOLUME

- Prior to sampling, the static water level and total depth of the well will be measured with a calibrated weighted line. Care will be taken to decontaminate equipment between each use to avoid cross contamination of wells.
- The number of linear feet of static water (difference between static water level and total depth of well) will be calculated.
- The static volume will be calculated using the formula:

$$V = Tr^2 (0.163)$$

Where:
V = Static volume of well in gallons;
T = Depth of water in the well, measured in feet;
r = Inside radius of well casing in inches;
and 0.163 = A constant conversion factor which compensates for r^2h factor for the conversion of the casing radius from inches to feet, the conversion of cubic feet to gallons, and (pi).
1 well volume (v) = _____ gallons.

Volume of Water in Casing or Hole

Diameter of Casing or Hole (in)	Gallons per Foot of Depth	Cubic Feet per Foot of Depth	Liter per Meter of Depth	Cubic Meters per Meter of Depth
1	0.041	0.0055	0.509	0.509×10^{-3}
11/2	0.092	0.0123	1.142	1.142×10^{-3}
2	0.163	0.0218	2.024	2.024×10^{-3}
21/2	0.255	0.0341	3.167	3.167×10^{-3}
3	0.367	0.0491	4.558	4.558×10^{-3}
31/2	0.500	0.0668	6.209	6.209×10^{-3}
4	0.653	0.0873	8.110	8.110×10^{-3}
41/2	0.826	0.1104	10.260	10.260×10^{-3}
5	1.020	0.1364	12.670	12.670×10^{-3}
51/2	1.234	0.1650	15.330	15.330×10^{-3}
6	1.469	0.1963	18.240	18.240×10^{-3}
7	2.000	0.2673	24.840	24.840×10^{-3}
8	2.611	0.3491	32.430	32.430×10^{-3}
9	3.305	0.4418	41.040	41.040×10^{-3}
10	4.080	0.5454	50.670	50.670×10^{-3}
11	4.937	0.6600	61.310	61.310×10^{-3}
12	5.875	0.7854	72.960	72.960×10^{-3}
14	8.000	1.0690	99.350	99.350×10^{-3}
16	10.440	1.3960	129.650	129.650×10^{-3}
18	13.220	1.7670	164.180	164.180×10^{-3}
20	16.320	2.1820	202.680	202.680×10^{-3}
22	19.750	2.6400	245.280	245.280×10^{-3}
24	23.500	3.1420	291.850	291.850×10^{-3}
26	27.580	3.6870	342.520	342.520×10^{-3}
28	32.000	4.2760	397.410	397.410×10^{-3}
30	36.720	4.9090	456.020	456.020×10^{-3}
32	41.780	5.5850	518.870	518.870×10^{-3}
34	47.160	6.3050	585.680	585.680×10^{-3}
36	52.880	7.0690	656.720	656.720×10^{-3}

1 Gallon = 3.785 liters
1 Meter = 3.281 feet
1 Gallon water weighs 8.33 lbs. = 3.779 kilograms
1 Liter water weighs 1 kilogram = 2.205 pounds
1 Gallon per foot of depth = 12.419 liters per foot of depth
1 Gallon per meter of depth = 12.419×10^{-3} cubic meters per meter of depth

INITIAL DEVELOPMENT WATER

WATER LEVEL (TOIC) 13.86'
WELL DEPTH (TD) 24'
COLOR Brown silty
ODOR Musty
CLARITY Opaque

FINAL DEVELOPMENT WATER

WATER LEVEL (TOIC) 14.26'
WELL DEPTH (TD) 24'
COLOR Clear
ODOR None
CLARITY Clear

DESCRIPTION OF DEVELOPMENT TECHNIQUE Stainless Steel Hand Bailer. Measured volume removed with bucket.

Figure 3 Example Well Development Record

WELL DEVELOPMENT - PARAMETER MEASUREMENTS

TIME	TOTAL VOL. WITHDRAWN		pH	COND. (µmhos/cm)	TEMP. (°C/°F)	TURB. (NTU)	COMMENTS
	GALS.	BORE VOL.					
0830	0	26	9.23	4.86	20°C	—	
0838	2	26	8.52	4.69	20.2°	—	
0845	4	26	8.49	4.67	20.3°	—	
0852	6	26	8.37	4.65	20.4°	—	
0900	8	26	8.14	4.63	20.5°	—	
0908	10	26	8.05	4.63	20.5°	—	
0913	12	26	7.96	4.58	20.4°	—	
0926	14	26	7.92	4.50	20.4°	—	
0933	16	26	7.91	4.49	20.6°	—	
0945	18	26	7.90	4.48	20.7°	—	
0953	20	26	7.89	4.42	20.8°	—	
1005	22	26	7.88	4.40	21.0°	—	
1014	24	26	7.88	4.39	21.1°	—	
1020	26	26	7.88	4.39	21.1°	—	

DEVELOPED BY: Kevin Miller DATE 1/14/17

Figure 3 Example Well Development Record (continued)

INVESTIGATION-DERIVED WASTE INVENTORY SHEET

Site: ABC Landfill, Midway, TN (ZZ-1020) No. of Drums: 6

Inventory Date: January 15, 2017

Waste Source	Drum/Container ID Number	Date Generated	Contents (Solid, Liquids, etc.)	Approximate Volume	Drum Location/Comments
MW1-1	ZZ001	1/6/17	Drill Cuttings	Full	Site 1 Staging Area
MW1-1	ZZ002	1/6/17	Drill Fluids	Full	Site 1 Staging Area
MW1-2	ZZ003	1/7/17	Drill Cuttings	Full	Site 1 Staging Area
MW1-2	ZZ004	1/7/17	Drill Fluids	Full	Site 1 Staging Area
MW1-1	ZZ005	1/14/17	Dev./Purge Water	1/2 Full	Site 1 Staging Area
MW1-2	ZZ006	1/14/17	Dev./Purge Water	1/2 Full	Site 1 Staging Area

Figure 4 Example Investigation-Derived Waste Inventory Sheet

6.2 Soil Classification

Soils should be described using the Unified Soil Classification System (USCS) and guidance in the geotechnical logbook, which are shown in Figure 5. Figure 6 provides the American Society for Testing and Materials (ASTM) criteria for describing soils that are included in the geotechnical logbook. E & E geologists sometimes use commercially available laminated cards or other sources of similar information.

Soil descriptions should be concise, stressing major constituents and characteristics, and should be given in a consistent order and format. The following order is recommended by the ASTM:

1. **Soil name:** The basic name of the predominant constituent and a single-word modifier indicating the major subordinate constituent.
2. **Gradation or plasticity:** Granular soils (i.e., sands or gravels) should be described, based on the perceived gradation of grain sizes, as well-graded (containing numerous grain sizes, also referred to in geologic literature as poorly sorted), poorly-graded (containing a narrow range of grain sizes, also referred to in geologic literature as well sorted), uniform (containing a single grain size), or gap-graded (containing multiple grain sizes but missing a major class). Cohesive soils (i.e., silts and clays) should be described as non-plastic, slightly plastic, moderately plastic, or highly plastic, depending on the results of manual evaluation for plasticity.
3. **Particle size distribution:** An estimate of the percentage and grain-size range of each subordinate constituent of the soil. This description may also include a description of angularity (see Figure 7).
4. **Color:** The basic color of the soil. Munsell Soil Color Charts or other standardized set of descriptions should be consulted.
5. **Moisture content:** The amount of soil moisture (dry, moist, or wet).
6. **Relative density or consistency:** An estimate of density of a granular soil or consistency of a cohesive soil, usually based on the standard penetration test results.
7. **Soil structure or mineralogy:** Description of discontinuities, inclusions, and structures.

6.3 Core Logging

6.3.1 Handling of Core

Rock cores should be placed in a core box for protection and storage. The top of the core should be placed at the back left corner of the core box, and the remaining core placed to the right of the preceding section (see Figure 8, which consists of two parts). The core box should be filled in this manner, moving to the front sections of the core box. The beginning of each run should be marked on the core and also noted with a marked wooden block.

SOIL AND SEDIMENT CLASSIFICATION

Grain-Size Classification (Unified Soil Classification System)

Name	Subdivision	Grain Size (mm)	U.S. Standard Sieve No.
Boulders	N/A		
		300	
Cobbles	N/A		
		75	
Gravel	Coarse		
		19	
	Fine		
		4.75	4
Sand	Coarse		
		2	10
	Medium		
		0.425	40
	Fine		
		0.075	200
Fines	Silt, Clay		

PROPORTIONS USED IN DESCRIBING SOILS

Trace - Particles are present but estimated to be less than 5%
Few - 5 to 10%
Little - 15 to 25%
Some - 30 to 45%
Mostly - 50 to 100%

i.e.: Sand with a trace of silt = 95% Sand, <5% Silt

(When sampling gravelly soils with a standard split spoon, the true percentage of gravel is often not recovered due to relatively small sample diameter.)

Soil Density from Standard Penetration Test (ASTM D1586)

Granular Soils	Cohesive Soils
0 - 10: Loose 10 - 30: Medium Dense 30 - 50: Dense Over 50: Very Dense	0 - 4: Soft 4 - 8 : Medium Stiff 8 - 15 : Stiff 15 - 30 : Very Stiff

Use second and third set of blow counts from each sample interval when determining relative soil density.

CLASSIFICATION CHART (United Soil Classification System)

MAJOR DIVISIONS		
GRAVELS (More than 1/2 of coarse fraction > No. 4 sieve size)	GW	Well-graded gravels or gravel-sand mixtures, little or no fines
	GP	Poorly graded gravels or gravel-sand mixtures little or no fines
	GM	Silty gravels, gravel-sand-silt mixture
	GC	Clayey gravels, gravel-sand-clay mixtures
SANDS (More than 1/2 of coarse fraction < No. 4 sieve size)	SW	Well-graded sands or gravelly sands, little or no fines
	SP	Poorly graded sands or gravelly sands, little or no fines
	SM	Silty sands, sand-silt mixtures
	SC	Clayey sands, sand clay mixtures
SILTS AND CLAYS LL< 50	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 clays of low plasticity
SILTS AND CLAYS LL> 50	MH	Inorganic silts, micaceous or diatamaceous, fine sandy or silty soils, elastic silts
	CH	Inorganic clays of high plasticity, fat clays
	OH	Organic clays of medium to high plasticity, organic silty clays, organic silts
HIGHLY ORGANIC SOILS	Pt	Peat and other highly organic soils

LL: Liquid Limits

Figure 5 Unified Soil Classification System Chart

ASTM CRITERIA FOR DESCRIBING SOIL

Criteria for Describing Angularity of Coarse-Grained Particles

Description	Criteria
Angular	Particles have sharp edges and relatively plane side with unpolished surfaces
Subangular	Particles are similar to angular description but have rounded edges
Subrounded	Particles have nearly plane sides but have well-rounded corners and edges
Rounded	Particles have smoothly curved side and no edges

Criteria for Describing Dilatancy

Description	Criteria
None	No visible change in the specimen.
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing.
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing.

Criteria for Describing Toughness

Description	Criteria
Low	Only slight pressure is required to roll the thread near the plastic limit . The thread and the lump are weak and soft.
Medium	Medium pressure is required to roll the thread to near plastic limit. The thread and the lump have medium stiffness.
High	Considerable pressure is required to roll the thread to near the plastic limit. The thread and the lump have very high stiffness.

Criteria for Describing Dry Strength

Description	Criteria
None	The dry specimen crumbles into powder with mere pressure of handling
Low	The dry specimen crumbles into powder with some finger pressure
Medium	The dry specimen breaks into pieces or crumbles with considerable finger pressure
High	The dry specimen cannot be broken with finger pressure. Specimen will break into pieces between thumb and a hard surface.
Very High	The dry specimen cannot be broken between the thumb and shard surface

Criteria for Describing Structure

Description	Criteria
Stratified	Alternating layers of varing material or color with layers at least 6 mm thick; note thickness.
Laminated	Alternating layers of varying materials or color with the layers less than 6 mm thick; note thickness.
Fissured	Breaks along definite planes of fracture with little resistance to fracturing.
Slickensided	Fracture planes appear polished or glossy, sometimes striated.
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown.
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay; note thickness.
Homogeneous	Same color and appearance throughout.

Figure 6 ASTM Criteria For Describing Soil

CRITERIA FOR DESCRIBING SOIL (Cont.)

Criteria for Describing the Reaction with HCl

Description	Criteria
None	No visible reaction
Weak	Some reaction, with bubbles forming slowly
Strong	Violent reaction, with bubbles forming immediately

Criteria for Describing Consistency

Description	Criteria
Very Soft	Thumb will penetrate soil more than 1 inch (25 mm)
Soft	Thumb will penetrate soil about 1 inch (25 mm)
Firm	Thumb will indent soil about 1/4 inch (6 mm)
Hard	Thumb will not indent soil but readily indented with thumbnail
Very Hard	Thumbnail will not indent soil

Criteria for Describing Cementation

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure
Moderate	Crumbles or breaks with considerable finger pressure
Strong	Will not crumble or break with finger pressure

Criteria for Describing Particle Shape

The particle shape shall be described as follows where length, width, and thickness refer to greatest, intermediate, and least dimensions of a particle, respectively.

Flat	Particles with width/thickness ratio > 3
Elongated	Particles with length/width ratio > 3
Flat and Elongated	Particles meet criteria for both flat and elongated

Criteria for Describing Plasticity

Description	Criteria
Nonplastic	A 1/8 inch (3 mm) thread cannot be rolled at any water content.
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.

Identification of Inorganic Fine-Grained Soils from Manual Tests

Soil Symbol	Dry Strength	Dilatancy	Toughness
ML	None to low	Slow to rapid	Low or thread cannot be formed
CL	Medium to high	None to slow	Medium
MH	Low to medium	None to slow	Low to medium
CH	High to very high	None	High

Criteria for Describing Moisture Condition

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

Figure 6 ASTM Criteria for Describing Soil (continued)

SEDIMENT PARTICLE SIZE AND SHAPE ESTIMATES

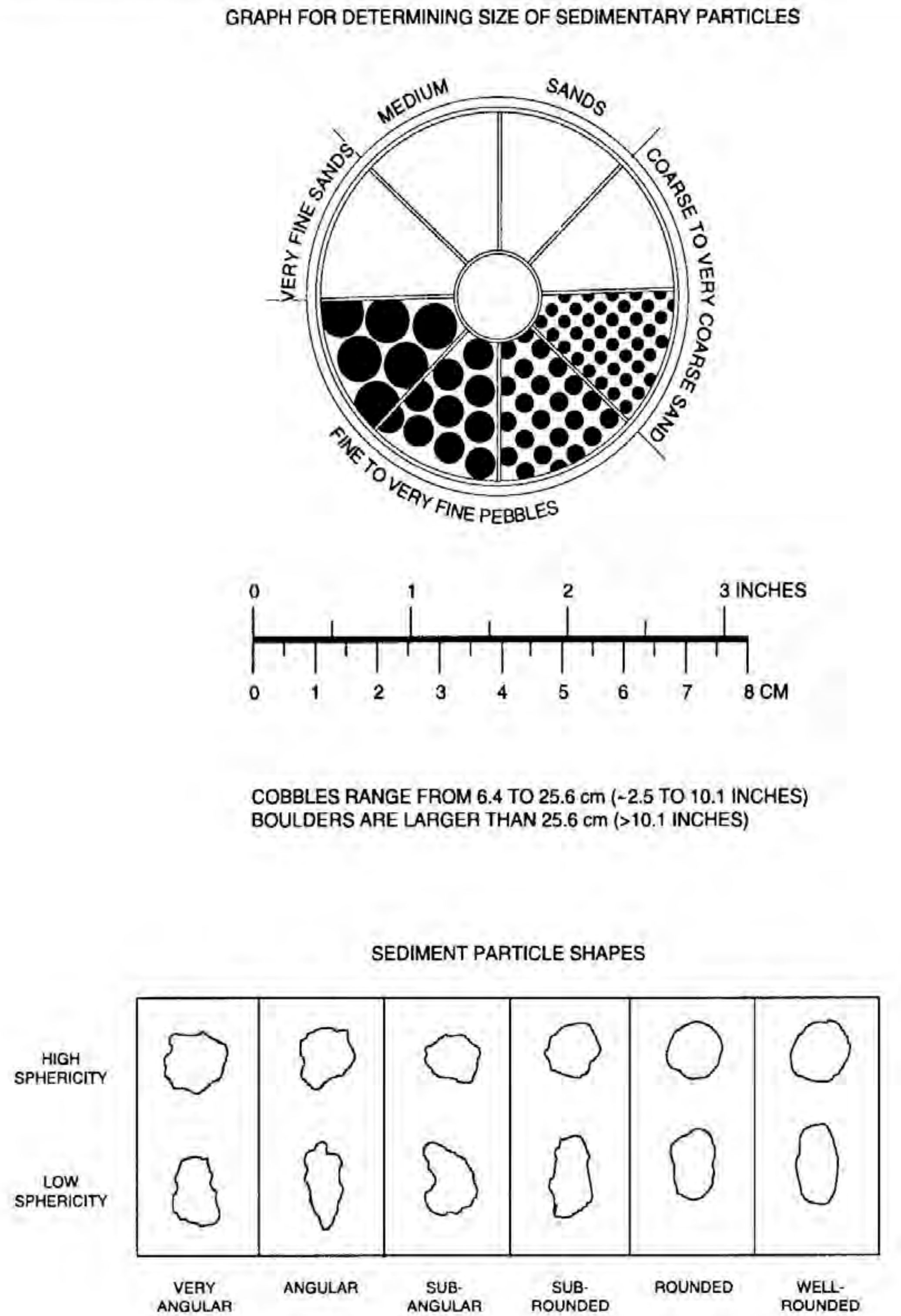


Figure 7 Sediment Particle Size and Shape Estimates

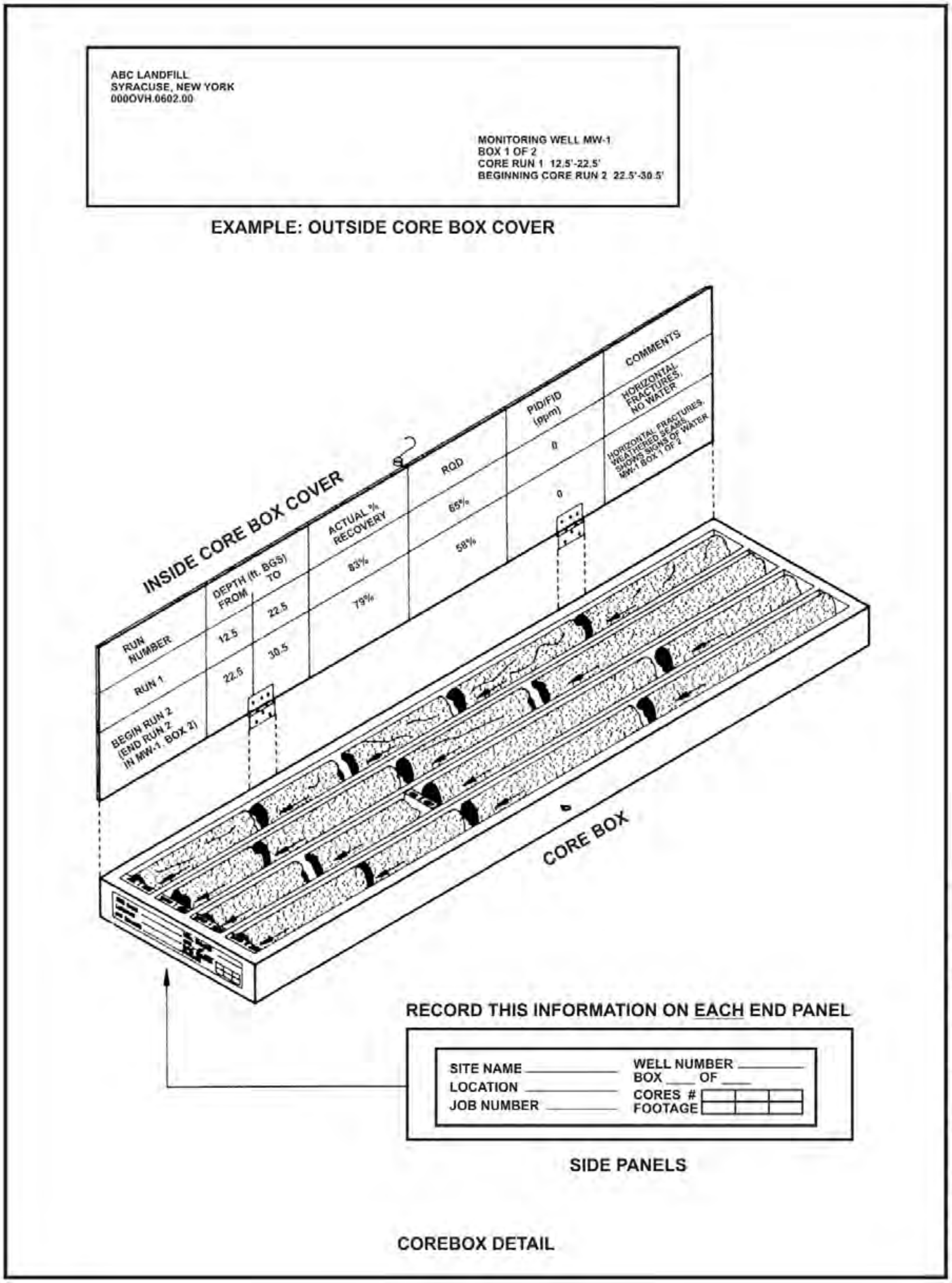


Figure 8 Core Box Handling Information

ROCK CORE HANDLING AND COREBOX PACKING

NOTES:

1. HANDLING OF CORE – THE TOP OF THE CORE SHALL BE PLACED AT THE BACK LEFT CORNER OF THE CORE BOX. THE REMAINING CORE SHALL BE PLACED TO THE RIGHT OF THE PRECEDING SECTION. THE CORE BOX SHALL BE FILLED IN THIS MANNER MOVING TO THE FRONT SECTIONS OF THE BOX AS NEEDED. THE BEGINNING OF EACH RUN SHALL BE MARKED ON THE CORE AND ALSO NOTED WITH A MARKED WOODEN BLOCK.

2. CORE LABELING – THE TOP OF THE CORE WILL BE SHOWN ON EACH PIECE OF CORE WITH AN ARROW WRITTEN IN A BLACK WATERPROOF MARKER. THE ARROW WILL INDICATE WHICH END OF THE CORE IS NEARER GROUND SURFACE.

   OTHER MARKS MADE ON CORES MAY INCLUDE:
   - MECHANICAL BREAKS
   - DRILLING FOOTAGES

3. CORE LOSS – MISSING SECTIONS OF CORE WILL BE SHOWN BY WOODEN SPACER BLOCKS. THE SITE GEOLOGIST WILL INSERT THE SPACER INTO THE COREBOX IN PLACE OF THE MISSING SECTION. THE SPACER SHOULD INDICATE THE RUN NUMBER AND FOOTAGE OF THE MISSING CORE.

4. CORE BOX LABELING – INCLUDE THE FOLLOWING:

   OUTER CORE BOX COVER

   TOP LEFT: PROJECT NAME
   CITY, STATE
   PROJECT NUMBER

   LOWER RIGHT: MONITORING WELL (MW1)
   (EXAMPLE) BOX 1 OF 2
   CORE RUN 1 12.5'–22.5'
   BEGINNING CORE RUN 2 22.5' – 30.5'

   BOTH OUTSIDE PANELS

   SITE NAME ____________ WELL NUMBER ________
   LOCATION ____________ BOX __ OF __
   JOB NUMBER ____________ CORE # | | |
   F00TAGE | | |

   INSIDE CORE BOX COVER

   THE FOLLOWING COLUMNS WILL BE RECORDED ON THE INSIDE CORE BOX COVER.

RUN NUMBER	DEPTH (FT. BGS)		ACTUAL % RECOVERY	RQD	PID/FID (ppm)	COMMENTS
	FROM	TO				

   ONE ROW REGARDING THE ABOVE INFORMATION WILL BE RECORDED FOR EACH CORE RUN OR PARTIAL CORE RUN CONTAINED WITHIN THE COREBOX.

5. CORE BOX STORAGE – CORE BOXES FROM ALL SITE WELLS WILL BE MOVED FROM WELLHEADS ON A REGULAR BASIS AND STORED IN A DESIGNATED AREA. THIS LOCATION SHOULD BE IN AN AREA WHERE THE CORE BOXES WILL BE UNDISTURBED. WHEREVER POSSIBLE, THE COREBOX STORAGE AREA SHOULD BE INDOORS.

CORE BOX LOGGING DETAIL

Figure 8 Core Box Handling Information (continued)

6.3.2 Rock Description

Each stratigraphic unit in the core should be logged. A line marking the depth of the top and the bottom of the unit should be drawn horizontally. In classifying the rock, the geologist should avoid being too technical, because the information presented must be able to be used by persons with varying levels of geotechnical knowledge. The focus should be on pertinent information relative to the objective (which typically is identification of potential contaminant transportation pathways), such as the type of rock, areas of high porosity, and fracture location and orientation. Figure 9 shows rock descriptive terms as included in the geotechnical logbook. The classification and description of each unit should be given in the following order, as applicable:

1. Unit designation (e.g., Miami oolite, Clayton Formation, Chattanooga shale).
2. Rock type and lithology (e.g., limestone, sandstone, shale).
3. Hardness.
4. Degree of weathering.
5. Texture.
6. Structure.
7. Color.
8. Solution and void conditions.
9. Swelling properties.
10. Slaking properties.
11. Additional description, such as mineralization, size, and spacing shale seams.

Variations from the general description of the unit and features not included in the general description should be indicated by brackets and lines to show the depth and interval in the core where the feature exists. These variations and features should be identified by terms adequate to delineate the variation or feature from the unit. These may be zones or seams of different color, texture, etc., from that of the unit as a whole, such as: staining; variations in texture; shale seams, gypsum seams, chert nodules, or calcite masses; mineralized zones; vuggy zones, joints, or fractures; open and/or stained bedding planes; faults, shear zones, or gouge; cavity thickness, open or filled, nature of filling; or any core left in the bottom of the hole after the final pull.

Some of the elements of rock description are further described below. In addition to these primary descriptors, the geologist should evaluate rock quality using the rock quality designation (RQD) and fracture frequency guidance in the geotechnical logbook (see Figure 10).

Rock Type and Lithology

Rock will generally be classified according to the following 24 types:

- Sandstone
- Conglomerate
- Coal
- Compaction Shale

ROCK DESCRIPTIVE TERMS

Term		Defining Characteristics	
Hardness	Soft	Scratched by fingernail	
	Medium Hard	Scratched easily by penknife	
	Hard	Difficult to scratch with a penknife	
	Very Hard	Cannot be scratched by penknife	
Weathering	Fresh	Rock is unstained. May be fractured, but discontinuities are not stained.	
	Slighty	Rock is unstained. Discontinuities show some staining on the surfaces of rocks, but discoloration does not penetrate rock mass.	
	Moderate	Discontinuity surfaces are stained. Discoloration may extend into rock along discontinuity surfaces.	
	High	Individual rock fragments are thoroughly stained and may be crumbly.	
	Severe	Rock appears to consist of gravel-sized fragments in a "soil" matrix. Individual fragments are thoroughly discolored and can be broken with fingers.	
Bedding Planes	Laminated	< .04 in.	< 1 mm
	Parting	.04 in. - .24 in.	1mm - 6mm
	Banded	.24 in. - 1in.	6 mm - 3 cm
	Thin	1 in. - 4 in.	3 cm - 9.1 cm
	Medium	4 in. - 12 in.	9.1 cm - 30.5 cm
	Thick	12 in.- 36 in.	30.5 cm - 1m
	Massive	> 36 in.	> 1 m
Joints and Fracture Spacing	Very close	< 2 in.	< 5.1 cm
	Close	2 in. - 1ft.	5.1 - 30.5 cm
	Moderately close	1ft. - 3 ft.	30.5 cm - 91.4 cm
	Wide	3 ft. - 10 ft.	91.4 cm - 3 M
	Very wide	> 10 ft.	> 3 M
Voids	Porous	Smaller than a pinhead. Their presence is indicated by the degree of absorbency.	
	Pitted	Pinhead size to a 1/4 inch. If only thin walls separate the individual pits, the core may be described as honeycombed.	
	Vug	1/4 inch to the diameter of the core. The upper limit will vary with core size.	
	Cavity	Larger than the diameter of the core.	

Rock Particle Percent Composition Estimation

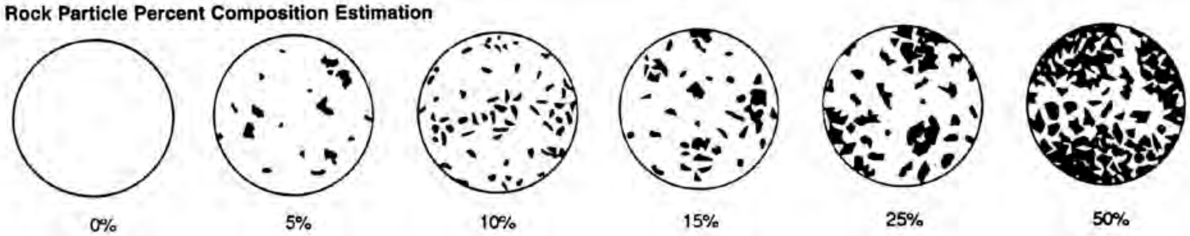


Figure 9 Rock Descriptive Terms

ROCK QUALITY DESIGNATION AND FRACTURE FREQUENCY

Core borings are a useful means of obtaining information about the quality of rock mass. The recoverable core indicates the character of the intact rock and the number and character of the natural discontinuities.

Another quantitative index that has proved useful in logging NX core is a rock quality designation (RQD) developed by Deere (1963). The RQD is a modified core recovery percentage in which all the pieces of sound NX core over 4 inches long are counted as recovery. The length of the core run is the distance to the nearest tenth of a foot from the corrected depth of the hole at the end of the previous run to the corrected depth of the hole at the end of subject run. The smaller pieces are considered to be due to close shearing, jointing, faulting, or weathering in the rock mass and are not counted. The RQD is a more general measure of the core quality than the fracture frequency. Core loss, weathered and soft zones, as well as fractures, are accounted for in this determination. The RQD provides a preliminary estimate of the variation of the in situ rock mass properties from the properties of the "sound" portion of the rock core. Thus, a general estimate of the behavior of the rock mass can be made. An RQD approaching 100 percent denotes an excellent quality rock mass with properties similar to that of an intact specimen. RQD values ranging from 0 to 50 percent are indicative of a poor quality rock mass having a small fraction of the strength and stiffness measured for an intact specimen.

RQD (Rock Quality Designation)

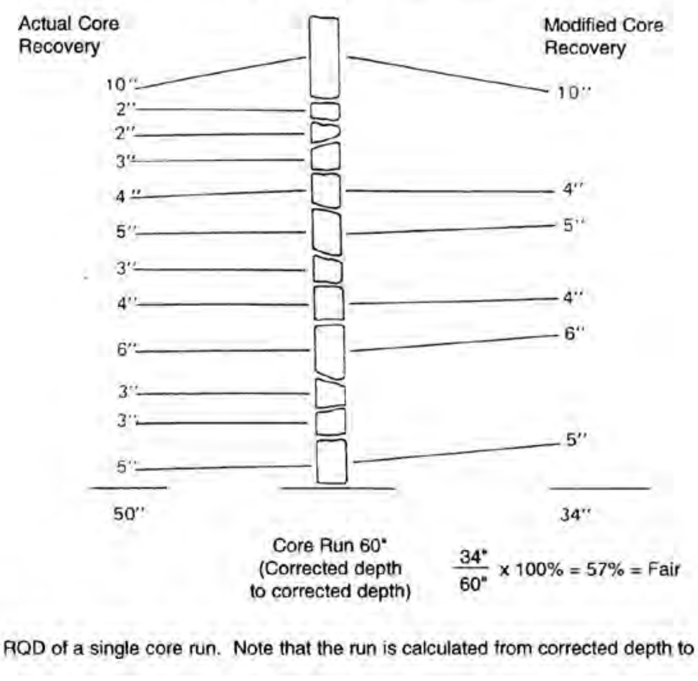
0 - 25 Very Poor
25 - 50 Poor
50 - 75 Fair
75 - 90 Good
90 - 100 Excellent

An example of determining the RQD from a core run of 60 inches measured from corrected depth to corrected depth is given in diagram below. For this particular case, the core recovery was 50 inches and the modified core recovery was 34 inches. This yields an RQD of 57 percent, classifying the rock mass in the fair category.

Problems arise in the use of RQD for determining the in situ rock mass quality. The RQD evaluates fractures in the core caused by the drilling process, as well as in natural fractures previously existing in the rock mass. For example, when the core hole penetrates a fault zone or a joint, additional breaks may form that, although not natural fractures, are caused by natural planes of weakness existing in the rock mass. These fresh breaks occur during drilling and handling of the core and are not related to the quality of the rock mass. The skill of the driller will affect the amount of breakage and the core loss that occurs. Poor drilling techniques will "penalize" the rock by lowering its apparent quality. It is difficult to distinguish between drilling breaks and those natural and incipient fractures that reflect the quality of the rock mass. In certain instances, it may be advisable to include all fractures when estimating RQD. Obviously, some judgment is involved in core logging.

Another problem with the use of the RQD index is that the determinations are not sensitive to the tightness of the individual joints, whereas in some instances, the in situ deformation modulus may be strongly affected by the average joint opening.

RQD OF A SINGLE CORE RUN



Typical calculation of RQD of a single core run. Note that the run is calculated from corrected depth to corrected depth.

Figure 10 Rock Quality Designation and Fracture Frequency Guidance

- Cemented Shale
- Indurated Clay
- Limestone
- Chalk
- Gneiss
- Schist
- Graywacke
- Quartzite
- Dolomite
- Marble
- Soapstone and Serpentine
- Slate
- Granite
- Diorite
- Gabbro
- Rhyolite
- Andesite
- Basalt
- Tuff or Tuff Breccia
- Agglomerate or Flow Breccia

Lithologic characteristics should be included to differentiate rocks of the same classification. These adjectives should be simple and easily understood, such as shaley, sandy, dolomitic, etc. Inclusions, nodules, and concretions should also be noted here.

Hardness

The terms for hardness, as outlined below, were modified to include the use of a rock hammer.

- **Very soft** or plastic: Can be deformed by hand (has a rock-like character but can be broken easily by hand).
- **Soft:** Can be scratched with a fingernail (cannot be crumbled between fingers but can be easily pitted with light blows of a geology hammer).
- **Moderately hard:** Can be scratched easily with a knife; cannot be scratched with a fingernail (can be pitted with moderate blows of a geology hammer).
- **Hard:** Difficult to scratch with a knife (cannot be pitted with a geology hammer but can be chipped with moderate blows of the hammer).
- **Very hard:** Cannot be scratched with a knife (chips can be broken off only with heavy blows of the geology hammer).

Weathering

The degree and depth of weathering should be accurately detailed in the general description and clearly indicated on the drilling log.

- **Unweathered:** No evidence of any mechanical or chemical alteration.
- **Slightly weathered:** Superficial discoloration, alteration, and/or discoloration along discontinuities; less than 10% of the rock volume is altered; strength is essentially unaffected.
- **Moderately weathered:** Discoloration is evident; surface is pitted and altered, with alterations penetrating well below rock surfaces; 10% to 50% of the rock is altered; strength is noticeably less than unweathered rock.
- **Highly weathered:** Entire section is discolored; alteration is greater than 50%; some areas of slightly weathered rock are present; some minerals are leached away; retains only a fraction of its original strength (wet strength is usually lower than dry strength).
- **Decomposed:** Saprolite; rock is essentially reduced to a soil with a relic rock texture; can be molded or crumbled by hand.

Texture

Texture is used to denote the size of the grains or crystals comprising the rock, as opposed to the arrangement of the grains or crystals, which is considered a structure.

- **Aphanitic:** Grain diameter less than 0.004 inch (0.1 millimeter [mm]); individual grains or crystals are too small to be seen with the naked eye.
- **Fine-grained, finely crystalline:** Grain diameter between 0.004 inch (0.1 mm) and 0.003 foot (1 mm); grains or crystals can be seen with the naked eye.
- **Medium-grained, crystalline:** Grain diameter between 0.003 foot (1 mm) and 0.0175 foot (5 mm).
- **Coarse-grained, coarsely crystalline:** Grain diameter greater than 0.0175 foot (5 mm).

Structure

The structural character of the rock should be described in terms of grain or crystal alignment, bedding, and discontinuities, as applicable. The terms may be used singularly or paired.

- **Foliation and/or lineation:** Give approximate dip uniformity, degree of distinctiveness, banding, etc.
- **Joints:**
  - Type: Bedding, cleavage, foliation, extension, etc.
  - Degree of openness: Tight or open.
  - Surface or joint plane characteristics: Smooth, rough, undulating.
  - Weathering: Degree, staining.
  - Frequency: See below.
- **Fractures, shears, gouge:**
  - Nature: Single plane or zone (note thickness).
  - Character of materials in plane or zone.
  - Slickensides.

- **Frequency:**
  - Intact: Spacing greater than 6 feet (2 meters [m]).
  - Slightly jointed (fractured): Spacing 3 feet (1 m) to 6 feet (2 m).
  - Moderately jointed (fractured): Spacing 1 foot (0.3 m) to 3 feet (1 m).
  - Highly jointed (fractured): Spacing 0.3 foot (9.1 cm) to 1 foot (0.3 m).
  - Intensely jointed (fractured): Spacing less than 0.3 foot (9.1 cm).
- **Bedding:** Used to describe the average thickness of individual beds within the recognized unit. The terms thick, medium, or thin should not be applied to the individual beds. "Parting" and "band" are used to describe a single stratum as outlined below:
  - Massive: Over 3 feet (1 m) thick.
  - Thick: 1 foot (30.5 cm) to 3 feet (1 m) thick.
  - Medium: 0.3 foot (9.1 cm) to 1 foot (30.5 cm) thick.
  - Thin: 0.1 foot (3.0 cm) to 0.3 foot (9.1 cm) thick.
  - Band: 0.02 foot (6 mm) to 0.1 foot (3.0 cm) thick, described to the nearest 0.01 foot.
  - Parting: Less than 0.02 foot (6 mm) thick.
  - Paper-thin parting: Thinner than parting.

The terms and descriptions for the structure of the rock are to be used to describe the character of the rock units recognized and are not to be used as a substitute for describing individual discontinuities. Except for areas where the rock is intensely fractured or jointed, each discontinuity should be described on the drilling log as to position, dip, staining, weathering, breccia, gouge, etc.

Color

Color is often valuable in correlating or differentiating rock samples, but can be misleading or uninformative. The color of a sample should represent the sample in terms of basic hues (e.g., red, blue, gray, black), supplemented with modifying hues as required (e.g., bluish gray, mottled brown). The core should be surface wet when describing the color; if it is dry, the drilling log should indicate "dry color." Subjective colors, such as buff or maroon, should not be used. Specific color charts, such the Color Index in the Quarterly of the Colorado School of Mines, Volume 50, No. 1, Classification of Rocks, are useful in describing color of samples. When such a chart or index is used, it should be noted on the drilling log.

Solution and Void Conditions

Solution and void conditions should be described in detail because these characteristics can affect the strength of the rock and indicate potential seepage paths. When cavities are detected by drill action, the depth to top and bottom of the cavity should be determined by measuring the stick-up of the drill tools when the cavity is first encountered and again at the bottom; it is difficult to reconstruct cavities from the core alone. Filling material, when present and recovered, should be described in detail opposite the cavity. When no material is recovered from the area of the cavity, the inspector should note the probable conditions of the cavity as determined from observing the drilling action and the color of the drill fluid. If the drill action indicates that filling material was present (e.g., slow rod drop, no loss of drill water, noticeable change in color of water return), it should be noted on the drilling log that the cavity was probably filled and the materials should be described as well as possible from the cuttings or traces left on the core. If drill action indicates the cavity was open (e.g., no resistance to the drill tools, loss of drill fluid), this should be noted on the drilling log. Partially filled cavities should also be noted. These observations require close observation of the drill action and water return by both the inspector and the driller, accurate measurement of stick-ups, and detailed inspection of the core. When possible, filling material should be wrapped in foil if left in the core box. If the material is to be tested or examined in the lab, it should be sealed in a jar with proper labels and a spacer, with a note showing the disposition of the material, should be placed in the core box at the point from which the material was taken. Terms to describe voids encountered are:

- **Porous:** Voids less than 0.003 foot (1 mm) in diameter.
- **Pitted:** Voids 0.003 foot (1 mm) to 0.02 foot (6 mm) in diameter.
- **Vug:** Voids 0.02 foot (6 mm) to the diameter of the core.
- **Cavity:** Voids greater than the diameter of the core.

6.3.3 Core Labeling

The top of the core should be shown on each piece of core with an arrow written in a black, waterproof marker. The arrow will indicate which end of the core is nearer the ground surface. Other core markings may include locations of mechanical breaks and drilling footages.

6.3.4 Core Box Labeling

The outer core box, inside core box, and outside panels should be labeled as shown in Figure 8.

6.3.5 Core Storage

Use proper-sized (HQ or NQ) wooden core boxes for rock core storage. After labeling the box and before closing the box for final storage or shipment, wooden spacers should be inserted into each compartment that contains rock core. This will prevent lateral movement of the cores, which could damage the rock material during handling.

After properly logging, labeling, and packing the cores, the core boxes should be stored in a dry location, preferably off the floor and on a pallet or similar. The boxes can be stacked to a reasonable height so as not to be unstable, with end labeling facing out.

7 Quality Assurance Quality Control

The project manager should identify personnel for the field team who have knowledge, training, and experience in the geologic logging to be conducted. At least one member of the team—typically the field geologist—should be designated as the lead for geologic logging and be responsible, with support from other field personnel, for implementing the procedures in this SOP. The project manager should also identify additional personnel, if necessary, to complete ancillary procedures, e.g., field logbook documentation, equipment decontamination, and waste disposal.

Prior to initiating field work, the project planning documents (e.g., work plan, sampling and analysis plan, quality assurance project plan, and site-specific health and safety plan [SHASP]) will be reviewed by field personnel to understand the procedures that have been specified to result in geologic logging data and information that will meet project DQOs. Project planning documents will define the quality assurance/quality control (QA/QC) procedures necessary to meet project DQOs. For geologic logging, these QA/QC procedures commonly consist of measures such as the following:

- Logbook entries should be made in real time (and not retroactively) and using indelible ink;

- Entries in the geotechnical logbook should be double-checked as they are entered;
- Standardized and industry-recognized soil classification and rock description systems and nomenclature should be used, as discussed in this SOP;
- Deviation from planned geologic and subsurface activities should be documented, together with authorization for such deviations;
- At the end of each day, the field geologist should check log entries for completeness and confirm drilling information, as necessary, with the drilling subcontractor;
- The project manager should review the geotechnical logbook periodically and at the end of the field activity; and
- At the completion of the field activity, the geotechnical logbook should be submitted to the project manager to include with the project files.

8 Health and Safety

Prior to entering the field, all field personnel will acknowledge in writing that they have read and understand the SHASP, which will be in compliance with the E & E Corporate Health and Safety Program.

Hazards associated with geologic logging primarily consist of the potential for contacting surface and subsurface soil contaminated with chemical, toxicological, radioactive, and/or pathogenic material. The SHASP will provide instruction for safe handling of contaminated site soils. The hazards associated with obtaining soil and rock cores and working around a drill rig are addressed in the SOPs for those activities, including GEO 4.7, Borehole Installation and Subsurface Soil Sampling; GEO 4.10, Monitoring Well Installation; and HS 5.3, Health and Safety on Drilling Rig Operations.

9 Special Project Requirements

Project-specific requirements will be included with the project planning documents.

10 References

American Society for Testing and Materials (ASTM). 2008. Standard Test Method for Determining Rock Quality Designation (RQD) of Rock Core. ASTM D6032-08. West Conshohocken, Pennsylvania.

__________. 2009. Standard Practice for Description and Identification of Soils (Visual-Manual Procedure). ASTM D2488-09a. West Conshohocken, Pennsylvania.

__________. 2011. Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils. ASTM D1586-11. West Conshohocken, Pennsylvania.

__________. 2017. Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System). ASTM D2487-17 (or most recent update). West Conshohocken, Pennsylvania.

Carpenter, Mark and Christopher M. Keane (ed.). 2016. The Geoscience Handbook 2016, AGI Data Sheets, Fifth Edition. American Geosciences Institute. Alexandria, Virginia.

Munsell Color X-Rite, Inc. 2009. Munsell Soil Color Charts. Grand Rapids, Michigan.

Travis, Russell B. 1955. Classification of Rocks. *Quarterly of the Colorado School of Mines*. Volume 50, Number 1. January 1955.

United States Environmental Protection Agency (EPA). 1986. *RCRA Ground Water Monitoring Technical Enforcement Guidance Document*. Office of Solid Waste and Emergency Response. OSWER Directive 9950.1. September 1986. Washington, DC.

END OF SOP

Title:	**MONITORING WELL INSTALLATION**
Category:	GEO 4.10
Revised:	March 1998

STANDARD OPERATING PROCEDURE

MONITORING WELL INSTALLATION

ecology and environment, inc.
368 Pleasant View Drive / Lancaster, New York 14086 / (716) 684-8060

TITLE:	**MONITORING WELL INSTALLATION**		
CATEGORY:	GEO 4.10	**REVISED:**	March 1998

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1. Scope and Application

The installation of monitoring wells is contingent upon the existing conditions at the project site. The purpose of this Standard Operating Procedure (SOP) is to delineate the quality control measures required to ensure the accurate installation of monitoring wells. The applicable site Field Sampling Plan should be consulted for specific installation instructions. The term "monitoring wells" is used generically and includes observation wells and piezometers.

2. Materials

a. Drilling Equipment (provided by subcontractor)
b. Material required for well installation as specified in the Field Sampling Plan accompanying this submittal
c. Hand Lens
d. Weighted Tape
e. Water Level Measuring Device
f. E & E's Standard Geotechnical Log Book

3. Procedure

3.1 Materials

Screens, casings, and fittings will conform to National Sanitation Foundation Standard 14 or the American Society for Testing and Materials (ASTM) equivalent for potable water usage. These materials will bear the appropriate rating logo. If the logos are not present, a written statement from the manufacturer/supplier stating that the materials contain the appropriate rating must be obtained. Material used will be new and essentially chemically inert to the site environment.

Water sources for drilling, grouting, sealing, filter placement, well installation, and equipment decontamination must be approved by E & E prior to arrival of the drilling equipment. Information required for the water source includes: water source (hydrant no., if applicable), owner, address and telephone number, type of treatment and filtration prior to point of discharge, time of access, cost per gallon (if applicable), dates and results associated with all available chemical analyses over the past two years, and the name and address of the analytical laboratory (where applicable).

Bentonite will be the only drilling fluid additive allowed unless otherwise specified in the project work plan. The use of any additives or materials must be approved by E & E and/or the governing regulatory agency prior to its implementation. The information required for evaluation includes: brand name, manufacturer, manufacturer's address and telephone number, product description, and intended use for the product.

Granular Filter Pack material must be approved by E & E prior to drilling. A one-pint representative sample must be supplied to E & E. Information required includes: lithology, grain size distribution, brand name, source, processing method, and slot size of intended screen.

3.2 Drilling

The hollow stem auger drilling method will be used for typical well installation. Air rotary methods using a rock bit will be used in hard lithologies. Any alterations to these methods will require prior approval by E & E, the client, and/or the governing regulatory agency.

A qualified Site Geologist will be present during all well drilling and installation activities, and will fully describe all tasks performed in support of these activities in the Geotechnical Log Book. A Site Geologist will be responsible at each rig for the logging of samples, monitoring of drilling operations, recording of water losses/gains and other observable groundwater data, preparing the boring logs and well diagrams, and recording the well installation procedures performed by the subcontractor.

Decontamination of all well installation equipment and construction material will be carried out as described in E & E's SOP for Equipment Decontamination (ENV 3.15)

Petroleum jelly, teflon tape, lithium grease, or vegetable-based lubricants shall not be used on the threads of downhole drilling equipment. Additives containing either lead or copper will not be allowed. In addition, polychlorinated biphenyls will not be contained in hydraulic fluids or other fluids used in the drilling rig, pumps, or other field equipment and vehicles. Surface runoff or other fluids will not be allowed to enter any boring or well during or after drilling/construction.

Antifreeze used to keep equipment from freezing during periods of cold weather and will not contain rust inhibitors and sealants. If the antifreeze is added in an area in contact with drilling fluid, the antifreeze will be completely purged from the equipment prior to use in drilling, mud mixing, or any integral part of the overall drilling operation. The contractor will note the following information in the boring log in regard to the use of antifreeze: date, reason, quantities, and brand name.

According to the Site Health and Safety Plan (HASP), monitoring of the borehole will be conducted at regular intervals using a photoionization detector or flame ionization detector to check for the presence of VOCs. Other screening methods may also be required according to the HASP.

3.3 Well Construction and Installation

The installation of monitoring wells will begin within 12 hours of boring completion for holes uncased or partially cased, and within 48 hours for holes fully cased with temporary drill casing or held open by auger. Once installation has begun, work will be continued until the well has been grouted and the drill casing has been removed. Exceptions must be requested in writing by the contractor to E & E prior to drilling. Unscheduled delays attributable to unforeseeable site occurrences will not require advance approval.

The construction of each well will be depicted in the well construction diagram contained within the Geotechnical Log Book. The diagram will remain attached to the borelog and will graphically denote the following components and their dimensions, where applicable:

a. Protective casing detail
b. Height of riser
c. Grout
d. Bentonite seal
e. Granular filter pack
f. Screen location
g. Joint location
h. Centralizers
i. Cave-in
j. Bottom of the boring

Screens, casings, and fittings will conform to the standards given in Section 3.1. All materials will be decontaminated prior to use and will be assembled without the use of lubricants, cements, or chemicals. The placement of all materials in the well boring will be observed and documented by the field geologist. Granular filter packs will be chemically and texturally clean, inert, siliceous, and of appropriate size.

Unless otherwise specified in the site-specific work plan (SSWP), or limited by site conditions, bentonite seals will be a minimum of two feet thick as measured immediately after placement. The final depth of the top of the bentonite seal will be measured and recorded in the Geotechnical Log Book. Any exceptions to the recommended thickness must be described in detail in the log. (Note: In order to prevent heaving, the top of a bentonite seal should not be less than 1.5 to 2 feet below ground surface.)

Unless otherwise required by the SSWP, grout used in construction will be composed by weight of:

- 20 parts cement (Portland cement, type II or V);
- 1 part bentonite; and
- 8-gallons (max) approved water per 94-lb bag of cement per 5 pounds of bentonite.

Neither additives nor borehole cuttings will be mixed with the grout. Bentonite will be added after the required amount of cement is mixed with the water. All grout material will be combined in an aboveground container and mechanically blended to produce a thick, lump-free mixture. The mixed grout will be recirculated through the grout pump prior to placement.

Grout placement will be performed using a commercially available grout pump and a rigid tremie pipe. The tops of all well casing will be telescopically capped with covers composed of materials compatible with the products used in the well installation. Caps will be constructed to preclude binding to the well casing caused by tightness of fit, unclean surfaces, or weather conditions, yet secure enough to preclude the introduction of foreign material into the well. In addition, caps will be loose enough to allow pressure equalization between the well and the atmosphere.

Well protective casings will be installed around all monitoring wells on the same day as the initial grout placement around the well. Any annulus formed between the outside of the protective casing and the borehole will be filled to ground surface with grout.

3.4 Monitoring Well Completion

Decontaminated well casing will be placed on polyethylene sheeting, and will not be allowed to touch the ground or any other object.

Assemble appropriate decontaminated lengths of casing and screen. Make sure these materials are clean and free of grease, soil, and residue.

Lower each section of casing and screen into the borehole, one at a time, screwing each section securely into the section below it. No grease, lubricant, glue, or teflon tape may be used in joining the pipe and screen sections. Rubber O-rings may be used to provide water-tight joint in wells of stainless steel construction.

When the well is set to the bottom of the borehole, temporarily place a cap on top of the casing to keep the well interior clean.

Place the appropriate filter pack material by gradually pouring it into the annular space through a tremie pipe. The tremie pipe should extend from the ground surface to the depth of the filter pack such that the material is added from the "bottom up." Monitor the rise of material in the annulus with a weighted tape to assure that bridging is not occurring.

After the filter pack is in place, wait three to five minutes for the material to settle. Remeasure the settled height of the filter pack and tremie more material, if necessary.

Install the bentonite seal by dropping bentonite pellets into the hole gradually, again monitoring for bridging with a weighted tape.

Wait 30 to 60 minutes for the bentonite pellets to hydrate and swell. If the pellets are above the water level in the hole, add several buckets of clean water to the boring. Document the amount and source of water added to the hole.

Mix a cement-bentonite slurry using clean water from an approved source, Portland Type II cement, and powdered bentonite. Be sure the mixture is thoroughly mixed and as thick as is practicable.

Lower a tremie pipe or hose into the annulus to the level of the bentonite pellet seal.

Pump the cement-bentonite slurry into the annulus while withdrawing the tremie pipe/hose. Continue filling the annulus with the slurry up to the ground surface.

Cut the riser casing off approximately 2 to 2.5 ft. above grade. Place a vented cap on the well.

Set the steel protective casing over the well and into the cement-bentonite slurry below the ground surface. Lock the cap.

Allow the cement-bentonite slurry to set overnight.

After allowing the cement-bentonite slurry to set, fill the remainder of the annulus with neat cement. Form a cement apron around the protective casing.

3.5 Logging

All borings for monitoring wells will be logged by a geologist or engineer. Logs will be recorded in the Geotechnical Log Book and/or field log book. If the information is recorded in a field log book, it will be transferred to Boring Log Forms on a daily basis. Field notes are to include, as a minimum:

a. Boring Number and Location
b. Geological Material Description (as discussed below)
c. Weather Conditions
d. Possible Indications of Contamination During Drilling
e. Groundwater Conditions (including measured water levels)
f. Daily Drilling Footage and Quantities (for billing purposes)
g. Drilling Method and Bore Hole Diameter
h. Any Deviations from Established Work Plans
i. Blow Counts for Standard Penetration Test
j. Core and Split-Spoon Recoveries
k. Name of Contractor, Driller and Rig Geologist
l. Date and Time of Start and Completion of Each Boring
m. Field Instrument Readings Such As HNu, OVA, etc.

Material description for soil samples must include:

a. Classification
b. Unified Soil Classification Symbol
c. Secondary Components and Estimated Percentages
d. Color
e. Plasticity
f. Consistency (if cohesive soil)
g. Density (if non-cohesive soil)
h. Moisture Content
i. Texture/Fabric/Bedding and Orientation
j. Grain Angularity
k. Depositional Environment and Formation
l. Presence of Calcium Carbonate ($CaCO_3$)
m. Sample Recovery

Material description for rock samples must include:

a. Classification
b. Lithologic Characteristics
c. Bedding/Banding Characteristics
d. Color
e. Hardness

f. Degree and Type of Cementation
g. Presence of Calcium Carbonate ($CaCO_3$)
h. Texture
i. Structure and Orientation
j. Degree of Weathering
k. Solution or Void Conditions
l. Primary and Secondary Permeability
m. Sample Recovery
n. Degree of Weathering and Friability

3.6 Well Development

Well development can be defined as the process by which drilling fluids, solids, and other mobile particulates within the vicinity of a newly installed monitoring well are removed thus restoring the inherent hydraulic conductivity of the aquifer. Well development will be initiated after 24 consecutive hours but not longer than seven calendar days following the completed installation of the surface protective casing of the well. A detailed record of the well development will be documented in the Geotechnical Log Book.

Materials required:

- Well Development Form (Geotechnical Log Book);
- Boring Log and Well Completion Diagram for the well (Geotechnical Log Book);
- Submersible pump, centrifugal pump, or bailer of appropriate capacity;
- pH, conductivity, and temperature meters;
- Electric well sounder and measuring tape; and
- Containers for purged water, if required.

Development of newly installed groundwater monitoring wells will be performed according to the following protocol. Development of monitoring wells will be recorded in the Geotechnical Log Book. The following development data will be recorded.

a. Well designation
b. Date of well installation
c. Date of development
d. Stable water level before and 24 hours after development
e. Quantity of water lost during drilling and fluid purging, if water is used
f. Quantity of standing water in well and annulus (30 percent porosity for annulus material is assumed for calculation) prior to development
g. Specific conductivity, turbidity, temperature, and pH measurements taken and recorded at the start of development, three or more times during, and at the conclusion

of development. Calibration standards will be run prior to, during, and after each day's operation of instruments in the field

h. Depth from top of well casing to bottom of well
i. Screen length
j. Depth from top of well casing to top of sediment inside well, before and after development
k. Physical character of removed water, including changes during development in clarity, color, particulate matter, and odor
l. Type and size/capacity of pump and/or bailer used
m. Description of surge technique, if used
n. Height of well casing above or below ground surface
o. Quantity of water removed and removal time

Development of wells will be accomplished by pumping the groundwater with an electric-powered submersible or centrifugal pump until the water is clear and the well is free of sediment, to the fullest extent practical. If well yields cannot sustain the flow rate of the submersible pump and the water is sediment free to the fullest extent practical, a dedicated bailer will be used to evacuate the well. Water will not be added to the well to aid in development, nor will any type of airlift technique be used.

The pump, bailer and cable will be decontaminated by the procedures outlined in ENV 3.15. Unless otherwise specified in the SSWP, development water will be discharged on site or containerized and transported to a central storage area, in accordance with local regulatory guidance. Based on the analysis of groundwater samples collected from the monitoring wells, any containerized water will be disposed of in a manner which is in compliance with appropriate government regulations.

Development will proceed until the following conditions are met:

a. Turbidity is <100 NTU, or parameters including pH, conductivity, and temperature have stabilized;

b. The sediment thickness remaining in the well is less than 5 percent of the screen length;

c. At least five well volumes (including the saturated filter material in the annulus) plus the volume of water added during the drilling process (if any) have been removed from the well; and

d. The cap and all internal components of the well casing above the water table have been rinsed with well water to remove all traces of soil/sediment/cuttings. Washing will also be conducted before and/or during development.

4. Maintenance

Not applicable.

5. Precautions

Refer to the site-specific Health and Safety Plan for discussion of hazards and preventive measures during well development activities.

6. References

Ecology and Environment, Inc., 1991, Geotechnical Log Book, copyright Ecology and Environment, Inc.

USATHAMA, March 1987, Geotechnical Requirements for Drilling, Monitoring Wells, Data Acquisition, and Reports.

STANDARD OPERATING PROCEDURE

WELL DEVELOPMENT

SOP NUMBER: GEO 4.11

REVISION DATE: 4/5/2013 **SCHEDULED REVIEW DATE: 4/5/2018**

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1 Scope and Application

The purpose of monitoring well development is to ensure removal of fine materials from the pore spaces in the newly installed filter pack and in the vicinity of the screen; to attain maximum specific capacity and better yield; and to reduce turbidity in water quality samples. This allows free flow of water from the formation into the well, compensates for disturbance done to the formation during drilling, and reduces the turbidity of the water during sampling events. A properly developed monitoring well will then provide a water sample representative of the natural groundwater in the vicinity of the well.

Additionally, during drilling activities, drilling fluids may be lost into the formation or fractures and cavities or may have been used to maintain hydraulic head during drilling activities (such as in flowing sands). Drilling mud may also have been used to seal the wall of the borehole. Drilling fluids must be recovered through development to ensure that samples collected are representative of formation water.

All types of drilling operations alter the hydraulic characteristics of formation material in the vicinity of the borehole. Development is an essential task in the proper completion of a water well. The techniques are applicable for all types of aquifer materials, from unconsolidated sediments to fractured bedrock. The appropriate well development method should be selected to accommodate site conditions and project requirements.

This SOP incorporates guidance found in American Society for Testing and Materials Designation D5521 – 05, *Standard Guide for Development of Groundwater Monitoring Wells in Granular Aquifers*. Additional sources of information that may be useful include *Groundwater and Wells* (Driscoll 2008) and United States Army Corps of Engineers guidance in *Monitoring Well Design, Installation, and Documentation at Hazardous, Toxic, and Radioactive Waste Sites* (USACE 1998).

2 Definitions and Acronyms

BGS	below ground surface
Conductivity or Specific Conductance	a measure of the ability to conduct electricity, typically measured in microSiemens per centimeter (µS/cm) or milliSiemens per cm (mS/cm)
DO	dissolved oxygen, which is the amount of oxygen dissolved in solution, typically measured in milligram per liter (mg/L)
pH	a measure of acidity (acidic) or alkalinity (basic) on a scale of 0-14 standard units (SU)
ORP	oxidation-reduction potential which is a measure of determining whether a substance is a strong oxidizing agent or a strong reducing agent, typically measured in volts (V) or millivolts (mV)
NTU	nephelometric turbidity units
SOP	Standard operating procedure
Turbidity	the measure of the degree of which water loses its clarity by the presence of suspended solids, typically measured in nephelometric turbidity units (NTUs)

3 Procedure Summary

This procedure covers monitoring well development. Federal and state regulatory agencies also have standards and guidance for monitoring well development that supersede this SOP if required for the project. Before developing a well, the well must be properly installed, especially the filter pack, seal, and grout, and the seal and grout must be allowed to set and cure for a period of at least 24 hours (see E & E Standard Operating Procedure [SOP] GEO 4.10, *Monitoring Well Installation*). Water levels and total depth should also be properly measured prior to initiating well development procedures (see E & E SOP GEO 4.15, *Measuring Water Level and Well Depth*).

The most common well development methods are bailing, overpumping, mechanical surging, air surging, and jetting. Often, a combination of methods is employed. Withdrawal of water is of primary importance in order to remove fine sediments and drilling fluids. However, proper development includes the induction of flow in two directions, into and out of the well. This aids in development of a proper grain size gradation in the filter pack surrounding the well screen. Well development should be performed until the development water is representative of groundwater conditions (i.e., not diluted from drilling fluids added/lost to the formation) and is free of sediments, or until the turbidity has stabilized at a level considered natural by the on-site geologist. Therefore, at least three times the volume of standing water plus saturated thickness (assuming 30 percent annular porosity), plus three times the volume of water added to the well bore during well construction, and and/or the volume of water lost to the formation from drilling fluids used during drilling must be removed. In addition, at a minimum, development should be continued until pH, temperature, and specific conductivity values have stabilized at values considered by the on-site geologist to be typical for the site conditions. Additional parameter stabilization such as oxidation-reduction potential (ORP) and dissolved oxygen (DO) may be considered on a site-specific basis; refer to project planning documents. Containerize all discharge water from known or suspected contaminated areas (treatment may be an acceptable alternative). Record all measurements in the logbook or on data collection forms. Ideally, dedicated well development equipment may be used for each well. However, dedicated development equipment may not be practical due to the number of wells, depth of wells, and equipment costs. In this case, development equipment should be cleaned prior to and between well locations using the decontamination procedures outlined in E & E's SOP for *Sampling Equipment Decontamination* (ENV 3.15).

4 Cautions

Cautions to be considered during well development include:

- Not waiting the prescribed period following well completion can cause damage to the well if the bentonite seal and grout are not allowed to properly set and cure and is drawn into the filter pack and/or well;
- Removal of an insufficient volume of water may result in groundwater samples that are not representative of the formation; and
- Not using dedicated equipment or not properly decontaminating non-dedicated equipment can cause cross contamination between wells.

5 Equipment and Supplies

The type of equipment used for well development depends on the characteristics of the well (e.g., casing and screen diameter, construction material, and total depth) and of the aquifer (e.g., expected yield and turbidity of the formation). For example, most rig-mounted pumps and suction-lift pumps can only lift water a maximum of 28 feet. Therefore, if the well's static water level (water table) is greater than 28 feet below ground surface (BGS), or the water level is expected to be drawn down quickly below 28 feet BGS by the pump, then an alternative method must be used (e.g., air lift, centrifugal pump, bailer).

In general, wells could be developed either by the well driller using the drilling equipment or by E & E personnel using purchased or rented equipment. Most drilling companies have air compressors, centrifugal pumps, or submersible pumps that may be used for the development process. Section 6 details the specific equipment necessary for each well development technique.

In addition to development equipment, the following general field equipment and materials will also be required.

- Camera to document procedures and water clarity at the completion of development.
- Field logbook and well development form (see Figure 1 for an example data form or refer to E & E's Geotechnical Logbook);
- Boring log and well completion diagram for the well (Geotechnical Log Book);
- Water quality meters and appropriate sample vials;
- Water level indicator and/or weighted measuring tape; and
- Containers for purged water, if required.

5.1 Reagents

No chemical reagents are used in this procedure. For equipment decontamination and reagents used therein, refer to E & E SOP ENV 3.15, *Sampling Equipment Decontamination*.

6 Procedures

6.1 Development Methods

6.1.1 Bailing

In bailing, a bottom-filling bailer (e.g., polyethylene, polyvinyl chloride [PVC], Teflon, stainless steel, etc.) is used to remove water from the well. Begin by securely tying one end of a nylon or polypropylene rope (typically ¼-inch thickness or less) to the top of the bailer and lower it to the bottom of the monitoring well. Next, cut the rope to a length that allows the bailer to reach the bottom of the well while providing approximately 3 to 5 extra feet of rope. Cut the rope off at the appropriate length and tie the end to the protective casing of the monitoring well or another object to prevent the rope and bailer from being accidently lost down the well. The bailer is then allowed to fall freely down the well until it impacts the surface of the water. The impact of the bailer produces an outward surge of water through the well screen and filter pack. As the bailer fills and is removed, the flow of water reverses and fine particulates migrate into the well and are brought to the surface in the bailer. A series of short rapid strokes with the bailer at the bottom of the well will also remove accumulated sediment.

WELL DEVELOPMENT RECORD

Site Name: ______________________ Well ID: ______________________

Project Number: ______________________ Date: ______________________

Location: ______________________ Diameter (inches): ____________

Initial Depth to Water (ft below TOIC): ____________ Final Water Level (ft below TOIC): ____________

Initial Well Depth (ft below TOIC): ____________ Final Well Depth (ft below TOIC): ____________

Initial Casing Volume (gallons): ____________ 3x Static Casing Volume (gallons): ____________

Description of development equipment and technique: ______________________

Time	Total Volume Removed		pH	Temp. (°F / °C)	Conductivity (µS/cm)	Turbidity (NTU)	Depth to Water (ft TOIC)	Comments
	Gallons	Number						

Personnel: ______________________ Signature: ______________________

______________________ Date: ______________________

Advantages

The advantages of bailing include:

- No new fluids or air are introduced into the aquifer;
- Fluids introduced during drilling are removed;
- Sediment/fine particulates are removed from the well; and
- Equipment used is relatively inexpensive, easily obtainable, and, if dedicated to the well, can be used for purging and sampling the same well later.

Disadvantages

The disadvantages of bailing are:

- It is time-consuming and physically demanding if done manually; and
- It is not effective in low-yield wells.

6.1.2 Overpumping

In overpumping, the well is pumped at a rate that substantially exceeds the ability of the formation to deliver water. Typically, a submersible centrifugal pump is used. Pump selection must account for the amount of head to be overcome; that is, the anticipated depth to which the water level is expected to be drawn down must be anticipated and considered during pump selection. Backwashing is often used in conjunction with overpumping. If the pump does not have a backflow prevention valve, alternately starting and stopping the pump (sometimes referred to as “rawhiding”) creates a surging effect in which water is driven back into the formation during the off cycle. Alternatively, clean water can be added to the well, but only as a last resort when the well screen appears to be clogged and preventing the groundwater from entering the well. Prior to adding clean water to a well, the field crew must check the applicable regulations and receive permission from the project manager. The volume of all clean water added to the well must recorded in the logbook, and at least 3 to 5 times the volume of water added to the well should be removed during the development process to ensure that representative formation water is being drawn in the well when water quality parameters are being monitored for final stabilization.

Advantages

The advantages of overpumping are:

- With the variety of pumps available, It is relatively convenient and is applicable to a variety of well sizes;
- Minimal time and effort are required;
- Generally, no new fluids are introduced; and
- Fluids introduced during drilling and some fine sediment are removed.

Disadvantages

The disadvantages of overpumping are:

- Can result in a large volume of water to be contained, treated, and disposed of;

- May not develop maximum efficiency in a well because it may not effectively develop and set the grains within the filter pack and surrounding formation unless bidirectional flow can be sufficiently induced, such as if combined with mechanical surging;
- May cause “bridging” within the filter pack or formation. This is caused by small particles forming a “bridge” across the pore space between larger particles and impeding hydraulic conductivity. This may be avoided by inducing bidirectional flow into and out of the well; and
- Excessive pumping rates can cause well collapse, especially in deep wells.

6.1.3 Mechanical Surging

Mechanical surging forces water into and out of the well screen by operating a plunger, called a surge block, which is attached to a rod or wire line (see Figure 2). There are multiple configurations for surge blocks. Surge blocks should be close fitting to the interior side walls of the well, but should allow for the passage of some water to avoid creating excessive pressure on the up or down stroke and potentially damaging the well screen. The surge block is lowered to the top of the well screen and operated in a pumping action with strokes typically about 3 feet in length and is gradually worked downward throughout the screened interval. The surge block can be constructed of any materials (e.g., sand-filled PVC pipe) that will not alter the water chemistry. Periodically, the surge block is removed and fines that have entered the well are removed by pumping or bailing. This method is equally applicable to small- and large-diameter wells and is among the most effective methods for small-diameter wells.

Advantages

The advantages of mechanical surging include:

- Low cost and easy to implement;
- Effectively arranges particles within the filter pack;
- Has greater suction action and surging than backwashing or bailing;
- No new fluids are introduced into the well; and
- The quantity of water to treat and dispose of is minimized;

Disadvantages

The disadvantages of mechanical surging are:

- It must be combined with pumping or bailing to remove drilling fluids and sediments;
- If screen becomes plugged with fines (clay), the well casing or screen can collapse;
- It tends to push fine-grained sediments into the filter pack;
- The well bentonite seal could be disturbed; and
- Excessive sand can result in sand-locking of the surge block within the well.

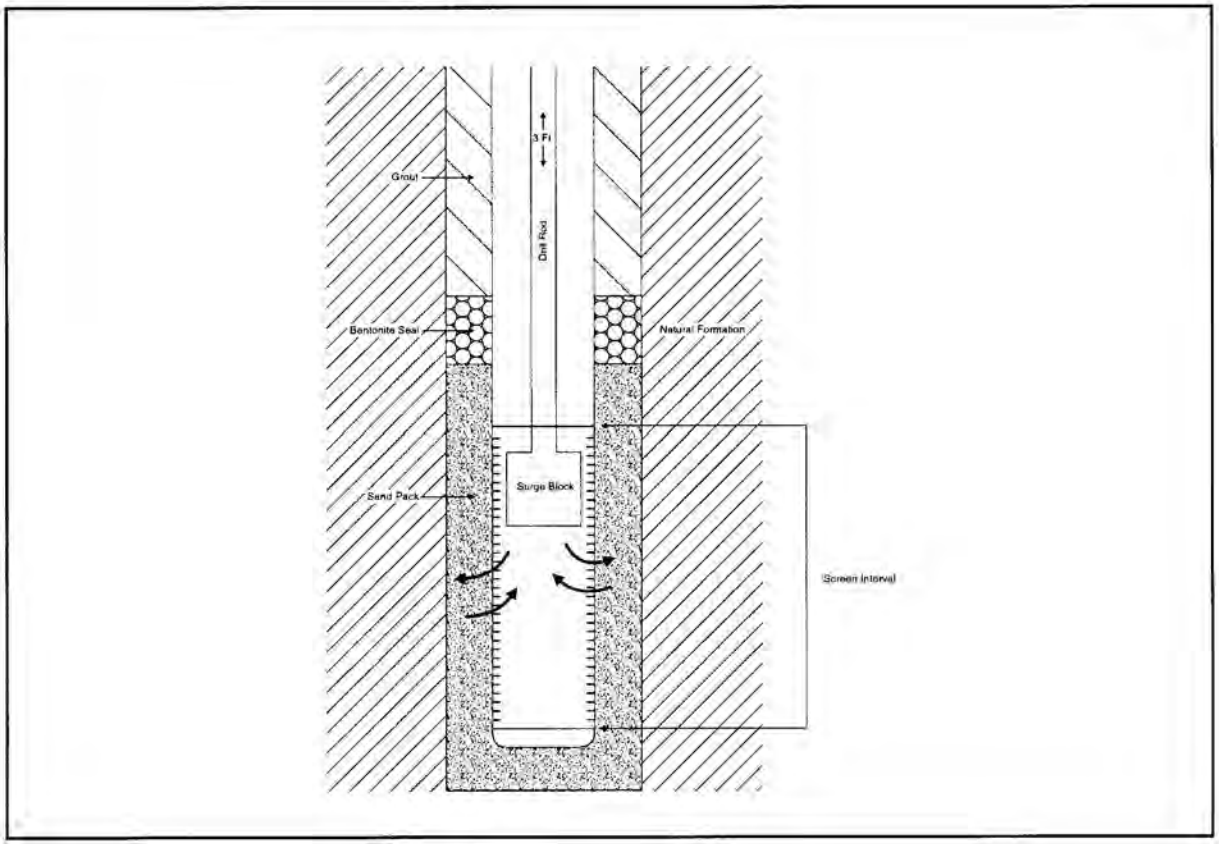

Figure 2 Mechanical Surging

6.1.4 Air Surging and Air-Lift Pumping

Compressed air can be used to surge and air-lift pump a well. In air surging, air injected through a pipe lifts the water column until it reaches the top of the well casing. Then the air is shut off, causing an outward surging action in the well's screened interval. Alternatively, sufficient air pressure can be used to lift water out of the well (see Figure 3). Air surging is not recommended for monitoring wells (but may be used successfully in production and supply wells). Injecting air into a monitoring well may force air into contact with the formation, altering the oxidation-reduction potential of the formation water and changing the groundwater chemistry. Air bubbles may also become entrapped within the screen, filter pack, or formation causing a decrease in well yield. Air bubbles may be difficult to remove.

A more suitable alternative is air-lift pumping combined with bailing or pumping to remove fine sediment. In air-lift pumping, air is not forced into the filter pack or formation. An airline is inserted inside a pipe known as an educator pipe and the assembly is lowered into the screen interval. The airline should not extend below the educator. The flow of air down the airline causes a reduction in specific gravity of the water at the bottom of the educator and the water flows up and out of the educator (see Figure 3). Air-lift pumping may remove some fine sediment, but should be supplemented with bailing or pumping to remove fines.

In either case, air injected into a well should be verified to be oil free.

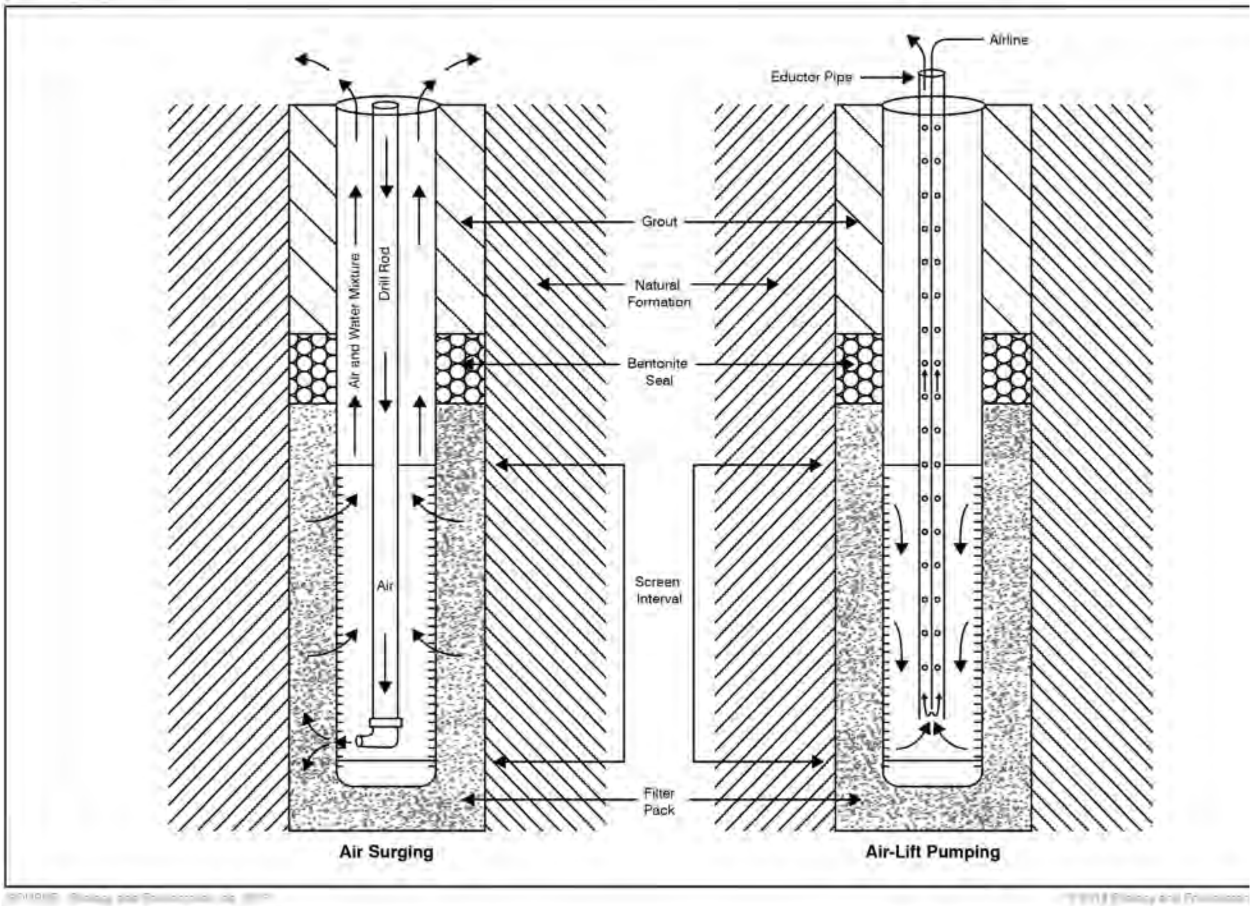

Figure 3 Air Surging and Air-Lift Pumping

Advantages

The advantages of air surging and air-lift pumping are:

- They are rapid methods for development;
- They are effective in a variety of well sizes and depths; and
- They are relatively easy to implement with minimal equipment needs (compressed air tanks or oil-free compressor, airline, and pipe).

Disadvantages

The disadvantages of air surging are:

- Air can become entrained in the screen or filter pack and reduce well yield;
- Air can be impure (contaminated with oil products) from the air compressor;
- Introduction of air can alter water chemistry and biology (iron bacteria) near the well (this can be mitigated by using nitrogen instead of compressed air); and
- Fine sediment is not removed unless combined with bailing or pumping.

The disadvantages of air-lift pumping include the following:

- Air impurities may contaminate groundwater near the well;
- Some fine sediment may be removed, but heavier coarse-grained particles may not be and bailing may be needed to remove additional particles.
- Significant volumes of groundwater may need to be contained, treated, and disposed of.

6.1.5 High-Velocity Jetting

In high-velocity jetting, a single or multiple-nozzle device is used to direct a horizontal stream of water against the well screen. The jetting tool is placed near the bottom of the screen and slowly rotated while being pulled upward. Material that enters the screen in the backwash of the jet stream is then removed by pumping or bailing. Air-lift pumping is typically combined with jetting because it can remove particulates without damage to pump impellers and can fit into a well with the jetting device. If the pumping rate can be maintained at approximately twice the injection rate of the jetting tool, then minimal water loss can be expected. Water pumped out during jetting may be recycled by reinjection for jetting water.

Advantages

The advantages of high-velocity jetting are:

- It is simple to use,
- It effectively rearranges and breaks down bridging in filter pack, and
- It effectively removes mud cake around screen.

Disadvantages

The disadvantages of high-velocity jetting are:

- Foreign water is introduced to the aquifer;
- It does not remove drilling fluids unless combined with pumping or bailing; and
- Jetting with simultaneous pumping is not always practicable because of the limited space available within the well.

6.2 Operation

Well development should be performed as soon as is practical after the well is installed, but no sooner than 24 hours after grouting is completed. Dispersing agents, acids, or disinfectants should not be used to enhance development of the well.

1. Assemble necessary equipment on a plastic sheet around the well.
2. Record pertinent information (e.g., personnel, date, time, location identification, etc.) in the field logbook and/or data forms.
3. Open the monitoring well and measure organic vapors or other gases within the headspace at the top of casing and in the breathing zone, as specified in project planning documents, and record readings and observations.
4. Measure the depth to water and the total depth of the well, and calculate the volume of water in the well. Depth measurements are described in E & E SOP GEO 4.15, *Measuring Water Level and Well Depth*. Calculations are in Section 6.3.

5. Begin development using the method specified in the project planning documents. If mechanical surging is performed prior to extracting water from the well, obtain a sample of the undeveloped water using a bailer or equivalent prior to initiating development.
6. Note the initial color and clarity of the water. Measure the initial water quality parameters required for the project. In the absence of site-specific requirements, obtain measurements of pH, temperature, specific conductance, and turbidity in addition the physical characteristics noted above.
7. Develop the well until the minimum volume of water is removed (i.e., three times the following volumes: standing water in the well including water in the annular space of the saturated thickness plus the volume of water added during well construction plus the volume of water lost to the formation during well drilling); the required water quality parameters have stabilized after three consecutive readings; and the turbidity is below the required threshold. In the absence of site-specific requirements described in the project planning documents, the target turbidity threshold is 50 nephelometric turbidity units (NTU). If this threshold cannot be achieved due to formation characteristics but the turbidity stabilizes, development may be considered complete after consultation with the project geologist and project manager. If not specified in project planning documents, guidance for the stabilization of water quality parameters is as follows:
    - ± 0.1 standard unit for pH;
    - ± 3% for temperature;
    - ± 3% for specific conductance; and
    - ± 10% for turbidity.

   If utilized at a specific site, the following stabilization guidance may also apply:
    - ± 10 millivolts for oxidation-reduction potential (ORP);± 10% for dissolved oxygen (DO).
8. All water produced by development in contaminated or suspected contaminated areas must be containerized and/or treated prior to proper disposal. Each container must be clearly labeled with the location identification, including site name, date, and monitoring well number. Determination of the appropriate disposal method should be specified in the project planning documents and may be based on the first round of analytical results from each well.
9. No water shall be added to the well to assist development without prior approval of the project geologist. If a well cannot be cleaned of mud to produce formation water (i.e., if the yield is insufficient), small amounts of potable water may be introduced, possibly via hydraulic jetting. At least three times the amount of water injected must be recovered from the well after injection to ensure that all injected water is removed from the formation. Minimize the amount of water injected. Once the well boring is cleared of drilling mud and formation water flows into the well, continue development with formation water only.
10. Measure the final pH, temperature, specific conductance, and turbidity of the water and record the measurements and the final color and visual clarity in the field logbook and/or data forms.

The following data shall be recorded in the field logbook:

- Site name and location;

- Well designation (location identifier);
- Date(s) and time of well development;
- Static water level and total depth before and after development;
- Water quality parameter measurements before and after development and at least every one well volume (static volume of water within the well casing prior to development);
- Type and size or capacity of pump and bailer used;
- Description of well development techniques used,
- Total quantity of water removed; and
- Storage location of development water.

Although not required, obtaining a photograph of the initial and final development water in a clear glass jar is recommended to verify changes made to the turbidity of the water during development.

Following completion of development, decontaminate all reusable equipment in accordance with project planning documents or E & E SOP ENV 3.15, *Sampling Equipment Decontamination.*

Store containers of water produced during development in a safe and secure area. Treat and/or dispose of wastewater in accordance with project planning documents or E & E SOP ENV 3.26, *Handling Investigation-derived Wastes*.

6.3 Calculations

To calculate the volume of the well, use the following equation:

$$V = \pi {r_i}^2 h_w + \pi({r_b}^2 - {r_o}^2) h_f n$$

where:

$V =$ total volume (well casing plus saturated filter pack);

${r_i}^2 =$ inside radius of well casing;

$r_b =$ radius of the well boring;

$r_o =$ outside radius of well casing;

$h_w =$ height of water in the well;

$h_f =$ height of water in the well or height of filter pack, whichever is less;

$n =$ porosity of the filter pack

If the radius of the well casing is measured in inches and the volume is measured in gallons, the following conversion factors may be used to calculate the volume of water within the well by multiplying the height of water measured in feet:

Well diameter (inches):	1	2	4	6
Linear Volume (gallons per foot):	0.041	0.163	0.653	1.47

Similarly, using the same units of measurement, the following conversion factors may be used to calculate the volume of water within the annular space of the filter pack by multiplying the saturated height of the filter pack measured in feet and assuming a porosity of 35%:

Borehole Diameter (inches):	2 ¼	8 ½	10 ½	12 ½
Well diameter (inches):	1	2	4	6
Linear Volume (gallons per foot):	0.050	0.959	1.17	1.67

7 Quality Assurance Quality Control

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

1. All data must be documented on field data sheets, and field/site logbooks.
2. All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the project planning documents. Equipment checkout and calibration activities must occur prior to or operation, and they must be documented.
3. All deliverables will receive peer review prior to release.

8 Health and Safety

Depending on the site-specific contaminants, various protective programs must be implemented prior to opening a well, taking water level measurements, or removing groundwater. The site-specific Health and Safety Plan (HASP) should be reviewed with specific emphasis placed on the protection program planned for well development tasks. Standard safe-operating practices, such as minimizing contact with potential contaminants in both the vapor phase and liquid matrix through the use of the respirators and personal protective clothing, should be followed.

9 Special Project Requirements

Project or program-specific requirements that modify this procedure should be entered in this section and included with the project planning documents.

10 References

American Society for Testing and Materials (ASTM), Designation D5521 - 05 *Standard Guide for Development of Groundwater Monitoring Wells in Granular Aquifers*.

Driscoll, F.G., 2008, *Groundwater and Wells*, (3rd edition), Johnson Division, VOP, Inc., St. Paul, Minnesota.

Ecology and Environment, Inc., 2012, Standard Operating Procedure ENV 3.15, *Sampling Equipment Decontamination*.

______, 2012, Standard Operating Procedure ENV 3.26, Handling Investigation-derived Wastes.

______, 2013, Standard Operating Procedure GEO 4.10, *Monitoring Well Installation*.

______, 2013, Standard Operating Procedure GEO 4.15, *Measuring Water Level and Well Depth*.

United States Army Corps of Engineers (USACE), 1998, "Monitoring Well Design, Installation, and Documentation at Hazardous, Toxic, and Radioactive Waste Sites, Engineer Manual 1110-1-4000, Washington, DC.

END OF SOP

STANDARD OPERATING PROCEDURE

GEOPROBE OPERATION

SOP NUMBER: GEO 4.12

REVISION DATE: 4/16/2013 **SCHEDULED REVIEW DATE: 4/16/2018**

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1 Scope and Application

This Standard Operating Procedure (SOP) describes the procedures utilized by Ecology and Environment, Inc. (E & E) for operation of the E & E owned Geoprobe® and collection of samples using the probe. Additionally, this document can be used as a primer for E & E personnel that are performing field oversight of direct-push operations being conducted by others.

There are a variety of direct-push machines currently being manufactured and the array of subsurface sampling tools grows each year. The two most common types of direct-push machines are vehicle-mounted (E & E's Geoprobe® is mounted in a pickup truck) and stand-alone track-driven units that are typically trailered to a site, then moved around the site on their "tracks" via a hand-held, radio-operated remote control box. Other less commonly used types of direct-push units include those that mount to tractors, skid-steers (Bobcats), all-terrain vehicles, and even hand carts. Additionally, because several equipment companies are now manufacturing their own rigs that use technology similar to that used by Geoprobe Systems, Inc., the generic term "direct-push" is commonly used in place of "Geoprobe". Because this SOP applies to all direct-push machines, the term Geoprobe® will be used only when referring specifically to the Geoprobe® brand.

This document provides basic information on the operation and application of the various direct-push models for subsurface investigations. This document is NOT intended to be used as an operator's guide or a training manual for the operation of Geoprobes® or other direct-push machines. Operating instructions for specific machines should be obtained from the manufacturer prior to use. Additionally, hands-on training with an experienced operator is a prerequisite to unsupervised operation of direct-push machinery and associated tooling. Field procedures and limitations of direct-push technologies are discussed. This document is meant to be used in conjunction with manufacturer's instructions and other E & E standard operating procedures for field operations. It incorporates safety precautions that should be followed when planning a subsurface investigation.

Procedures for sample handling are defined in E & E Environmental Sample Handling, Packaging and Shipping SOP ENV 3.16. Site-specific sample handling procedures are dependent on the project data quality objectives (DQO).

Procedures for equipment decontamination are defined in E & E Sampling Equipment Decontamination SOP ENV 3.15. Site-specific equipment decontamination procedures are dependent on the project DQOs.

This is intended for use by personnel who have knowledge, training and experience in the direct-push operation and sampling activities being conducted.

1.1 Objectives

Direct-push machines can be used to collect subsurface samples to determine the presence and/or extent of contaminants in soil gas, groundwater, and soils with minimum disturbance to the ground surface. Direct-push machines are hydraulically powered units which may be mounted in a van, truck, small 4-wheel drive all-terrain vehicle or can be self-propelled. They are capable of advancing sampling tools below the ground surface to collect subsurface soil gas samples, subsurface soil samples, and groundwater samples. The information obtained from an investigation using these tools can be used to define the extent of contamination in the area, assist in determining the placement of monitoring wells and be used to install monitoring wells.

2 Definitions and Acronyms

DQO	Data Quality Objective
E & E	Ecology and Environment, Inc.
HSA	Hollow-Stem Auger
ID	Inside Diameter
IDW	Investigation-Derived Waste
OD	Outside Diameter
OSHA	Occupational Safety and Health Administration
PM	Project Manager
PVC	Polyvinyl Chloride
PRP	Potentially Responsible Party
SHASP	Site Specific Health and Safety Plan
SOP	Standard Operating Procedure
SSC	Site Safety Coordinator
TSP	Trisodium Phosphate
VOC	Volatile Organic Compound

3 Procedure Summary

The various direct-push units are hydraulically powered probing devices. The units consist of a powered percussion hammer that is slide-mounted on a derrick and has a nominal stroke ranging from 3.5 to more than 6.5 feet. The derrick assembly hydraulically folds and unfolds from the traveling or storage position in the rear compartment of a vehicle or onto the track-driven unit. The derrick is also adjustable in both the fore and aft directions, side to side as well as angled, to ensure the derrick is vertical during operations. Direct-push machines use the weight of the unit and a hydraulically powered percussion hammer to advance probe rods into the ground. The probe rods are hardened steel with various inside diameters (IDs) and outside diameters (ODs) ranging from 1 to 4.5 inches. The operator controls the hydraulic cylinders and the percussion hammer through the use of levers, and the helper assists by adding sections of rod. Depending on the purpose of the investigation, the lead rod will be equipped to collect soil, groundwater, or soil gas samples. After the lead rod has been driven into the ground, the helper attaches an additional section of rod and the process is repeated until the desired depth has been reached. Additionally, some direct-push machines are equipped with rotary heads that can be used for turning augers. Auger drilling, however, is not described in this SOP.

4 Cautions

Direct-push machines and sampling tooling provide a means of collecting subsurface samples that can be used to rapidly assess the presence of contaminants in near-surface unconsolidated soils. E & E's current Geoprobe® machine and associated tooling can penetrate much farther in moist, cohesive soils, as the probe hole tends to stay open in these conditions. Dry, loose soils tend to collapse onto the top of the sampling tool at depth, making it difficult to return the sampler through the collapsed probe hole to the ground surface. Tightly bound clay, rocky soils, and tightly compacted glacial till deposits may offer too much resistance to the sampling tools resulting in little or no advancement of tool strings. In these cases, other subsurface investigation methods (such as auger or rotary drilling) or larger direct-push machinery should be considered. Use of under-sized direct-push machines in these situations may result either in damage to the machine or injury to the operator.

Cautions associated with direct-push sample acquisition include decontamination procedures, depth control, and health and safety associated with heavy equipment use. All equipment that is brought on site must be clean prior to arrival and all downhole equipment must be decontaminated prior to drilling each boring location. This is an important factor to ensure that off-site contaminants are not introduced to the soils (and groundwater) being collected and that contaminants encountered at one site location are not spread throughout the site.

Depth control is also an important factor to ensure that exact soil horizons, formations, and zones of contamination identified during sampling are accurately documented and will allow for accurate placement of well materials. The operator and oversight geologist should be familiar with the drilling methodology and independently verify measurements on a regular basis.

As with any heavy equipment operation, proper personal protective equipment is essential. At a minimum, Level-D protection will be required for all probing operations.

5 Equipment and Supplies

Direct-push soil, soil vapor, and groundwater sample collection tools are typically proprietary to the manufacturer of the direct-push machine. Field sample collection typically involves a combination of non-expendable tooling and expendable sampler liners or tubing. The direct-push equipment and expendable supplies required for field work depend on the program/project DQOs, and may include:

- Sampler such as thin-walled tube sampler (e.g., shelby tube sampler), split-spoon sampler, continuous soil core sampler (e.g. Laskey), continuous-flight auger, or direct push soil corer (e.g., Dual Tube or Macro-Core®).
- Liners and/or catchers for augers or core samplers as specified in the project planning documents
- Tubing for the retrieval and collection of soil vapor and groundwater samples.

The following is a general list of equipment and supplies used to process samples of various media after they are originally obtained by the proprietary down-hole direct-push sample collection tooling. A detailed list of equipment and supplies should be prepared based on the project planning documents. In general, the use of dedicated or disposal equipment is preferred but equipment may be re-used after thorough decontamination between sample locations (refer to E & E Sampling Equipment Decontamination SOP ENV 3.15).

- Stainless-steel or Teflon™ spoons, trowels, or scoops. Other construction material may be acceptable depending upon the program/project planning documents and DQOs
- Stainless-steel mixing bowls. Other bowl construction material may be acceptable depending upon the program/project planning documents and DQOs
- Spade(s) and/or shovel(s)
- Pipe cutter(s), stainless steel knives(s), or power saw to cut liners
- Survey stakes or flags to mark locations
- Ancillary equipment and supplies, e.g., meter stick or tape measure, aluminum foil, plastic sheeting, disposable gloves.

Supporting equipment and supplies also may be required to address the following:

- Field logbooks and supplies (Refer to project planning documents and the E & E Field Activity Logbooks SOP DOC 2.1 for details)
- Decontamination equipment and supplies (Refer to project planning documents and E & E Sampling Equipment Decontamination SOP ENV 3.15for details)
- Sample containers, preservatives, and shipping equipment and supplies (Refer to project planning documents and the E & E Environmental Sample Handling, Packaging and Shipping SOP ENV 3.16 for details)
- Waste handling supplies (Refer to project planning documents and E & E Handling Investigation-Derived Wastes SOP ENV 3.26 for details)

6 Procedure

The most accurate method for obtaining information on the characteristics of unconsolidated deposits is to collect representative samples of the soil at measured depths and at intervals that will provide a complete lithologic profile of the soils. E & E staff will use the following procedures for completing subsurface soil sampling:

- Review relevant project planning documents, e.g., work plan, sampling and analysis plan, quality assurance project plan, health and safety plan, etc.
- Select the sampling procedure(s) that meet project DQOs.
- Refer to the E & E Field Activity Logbooks SOP DOC 2.1 for guidance on the types of information that should be recorded for each sample.
- Refer to the E & E Environmental Sample Handling, Packaging and Shipping SOP ENV 3.16 for guidance on how samples should be labeled, packaged, and shipped.

6.1 Responsibilities

6.1.1 Operator

The typical direct-push crew consists of an operator and a helper. The operator is responsible for the safe and efficient operation of the machine, and also performs the daily inspections and maintenance. In addition, the operator inventories the supplies and equipment daily and ensures that an adequate supply of expendable parts are available to complete the job.

The operator is responsible for completing the subsurface investigation in accordance with the site-specific work plan and in a safe manner consistent with the site health and safety plan. Routinely, the operator is also responsible for (1) the quality of the samples recovered; (2) compliance with the project's quality assurance/quality control requirements; and (3) completion of daily summary documentation of activities.

If the operator observes any unsafe or potentially dangerous situations, the operator will stop operations until the proper corrective actions have been taken. The operator has the authority to cease operations at any location if the operator concludes that the conditions are dangerous or could compromise the quality of the samples.

6.1.2 Helper

The primary function of the helper is to assist the operator in conducting the subsurface investigation. The helper is responsible for assembling, securing, and disassembling the rods and other sampling tools used in the investigation. The helper is also responsible for ensuring that all of the equipment is properly decontaminated and that all tools are in proper working order.

If the helper notices any unsafe or potentially dangerous situations, the helper will inform the operator immediately. The helper must be attentive to conditions around the direct-push machine because the operator will be concentrating on the operation of the unit.

6.1.3 Site Safety

The site safety coordinator (SSC) is responsible for ensuring that the subsurface investigation follows the procedures as outlined in the site-specific health and safety plan. The SSC, at the direction of the project manager (PM) will ensure that overhead and buried utilities (e.g., electrical lines, telephone lines, natural gas lines) have been identified and located prior to commencing the subsurface investigation (see Section 6.3.1 of this SOP). The SSC will be familiar with the operations of the direct-push machine and the potential hazards posed by its operation. In many cases, the operator or helper also serves as the SSC for the drilling contractor. In addition to direct-push contractor’s PM, E & E is also responsible for all items described above to the extent practicable.

6.2 Planning the Survey

In planning for direct-push field activities, research should be conducted on governmental agency stipulations which may require drilling permits and/or drillers’ licenses; local and regional geology and hydrogeologic conditions; historic records on the size of the site; past waste disposal practices; types of waste material disposed of at the site; and depth and orientation of waste material. Sites should be evaluated in terms of their hydrogeologic setting. This evaluation will help maximize the effectiveness of the survey, given site conditions.

6.2.1 Researching the Site

- Prior to designing the field survey, the following information should be collected, if available, from reconnaissance surveys, interviews, and research reviews:
- Verify whether permits will be required prior to conducting field activities. Additionally, some agencies require that persons operating direct-push machinery be licensed prior to conducting the proposed work. Requirements are typically enforced by state, county and municipal agencies; usually require fees; and occasionally require bonds and proof of insurance.
- Information on the types and locations of materials that may be buried on site to determine where subsurface investigations should not be conducted with a direct-push machine, and to identify the type(s) of samples to be collected;
- Information on the surface layout of the site being studied, including information on topography, site boundaries, and the locations of buildings, rail lines, overhead and buried utility lines (e.g., electric lines, pipelines, etc.), scrap disposal areas, vaulted sidewalks, and other structures that may prevent the proper operation of the direct-push machine; and
- Maps, drawings, photographs of the area, and historical aerial photographs may indicate previous disposal areas and poor waste disposal practices, and can also provide a base map for plotting data.

6.2.2 Defining and Mapping the Survey Site

After obtaining background data, the proposed sampling locations should be laid out based on the locations of buried material or expected soil, groundwater or soil-gas contamination. Safety and accessibility are other factors to consider when locating sampling locations.

6.3 Field Procedures

6.3.1 Overhead and Buried Utilities

The use of a direct-push machine on a site or project requires that special precautions be taken by both the operator and the helper. Electricity from electrical power lines and other utilities can shock, burn, and cause death. Applicable regulations and codes and good practice mandate that overhead and buried utilities must be located, noted, and emphasized on all subsurface investigation location plans and assessment sheets. When overhead electrical power lines exist at or near the site, consider all wires to be live and dangerous. Watch for sagging power lines before entering the site. Do not lift power lines to gain entrance; call the power company and ask them to raise the lines or de-energize the lines. Before raising the derrick near power lines, walk completely around the unit. Determine what the minimum distance from any point on the unit to the nearest power line will be when the derrick is being raised. Do not raise the derrick or operate the unit if this distance is less than 25 feet or, if known, the minimum clearance stipulated by federal, state, and local regulations. To avoid contact with power lines, never move the direct-push machine with the derrick in a raised position.

If there are any questions concerning the safety of drilling on sites near overhead power lines, contact the power company. The power company will provide expert advice at the site as a public service at no cost.

Underground electrical utilities are as dangerous as overhead power lines, but are not visible. Be aware and always suspect the existence of underground utilities. If a sign warning of underground utilities is located on a site boundary, do not assume that underground utilities are located on or near the boundary or property line under the sign. Always contact the owners of utilities and determine jointly the precise location of underground utility lines, and mark or flag the locations. Besides electrical, other utilities that need to be checked are gas, telephone, water, cable TV, fiber optics (very important because of the cost to repair them), and sewer.

Most states and some municipalities have universal one-call systems that are used to notify utility owners of proposed work in the vicinity of their buried facilities. In many places, laws exist that mandate a call to the one-call system prior to conducting any excavation, drilling or probing activities. Be warned, however, that not all entities that own buried utilities subscribe to the one-call systems. It is the responsibility of the company performing the intrusive work to identify all buried utilities in the area prior to commencement of field activities. Additionally, a nation-wide system has been implemented to notify owners of utilities in specific project areas. A universal telephone number of "811" is dedicated to this function. Additional information is available at www.call811.com. There is always a waiting period after the time of a utility locate request before the utility owners are required to have their facilities properly marked (usually two working days).

Typically, utility companies are required to locate their utilities from a right-of-way or easement to property lines of a facility or to a meter or regulator that may be located on private property. Locating redistributed utilities on private property is the responsibility of the property owner. However, potentially responsible parties (PRPs) are often uncooperative in marking their own utilities. Private locators may need to be contracted to survey areas that the utility locators and property owners will not.

6.3.2 Work Area Set-Up

Prior to beginning sampling operations with a direct-push machine, precautions should be taken to reduce physical risk in the work area. Situational awareness is paramount. Recognize that work is typically being conducted in a dynamic environment. Position the direct-push machine and support vehicles in a manner that will not interfere with traffic, or movement of other vehicles such as cars, trucks, forklifts, railcars, etc. Anticipate future traffic flow patterns and activities (e.g., don't block facility egress routes, [especially at quitting time]). If street traffic is to be blocked, ensure that all requirements are met regarding signage and placement of traffic pylons. Additionally, wear safety vests in any area where traffic is anticipated.

6.3.3 Operating Direct-Push Machines

Refer to the operator's manual of the specific Geoprobe® or other direct-push machine being used for specific operating procedures. Direct-push machines as with drill rigs and other machinery and tooling should only be operated by qualified personnel. As a courtesy, the following safety information for truck-mounted and track-mounted units was provided by Geoprobe Systems®:

6.3.3.1 Truck-Mounted Geoprobe® Safety

1. Always set the carrier vehicle parking brake and shut off the engine before exiting the cab. Refer to the carrier vehicle owner's manual for additional safety guidelines.
2. Heed all CAUTION, WARNING, and DANGER decals posted on the machine.
3. Operators should wear OSHA-approved steel-toed shoes and keep feet clear of probe foot.
4. Operators should wear OSHA-approved safety glasses at all times during the operation of this machine.
5. Operators must wear hearing protection. OSHA-approved hearing protection for sound levels exceeding 85 dba is recommended.
6. The Emergency Kill switch button on the control panel will immediately shut off the engine when pushed. Familiarize yourself with the location of this button before operating the machine.
7. Ensure that everyone is clear of all moving parts before starting the engine.
8. Do not drive the machine with the probe cylinder or winch mast extended. This practice could result in equipment damage and/or personal injury from contact with overhead objects such as power lines.
9. When operating the unit on sloped surfaces, always position the unit parallel with the slope. This provides the greatest degree of stability and will limit shifting during probing or augering operations. Position the machine with the control panel upslope whenever possible so the machine will roll away from the operator if it becomes unstable and moves unexpectedly.
10. Designate one person to operate the machine while probing or augering. This will avoid injuries from having someone unexpectedly engage the machine controls while another person is working near moving parts.
11. Operators must stand to the control side of the machine, clear of the probe foot and derrick, while operating the controls. Never reach across the probe assembly to manipulate the machine controls.
12. Never place your hands on top of the tool string while raising or lowering the GH60 hammer.
13. Never move the probe assembly (swing, extend, fold, etc.) while anyone is in physical contact with the tool string.
14. Use caution when probing on loose or soft surfaces. Reduced weight on the rear wheels may allow the carrier vehicle to shift or slide under such conditions.
15. Limit the rate at which the GH60 hammer is lowered while advancing the tool string to avoid raising the probe foot more than approximately 6 inches off of the ground surface.

16. Never raise the machine foot more than a few inches from the ground surface with the probe cylinder and/or winch mast fully extended. If the foot must be raised significantly, first lower the hammer and winch.

17. Always place the machine foot firmly on the ground when pulling tools from the subsurface.

18. In the event of a problem, the operator should release all control levers. The spring-loaded levers will automatically return to the neutral position and machine operation will cease.

19. Rotating parts can cause serious injuries. Shut off the engine before attempting to clean or service the unit.

20. Do not make modifications or add attachments to this machine which are not approved by Geoprobe Systems®.

21. Do not wear loose clothing while operating this machine. Severe injury will result if clothing becomes entangled in moving parts.

22. Avoid hydraulic fluid leaks. Pressurized fluid may be injected into the skin resulting in serious bodily injury. In the event of an accident, seek medical attention immediately.

6.3.3.2 Track-Mounted Geoprobe® Safety

1. Refer to the Kubota Diesel Engine Operator's Manual for all engine-related safety instructions before operating the Geoprobe® track-mounted machine.

2. Heed all CAUTION, WARNING, and DANGER decals posted on the machine.

3. Operators should wear OSHA-approved steel-toed shoes and keep feet clear of probe foot.

4. Operators should wear OSHA-approved safety glasses at all times during the operation of this machine.

5. Operators must wear hearing protection. OSHA-approved hearing protection for sound levels exceeding 85 dba is recommended.

6. The Emergency Kill switch button on the control panel will immediately shut off the engine when pushed. Familiarize yourself with the location of this button before operating the machine.

7. Ensure that everyone is clear of all moving parts before starting the engine.

8. Check that both outriggers are fully raised before attempting to drive the unit.

9. Do not drive the machine with the probe cylinder or winch mast extended. This practice could result in equipment damage and/or personal injury from contact with overhead objects such as power lines.

10. The unit should only be driven using the remote control box. The steering levers located on the machine are for positioning only. Do not attempt to drive using the levers on the machine as this requires the operator to walk too close to the tracks while the vehicle is in motion.

11. Do not attempt to drive the unit on slopes of more than 20 degrees. Always drive straight up or down steep grades. Avoid sideslopes whenever possible. Continuous operation should be limited to slopes of less than 20° to avoid engine damage.

12. When maneuvering the unit in close quarters, lower engine speed to provide more precise control of the track assemblies.

13. A track-mounted machine is generally transported on a trailer. Use special caution when loading the unit with wet ramps as it is significantly easier for the tracks to slip under such conditions.

14. When operating the unit on sloped surfaces, always position the unit parallel with the slope. This provides the greatest degree of stability and will limit shifting during probing or augering operations. Position the track-mounted machine with the control panel upslope whenever possible so the machine will roll away from the operator if it becomes unstable and moves unexpectedly.

15. Do not extend the outriggers such that the tracks are raised off of the ground more than one or two inches. Raising the tracks several inches off of the ground surface decreases the stability of the machine and provides no operational advantage.

16. Designate one person to operate the machine while probing or augering. This will avoid injuries from having someone unexpectedly engage the machine controls while another person is working near moving parts.

17. Operators must stand to the control side of the machine, clear of the probe foot and derrick, while operating the controls. Never reach across the probe assembly to manipulate the machine controls.

18. Never place your hands on top of the tool string while raising or lowering the GH60 hammer.

19. Never move the probe assembly (swing, extend, fold, etc.) or operate the tracks while anyone is in physical contact with the tool string.

20. Use caution when probing on loose or soft surfaces. Reduced weight on the tracks may allow the unit to shift or slide under such conditions.

21. Limit the rate at which the GH60 hammer is lowered while advancing the tool string to avoid raising the probe foot more than approximately 6 inches off of the ground surface.

22. Never raise the machine foot more than a few inches from the ground surface with the probe cylinder and/or winch mast fully extended. If the foot must be raised significantly, first lower the hammer and winch.

23. Always place the machine foot firmly on the ground when pulling tools from the subsurface.

24. In the event of a problem, the operator should release all control levers. The spring-loaded levers will automatically return to the neutral position and machine operation will cease.

25. Rotating parts can cause serious injuries. Shut off the engine before attempting to clean or service the unit.

26. Do not make modifications or add attachments to this machine which are not approved by Geoprobe Systems®.

27. Do not wear loose clothing while operating this machine. Severe injury will result if clothing becomes entangled in moving parts.

28. Avoid hydraulic fluid leaks. Pressurized fluid may be injected into the skin resulting in serious bodily injury. In the event of an accident, seek medical attention immediately.

When using a subcontractor to perform direct-push operations, the subcontractor's SOP must be included in their site-specific health and safety plan. These procedures in addition to those described in E & E's site-specific work plan must be followed.

6.4 Subsurface Soil Sampling

Direct-push machines can be used to collect subsurface soil samples. Soil samples are typically collected in steel sampling tubes that are fitted with a PVC, Teflon, or other liner manufactured from various polymers. Once the sampler is driven to depth then retrieved, the liner containing the soil core is removed and the sampler is reloaded with a new liner. Most commonly, soil samples are collected by advancing an open-ended soil sampler from the ground surface to a depth equal to the length of the sampler. The sampler is then removed from the ground leaving an open probe hole. The soil core is removed from the soil sampling tool, the open-ended sampler is reassembled, and advanced through the open probe hole to the next deeper sampling interval. This process is repeated until the desired depth is reached. In the event that the probe hole collapses or only one discreet sampling interval is desired, a closed-piston soil sampler can be used to advance the sampler to a specified depth without allowing soil into the sampler until the closed tip is deployed by the operator, allowing soil into the core liner. Additionally, dual tube sampling systems are available that case the probe hole as the soil sampling depth increases, preventing the inadvertent collapse of the probe hole during sampling operations.

Soil samplers ranging in size from one-inch OD to 4.5-inch OD are available. Each soil sampling tool is used in conjunction with specific combinations of direct-push machines and probe rods. Soil can be collected using open- and closed- tip samplers as described above. See manufacturer's operating instructions and tooling requirements for specific sampling equipment.

6.5 Groundwater Sampling

Direct-push machines can be used to advance sampling tools that are specifically designed for the collection of groundwater. Each groundwater sampling tool is combined with probe rods to access saturated zones and to provide a conduit for sample retrieval. A bailer, tubing attached to an above-ground pump (e.g., peristaltic pump), or tubing with a check valve at its base is required to retrieve groundwater from the sampling tool/probe rod combination. Groundwater sampling tools fall into two categories; those that have exposed "well slots" and those that are sheathed or protected from contacting soil and groundwater while being driven to their final depth.

A mill-slot groundwater sampler is essentially a probe rod that has a series of thin slots cut into its sides to allow for the passage of groundwater into the probe rods. Typically, the lead "mill-slot" rod is tipped with a threaded point to prevent the intrusion of soil into the bottom of the sampler while driving the rods to their final depth. In the event that the probe hole needs to be grouted from the bottom to the surface after groundwater sample collection, the threaded point can be substituted with an expendable point that is deployed by the operator prior to grouting operations. Grout is pumped through the probe rods while they are retracted from the ground. Mill slot samplers typically work better in coarse-grained soils. If used in cohesive soils, the slots can become smeared or plugged, limiting the passage of water into the probe rods.

A sheathed sampling tool consists of a well screen inserted into an outer sheath tipped with an expendable point. The sampling tool is advanced in the closed position to the desired sampling interval. The expendable point is deployed by the operator and the probe rods are retracted the length of the sampling screen. Retracting the probe rods cause the sheath to also retract. This operation exposes the well screen to the saturated formation allowing groundwater to enter the screen. If grouting of the probe hole needs to be conducted, a plug located at the bottom of the well screen is knocked out by the operator, allowing grout to be pumped through the tool string into the probe hole as the rods are being removed from the ground. Sheathed samplers work well in most formations that will produce pumpable water. However, because of the extra steps involved in deploying the well screen, set-up time is greater than that of a mill-slot sampling tool.

6.6 Soil-Gas Sampling

Direct-push machines can be used to advance sampling tools that are specifically designed for the collection of discrete soil-gas samples. Soil gas is drawn from a discreet subsurface sampling point to the surface using a vacuum pump that is mounted on the direct-push unit. Three soil gas sampling tools are typically used; one type uses the probe rods as the conduit for transporting soil gas to the surface and two types use polymer tubing to transport soil gas to the surface. See specific instructions provided by the manufacturer of the samplers that are being used.

The method that uses the probe rods as a conduit consist of a retractable point, a string of probe rods, and a threaded top cap fitted with a barbed tubing connector. The sampling point is advanced to the desired sampling depth (in an unsaturated zone) in the closed position. The probe rods are then retracted to open the soil gas sampling point. The top cap is then threaded to the top of the probe rod and the vacuum pump is connected to the fitting with flexible tubing. Soil gas is then evacuated from the probe rods using the vacuum pump. A sample can be collected by placing the sample container in-line between the probe rods and the vacuum pump. Alternatively, samples can be collected by placing a pre-evacuated sample container (e.g., Summa canister) directly on the probe rod top cap after a predetermined number of probe rod volumes is purged using the vacuum pump.

One of the sampling methods that employ polymer tubing also uses a retractable point as described above. However, polymer tubing is lowered through the probe rods when the desired sampling depth is reached and is attached to the upper end of the retractable point (inside of the probe rods). The polymer tubing that extends beyond the top of the probe rods is attached to the vacuum pump. Purging and sampling is subsequently conducted as described above. Upon completion of sample collection, the probe rods and retractable point are removed from the probe hole, along with the tubing.

In the other soil gas sampling method that uses polymer tubing, probe rods are used to deploy small diameter screens at the selected soil gas sampling interval. Tubing is attached to the top end of the soil gas sampler screen and the probe rods are removed from the ground leaving the sampler and tubing in place. This method usually requires that the annular space of the hole be sealed to prevent the downward migration of gas along the outside of the tubing. The polymer tubing that extends beyond the ground surface is then attached to the vacuum pump. Purging and sampling is subsequently conducted as described above.

6.7 Abandonment of Probe Holes

Before probe holes can be abandoned, regulations from the appropriate governmental agency with regulatory authority in which the soil boring and well abandonment will be performed should be consulted. Each agency may have specific regulations for soil boring and well abandonment, and these regulations can dictate the method and material that will be used to plug the probe holes. However, in most cases, the regulatory authority will require that the probe holes be backfilled with some sort of bentonite clay (granular, chips, or a slurry). Geoprobe Systems® as well as other manufacturers have pumps designed specifically for the grouting of probe holes.

Any soil or groundwater removed from the earth during the sample collection procedures may be considered investigation-derived waste (IDW). It is imperative that IDW handling procedures be addressed prior to conducting any field sampling activities.

6.8 Decontamination

Decontamination requirements will be determined on a site by site basis, and will be dependent on both the subsurface conditions and nature of the investigation. Standard operating procedures will be employed to minimize the degree of possible cross-contamination and IDW production. The following decontamination methods or a combination of the methods are typically used.

The direct-push machine and all appurtenances must be decontaminated prior to arrival on site. All equipment will be decontaminated again upon arrival to the site to remove road dirt only. Moreover, it is the operator’s responsibility to decontaminate all equipment prior to leaving the site.

Decontamination of the direct-push unit and all down-hole equipment will consist of:

- Removal of foreign matter;
- Scrubbing with brushes in TSP/water solution (Alconcox);
- Rinsing in potable water; and
- Final rinse with Distilled/Deionized water.

Once clean, no equipment may touch the ground prior to use. The equipment must be stored on the direct-push machine tool rack, support truck, or on plastic sheeting.

* Note: Geoprobe® soil, groundwater and soil gas sampling equipment/methodology are being continuously improved. To obtain current information regarding Geoprobe® operation or description of sampling equipment go to www.geoprobe.com.

7 Quality Assurance/Quality Control

Prior to initiating field work, the project planning documents (e.g., work plan, sampling and analysis plan, quality assurance project plan, SHASP, *et al*) should be reviewed by field personnel to identify sampling procedure(s) that will most likely provide surface and shallow subsurface soil samples that meet project DQOs.

The program/project manager should identify personnel for the field team who have knowledge, training and experience in the direct-push sample collection methodologies being conducted (typically a trained geologist). The geologist should document all borehole sampling and lithological information in E & E's geotechnical logbook. All project personnel, if necessary, can complete ancillary procedures, e.g., field logbook documentation, equipment decontamination, sample shipment, and waste disposal.

The lead geologist should prepare a detailed equipment checklist before entering the field and verify that sufficient and appropriate equipment and supplies are taken into the field.

Quality assurance/quality control samples (e.g., co-located samples) are collected according to the site quality assurance project plan. Field duplicates are collected from one location and treated as separate samples. Field duplicates are typically collected after the samples have been homogenized. Collocated samples are generally collected from nearby locations and are collected as completely separate samples. Rinsate blanks may be necessary to evaluate the effectiveness of field decontamination procedures (see E & E SOP Env 3.15).

In cases where multiple hand-collected scoop, auger or core samples are required to generate an adequate sample volume, homogenization is important. Field personnel should collect sample aliquots only after mixing has produced soil with textural and color homogeneity.

At sites with known or suspected contamination, samples should be collected moving from least to most contaminated areas.

8 Health and Safety

Prior to entering the field, all field personnel formally acknowledge that they have read and understand the project specific health and safety plan.

Direct-push machinery and tooling are inherently dangerous pieces of heavy equipment which a high "pinch" potential. Care should be taken at all times when handling such equipment, not just during sample collection.

Prior to any subsurface work, verify that underground utilities have been located and marked as described in Section 6.3.1.

9 Special Project Requirements

Project or program-specific requirements that modify this procedure should be entered in this section and included with the project planning documents.

10 References

See E & E SOP Env 3.13 for additional sources of technical information on soil sampling.

END OF SOP

STANDARD OPERATING PROCEDURE

CONTROLLED PUMP TEST

SOP NUMBER: GEO 4.13

REVISION DATE: 5/25/2012 **SCHEDULED REVIEW DATE: 5/25/2017**

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1 Scope and Application

Pump tests and slug tests are performed to calculate aquifer parameters. Slug tests are used to estimate the hydraulic conductivity, and are an appropriate means for groundwater classification and the evaluation of the heterogeneity of the groundwater bearing units. Slug tests are relatively simple field tests that may be conducted in existing wells and do not generate wastewater. The Standard Operating Procedure (SOP) for slug tests is provided in GEO 4.14.

Step drawdown and constant rate pump tests are performed to evaluate the response and sustainability of the aquifer to pumping, and are typically needed for the evaluation, design, and optimization of groundwater pumping systems. Aquifer parameters are calculated from both the pumping and recovery phases of the step drawdown test and the constant rate pump test. Step drawdown tests are performed initially to estimate the well yield and to select the pumping rate for the subsequent constant rate pump test. The pumping phase of the step drawdown test is used to estimate the well yield, to select the pumping rate for the subsequent constant rate pump test, and to estimate well loses. The recovery phase is used to calculate the transmissivity of the pumped interval. The constant rate pump test is used to calculate the transmissivity and storativity of the pumped interval, and when the pump test is sustained, it is used to estimate the sustainability, the delayed yield in unconfined aquifers, the leakage from confining intervals, changes in confining conditions, and the influences of heterogeneity, boundary conditions, atmospheric influences, tides in coastal areas, earth tides in deep wells, and other interferences. The pump test recovery provides redundant measurements of the transmissivity, and is less prone to error due to fluctuations in the pumping rate. Pump tests typically include the installation of extraction and observation wells, baseline monitoring, groundwater pumping and wastewater management, and monitoring during pumping and recovery phases.

This SOP describes design considerations needed to perform pumping tests, including the identification of pumping rates and the specification of the groundwater pump, the specification of the extraction and observation wells, the evaluation of baseline conditions, and the planning of step drawdown and constant rate pump tests. The SOP summarizes potential problems and prescribes procedures for the preparation, baseline evaluation, set up, and performance of the step drawdown and constant rate pump tests. Wastewater management considerations are described, and potential sampling requirements are discussed. The SOP provides a preliminary equipment list and references example data acquisition forms. Data management and quality assurance are discussed, and external references are identified for calculating aquifer parameters.

2 Definitions and Acronyms

SOP Standard Operating Procedure

3 Procedure Summary

3.1 Pumping Rate

The pumping rate should be estimated from known or estimated site parameters in order to specify the extraction well and estimate the volume of water to be extracted. The pumping rate should stress the aquifer without depleting it, should sufficiently drawdown water levels in the observation wells, should be of comparable scale to anticipated single-well pumping rates of the pumping system, and should be constrained by the management of the wastewater. Although the Theis solution is developed for confined aquifers, it can be used to estimate the drawdown in the extraction and observation wells.

3.2 Pump Selection

The groundwater pump should be selected for the anticipated pumping rates and extraction well diameter. The groundwater pump should reliably deliver a constant flow rate. Pneumatic pumps are not allowed. The pump curve should be relatively flat in the operational range, such that the pumping rate has minimal decline with increasing head. The flow rate shall be controlled using a variable flow controller and one or two ball or gate valves in series on the discharge line. The pump shall be powered by a non-interruptible power supply. The power supply should be sufficient for the pump and have minimal fluctuation in the voltage. When a generator is used, the generator should have sufficient fuel capacity and/or safe refill capability during its operations. Appropriate health and safety precautions should be followed when refueling generators.

3.3 Extraction Well

Ideally, the extraction well should fully penetrate and be screened across the saturated interval of the aquifer. Partially penetrating wells can be used when pumping from existing wells or when the thickness of the formation makes fully penetrating wells impractical. Because the flow of water to partially penetrating wells is 3-dimensional, specialized methods are needed to calculate the aquifer parameters. In order to neglect 3-dimensional flow, the observation wells should be 1.5 times the thickness of the aquifer from the extraction well, when the horizontal and vertical hydraulic conductivity are equivalent. For thick aquifers, partially penetrating wells should penetrate across the anticipated interval for the anticipated pumping system and should penetrate to a minimum of 10% of the aquifer thickness.

The extraction well diameter should be sized based on the anticipated pumping rate, drawdown, and radius of influence. Although 2-inch diameter wells may be used, they restrict the pump selection and may have excessive drawdown and well losses. Pump tests are typically performed in 4- and 6-inch diameter wells, with 6-inch diameter wells being used for larger pumping rates (e.g., greater than 30 gallons per minute).

The well screen should fully penetrate the confined or saturated interval of the aquifer or exclusively across the test interval in layered intervals. The screen and filter pack should be designed to minimize well losses, but to inhibit the infiltration of fine particles into the well.

3.4 Observation Wells

Ideally, three observation wells should be installed in the same formation as the extraction well and in opposing directions at varying radial distances from the extraction well. When prohibited, a minimum of one observation well is needed to evaluate storativity, and two observation wells are needed to discount well losses in the extraction well. The radial distance from the extraction well is dependent on the thickness of the aquifer, the pumping rate, and the transmissivity. Recommended observation well spacing from the extraction well may be at distances of one, two, and four times the aquifer thickness; however, this spacing may not be practical or warranted. The Theis equation should be used to space the observation wells and to assure that the drawdown in the observation well is measurable and primarily influenced by pumping. The observation wells should be installed sufficiently below the calculated pumping-induced water level. The pumping well and these observation wells should be gauged using a transducer, and the results will be used to calculate the aquifer parameters.

Additional wells should be evaluated during a pump test. Existing site wells may be used to estimate the zone of influence and to assess water level changes outside of the zone of influence. In layered stratigraphy, additional observation wells may be placed in alternate intervals to evaluate the impact of pumping. These additional wells may be gauged using a transducer or a water level meter and will not be used to calculate aquifer parameters.

3.5 Baseline Conditions

The step drawdown test and constant rate pump test should be initiated with static groundwater levels. Irrigation systems should be turned off several days prior to initiating the pump tests. If existing groundwater pumping systems operate, they should be shut down and the water table allowed to recover prior to conducting the pumping tests. The groundwater pumping system should be shut down for at least a week, and for a month if allowable. The aquifer recovery from the pumping system may be monitored to assess when static water levels are achieved.

When allowable, the baseline conditions should be gauged with a transducer for one week prior to initiating the pump tests. Data should be recorded at a five minute interval or at event intervals. The data should be evaluated to assess water level changes due to diurnal barometric changes, precipitation, irrigation systems, other pumping systems, tidal influences in coastal areas, and earth tides in deep wells.

3.6 Step Drawdown Test

The step drawdown test is primarily performed to select the pumping rate for the constant rate pump test, but may also be used to calculate the transmissivity and well loss coefficient, and to assess the sustainable pumping rate. The step drawdown test can be omitted when the planned pumping rate is much lower than the well yield in a highly transmissive aquifer. The step drawdown test is performed by progressively increasing the pumping rate at approximate one-hour intervals. Ideally, at least three pumping rates should be below the planned constant pumping rate, and one pumping rate should be above the planned constant pumping rate.

The drawdown in the extraction well should be plotted with logarithmic time on the x-axis. The stabilized drawdown data from each step interval should plot as parallel lines for sustainable pumping rates. The sustainable pumping rate is exceeded when the steeper drawdown line is not parallel. The specific capacity (flow divided by drawdown) decreases with increased flow because of well losses. The well loss coefficient can be estimated from the parallel lines. The pumping rate should be selected so that the aquifer is stressed, the pumping rate is sustainable, the pump and transducer remain fully submerged for the duration of the constant rate pump test, and the wastewater can be appropriately managed during the pumping tests.

The pumping phase of the step drawdown test is typically performed for four to eight hours. The water levels in the extraction well and observation wells are gauged during the pumping phase. The transducer logging interval may be preset to a constant interval of one to five seconds, or may be reset to a logarithmic interval prior to increasing the pumping rate each time. The flow rate should be measured using a flow gauge, and in many cases, should be calculated by measuring the time to fill a 5-gallon bucket of water. Because the flow rate changes with small differences in head, the discharge elevation of the hose should be kept as uniform as possible during flow measurements. The extraction well should be monitored during the test to assure that the water level does not decline below the transducer (the transducer should be installed above the pump). When a generator is used, the generator should be monitored and refilled during the pumping phase to ensure that constant pumping is maintained.

The recovery phase of the step drawdown test starts when the pump is shutdown. The transducers should record at a logarithmic interval starting at or before the shutdown of the pump. The recovery phase should extend for at least as long as the pumping phase and until the water levels recover by a minimum of 90%. Ideally, the constant rate pump test is performed after the water levels recover by 99%. The constant rate pump test is normally performed on the day following the step drawdown test. After securing the site, the recovery phase of the step drawdown test does not need to be actively monitored.

3.7 Constant Rate Pump Test

The constant rate pump test is performed following the recovery of the step drawdown test. After downloading data from the transducers, the batteries are preferably replaced and the transducers are programmed to record at a logarithmic interval. The pumping controls are positioned to pump at the pre-selected constant pumping rate. Once the pump is started, the pumping rate is not adjusted. Constant rate pump tests are normally performed for a minimum of 6 to 12 hours for confined aquifers, and may be performed for 24 to 72 hours for unconfined aquifers. The pump rate is measured at discrete intervals during the pump test to assess the constant flow rate and the declining flow with increasing head. The flow rate should be measured using a flow gauge, and in many cases, should be calculated by measuring the time to fill a 5-gallon bucket of water. Because the flow rate changes with small differences in head, the discharge elevation of the hose should be kept as uniform as possible during flow measurements. When a generator is used, the generator should be monitored and refilled during the pumping phase to ensure that constant pumping is maintained.

Data are downloaded from the transducers during the pump test. The response to pumping can be followed by plotting drawdown verses time, drawdown verses log time, and log drawdown verses log time. The drawdown verse time data can be used to assess the operation of the pump test, changes in flow due to changing head, changes in water level during flow measurements, and any deviations. The drawdown verses log time data should plot as a straight line, and can be used to predict when water levels will decline beneath a critical level. The log drawdown verses log time curve can be used to assess when delayed yield is encountered in an unconfined aquifer due to dewatering. Data should be downloaded from the transducers before concluding the pumping phase.

The transducers are reprogrammed to record at a logarithmic interval during the recovery phase. The recovery phase should be monitored with transducers for a minimum duration equal to the pumping phase duration. After securing the site, the recovery phase of the constant rate pump test does not need to be actively monitored. The data should be downloaded from the transducers at the conclusion of the recovery phase.

3.8 Wastewater Management

Pump tests are normally constrained by the volume of wastewater. Wastewater may be collected in frac tanks or treated and discharged under authorization by the regulatory authority. In cases where the wastewater is treated and discharged to land (e.g., by an irrigation system or to a storm water conveyance), the discharge shall be at a sufficient distance from the extraction and observations wells to not influence the pump test.

3.9 Sample Collection

If the pump test is conducted in a well that contains or could potentially draw contaminated groundwater, wastewater samples must be collected for waste characterization or discharge compliance, and water samples may be collected to assess contaminant mass removal from the aquifer or treatment system effectiveness. The sample frequency and analytical parameters are dependent on the site contamination and the requirements of the disposal facility or the regulatory authority for wastewater disposal.

4 Cautions

The following factors may adversely impact the pump tests:

- Power disruptions and fluctuations in the pumping rate;
- Non-operable equipment, including flow gauges, pressure transducers, and water level indicators;
- Insufficient wastewater storage volume (should have sufficient volume to allow for compliance monitoring and downtime in the treatment and discharge system);
- Improper installation of pumping and/or observation wells (e.g., site monitoring wells or observation wells installed in lower permeability soil);
- Heterogeneity of the water-bearing formation;
- Incomplete well development;
- Precipitation and atmospheric conditions;
- Impact of sprinkler systems;
- Impact of pumping systems, including offsite wells and recovery from onsite pumping systems;
- Compression of the aquifer due to trains, heavy traffic, etc.;
- Tides in coastal zones and earth tides in deep wells; and
- Discharge to or recharge from surface water bodies.

5 Equipment and Supplies

The equipment listed in Table 1 is needed to perform pump tests. All of the equipment should be decontaminated and tested prior to commencing field activities at hazardous waste sites (sites with potential water and soil contamination) or nonhazardous study areas (e.g., water supply well and/or other drinking water wells).

Table 1 Equipment Checklist

Check	Equipment
______	Submersible pump and associated discharge systems, including a sampling hose, flow meter, and discharge regulator
______	Discharge tubing, flow control valves, hose barbs and clamps, heat gun
______	Appropriate equipment for handling site-specific discharge water (e.g., frac tanks, portable water treatment system, etc.)
______	Generator, appropriately sanctioned fuel container, and funnel
______	Water pressure transducers of appropriate pressure range for both pumping wells and observation wells
______	Appropriate length of transducer cable or extension cable to reach each monitored well with its full expected drawdown
______	Transducer data acquisition equipment and software
______	Batteries for transducers
______	Laptop computer with MS Excel and data acquisition software for transducers
______	Water level indicator (subdivided into 100ths of feet) and weighted tapes
______	Measuring wheel
______	Tape measure
______	5-gallon bucket or other appropriate container for flow measurement
______	Watch or stopwatch with second hand
______	Waterproof ink pen and logbook
______	Fasteners for pump, transducers, and discharge tubing (e.g., cable-holders, zip-ties, etc.)
______	Toolbox with electrical and mechanical tools, including screw drivers, socket wrenches, and electrical tape.
______	Appropriate health and safety equipment
______	Appropriate sampling equipment (e.g., sample containers, preservatives, labels, chains-of-custody, etc.)
______	Appropriate references and calculator
______	Identify nearby meteorological station or provide rain gauge and barometer.

6 Procedures

6.1 Preparation

- Review the site work plan, and become familiar with the geology and groundwater bearing units; the pump test and other potential observation well logs (including depth to water, screen interval, and anticipated drawdown); property access; the presence and shutdown of pumping and sprinkler systems; and the weather forecast.
- Ensure the proper operation of all field equipment, including downloading data acquisition software for the transducers to the laptop computer. Be familiar with the software and the operation of the transducers.
- Assemble a sufficient number of field forms and other relevant documents to complete the field assignment. Example data acquisition sheets are available on E & E's intranet site. Identify and bring copies of boring logs for pump test wells and additional potential monitoring wells at the site.
- Properly develop the extraction well prior to testing and allow sufficient recovery time.
- Provide an orifice, weir, flow meter, container, or other type of water measuring device to accurately measure and monitor the discharge from the pumping well. When appropriate for small pumping rates, use a bucket and stopwatch to periodically measure and verify the pumping rate. The bucket should be marked with several fill volumes. Either before or after the pump test, the fill volumes should be calculated from the full weight of the bucket (tare weight + water weight) for each demarcation and the empty weight of the bucket (tare weight).
- Supply sufficient discharge hose from the groundwater pump to extend to the storage tank or to extend beyond the zone of influence of the pump test.
- Provide redundant ball or gate valves on the discharge line to control the pumping rate, and allow fine adjustments. Provide appropriate hose barbs and clamps and, when warranted, a heat gun to install the tubing on the hose barb.
- Identify or provide a sampling port for the discharge. If samples are collected from the discharge, minimize changes to the head differential between the discharge and water table when collecting samples.
- Determine if treatment, special handling, or a discharge authorization is required to discharge extracted groundwater. When warranted, use a temporary treatment system for the treatment of extracted groundwater. Extracted water should be discharged beyond the zone of the influence or should be held in storage pending the recovery of the constant rate pumping test. Ensure that sufficient storage volume is available to allow periodic downtime for the treatment system and, when warranted, confirmation sampling. Ensure sufficient storage volume for the anticipated pumping rate and duration of the pump tests.

6.2 Baseline Conditions

- Any existing groundwater pumping system should be shutdown at least one week, and preferably one month, prior to the conducting the pump tests. Use transducer or water level indicator to monitor the recovery of the water table in nearby monitoring wells.

- If allowable, measure the water levels in an observation well adjacent to the extraction well for one week prior to the pump tests. Synchronize transducer with laptop computer. Record data at a five-minute interval or an event interval.
- Identify nearby weather station and monitor precipitation and barometric pressure. Monitor weather forecast for pump tests. Avoid conducting pump tests during precipitation events when possible.

6.3 Set-Up Activities

- Graphic depicting pump test in a confined aquifer with fully penetrating wells are available in the references cited in Section 10.
- Set up should ideally be performed on the day preceding the step drawdown test to allow sufficient recovery time from installation and preliminary testing.
- Use water level indicator to measure the static water level and depths of the extraction well and observation wells.
- Install groundwater pump, discharge tube, electrical cable, and retrieval cord in extraction well. Pump should have at minimum 1 foot of clearance above the bottom of the well. Securely fasten pump to ensure that the pump does not slip during the pump test.
- Install transducers in extraction and observation wells. The transducers should be set sufficiently below anticipated drawdown levels. The transducer in the extraction well should be placed above the pump. Securely fasten transducers to ensure that transducers do not slip and the elevation does not change due to surface actions (e.g., tripping, snagging, etc.). Connect transducers to data acquisition device. Measure the head above the transducers in feet. Test transducers by raising the transducer by approximately 1 foot and confirm the response of the transducer.
- Install sample port and flow control valves on discharge line as appropriate. Securely fasten discharge hose to storage tank or discharge location. Ensure that discharge elevation is constant, and that the hose discharges above the water level in the storage tank or discharge body.
- When used, install and fuel generator. Connect pump to power supply.
- Start pump to assess its operability for a short duration. Test impact of flow control devices on pumping rate. Identify positions of flow control devices for the step drawdown test. Monitor and allow recovery of the water table to static conditions following testing of the pump.
- When warranted, manifold frac tanks and set up treatment and discharge system.
- Measure radial distances from extraction well to observation wells using a measuring wheel or tape measure. Measure radial distances to additional monitoring wells at site that can be used as observation wells. Measure radial distance from extraction well to any nearby surface water body, extraction well, or other potential influence using a measuring wheel or aerial map. Ensure that site coordinates have been recorded for any new wells, and measure distances to nearby site features (e.g., building corner) when practical.
- Record the well name, location, diameter, depth or height to top-of-casing, depth from top-of-casing to the bottom of the well, and depth from top-of-casing to the initial water

level for the extraction well, the pump test observation wells, and all additional monitoring wells that are gauged during the pump tests. Identify well and boring logs for all wells.

6.4 Step Drawdown Test

- Confirm that water levels have returned to static conditions following set up and testing of the pump and transducers.
- Download and archive previous data from transducers, then delete data from transducers. Change batteries in transducers, as appropriate, to ensure that transducers have sufficient storage space for the duration of the step drawdown test.
- Program transducers for the step drawdown test. Synchronize transducers and personnel watches with laptop computer. Transducer data are normally collected at a logarithmic interval for any change in pumping rate, or at increasing intervals with increased elapsed time since the change in pumping rate. The minimum recording interval is 0.5 seconds at the change of pumping rate and the maximum recording interval is 5 minutes after the change in water level has stabilized. Table 2 provides recommended recording intervals for each change in flow rate. For practical reasons, data are sometimes collected at a linear interval during the pumping phase of the step drawdown test. When linear data are collected, ensure that excessive recording does not exceed the storage space of the transducer, overwrite previous data, or deplete the battery.

Table 2 Potential Transducer Recording Intervals

Elapsed Time Since Change in Pumping Rate	Intervals Between Measurements
0 – 5	0.5 Seconds
5 – 20 Seconds	1 Seconds
20 – 120 Seconds	5 Seconds
2 – 10 Minutes	30 Seconds
10 – 100 Minutes	2 Minutes
>100 Minutes	5 Minutes

- Fuel and start generator.
- Set pump control devices to pre-determined initial positions for the initial pumping rate.
- Initiate transducers and then start groundwater pump.
- Record the pumping rate frequently during first 10 minutes of each step and at 10 to 15 minute intervals thereafter. Measure the flow rate initially after changes in flow and at 15 minute intervals by recording the time required to fill the 5-gallon bucket to appropriate demarcations, when appropriate.
- Monitor the response to pumping using transducers, and when necessary, using a water level indicator. Exercise care when using a water level indicator in a well with a transducer to avoid snagging the transducer. Monitor the response to pumping in

additional observation wells as warranted (should be emphasized in constant rate pump test).

- Download data and reprogram the transducers, as necessary, prior to changing the pumping rate.
- Increase the pumping rate in accordance with the work plan (approximate one-hour intervals). Record and mark the positions of the flow control devices for each pumping rate.
- Monitor water level data to confirm that transducers remain submerged during the test.
- Periodically download data from transducers and plot the drawdown verses the logarithmic elapsed time since the start of the test. Examine whether the data for each pumping rate plot as parallel lines, and assess whether the rate of drawdown increases, which indicates excessive pumping.
- Download data and reprogram the transducers for the recovery phase before shutting down the pump. Transducer data are normally collected at a logarithmic interval for any change in pumping rate, or at increasing intervals with increased elapsed time since the change in pumping rate. The minimum recording interval is 0.5 seconds at the change of pumping rate and the maximum recording interval is 5 minutes after the change in water levels has stabilized. Table 1 provides potential recording intervals for each change in flow rate.
- Initiate the transducers to monitor the recovery phase and then shut down the pump.
- Secure the site and allow the water table to recover overnight. The recovery phase of the step drawdown test should extend for at least as long as the pumping phase.

6.5 Constant Rate Pump Test

- Confirm that water levels have returned to static conditions following the step drawdown test. Calculate the percent recovery of the drawdown in the extraction well. The pump test should not be initiated until the water level has recovered by 90%, and ideally, not until the water level has recovered by 99%.
- Select pumping rate for the constant rate pumping test. Set pump control devices to appropriate positions for the constant rate pump test.
- Download and archive previous data from transducers, then delete data from transducers. Change batteries in transducers, as appropriate, to ensure that transducers have sufficient storage space for the duration of the constant rate pump test.
- Program transducers for the constant rate pump test. Synchronize transducers and personnel watches with laptop computer. Transducer data are normally collected at a logarithmic interval during the pumping phase and recovery phase of the constant rate pump test, or at increasing intervals with increased elapsed time since the change in pumping rate. The minimum recording interval is 0.5 seconds at the change of pumping rate and the maximum recording interval is 5 minutes after the change in water level has stabilized. Table 1 provides potential recording intervals for each change in flow rate.
- Fuel and start generator.
- Initiate transducers and then start groundwater pump.

- Record the pumping rate frequently during first 10 minutes, then at 10 to 15 minute intervals for the first 2 hours, and then at 30 to 60 minute intervals thereafter. Measure the flow rate initially, then at 15 minute intervals for the first 2 hours, then at 30 to 60 minutes intervals thereafter by recording the time required to fill the 5-gallon bucket to an appropriate demarcation, when appropriate.
- Monitor the response to pumping using transducers, and when necessary, using a water level indicator. Exercise care when using a water level indicator in a well with a transducer to avoid snagging the transducer.
- Monitor the response to pumping in additional observation wells using a water level indicator. This is performed to assess the radius of influence in the pumped interval, pumping influences in other intervals, and influences other than pumping.
- Monitor water level data to confirm that transducers remain submerged during the test. Assess when water levels decrease below the confining layer in each well.
- Periodically download data from transducers and plot the drawdown verses elapsed time, the drawdown verses the logarithmic elapsed time, and the logarithmic drawdown verses the logarithmic elapsed time. Examine data for changes in flow due to increased head and flow measurements, changes in transmissivity due to heterogeneity, and delayed yield in unconfined aquifers.
- Monitor the fuel supply in the generator. Ensure that the power supply is not interrupted. Refuel the generator as necessary, following appropriate health and safety requirements.
- Monitor extracted groundwater, and sample, treat, and discharge as appropriate. Assess duration constraint for the pump test due to wastewater management, and minimize the effects as necessary.
- Perform the pumping phase of the pump test pursuant to the work plan and to appropriate end-points (e.g., appearance of delayed yield) within the constraints of labor; wastewater storage, treatment, and disposal; and property access.
- Download and archive data from transducers, change batteries as appropriate, and reprogram the transducers for the recovery phase before shutting down the pump. Transducer data are normally collected at a logarithmic interval for any change in pumping rate, or at increasing intervals with increased elapsed time since the change in pumping rate. The minimum recording interval is 0.5 seconds at the change of pumping rate, and the maximum recording interval is 5 minutes after the change in water level has stabilized. Table 1 provides potential recording intervals for each change in flow rate.
- Initiate the transducers to monitor the recovery phase and then shut down the pump.
- Secure the site and allow the water table to recover.

6.6 Close-Out Activities

- Disconnect the power for the groundwater pump, and return generator to its owner.
- Groundwater pump and transducers must remain in the wells until the completion of the recovery phase.

- Perform waste characterization or treatment, compliance monitoring, and discharge operations for the extracted groundwater. The discharge of the groundwater should be conducted in a manner that does not interfere with the recovery of the pump test.
- Confirm that water levels have returned to static conditions following the constant rate pump test. Calculate the percent recovery of the drawdown in the extraction well. The recovery test should continue for the same duration as the pumping phase and until the drawdown in the extraction well recovers by 90%.
- Download and archive data from the transducers.
- Retrieve transducers from wells, decontaminate, and place in transport containers.
- Retrieve groundwater pump from well, decontaminate, and place in transport container.
- Return equipment to vendors or equipment manager, as appropriate.
- Appropriately dispose of expendable materials.
- Conclude wastewater management activities. Perform appropriate waste characterization, clean equipment, and arrange for the return of the equipment to the equipment owner.

6.7 Calculations/Data Interpretation

The aquifer and well loss parameters are calculated using established methodologies described in hydrogeology textbooks, peer-review literature, and proprietary software. The following textbooks provide a review on analysis methods for confined, leaky, and unconfined aquifers.

- *Groundwater Hydrology* (Bouwer 1978).
- *Groundwater* (Freeze and Cherry 1979).
- *Groundwater and Wells* (Driscoll 1986).

Many of the analytical procedures use graphical methods to calculate aquifer parameters from the drawdown and elapsed time, along with flow, well, and formation parameters. The drawdown and elapsed time data from the transducers are normally adjusted to the start of the test and in some cases filtered to reduce the size of the data. The drawdown verses elapsed time data are reconciled for all wells, and reviewed. Background data, including baseline data, water level data from additional observation wells during the pumping phase, meteorological data, and site observations, are reviewed to assess non-pumping impacts to the pump test data. The drawdown verses elapsed time data are then used to calculate the aquifer parameters. Pumping rates should be adjusted from nominal to actual volumes as described in Section 7, when warranted.

Calculations may be performed using spreadsheets and graphical methods. The application of proprietary software is recommended for the calculation of groundwater parameters.

7 Quality Assurance/Quality Control

All gauges, transducers, flow meters, etc., used in conducting pump tests shall be calibrated before use at the site. Copies of the documentation of instrumentation calibration shall be obtained and filed with the test data records. The calibration records shall consist of measurements taken in the warehouse prior to field mobilization and, if necessary, any on-site zero adjustment or calibration performed.

When feasible, the flow meter should be verified on site by filling a container (e.g., a 5-gallon bucket) with demarcated volumes and measuring the elapsed time with a stopwatch. The volume of the demarcations in the container should be calculated by measuring the weight of the container with water (tare weight + water weight), and the weight of the empty container (tare weight). The pumping rate calculations should be adjusted from nominal to actual flow rates based on the demarcated volumes used for flow measurements, when warranted.

Data are collected to assess the non-pumping impacts to the water levels. These include baseline water levels, water level measurements in surrounding monitoring wells during pumping phases, precipitation and barometric data from a nearby weather station when warranted, and observations during test activities. These data may be used to understand and explain non-pumping influences in the data, and to evaluate their impact to the calculated parameters.

Calculations will be performed using established methodologies described in appropriate hydrogeology textbooks, peer-reviewed papers, and proprietary software.

8 Health and Safety

Depending on the site-specific contaminants, various protective programs must be implemented prior to pumping or taking water level measurements at any well. The site Health and Safety Plan shall be reviewed with specific emphasis placed on the protection program planned for well sampling tasks and equipment operation. Standard safe operating practices, such as minimizing contact with potential contaminants in both the vapor phase and liquid matrix through the use of respirators and disposable clothing, shall be followed.

Depending on the type of contaminant expected or determined from previous sampling efforts, appropriate safe work practices shall be used.

Particulate or Metal Contaminants

- Avoid skin contact with, and incidental ingestion of, purge water.
- Use long-sleeved protective gloves and splash protection.

Volatile Organic Contaminants

- Avoid breathing constituents venting from the well.
- Pre-survey the well headspace with photoionization and/or flame ionization detectors prior to taking water level measurements or at the opening of the well cap. If headspace readings indicate a decrease in organic vapors, leave the well open for two to five minutes prior to beginning purging.
- If monitoring results indicate persistent organic constituents, sampling activities may be conducted in Level C protection. At a minimum, skin protection will be afforded by disposable protective clothing.

Exercise appropriate care when refueling generators during operation. Fuel should be poured through a funnel, and caution should be exercised to ensure that fuel does not contact a spark plug or other ignition source. Fueling active equipment should be performed by a minimum of two people, with one serving as an observer.

9 Special Project Requirements

See the Health and Safety Plan, quality assurance project plan, and/or site-specific sampling plan for special project requirements.

10 References

Bouwer, H. 1978. *Groundwater Hydrology*. McGraw-Hill, Inc., New York, New York, p. 480.

Driscoll, F. G. 1986. *Groundwater and Wells*, Second Edition. Johnson Screens, St. Paul, Minnesota, p. 1089.

Freeze, A. R., and J. A. Cherry. 1979. *Groundwater*. Prentice-Hall, Inc., Englewood Cliffs, New Jersey, p. 604.

END OF SOP

ecology and environment, inc.

STANDARD OPERATING PROCEDURE

SLUG TEST

SOP NUMBER: GEO 4.14

REVISION DATE: 11/1/2012 **SCHEDULED REVIEW DATE:** 11/1/2017

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APPENDIX A SLUG TEST FIELD FORMS 16

1 Scope and Application

A slug test involves the instantaneous injection or withdrawal of a mass of water or object (slug), displacing a known volume of water into or from a well and measuring the artificial fluctuation of the groundwater level.

Slug tests may be used to determine the horizontal hydraulic conductivity of distinct geologic horizons under *in situ* conditions. The hydraulic conductivity (K) is an important hydraulic parameter for modeling the solute transport and flow of groundwater in an aquifer and for remediation of identified contaminated groundwater or soil.

The primary advantages of using slug tests to estimate hydraulic conductivities are:

- Estimates are made *in situ* without any disturbance of water-bearing material, thereby avoiding errors incurred in laboratory testing of potentially disturbed aquifer materials;
- Tests can be performed quickly at relatively low costs because pumping, observation wells, heavy field equipment, and disposal of large quantities of groundwater are not required;
- The hydraulic conductivity of small, discrete portions of an aquifer can be estimated (e.g., sand layers in a predominantly clay horizon); and
- The equipment needed and the decontamination are minimal in comparison to other aquifer test techniques. A slug test is the most inexpensive aquifer-testing technique.

This SOP describes design considerations needed to perform pumping tests, including the identification of pumping rates and the specification of the groundwater pump, the specification of the extraction and observation wells, the evaluation of baseline conditions, and the planning of step drawdown and constant rate pump tests. The SOP summarizes potential problems and prescribes procedures for the preparation, baseline evaluation, set up, and performance of the step drawdown and constant rate pump tests. Wastewater management considerations are described, and potential sampling requirements are discussed. The SOP provides a preliminary equipment list and references example data acquisition forms. Data management and quality assurance are discussed, and external references are identified for calculating aquifer parameters.

2 Definitions and Acronyms

Hydraulic Conductivity:	The rate of groundwater flow through a cross section with a specific change in groundwater elevation over a specific distance.
In situ:	A phrase in the context of slug testing means “In its natural position within the subsurface”.

3 Procedure Summary

Slug tests are performed by installing a pressure transducer in a particular well to measure changes in water levels after instantaneously injecting (falling head test) or withdrawing (rising head test) a known volume of clean water or solid slug. The rise or fall in head resulting from the slug test is mechanically recorded by the pressure transducer and datalogger until the well recovers to a certain percentage if it’s original state. The data is then downloaded into appropriate software for processing. The result is the calculated hydraulic conductivity of the well in the immediate vicinity of the screened portion of the well. The pressure transducer and solid slug are then decontaminated before used again in another well as per E & E SOP ENV 3.15.

4 Cautions

Limitations of slug testing include:

- Only the hydraulic conductivity of the area immediately surrounding the well is estimated, which may not be representative of the average hydraulic conductivity of a study area;
- The storage coefficient of the test aquifer cannot be determined by this method; and
- There are no specific sizes of slugs provided for a given monitoring well or aquifer (e.g., for a thick, thin, high-yield, low-yield water table or artesian aquifer). Appropriate slugs need to be designed and constructed for a designated well.

5 Equipment and Supplies

The following equipment is needed to perform slug tests. All of the equipment should be decontaminated and tested prior to commencing field activities at hazardous waste sites (sites with potential water and soil contamination) or nonhazardous study areas (e.g., water supply well and/or other drinking water wells).

Equipment List

- Electronic water level indicator.
- Vented pressure transducer and datalogger of appropriate pressure (e.g. one pound per square inch (psi) of pressure equals 2.31 feet of water pressure, so a 10 psi probe is typically appropriate for slug tests).
- Site-specifically designed stainless steel or sand-filled polyvinyl chloride (PVC) slug of a known volume with nylon rope, or a clean bailer of known volume. To calculate volume of the slug:

  $$V = \pi r^2 L$$

  where

  r = Radius of the slug

  L = Length of the slug.
- Pneumatic slug system (if required).
- Slug test field forms, logbook, and calculator.
- Portable computer with associated pressure transducer program installed.
- Health and safety equipment (if required).
- Deionized (DI) water or other decontamination equipment.

6 Procedures

1. Review site's operation plans, including the work plan, health and safety plan, and information on each well to be tested (e.g., well accessibility, well diameter, location, total depth, and water level if possible).
2. Rent and assemble appropriate field equipment, as well as coordinate schedules with office and field personnel.
3. Review the operators manual and computer program provided with the pressure transducer.
4. Check out and ensure the proper operation of all field equipment. Test the pressure transducer using a container of water (e.g., sink or bucket of water). It is recommended to bring additional transducers in case of malfunctions.
5. Assemble a sufficient number of field forms (see Appendix A) to complete the field assignment.

6.1 Field Procedures

6.1.1 Automatic Data Collection

The following general procedures may be used to collect and report slug test data when using a datalogger. These procedures may be modified to reflect site-specific conditions:

1. Prior to starting the test, make initial water level measurements on monitoring wells in an upgradient to downgradient sequence, if possible. Record all preliminary information on slug test data form (see Appendix A). Determine the static water level in the well by measuring the depth to water (see E & E SOP GEO 4.15).
2. Calculate the expected initial displacement for a given well:
3. $H_o = V_{slug} / \pi r^2_{casing}$

   where

   V_{slug} = Calculated volume of the slug

   r^2 casing = Radius of the well casing.
4. Decontaminate the transducer and cable with appropriate decontamination solutions prior to testing the well (see E & E SOP ENV 3.15).
5. To avoid or minimize cross-contamination, test wells from least contaminated to most contaminated, if possible.
6. Cover sharp edges of the well casing with duct tape to protect the transducer cables.
7. The external diameter of the slug should be at least 1 inch smaller than the internal diameter of the well casing, thus allowing access for the transducer cable alongside of the slug. Install the transducer and cable in the well to a depth below the target drawdown estimated for the test, but at least 0.5 to 1.0 foot from the bottom of the well. Make sure that this depth of submergence is within the design range stamped on the transducer. Temporarily tape the transducer cable to the well to keep the transducer at a constant depth. Do not let the transducer touch the bottom of the well because sediment may plug the sensor ports and cause the transducer to malfunction.

8. Connect the transducer cable to a computer and program the pressure transducer to collect data on a logarithmic time scale.
9. When the well equilibrates after inserting the transducer, set the reference level to zero on the recording device.
10. Two types of slug tests can be performed: Rising Head and Falling Head.

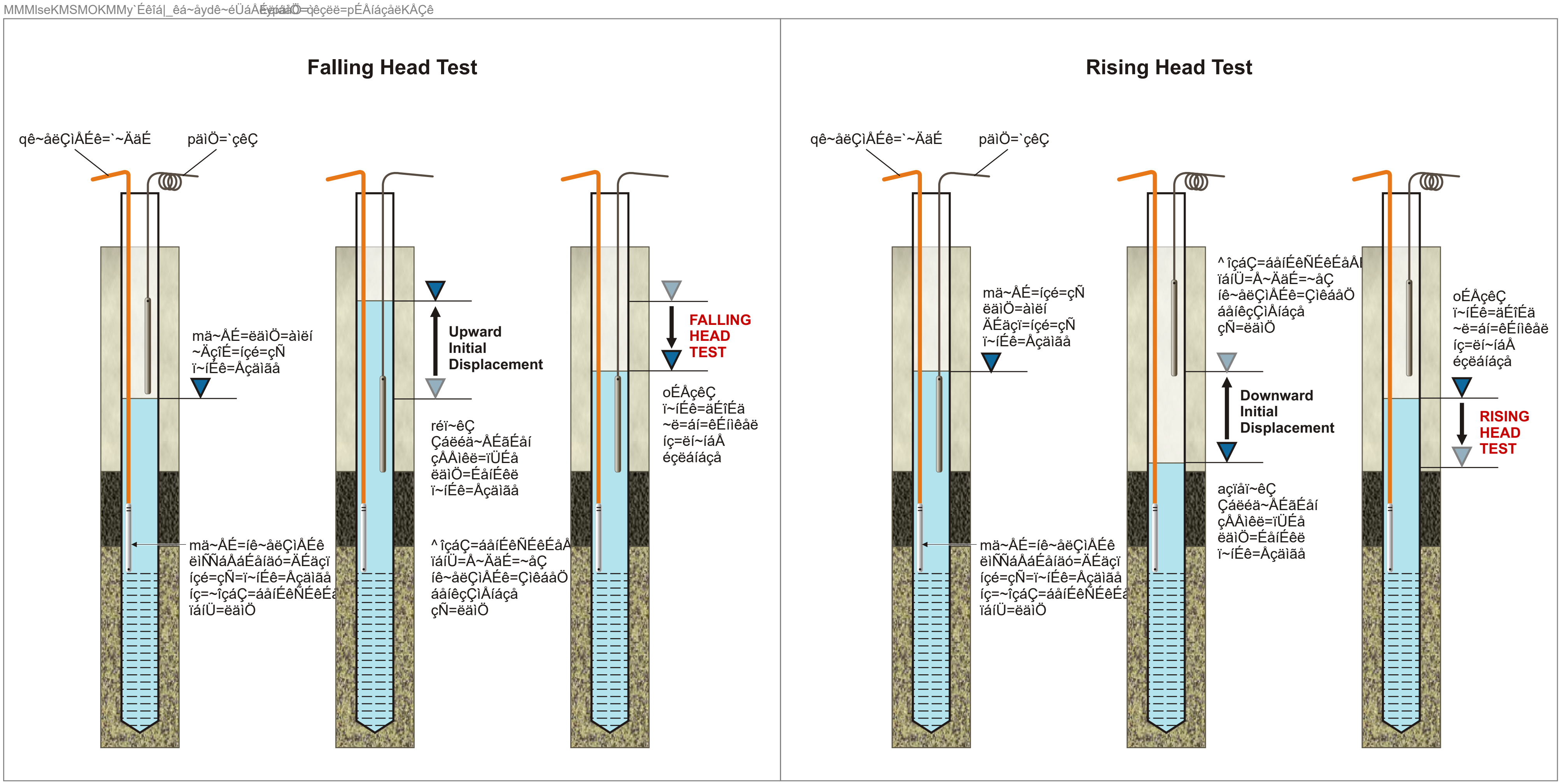
    A falling-head test is performed by adding a slug of water or solid slug of known volume to the well and recording the falling water level as the well returns to static condition (see Figure 1). If using a solid slug, place the bottom of the slug just above the top of the water column and measure the length of the slug plus 1 foot on the cord from the top of the well casing. If using a water slug, use at least 1 to 5 gallons of clean water, but before introducing the water, calculate the volume of water that would fill the unsaturated portion of the casing to make sure the water does not spill out the top of the casing due to lack of capacity. Use a wide mouth funnel to facilitate the water injection. Where large volumes (10's of gallons) are needed (large diameter wells), 30 or 55 gallons drums can be used if modified to release water quickly and directly into the well casing.

    A rising-head test is performed by removing a solid slug or water slug of known volume from the well and recording the rising water level as the well returns to static condition (see Figure 2). Place the top of the solid slug or bailer just below the top of the water column and measure the removal distance on the cord (length of the slug plus at least 1 foot).

    If the well screen and sand pack are completely submerged below the water table, both rising- and falling-head tests can be performed. If any part of the screen or sand pack is above the water table, then only a rising-head test can be performed. Falling-head tests are not applicable in this case because the added slug will force water into the unsaturated sand pack and thus simulate hydraulic conductivities of the sand pack rather than the formation.
11. Start the pressure transducer logging data, "instantaneously" introduce or remove the solid slug to the well, and secure the slug cord. It is important to remove or add the volumes as quickly but smoothly as possible because the analysis assumes that an "instantaneous" change in volume is created in the well.
12. Continue measuring and recording depth-time measurements until the water level returns to within at least 10% of its initial or static level or a sufficient number of readings have been made to clearly show a trend on a semilog plot of time versus depth.
13. Once the test for a well is complete, connect the computer to the transducer cable and download the data to verify sufficient data was collected.
14. If necessary, reprogram the pressure transducer and repeat the test(s).
15. Once testing at a well is complete, review the field form for completeness, decontaminate the equipment, and dispose of waste.

NOTES:

Perform at least two or more tests on each well to compare and verify the repeatability of the results. It's best to perform the falling head test first (when using solid slugs) so that the slug is already in place below the water table when the well recovers so it can be rapidly removed to perform the rising head test, thus eliminating the equilibration time necessary after the slug is inserted prior to rapid removal.



Falling and Rising Head Test

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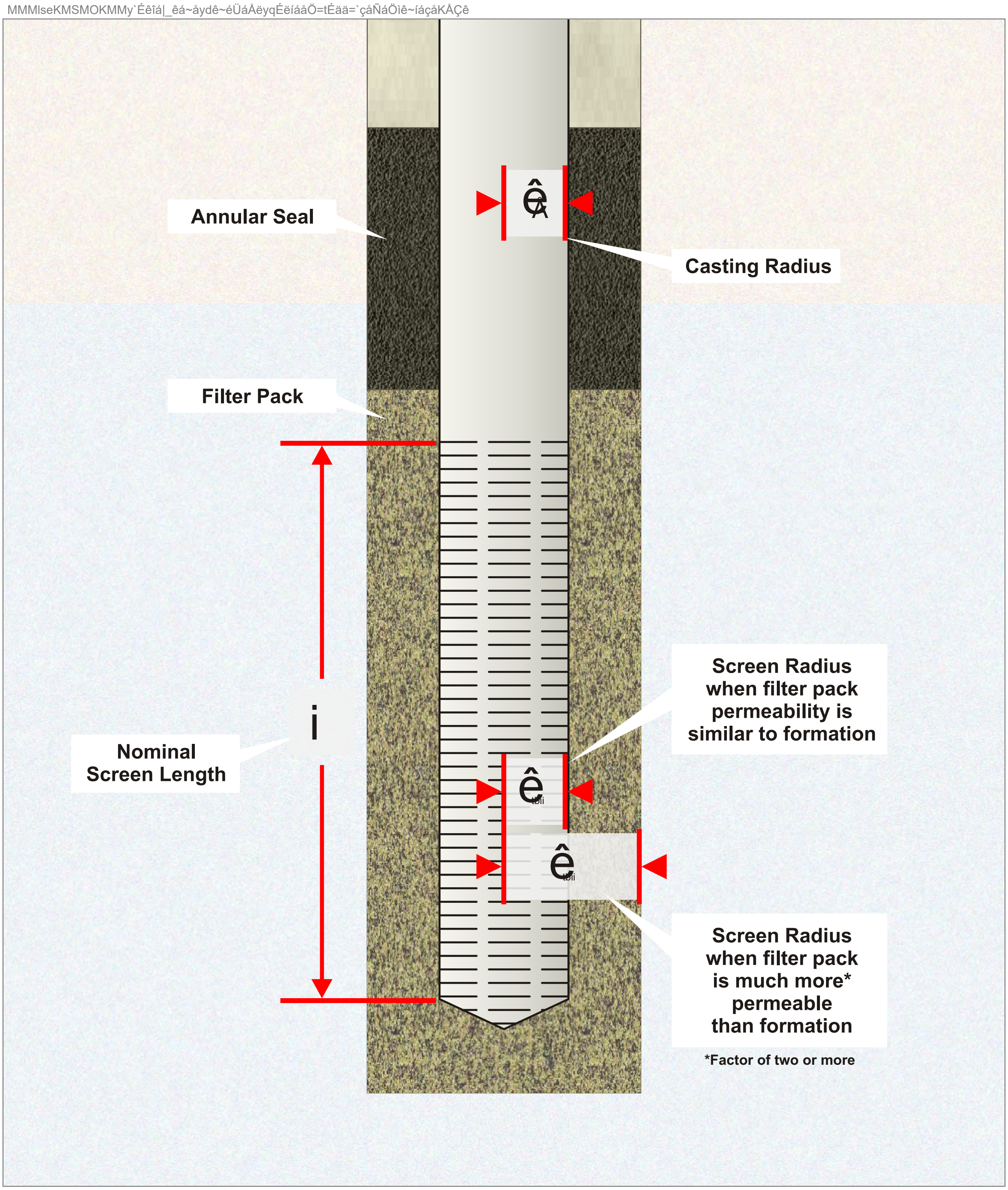


Testing Well Configuration

The time required for a slug test to be completed is a function of the volume of the slug, the hydraulic conductivity of the formation, and type of well completion. The slug volume should be large enough so that a sufficient volume of water is displaced or a sufficient number of water level measurements can be made before the water level returns to equilibrium conditions. The length of the test may range from less than a minute to several hours.

If the well is to be used as a monitoring well, precautions should be taken that the wells are not contaminated by material introduced into the well. The use of solid slugs is preferred over water injection as there is a delay effect of water running down the well casing that will skew the data. All monitoring devices should be cleaned prior to the test. If tests are performed on more than one monitoring well, care must be taken to avoid cross-contamination of the wells.

Slug tests shall be conducted on relatively undisturbed wells. If a test is conducted on a well that has recently been pumped for water sampling purposes, the measured water level must be within 0.1 foot of the water level prior to sampling. At least 24 hours should elapse between development of a well and the performance of a slug test. Slug tests should not be conducted on undeveloped wells.

6.2 Data Processing

To compare the results of different tests performed on the same well, as well as with other wells, the data needs to be normalized.

1. Import the data into the software and graphical solution package (e.g., *AQTESOLV, or equivalent*) and plot the raw data of pressure head (water elevation) vs. time.
2. Estimate the time the test began (t_o) and the initial/static head condition (H_s) from the raw data plot of water levels vs time.
3. Subtract t_o (time test began) from t (recorded time). Subtract H_s (static head) from H_p (recorded pressure head) to calculate the changes in head from the start of the test. The greatest change is the pressure head is H_o or the “instantaneous” change of head at the beginning of the test.
4. Normalize the data by dividing H_p (the pressure head readings) by H_o (the “instantaneous” change of head) and plot the normalized head vs. time. The normalized head values should range between 1 (initial displacement) and 0 (static conditions).

Compare the expected initial displacement calculated from the volume of the slug to the observed displacement measured in the well. If they are significantly different (> 10%), possible explanations include: 1) effective casing radius is different from the actual casing radius; 2) “instantaneous” change in head was too slow; and 3) in high K formations, the transducer was set too deep.

Compare normalized data plots from repeat tests at the same well. If plots do not coincide, either more well development may be necessary, non-laminar flow losses are occurring, or the underlying assumptions about the well are not valid.

6.3 Data Analysis

Most of the pump test data interpretation packages also provide an option for slug test data interpretation. Depending on the formation and well characteristics, a variety of methods can be used to interpret the data and provide the hydraulic conductivity surround the monitoring well.

6.3.1 Confined Formations

For wells that fully penetrate a confined formation, use the Cooper, *et al.*, and Hvorslev methods. Cooper, *et al.*, is a type curve method similar to the Theis method. For this method, the normalized head data is plotted versus a logarithmic scale of time and a type curve is matched to the data. If using the *AQTESOLV* program, manually attempt to match the data and the program will estimate the hydraulic conductivity and storage values.

Hvorslev (1951) is a straight line method where normalized head data on a logarithmic scale is plotted versus time. A straight line is applied to the data (with emphasize on the normalized head values between 0.15 – 0.25) and the slope of the line is used to for the calculation of hydraulic conductivity using the following formula:

Hvorslev's expression for hydraulic conductivity (K) is:

$$K = \frac{r^2 \, 1n(L/R) \text{ for } L/R > 8}{2 L T_o}$$

where:

K = hydraulic conductivity (ft/sec)

r = casing radius (ft)

L = length of open screen (or borehole) (ft)

R = filter pack (borehole) radius ft

T_o = basic time lag (sec)

If the storage estimate is not plausible or the well only partially penetrates the confined formation, either use the Hvorslev model discussed above or use the KGS model. KGS is another type curve method where the normalized head data is plotted versus a logarithmic scale of time and a type curve is matched to the data. If the calculated storage estimate is not plausible, this likely indicates further development is necessary.

6.3.2 Unconfined Formations

For wells screening in a unconfined formation, either use the KGS discussed above or the Bouwer and Rice method. Bouwer and Rice is a straight line method where normalized head data on a logarithmic scale is plotted versus time. A straight line is applied to the data (with emphasize on the normalized head values between 0.2 – 0.3) and the slope of the line is used for the calculation of hydraulic conductivity using the following formula:

$$K = \frac{r_c^2 \, 1n\left(R_e / r_w\right)}{2L} \frac{1}{t} 1n \frac{y_o}{y_t}$$

where

rc = Radius of the unscreened part of the well where the head is rising

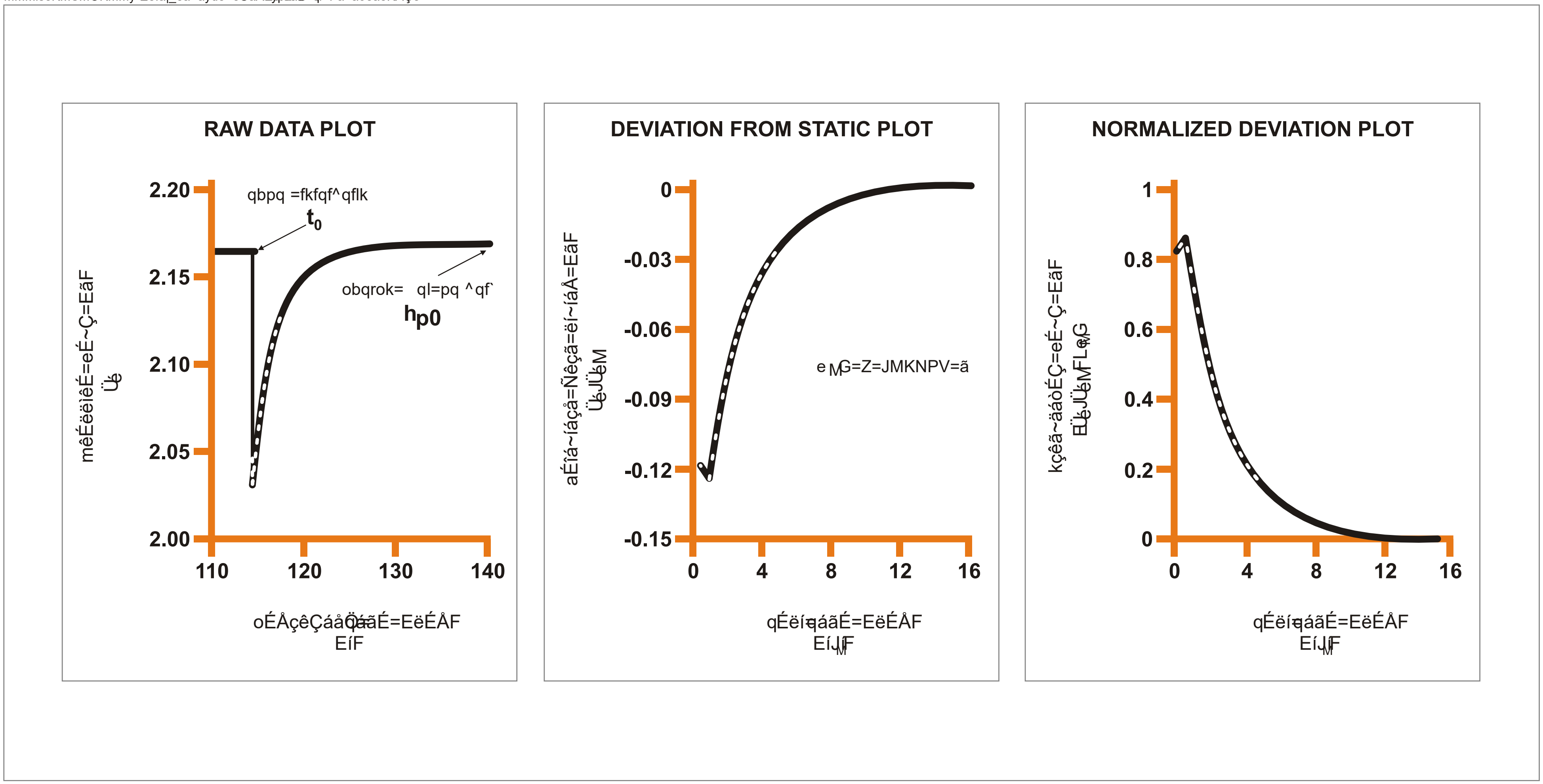
rw = Horizontal distance from well center to undisturbed aquifer

Re = Radial distance over which the difference in head, ho, is dissipated in the flow system of the aquifer.

L = Length of the well screen or open section of the well.

yo = Maximum linear displacement of water table at time to.

yt = Linear displacement at time t.



RAW DATA PLOT
DEVIATION FROM STATIC PLOT
NORMALIZED DEVIATION PLOT
2.20
2.15
2.10
2.05
2.00
110
120
130
140
t0
hp0
0
-0.03
-0.06
-0.09
-0.12
-0.15
0
4
8
12
16
1
0.8
0.6
0.4
0.2
0
0
4
8
12
16

Bouwer and Rice determined the values of R_e experimentally. They derived the following empirical equations, which relate R_e to the geometry and boundary conditions of the system:

For partially penetrating wells:

$$1n\frac{R_e}{r_w} = \left| \frac{1.1}{1n(H/r_w)} + \frac{A + B\ 1n[(D - H)/r_w]^{-1}}{d/r_w} \right|$$

where A and B are dimensionless parameters, which are functions of d/r_w; D is the thickness of the aquifer; and H is the length of well penetration through the aquifer (both casing and screen), or the total head in the well at the time t_o.

For fully penetrating wells:

$$1n\frac{R_e}{r_w} = \left[\frac{1.1}{1n(H/r_w)} + \frac{C}{d/r_w} \right]^{-1}$$

where C is a dimensionless parameter, which is a function of d/r_W (Kruseman and deRidder 1991).

7 Quality Assurance Quality Control

The following general quality assurance (QA) procedures apply:

- All data must be documented on standard slug test forms and/or within field/site logbooks.
- All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to field operation, and they must be documented.
- All equipment placed in the well must be properly decontaminated before and after use in each well.
- Additional readings of drawdown and recording of time should be taken during the recording of data by the datalogger for the purpose of QA/QC.
- When lowering the transducer into the well the readings (the water level and drawdown) should be checked on the datalogger to confirm accurate data recordings.
- All deliverables will receive peer review prior to release.

The following specific quality assurance activity will apply:

- When and where possible, run both falling- and rising-head tests at each well.
- Each well should be tested at least twice to compare results.
- To avoid erroneous data, care should be taken to conduct slug tests in formations with medium permeability (highly permeable or very low permeable aquifers may produce uninterruptable data).

8 Health and Safety

The degree of concern for health and safety depends on the specific contamination present on site. Site personnel should refer to the site's safety plan, which details levels of protection, standard safety operating practices, and monitoring procedures. Compliance with specific provisions of the health and safety plan is primarily the responsibility of the individual.

Specific risks unique to performing slug tests include the following:

- Heat and cold stresses while working in protective clothing and during exposure to temperature extremes.
- Exposure to volatile compounds during activities that require work over the open well head.
- Contact with contaminated groundwater on the slug and transducer.
- Slip, trip, and fall hazards associated with splashed groundwater around the work area and equipment components on the ground.

9 Special Project Requirements

Project or program-specific requirements that modify this procedure should be followed and included with the project planning documents.

10 References

Bouwer, H., and R.L. Rice, 1976, “A Slug Test for Determining Hydraulic Conductivity of Un confined Aquifers With Completely or Partially Penetrating Wells,” *Water Resources Research*, Vol. 12, No. 1.

Bouwer, H., 1978, *Groundwater Hydrology*, McGraw-Hill Book Company, New York, New York.

Bouwer, H., and R.C. Rice, 1980, A Slug Test for Determining the Hydraulic Properties of Tight Formations, *Water Resources Research*, Vol. 16, No. 1, pp. 233-238.

Cooper, H.H., Jr., J.D. Bredehoeft, and S.S. Papadopulos, 1967, Response of a Finite-Diameter Well to an Instantaneous Charge of Water, *Water Resources Research*, Vol. 13, No. 1.

Earlougher, R.C., 1977, *Advances in Well Test Analysis*, Society of Petroleum Engineers of AIME.

Ferris, J.G., and D.B. Knowles, 1954. The Slug Test for Estimating Transmissivity, *U.S. Geological Survey, Ground Water Note 26*.

Freeze, R.A., and J.A. Cherry, 1979, *Groundwater*, Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

Hvorslev, 1951, "Time Lag and Soil Permeability in Ground Water Observations," Bulletin No. 36, U.S. Army Corps of Engineers, p.50.

Johnson Division, UOP, Inc., 1966, *Ground Water and Wells*, Johnson Division, UOP, Inc., St. Paul, Minnesota.

Kruseman, G.P., and N.A. deRidder, 1991, *Analysis and Evaluation of Pumping Test Data*, 2nd ed., Internation Institute for Land Reclamation and Improvement; Wagening in the Netherlands.

Lohman, S.W., 1982, Ground Water Hydraulics, *U.S. Geological Survey, Paper 708*, p. 70.

Midwest GeoSciences Group, 2009, Advanced Aquifer Testing Techniques Featuring AQTESOLV, Midwest GeoSciences Group, Waverly, Minnesota.

Neuman, S.P., 1972, Theory of Flow in Unconfined Aquifers Considering Delayed Response of the Water Table, *Water Resources Research*, Vol. 8, No. 4, p. 1031.

Papadopulos, S.S., J.D. Bredehoeft, and H.H. Cooper, Jr., 1973, On the Analysis of Slug Test Data, *Water Resources Research*, Vol. 9, No. 4.

Todd, D.K., 1980, *Ground Water Hydrology*, (2nd ed.), John Wiley & Sons, U.S. Department of the Interior, *Ground Water Manual*, U.S. Government Printing Office, Washington, D.C.

APPENDIX A
SLUG TEST FIELD FORMS

Slug Test - Data Acquisition Sheet

General Information

Well Number____________________
Well Location____________________
Project____________________

Date____________________
Tests Performed by:____________________

Reported Well Depth from Land Surface__________
Measured Depth from TOC (top of casing)__________
Casing Diameter and Schedule__________
Screen Length and Slot Size__________
Depth to Top of Screen from TOC__________
Filter Pack Details__________

Date of Last Well Development__________
Initial Static Water Level from TOC__________
Final Static Water Level from TOC__________
TOC from land surface__________
Borehole Diameter__________
Annular Seal Details__________

	Type	Serial Number	Purpose and Placement	Reading in Air
Transducer #1				
Transducer #2				

Data Logger Type and Serial Number____________________
Logging Program:____________________ Acquisition Rate:__________
Pressure or Pressure Head Units: Time Units:
Comments:

Test Information

	Test 01	Test 02	Test 03	Test 04	Test 05
Initiation method					
Rising/falling head					
Pre-test value					
Post-test value					
Expected H_0					

Additional comments	
Test 01	
Test 02	
Test 03	
Test 04	
Test 05	

	Test 06	Test 07	Test 08	Test 09	Test 10
Initiation method					
Rising/falling head					
Pre-test value					
Post-test value					
Expected H_0					

Additional comments	
Test 06	
Test 07	
Test 08	
Test 09	
Test 10	

File for Field Data:

END OF SOP

STANDARD OPERATING PROCEDURE

MEASURING WATER LEVEL AND WELL DEPTH

SOP NUMBER: GEO 4.15

REVISION DATE: 4/3/2013 **SCHEDULED REVIEW DATE: 4/3/2018**

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1 Scope and Application

Most subsurface investigations require measurement and monitoring of groundwater levels to characterize contaminant movement and aquifer conditions as they relate to specific investigation sites. This document describes E & E's standard operating procedure (SOP) for measuring water level and well depth in monitoring wells and piezometers.

2 Definitions and Acronyms

BGS	below ground surface
DNAPL	dense non-aqueous phase liquid
LNAPL	light non-aqueous phase liquid
MSL	mean sea level
SOP	Standard Operating Procedure
TOC	top of casing
TOIC	top of inner casing (i.e., top of the well casing inside the outer protective casing)

3 Procedure Summary

Water level and total well depth measurements in monitoring wells are performed by using a water level indicator that has a graduated cable, typically to the nearest 0.01 foot. The precision of the device selected for measurement should be determined at the time of data quality objective development for the specific project. Water level and total depth measurements must be referenced to a consistent, repeatable, and known reference point. Typically, this is the top of (TOC) of the well or piezometer, which in many cases is more specifically the top of inner casing (TOIC) of the well or piezometer because most wells have an outer protective casing. The measurement reference point may also be ground surface, especially if the well is completed with a flush-mount cover. Measurements referenced to ground surface are typically reported in feet or meters below ground surface (BGS). Measurements of groundwater head elevation are typically required to determine flow gradients and other hydraulic properties. Therefore, the elevation of the measurement reference point may be determined via vertical surveying of the reference point. The resulting elevation of the reference point and groundwater level must reference the appropriate datum used to develop the elevations. This may be a local site datum of an assumed value or mean sea level (MSL) referenced to an ellipsoid such as the World Geodetic System 1984 or a geoid such as the North American Vertical Datum 1988. The water level indicator must be decontaminated according to E & E SOP for Equipment Decontamination (ENV 3.15) between each use in different well.

4 Cautions

If a noticeably anomalous depth to water or well depth is encountered (based on previous measurement, well logs, or comparison of data to other nearby wells of similar construction), re-measure and verify the measurements before leaving the site.

Because some casings have rough or sharp edges, use caution when lowering and retrieving the water level cable from within the well casing. These edges can cut and scrape the cable, obscuring the calibrated markings on the cable, and can eventually lead to failure (shorting out) of the electronic cable.

The top of well casings may not be level (due to imperfections when the casing was cut to length at the time of well installation). Therefore, a mark should be placed on the top of the casing to be used as a reference point for measuring. If a mark is not present, assume the measurement was taken at the highest point on the top of the well casing, because this is likely the point surveyed.

Always use caution when opening capped wells, because escaping (venting) headspace gases may be hazardous.

Changes in atmospheric pressure may cause the monitoring well to be under pressure or under vacuum if a gas-tight cap is present. This can result in a temporarily high or low water level within the well. Often the sound of air escaping from the well can be heard from the well when the cap is removed. If a sealed, gas-tight cap or plug is present, the water level within the well should be allowed to equalize to atmospheric pressure before collecting a depth to water measurement. Only stabilized measurements should be recorded.

5 Equipment and Supplies

The following is a list of equipment and items typically used for measuring water levels and well depths:

- Electronic water level indicator or oil/water interface probe with graduated cable;
- Extra batteries for water level indicator or oil/water interface probe;
- Detergent solution (laboratory grade, phosphate-free detergent such as Liquinox);
- Deionized or distilled water;
- Sterile gloves (nitrile or other material suitable to site conditions);
- Paper towels;
- Logbook and other site documentation; and
- Folding ruler or pocket steel tape.

6 Procedures

6.1 Preliminary Steps

1. Locate the well or piezometer and verify its position on the site map. Record whether positive identification was obtained, including the well number and any identifying marks or codes contained on the well casing or protective casing. Gain access to the top of the well casing and note the date and time the well was opened. If specified in the work plan or site health and safety plan, use monitoring equipment to measure or take readings of the well headspace. Record all measurements and observations (e.g., organic vapor readings, release of pressure when cap is removed, odor, etc.).
2. Locate and record the specified benchmark or survey point for the well or piezometer, which may be a mark at the top of the casing or a surveyor's pin embedded in the protective structure. Determine the elevation of this point from the records (if available) and record in the notebook. Measure and record the vertical distance from the benchmark to the top of the well casing to the nearest 0.01 foot. Measure and record

the metal casing stickup (i.e., the distance between the top of the casing and nominal ground level).

3. Record any observations and remarks regarding the completion characteristics and well condition, including evidence of cracked casing or surface seals, security of the well (locked cap), and evidence of tampering.
4. Decontaminate all portions of the equipment that will enter the well according to E & E SOP ENV 3.15. Keep all equipment and supplies protected from contamination when not in use.
5. If free product is suspected to be present in a monitoring well, an oil/water interface probe will be used to measure the thickness of light non-aqueous phase liquid (LNAPL), which floats on top of the water table, or Dense Non-Aqueous Phase Liquid (DNAPL), which will collect in the bottom of the well. Procedures for operating an oil/water interface probe are described below.

6.2 Operation

1. Remove the water level indicator probe from the case (if so equipped), turn on the sounder, and test the battery and audio-visual indicator by pushing the test button. Adjust the sensitivity scale until you can see and/or hear the indicator. Release the test button if successful. If the indicator does not sound or illuminate, turn up the sensitivity until it does. If the indicator still fails to sound or illuminate, check and replace the batteries as needed.
2. Slowly lower the probe into the well, allowing the cable reel to unwind slowly and do not allow the cable to rub on any sharp casing edges. Continue lowering the probe until the indicator sounds and/or illuminates. Raise and lower the probe very slowly at least two additional times until the indicator sounds/illuminates at a consistent depth. False signals may be encountered by moisture in the inside walls of the well casing above the level of groundwater. Make note of the depth reading on the cable at the reference point on the well casing or mark the spot on the cable by grasping it with the thumb and forefinger at the top of the casing and withdrawing the cable to note the measurement. Record the depth measurement in the logbook or other site documentation. Be careful to read the tape properly from bottom to top (e.g., a water depth of 11.50 feet could be mistaken for 12.50 feet if the operator looks at the tape from the top down rather from the bottom up).
3. Use of an oil/water interface probe is similar to that of an electronic water level indicator in that the probe has a graduated reel tape, typically also in increments of 0.01 foot. Lower the probe into the well slowly so as not to disperse an LNAPL on the water surface. When the probe comes in contact with LNAPL, it will emit a solid tone. Record the depth at which this is encountered as described in Number 2 above. Next, continue to lower the probe slowly to the depth at which the probe emits a beeping or non-continuous tone. This is the interface between the LNAPL and water table. Record this measurement as described above. The difference between these two measurements is the LNAPL thickness within the well. Similarly, DNAPL may be encountered at the bottom of a well at some project sites. In this case, the beeping tone will change to a solid tone within the water column of the well. Record this depth and the total depth of the well to determine the DNAPL thickness. Use caution when sounding the total depth of the well so as not to damage the probe sensors.

4. To measure the total well or piezometer depth, lower the probe until slack is felt in the cable. The indicator on the probe may be turned off prior to taking this measurement. Very slowly raise and lower the cable until the bottom of the well is detected and no more slack is felt in the cable. If there is soft sediment on the bottom of the well, it may be difficult to determine the exact depth. Note this condition in the site logbook. As described above, note the measurement on the cable at the reference point or grasp the cable with the thumb and forefinger at the top of the casing and note the depth. IMPORTANT: the “zero” reference point on the probe may not be at the bottom of the probe (e.g., Solinst Model 101 probes have a weighted stainless steel tip that extends 0.28 feet or 8.53 centimeters beyond the calibrated "zero" point of the measuring cable). If this is the case, use the cable to accurately measure the distance from the end of the weight to the water level sensor and add this length to the measurement noted above. Record the sum of these two lengths as the total depth of the well.
5. Withdraw the cable and probe, and decontaminate according to the SOP for Equipment Decontamination (ENV 3.15).

6.3 Data Recording and Manipulation

Record the following computations, first ensuring that all measurements are in the same units:

- Measurement reference point (e.g., TOC) elevation, as determined by site survey or from site documentation
- Water level elevation = [TOC elevation] - [depth to water]
- Total well depth = [cable-measured depth from top of casing] + [correction factor (as described above) for length of probe below the water sensor]
- Well bottom elevation = [TOC elevation] - [total well depth]
- If an oil/water interface probe is used, record readings as described in Section 6.2 (3).

In the presence of LNAPL, groundwater elevations need to be corrected to account for displacement caused by the product. To make the corrections, perform the following computation:

- Corrected water level elevation = [LNAPL thickness] x [LNAPL specific gravity] + [calculated groundwater level elevation (as described above)]

6.4 Calibration

No calibration is needed for the electronic water level indicator; however, a check of the responsiveness of the indicator must be performed.

7 Quality Assurance / Quality Control

Check functionality of the water level indicator or oil/water interface probe by pressing the test button, and if necessary, by dipping the probe in a jar or bucket of water to check responsiveness. Note condition of measuring cable/tape (i.e., make sure the numbers are readable. Lastly, if a noticeably anomalous depth to water or total depth is encountered (based on previous measurements, well logs, or comparison of data collected from other nearby wells of similar construction), re-measure before leaving the site.

8 Health and Safety

Comply with the general and site-specific health and safety protocols described in the site-specific health and safety plan. Wells may be located in a variety of settings each with their own safety concerns, such as traffic, animals, etc. Be wary of the presence of insects (e.g., ants, bees, wasps) that may be in the well via holes or cracks in the riser or riser cap. Additionally, be prepared for the presence of gases that may have built up in the well while it was sealed. If gases from the well are expected or detected, keep a safe distance once the riser cap is removed and allow the well to degas before continuing with water level measurements.

9 Special Project Requirements

Project or program-specific requirements that modify this procedure should be included with the project planning documents.

10 References

None.

END OF SOP

ecology and environment, inc.

STANDARD OPERATING PROCEDURE

EVALUATION OF EXISTING MONITORING WELLS

SOP NUMBER: GEO 4.19

REVISION DATE: 4/2/2013 **SCHEDULED REVIEW DATE: 4/2/2018**

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1 Scope and Application

The purpose of this Standard Operating Procedure (SOP) is to establish protocols for determining the integrity of existing monitoring wells. Existing wells represent valuable sources of information for subsurface environmental investigations and may provide the following information:

- Subsurface lithology and hydrogeology based on existing logs;
- Access for downhole geophysical logging or hydraulic testing (e.g., slug and pump tests);
- Monitoring of water levels for development of potentiometric surface maps and interpretation of groundwater flow direction;
- Regional drinking water quality may be evaluated and monitored; and
- Mapping and monitoring changes in contaminant plumes.

Data from existing wells should only be used when the characteristics of the wells have been sufficiently documented to determine that they satisfy the data quality objectives of the investigation.

Guidance for planning appropriate data quality objectives may be found in USEPA's *Guidance on Systematic Planning Using the Data Quality Objectives Process* (2006). The selection of wells and a description of well documentation procedures may be found in ASTM's *Standard Guide for Selection and Documentation of Existing Wells for Use in Environmental Site Characterization and Monitoring* (1996).

This SOP is intended for use by personnel who have knowledge, training and experience in the monitoring well installation and maintenance activities being conducted.

2 Definitions and Acronyms

ASTM	American Society for Testing and Materials
SOP	Standard Operating Procedure
USEPA	United States Environmental Protection Agency

3 Procedure Summary

Prior to inspecting wells, a review of project planning documents and existing site documentation (including, if available, previous sampling and analysis results, well drilling/installation logs, etc.) is important and should be performed. This will allow the inspector to properly identify the location of the well, confirm the well ID, anticipate the depth and construction of the well, allow the well to be opened with the proper keys and tools, and whether contamination will be a health and safety issue. Once on site, the inspector should focus on the following:

a. Well identification;
b. The condition of the protective casing, cap, and lock;
c. The condition of the drainage pad surrounding the protective casing;

d. The presence of depressions or standing water around the casing;

e. The condition of the inside well casing; and

f. The depth to water and total well depth.

The final inspection shall include opening the well, and measuring and recording the depth to water and total depth as per E & E's SOP for Measuring Water Level and Well Depth (GEO 4.15).

4 Cautions

Cross-contamination of wells can occur if probes or other down-hole tools are not properly decontaminated between well inspections. Low-quality or unusable analytical data may result if samples are collected from wells where the well integrity has not been properly characterized. Additionally, loss or damage of equipment may occur if obstructions in the well are not properly identified.

Also refer to the cautions described in E & E's SOP for Measuring Water Level and Well Depth (GEO 4.15) for information related to down-hole measurements.

5 Equipment and Supplies

a. Field logbook and other site documentation;

b. Indelible black ink pen;

c. Organic vapor meter (e.g., photo- or flame-ionization detector);

d. Water level indicator or oil/water interface probe, as appropriate for site conditions

e. Steel tape or folding ruler;

f. Flashlight;

g. Deionized or distilled water;

h. Extra batteries for water level indicator;

i. Camera;

j. Well lock keys; and

k. Tools to open flush-mount well covers or cut-off well locks.

6 Procedures

The following steps shall be conducted for each well inspection:

1. Review the original work plan for monitoring well construction and installation details, if available. The physical features which must be identified and detailed include:

   a. Well identification number, permit number, and location by referenced coordinates or as related to prominent site features;

   b. Installation dates, drilling methods, and contractors;

   c. Depth to bedrock (if applicable).

   d. Borehole depth and diameter;

   e. Well completion type (stick up or flush mount);

   f. Depth of bottom of well;
   g. Type of well materials, screen type and length, and elevation of top and bottom of screen;
   h. Depths of tops and bottoms of well seals and filter packs.

2. Conduct an on-site inspection of existing monitoring wells. Prior to opening the well, features to be noted include:
   a. The condition of the well identification marks, protective casing, cap, and lock;
   b. The condition of the concrete drainage pad surrounding the protective casing;
   c. The presence of depressions or standing water around the casing; and
   d. The presence of any electrical cables (for pumps or transducers) and its connections.

   Record the above and subsequent observations described below in the field logbook, on data collection forms, and/or in the form of annotated sketches. An example Well Inspection Checklist is attached at the end of this SOP.

3. Remove the lock and/or open the protective cover. For flush-mount completions, note whether water is present within the annular space between the well casing and protective cover and whether the inner well cap is present and sealed. Remove water from the annular space using a cup, basting syringe, or other suitable method prior to removing the inner well cap. Check for the presence of organic vapors in the headspace at the top of the inner casing to determine the appropriate worker safety level, if required by the project planning documents. Record the following information:
   a. Presence, condition, and type of the inner well cap, including whether the cap is vented;
   b. Physical characteristics and composition of the inner casing or riser, including inner diameter and annular space;
   c. Presence of grout between the riser and outer protective casing and the presence or absence of drain holes in the protective casing;
   d. Presence of dedicated sampling equipment (bailer, pump, tubing, rope, etc.); if possible, remove such equipment and inspect size, materials of construction and condition.
   e. Any other pertinent observations.

4. Measure depth to water and total depth of the well (see E & E SOP GEO 4.15). Note observations made during measurements such as the presence of soft sediment at the bottom of the well, obstructions that prevent measuring to the bottom of the well, etc.

5. Photo document the well conditions.

7 Health and Safety

Comply with the general and site-specific health and safety protocols described in the site-specific health and safety plan. Wells may be located in a variety of settings each with their own safety concerns, such as traffic, animals, etc. Be wary of the presence of insects (e.g., ants, bees, wasps) that may be in the well via holes or cracks in the riser or riser cap. Additionally, be prepared for the presence of gases that may have built up in the well while it was sealed. If gases from the well are expected or detected, keep a safe distance once the riser cap is removed and allow the well to degas before continuing with water level measurements.

8 Quality Assurance / Quality Control

Refer to E & E SOP GEO 4.15 for QA/QC issues associated with measurement of depths to water and total wells depths. In addition, it is important to verify the correct well identification prior to recording observations. Where well clusters are present but lack identification, prior knowledge of the well depths are important to allow for proper identification of the well.

9 Special Project Requirements

Project or program-specific requirements that modify this procedure should be followed and included with the appropriate project planning documents.

10 References

American Society for Testing and Materials, 1996, *Standard Guide for Selection and Documentation of Existing Wells for Use in Environmental Site Characterization and Monitoring*, Designation D5980-96.

United States Environmental Protection Agency, February 2006, *Guidance on Systematic Planning Using the Data Quality Objectives Process EPA QA/G-4*, Office of Environmental Information Washington, DC 20460, EPA/240/B-06/001

Well Inspection Checklist **Site Name & Location:** ____________________

Well Number	Inspection Date	Time	Depth to Water (feet TOIC)	Total Depth (feet TOIC)	Well Paint (G/F/P)	Well Label (G/F/P)	Completion (s/u or curb)	Concrete Pad (G/F/P)	Casing Lock (G/F/P)	Protective Cover (G/F/P)	Inner Well Cap (G/F/P)	Obstructions in Well (Y/N)	Water in Annulus (Y/N)	Equipment in Well	Comments/Other Observations

Key:

curb =	curb box/flush-mount	N =	No	TOIC =	Top of inner casing
F =	Fair	P =	Poor	Y =	Yes
G =	Good	s/u =	stick-up		

Name & Affiliation of Inspector(s): ____________________

____

END OF SOP

STANDARD OPERATING PROCEDURE

HEALTH AND SAFETY ON DRILLING RIG OPERATIONS

SOP NUMBER: HS 5.3

REVISION DATE: 6/30/2017 **SCHEDULED REVIEW DATE: 6/30/2022**

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1 Scope and Application

Ecology and Environment, Inc., (E & E) often hires subcontracted drilling firms to install monitoring wells and piezometers and collect soil and rock samples from wells and boreholes, during which E & E geologists and other personnel supervise/oversee the drilling operation. E & E personnel do not themselves operate drill rigs. This standard operating procedure (SOP) describes potential safety hazards to E & E personnel who work around the drill rig, as well as key safety functions and responsibilities of E & E and subcontractor personnel working around drilling operations.

2 Definitions and Acronyms

CPR	Cardiopulmonary resuscitation
E & E	Ecology and Environment, Inc.
Exclusion zone	Designated area surrounding the work site in which only authorized personnel with proper training and personnel protective equipment are allowed to enter
FID	Flame ionization detector
HAZWOPER	Hazardous Waste Operations and Emergency Response
OSHA	Occupational Safety and Health Administration
PID	Photoionization detector
PPE	Personal protective equipment
RSC	Regional Safety Coordinator
SHASP	Site-specific health and safety plan
SOP	Standard operating procedure
SSO	Site Safety Officer
Super exclusion zone	The area immediately surrounding the borehole where drilling equipment is operating

3 Procedure Summary

This procedure addresses health and safety considerations specific to drilling operations at E & E field sites. In general, health and safety considerations related to drilling are similar regardless of the actual drilling technique used. Where applicable, this SOP describes health and safety considerations that may be unique to certain types of drilling. Specific project health and safety considerations will be addressed in the site-specific health and safety plan (SHASP), which will be in compliance with the Corporate Health and Safety Program.

4 Cautions

Drilling operations present numerous health and safety hazards to site personnel, subcontracted drillers, and members of the public who may approach the rig. Because this is a health and safety SOP, drilling hazards and control measures are addressed as procedural items in Section 6.1.

This SOP does not address potential hazards that are not unique to the drilling operation, such as heat and cold stress, historical site contaminants (chemicals, radioactive materials), and biological hazards on site (insects, snakes, etc.). Those hazards will be addressed in the SHASP.

5 Equipment and Supplies

The following equipment and supplies may be required for health and safety activities unique to drilling operations:

- Ambient exposure monitoring instrumentation;
- Appropriate PPE: minimum of hard hat, hearing protection, eye protection, work gloves, and steel-toed boots, with protective coverall (e.g., Tyvek® suit or equivalent) as applicable;
- Eyewash station; and
- Fire extinguisher.

6 Procedure

6.1 Drilling Hazards and Control Measures

This section describes the common hazards that could be encountered during the types of drilling activities typically prescribed for E & E projects. The SHASP will be required to address all potential drilling hazards.

6.1.1 Slip/Trip/Fall Hazards

Personnel may be injured if they trip over tools or objects, walk on uneven terrain, fall from heights or into holes, or slip on surfaces in and near the drilling area. Drill cuttings, water blown from the borehole, and the use of drilling mud could make the work area slippery. The drill equipment decontamination area also could be slippery due to the use of decontamination fluids such as hot water (steam cleaning).

Controls

- Store tools and supplies away from the super exclusion zone (see Definitions).
- Personnel should use caution when walking on uneven surfaces so that they do not lose their balance.
- Subcontracted drillers must wear a lifeline or safety belt if mast climbing is necessary.
- Boreholes should be barricaded or marked with flags when drilling has been completed, to prevent personnel from stepping in the hole.
- Soil or sand should be applied to wet or slippery surfaces.
- Drill cuttings, debris, mud, water, and spills in the drilling area should be removed and/or cleaned up as promptly as practicable.

6.1.2 Unguarded Points of Operation

The spinning auger on a drill rig, the V-belt drive on a motor, and the cathead pulley are unguarded points of operation that can pull site personnel into the machinery and cause serious injuries.

Controls

- Mechanical guards cannot be placed around the spinning auger on a drill rig. Site personnel must stay away from the spinning auger and avoid wearing loose clothing that could get caught in the auger.
- Mechanical guards must be placed over V-belt drives.
- Site personnel must stay clear of moving parts of the cathead pulley.

6.1.3 Overhead Equipment

Standard drilling operations and/or the use of wire line core sampling involve raising heavy drill steel and equipment overhead, increasing the risk that heavy equipment could be accidentally dropped from a height.

Controls

- Drillers must inspect drilling and sampling equipment to ensure it is in good condition prior to the start of drilling operations.
- Drillers must ensure that proper hoisting procedures are used, to reduce the likelihood of dropping drill steel or sampling gear.

6.1.4 Drill Rig Lurching

The drill rig has a tendency to lurch and shake when the auger comes into contact with harder materials. This is especially true when hollow-stem auger drilling methods are used. The rig can also lurch in heaving sands. A rig that lurches could cause equipment breakage, throw parts and debris, or fall over, thereby injuring personnel.

Controls

- Site personnel should be aware of possible drill rig movement and move away from the rig if lurching or shaking occurs.

6.1.5 Noise

Excessive noise is associated with almost every drilling technique and has a variety of sources, including oscillating drill head, engine noise, air compressors, and direct pounding on drilling equipment (e.g., casing drivers, hammers, Geoprobe®, split spoon sampling). Excessive noise can cause hearing damage, distract workers, and interfere with communications.

Controls

- In excessive noise areas, wear the hearing protection recommended by the SHASP.

6.1.6 Buried or Overhead Utilities

Contact of drilling tools with electric, gas, steam, process, or other utility lines can result in fires, explosions, electric shock hazards, burns, and other incidents.

Controls

- Use the "one-call" system to arrange for utilities to be located and marked prior to beginning drilling operations. If this is the responsibility of the subcontracted driller, the supervising E & E geologist must ensure that this has been completed.
- The boom on the drill rig must be kept at least 25 feet from overhead and buried utilities.
- As appropriate, a site-specific geophysical survey can be conducted to identify suspected utility lines if they cannot be accurately located using a one-call system. Maps of underground utilities should also be checked, if available, to verify locations.
- Drilling operations should proceed slowly in areas near buried utilities because the actual utility location may not exactly correspond to the area identified by a flag or paint or as illustrated on a map.
- Hand augering or vacu-digging should be conducted for the initial 5 feet at locations where actual utility locations are uncertain.

6.1.7 Lightning

The elevated mast on a drill rig is a potential target of lightning.

Controls

- The site safety officer (SSO) will monitor weather conditions and halt drilling operations when electrical storms approach the drilling location.

6.1.8 Moving or Thrown Objects

Site personnel may be injured if they are struck by debris from the borehole or by drilling machinery or components.

Controls

- Site personnel must wear the appropriate personal protective equipment (PPE) such as safety boots, safety glasses, and a hard hat.
- Site personnel should keep an appropriate distance from the borehole and be aware of the possibility of materials being expelled from the borehole.
- Adequate inspection and maintenance of the drill rig will reduce the likelihood of worn equipment or failing parts that could be thrown and cause injury.

6.1.9 Chemical Hazards

Chemical contaminants may be present in the form of gases, vapors, aerosols, fumes, liquids, or solids. Drilling into the subsurface environment could release site contaminants that might not otherwise have been encountered, or penetrate pockets or zones of natural subsurface gases such as methane or hydrogen sulfide. Site personnel may be exposed to these contaminants through one or more of the following pathways: inhalation, ingestion, and/or skin/eye contact.

Controls

- Use exposure monitoring instrumentation such as an aerosol monitor, single gas monitor, colorimeter tubes, organic vapor analyzer (photoionization detector [PID], flame ionization detector [FID]), combustible gas meter/O_2 meter/explosimeter, and/or dust monitor to monitor airborne constituents in the borehole and worker breathing zones. Specific thresholds and action levels will be included in the SHASP.

- Wear appropriate PPE as prescribed by the SHASP.
- Practice contamination avoidance.
- Stay upwind during grout mixing (silica inhalation hazard).

6.1.10 Ergonomic Hazards

Drilling equipment is heavy. Muscle strains, sprains, and injuries can occur when personnel use improper lifting methods, lift objects that are too heavy, improperly reach for objects, or work in awkward positions. The subcontracted driller will handle the drilling equipment; however, E & E personnel handle the samples collected during drilling, which will be collected in relatively heavy equipment such as split-spoons. E & E personnel also could handle heavy drums containing drill cuttings or decontamination water.

Controls

- Lift with the back as straight as possible, use a wide stance, and bend the knees. Keep elbows close to the body, lift with your legs, and keep the object close to the body.
- Ensure that two people are used to move heavy objects such as drill augers.
- Avoid excessive stretching of the arms when picking up objects.
- Avoid twisting of the back or working in awkward positions.
- Ensure that filled drums are lifted using appropriate hoists or approved lifting methods.

6.2 Drilling Safety Responsibilities and Authority of Subcontracted Driller

The subcontracted driller is responsible for setting up and operating the drill rig in accordance with established safety standards, such as those of the National Drilling Association (National Drilling Association 2005).

The subcontracted driller has authority to direct its personnel within the area while drilling operations are in progress. Access to the hazardous area around the auger and borehole is restricted by a super exclusion zone that can be delineated by a 4-foot-by-8-foot sheet of plywood centered over the borehole before drilling. A large hole cut in the plywood allows penetration of the auger. Alternatively, the super exclusion zone can be delineated by traffic cones. If plywood or similar is not used, E & E and subcontracted drilling personnel will assume that a 4-foot-by-8-foot super exclusion zone exists around the borehole. E & E personnel are not allowed in the super exclusion zone at any time while drilling is under way.

Drilling personnel will not refuel the rig until rig engines are shut down. Motor fuels should be stored and dispensed from spring-loaded, Occupational Safety and Health Administration (OSHA)-approved metal or polyethylene gas cans.

Housekeeping around the rig is the responsibility of the driller, but all team members should, when necessary, participate in this effort.

The subcontracted driller also will perform any decontamination of drilling equipment prescribed by the project work plan, which usually consists of steam cleaning. The drilling team will be responsible for keeping the decontamination area free of the slip/trip/fall hazards that can be associated with steam cleaning.

6.3 Drilling Safety Responsibilities and Authority of E & E Site Safety Officer

The SSO at a drilling site where a subcontracted driller is used is responsible for oversight of safety conditions such as the setup of the drill rig, ambient and personnel exposure monitoring, and the use of PPE. In many instances, the supervising geologist may also function as the SSO.

6.3.1 Drill Rig Inspection

The SSO, in concert with the subcontracted drilling team, will perform a drill rig inspection prior to the start of each day's drilling activities. This inspection will verify items such as the following:

- The mast is located at least 25 feet from any overhead or underground utility lines;
- The location, operation, and unencumbered access to kill switches have been reiterated to all site personnel, and kill switches have been tested;
- Outriggers, stabilizers, or jacks are in place and the rig is level;
- A utility "one-call" locating survey has been completed prior to drilling. Depending on the site, a geophysical survey (e.g., electromagnetic or ground-penetrating radar) or a reliable site history may be required to verify the absence of underground utilities, buried obstacles, tanks, and drums;
- The drilling location is a minimum of 48 inches from any marked utility;
- A first aid kit and filled eyewash bottle are readily available;
- A fire extinguisher, charged to the proper pressure, has been placed at the rear of the rig during drilling;
- The condition of ropes, chains, and cables has been checked to ensure that they are in operating condition (e.g., not frayed, loose, or otherwise broken);
- A lifeline or safety belt is available and used by drilling personnel if mast climbing is necessary;
- The SHASP is posted and includes an emergency phone list and map of hospital route; and
- The super exclusion zone is established around the borehole, using traffic cones or a 4-foot-by-8-foot sheet of plywood. This defined area will be entered during active drilling only by the subcontracted drilling personnel, except in emergency situations.

If the SSO determines that any material item noted above requires replacement or repair, the SSO will require that the subcontracted driller effects the repair or replacement, after which the SSO must verify that the repair or replacement is sufficient before drilling begins. Similarly, if any other condition above is not met, the SSO must request that the condition be corrected and meet the SSO's satisfaction before allowing drilling to proceed. Working together, the SSO and the subcontracted driller will verify that the rig also has been checked against the operator's checklist.

6.3.2 Safety Meetings

The SSO is responsible for holding a site safety meeting at the start of the field effort and before each daily work shift over the course of the project. Subcontracted drilling personnel and E & E personnel are required to attend these meetings. With respect to drilling safety, the safety meetings should address the following at a minimum:

- Planned drilling activities and presumed potential hazards;
- Personnel responsibilities for drilling activities;
- Levels of protection, exposure monitoring plan, and equipment;
- Location of super exclusion zone around the borehole;
- Emergency scenario plans, including location, operation, and use of kill switches;
- Location of fire extinguisher and first aid kit; and
- General housekeeping around the drill rig area.

Site safety meeting topics, as well as the names of meeting attendees, will be recorded in the field logbook or site safety logbook, or on the Daily Safety Meeting Record form.

6.3.3 Exposure Monitoring

The SSO's exposure monitoring duties include on-site calibration and setup of the monitoring equipment specified in the SHASP. For drilling activities, this generally includes at a minimum an O_2 meter/explosimeter and real-time organic vapor monitoring (e.g., PID, FID). Noise and heat stress monitoring are employed where appropriate. If the SSO believes that additional monitoring equipment beyond the directive of the SHASP should be employed, it is the SSO's responsibility to obtain this equipment from the nearest E & E office, with the cooperation of the Regional Safety Coordinator (RSC) or Corporate Health and Safety Group. The SSO is also responsible for ensuring that a trained operator for this additional equipment is on site.

Because E & E personnel are prohibited from entering the super exclusion zone around the borehole while drilling is under way, the SSO must not attempt to take instrument measurements in or around the auger while it is in use, or from cutting samples while the auger is in motion. If possible, the O_2 meter/explosimeter should be set up for unmanned (alarmed) operation at the rig, using an extension hose to continuously draw samples from the borehole area during drilling operations.

6.3.4 Other SSO Responsibilities

Although E & E contractually requires subcontracted drillers to provide properly trained and outfitted staff, the SSO will verify at the project kickoff safety meeting (or otherwise before fieldwork starts) that all field staff (subcontractor and E & E) have the required training and approvals (see Section 8).

The SSO has ultimate authority over the subcontracted driller with regard to whether work practices meet the requirements of the SHASP. Shutdown of work or restriction of personnel are options available to the SSO if safety standards are not met.

The SSO will be responsible for shutting down the drilling operation if electrical storms occur in the site area.

The SSO should ensure and document that boreholes are not left open or unfilled after drilling equipment is moved. In instances where a hole must be left open and unattended, suitable barricades or the equivalent will be staged around the hole to prevent personnel and equipment from falling in.

If the SSO has reason to believe that either E & E or subcontractor personnel are under the influence of alcohol or drugs, or are otherwise ill before or during work on site, the SSO has the authority to restrict those team members from site work.

6.4 Drilling Safety Responsibilities and Authority of Other E & E Personnel

It is the responsibility of E & E personnel to have with them on site, and don when required, the non-disposable PPE (such as hard hat, face shield, safety glasses, steel-toed boots, and appropriate outerwear) required for the drilling activity. It is the E & E employee's responsibility to ensure that his/her PPE is in proper working order.

Personnel should be aware of emergency facility locations and site egress routes. As with all E & E fieldwork, the buddy system is to be enforced.

E & E personnel on site are required to follow the terms of the SHASP and the direction of the SSO.

E & E personnel working at a drilling site may provide certain necessary support to the subcontracted drilling team; however, it is important that E & E personnel do not interfere with the drilling process. E & E personnel are prohibited from approaching the super exclusion zone while drilling is under way.

Because the SSO cannot be in all places at all times, other E & E team members should be aware of the drilling activity at all times, and observe the subcontractor and condition of their equipment. If an E & E team member recognizes an unsafe condition in the work area or on the rig, he/she should bring it to the attention of the subcontractor, SSO, and team leader. If the condition is not resolved in a timely manner by the subcontracted driller and conditions are still deemed to be hazardous, E & E team members should contact their RSC or the Corporate Health and Safety Group in Buffalo.

7 Quality Assurance/Quality Control

Prior to beginning field operations, the SSO will verify that E & E and subcontracted drilling personnel have the required project-specific training (see Section 8). The SSO will conduct a project kickoff safety meeting and daily safety meetings and document them in the field/safety logbook or on the Daily Safety Meeting Record form.

8 Training Requirements for Site Personnel

8.1 E & E Site Safety Officer

To function as an SSO for a drilling project, the E & E SSO must have received, at a minimum, 40-hour basic health and safety training that fulfills the requirement for 40-hour OSHA Hazardous Waste Operations and Emergency Response [HAZWOPER] training (29 CFR 1910.120), applicable annual 8-hour health and safety refresher training, and first aid/cardiopulmonary resuscitation (CPR) training within the past two years. The SSO also should have previous experience as a team member on a drilling project in order to have a working knowledge of the drill rig and the potential hazards that can occur with its operation. The SSO must understand applicable work modifications to protect field staff from potential injury. E & E's other requirements for medical fitness and respiratory protection approval also apply.

Where exposure monitoring instrumentation is to be used, the SSO must be properly trained prior to fieldwork.

8.2 Other E & E Personnel

All E & E personnel present on the site of a drilling activity must have received, at a minimum, 40-hour basic health and safety training that fulfills the requirement for 40-hour OSHA HAZWOPER training, applicable annual 8-hour health and safety refresher training, and first aid/CPR training within the past two years. E & E's other requirements for medical fitness and respiratory protection approval also apply.

8.3 Subcontracted Drilling Personnel

Subcontracted drilling personnel must have received health and safety training appropriate to drilling activities in accordance with industry standards (for hazardous waste sites, this training also must fulfill the requirement for 40-hour OSHA HAZWOPER training [29 CFR 1910.120]) and first aid/CPR training within the past two years. They will be medically approved and trained to use the level of respiratory protection required on site. Certification of training by the subcontractor will be required as a deliverable in E & E's contractual documentation. This training will be verified and documented by the SSO (or designee) before fieldwork starts.

9 Special Project Requirements

Each project site is unique and may present different health and safety concerns as they relate to drilling operations. This may include terrain, geology, vegetation, and drilling techniques to be used. The SHASP will address all health and safety aspects related to the drilling activity.

10 References

AntiEntropics, Inc. 2008. Environmental Remediation Drilling Safety Guideline. Revision 1. September 2008. Prepared for the Safety Subcommittee to Professional Development of the National Ground Water Association.

National Drilling Association. 2005. Drilling Safety Guide. Published 1985; revised 1991, 2000, and 2005.

END OF SOP

Title: Boating Safety

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1 SCOPE AND APPLICATION

The scope of this Standard Operating Procedure (SOP) is to describe safety procedures for boating operations. Some Ecology and Environment, Inc. (E & E) work activities require use of conventional boats or other water vessels to transport personnel and conduct work tasks. This SOP applies to all E & E operations (including transport) from any type of water vessel.

2 DEFINITIONS AND ACRONYMS

E & E	Ecology and Environment, Inc.
Freeboard	The distance from the water to the upper edge of the side of the boat.
JSA	job safety analysis
PFD	personal flotation device
PPE	personal protective equipment
SOP	Standard Operating Procedure. SOPs are written instructions documenting routine or repetitive activities followed by E & E. The development and use of SOPs facilitates consistency in the quality and integrity of E & E services and products.
USCG	U.S. Coast Guard
VDS	visual distress signal

3 RESPONSIBILITIES

E & E is responsible for providing training and equipment to their employees to enable them to safely execute the tasks described in this SOP. Employees are responsible for following the procedures described in this document and are authorized to stop any work task or operation where their safety or the safety of others are at risk. E & E employees shall conduct a job safety analysis (JSA) to identify potential hazards and determine mitigation measures to eliminate, control, or properly protect themselves from identified hazards.

4 PROCEDURES

4.1 Recruiting Appropriate Vessels

When recruiting vessels for operations over water, adequate lead-time must be allocated for the selection of a vessel appropriate for the project tasks. Work activity, equipment needed onboard the vessel, insurance, and licensing must all be considered. If a boat and captain must be consigned, staff will coordinate with E & E subcontracting personnel. All contractors will be appropriately licensed for the vehicle they will operate and satisfy insurance requirements before waterborne operations are initiated.

4.2 Subcontractor Boat Operation

When using a subcontracted vessel, the boat captain has full safety authority during waterborne operations from boarding to disembarking. This authority includes decisions regarding personal protective equipment (PPE) and capability of passengers to contribute to boating operations.

Any hazardous materials must be appropriately identified, classified, packaged, marked, labeled, and manifested according to E & E's Hazardous Materials Shipping Dangerous Goods Guidance Manual. If these requirements are not met, the vessel caption has the full authority to refuse transportation of hazardous materials.

4.3 Equipment Required for Boat Operations

Equipment required for boat operations applies to E & E-owned and operated boats and subcontracted vessels. It is the responsibility of the owner-operator to provide properly trained operators and the required safety equipment.

4.3.1 Personal Flotation Devices

All boats must carry one wearable personal flotation device (PFD; Type I, II, III or Type V PFD) for each person aboard. A Type V PFD provides performance of a Type I, II, or III PFD (as marked on its label) and must be used according to the label requirements. A Type I PFD should be worn for remote offshore work where rescue may take some time. Any vessel 16 feet and longer (except canoes and kayaks) must also carry one throwable Type IV PFD. PFDs must be U.S. Coast Guard (USCG) approved, in good and serviceable condition, and the appropriate size for the user.

A PFD should be worn at all times when the vessel is on the water. A wearable PFD can save your life, but only if you wear it. PFDs should not be stowed in plastic bags, in locked or closed compartments, or have other gear stowed on top of them. Throwable devices also must be immediately available for use.

In the event of an emergency, the boat operator shall call for assistance. If the boat operator is incapacitated, any person onboard should contact emergency rescue services using the marine radio or cellular phone. If the emergency does not affect the integrity of the boat (i.e., medical emergency or motor failure), remain onboard until a rescue crew arrives and follow their instructions. Do not enter the water unless the integrity of the boat is severely affected or in the event of an uncontrollable fire or explosion. If this is the case, swim away from the boat and stay with the rest of the crew. Remain as calm as possible and huddle with other crewmembers to conserve energy until a rescue crew arrives.

4.3.2 Visual Distress Signals

All vessels used on coastal waters, the Great Lakes, territorial seas, and those waters connected directly to them, up to a point where a body of water is less than 2 miles wide, must be equipped with USCG-approved visual distress signals (VDSs). Vessels owned in the United States operating on the high seas must be equipped with a USCG-approved VDS.

VDSs must be USCG-approved, in serviceable condition, and readily accessible. It should be marked with an expiration date. An expired VDS may be carried as extra equipment, but cannot be counted toward meeting the VDS requirement, since they may be unreliable. A minimum of three VDSs are required. That is, three VDS for day use and three VDS for night. Some VDS meet both day and night use requirements. VSDs should be stored in a cool, dry location. A watertight container painted red or orange and prominently marked “DISTRESS SIGNALS” or “FLARES” is recommended.

4.3.3 Fire Extinguishers

USCG-approved fire extinguishers are required on boats where a fire hazard could be expected from the motors or the fuel system. Extinguishers are classified by a letter and number symbol. The letter indicates the type of fire the unit is designed to extinguish (Type B for example are designed to extinguish flammable liquids such as gasoline, oil, and grease fires). The number indicates the relative size of the extinguisher. The higher the number, the larger the extinguisher.

USCG-approved extinguishers required for boats are hand portable of either B-I or B-II classification and have a specific marine type mounting bracket. It is recommended the extinguishers be mounted in a readily accessible position, away from the areas where a fire could likely start such as the galley or the engine compartment.

4.3.4 Ventilation

A powered ventilation system is required for each compartment in a boat that has a permanently installed gasoline engine with a cranking motor for remote starting.

4.3.5 Sound Producing Devices

Any vessel less than 39.4 feet/12 meters in length may carry a whistle or horn, or some other means to make an efficient sound to signal your intentions and to signal your position in periods of reduced visibility.

4.3.6 Navigation Lights

Recreational vessels are required to display navigation lights between sunset and sunrise and other periods of reduced visibility (e.g., fog, rain, and haze).

4.3.7 Communication

Marine radios are preferred on every powered vessel when E & E employees or their representatives are present. Cell phones should be carried and be fully charged prior to initiating work from any boat.

4.3.8 Additional Safety Equipment

- First aid kit;
- Marine radio, as applicable;
- Dewatering device and operable backup bilge pump, alternative bailing device available;
- Anchor and adequate anchor line for work area;
- Capacity/Certification of Compliance;
- Charts of the area;
- Mooring lines - bow, stern, and spring lines;
- Bright flashlight or searchlight;
- Alternate propulsion - paddle or oar;
- Compass, as applicable;
- Sunscreen and sunhat; and
- Drinking water.

4.4 Weather Conditions

Weather conditions can adversely affect a body of water in a relatively short period of time. If a boat and crew are in an exposed position this change could seriously jeopardize their safety. A boat operator should be knowledgeable relative to the weather patterns typical of the area in which work is to be done, and be able to identify rapidly approaching frontal systems that could place the boat and crew in danger.

4.4.1 Wind

Heavy wind is one of the most significant hazards to a small boat on a large body of water. Wind can quickly whip the water surface into a severe chop with breaking white-capped waves. The greater the fetch (upwind distance over water) from the boat's position the worse the wind-driven surface waves can be. If the boat is located in a shallow area, downwind from deeper water, the height of the wind-driven waves can increase dramatically as they enter shallow water. Wind blowing in opposition to the direction of flow can create large swells and threaten the safety of boat and crew.

A boat operator must carefully assess wind conditions upon arrival to work in an area and determine if a significant hazard exists that could be avoided on a calmer day. A rule-of-thumb for estimating wind speed is to look for white caps, which generally begin to appear at wind speeds approaching 20 miles per hour over calm water.

If possible, working with the bow into the wind is the safest position for the boat in windy conditions. However, working in a river requires that the bow be held against the direction of flow. If the wind opposes the current this could place the boat and crew in jeopardy, as the steep wind driven swell will affect the boat's stern. This situation could potentially swamp the boat if the waves increase in size and begin to break over the transom.

4.4.2 Rain and Lightning

Light rain does not present an extreme hazard to crews in small boats. Heavy rain over long durations can constitute a significant hazard if allowed to accumulate in the bottom of the boat. If the boat is transporting a load near maximum for its hull configuration the weight of the accumulated rainwater could adversely affect stability or significantly reduce freeboard. These conditions could result in swamping or capsizing.

Lightning storms are common in some locations and must be considered as a serious threat to the safety of the boat and crew. When active lightning storms are in proximity to the vessel, work activities shall cease and the boat captain will determine whether it is safe to remain on the water or return to shore. It is the operator's responsibility to assess the severity of the situation and react to protect the safety of the boat and crew. This action could include pumping the excess rainwater overboard on a periodic basis or may require postponement of the work effort until the rain or lightning dissipates to a non-threatening level.

4.4.3 Extreme Conditions

Weather extremes range from hot temperatures and sun exposure to cold temperatures and freezing conditions. Most often, small boats do not provide protection from the elements. Working in the middle of a body of water almost always means complete exposure to the existing weather extremes.

The hazards include health risks as well as some potential for physical injury. In the case of extreme heat and sun exposure, the crew should always carry drinking water to help minimize the potential for dehydration. Some form of protection (e.g., sunscreen, long-sleeved shirts, and hats) from the sun is essential and will aid in reducing the potential for dehydration in addition to minimizing the harmful effects of ultraviolet rays on human skin. Extreme heat combined with high wind can increase the rate of dehydration.

Extreme cold and freezing conditions may be more hazardous than heat. In addition to the more obvious concerns about hypothermia, dehydration is still a potential problem. Protective clothing is essential to minimize the effects of hypothermia. An accidental fall overboard could prove fatal if the victim is not properly clothed. Water reduces the body of heat 25 times faster than air so the immediate problem is rescuing the overboard victim. Remember the 50/50 rule (i.e., an unprotected overboard victim in water less than or equal to 50° Fahrenheit has a 50 percent chance of surviving for 50 minutes). In addition to these potential health risks, a boat operator working in extreme cold and freezing conditions must watch for ice build-up on the boat's hull. Even though ice floats, its mass above the waterline adds to the weight of the boat and its load. If ice is allowed to accumulate above the waterline because of splash from the wake or spray from wind-blown waves, the boat can become overloaded and settle in the water to a point where an otherwise insignificant volume of water could swamp and sink the boat. Icy working surfaces may form under extreme cold conditions that create traction concerns and slip hazards. Always wear proper footwear for the conditions and properly maintain ice-covered surfaces.

4.4.4 Restricted Visibility

The most common cause of restricted visibility is fog. Heavy rain and snow, or in some areas, blowing dust can reduce visibility as well. Operation during periods of extreme restricted visibility is not advised, particularly in areas frequented by large commercial vessel traffic. When operation is essential during periods of restricted visibility standard navigation lights must be displayed. If the small work boat is not equipped with navigation lights it should not be used in these conditions. In addition, proper horn or bell signals should be given as required by inland or international navigation rules for the size of vessel underway or anchored during periods of restricted visibility.

4.5 Navigation

4.5.1 Tidal Reaches

Streams in coastal areas present the boat operator with flow conditions generally unknown or inexperienced by most inland boat operators. The lower reaches of nearly all coastal streams are tidally affected. Changes in flow characteristics associated with daily tidal variations include some or all of the following: rise and fall of stage; increase and decrease in flow velocity; sudden appearance of breaking waves and turbulence; and possible reversals in flow direction. Boat operators working in tidal affected areas must understand these flow characteristics. Consulting tide and current tables and navigation charts is essential to planning daily activities and minimizing potential hazards. Operating guidelines in tidal reaches include:

- Moving through shallows during rising (flood) tides to provide the greatest margin for error in the event of grounding the boat;

- Timing of bar crossings from riverine into marine conditions during flood tides and never during the maximum ebb currents; and
- Timing of sampling and measuring activities relative to tidal effects when flow reversals are common.

4.6 Flow Near Fixed Structures

Fixed structures including bridges and dams are of particular concern to operators and crews working from boats. Boat operators should always familiarize themselves with any in-channel structure that could ultimately threaten the safety of their vessel and crew. Charts or maps of an area can provide valuable information related to the size and location of a structure across the channel. Regulatory agencies such as the State Department of Transportation, U. S. Army Corps of Engineers, and Bureau of Reclamation can generally provide detailed local information.

4.6.1 Bridges

Bridges may constitute major hazards to the boating public by restricting overhead clearance, generating extreme turbulence near piers or abutments located in the flow, or trapping debris and reducing the opening available between piers. During high stages, overhead clearance may be minimal for the passage of river traffic. In this case, if work is performed downstream of the bridge, one of two courses of action are necessary to protect the safety of vessel and crew: 1) find an alternate location for launching the boat below the bridge; or 2) call the bridge tender and request an opening of the lift or swing span if so equipped. General safety precautions associated with working on a boat near bridges include:

- Avoid working in proximity to bridge piers if possible;
- Never work from a boat in close proximity to and upstream of an excessively submerged bridge structure;
- If it is necessary to work from a boat upstream or anytime the structure presents a threat to safety, ensure that two sources of power (main engine plus auxiliary or twin engines) are onboard and running in the event the backup is immediately needed.
- Always carry an anchor of adequate size and design securely attached to a length of chain equal to three to five times the anticipated depth, to stop the vessel and hold it against the flow. This equipment must be ready to deploy in an instant with the end of the line attached to the boat;
- Cutting devices adequate to clear any line that becomes fouled or threatens its safety must be at the ready. These should include, but are not limited to, garden loppers, bolt cutters, cable shears, and a hatchet or machete;

- If it is necessary to work close to a bridge pier, approach the pier in the tail-wake from downstream keeping a sharp lookout for debris caught on the pier. Carefully work alongside the pier and inside the wake or eddy line generated by its upstream face;
- Never pull the boat across the upstream face of the pier where it could be trapped by the force of the current; and
- Always follow the directions of posted signs or other markers in the water or on the bridge.

4.6.2 Dams

Dams impounding the flow are another source of hazards to boats operating in their vicinity. Dams are generally of two types, which present different hazards to boat operators and crews. The first to consider are large dams (structure that are tens or possibly hundreds of feet high) impounding a large reservoir for the purpose of power generation and/or flood control. These structures may have a lock channel to allow passage of vessels from one pool level to the next in the upstream or downstream direction. Boat operation near these large structures should be limited to the approaches to the navigation lock. Operation near any intake structure or in the tailrace channel should be avoided as flow volumes, stream velocities, river stages, and associated turbulence can change unexpectedly. Smaller boats can be swamped or capsized by an unexpected wave surging from the outflow gates when the gates are reset to increase power generation or flows are increased to pass storm runoff.

Low-head dams are the second type to consider. These structures may constitute the most dangerous man-made obstruction a boat operator might encounter. Most low-head dams span the entire width of the channel usually to pool the flow for diversion into an irrigation system or for some other purpose requiring a low hydraulic head as the driving force. Water passing over the face of these structures appears as a smooth even flow across the entire stream width usually falling 10 feet or less. To the uninitiated there does not seem to be any hazard because the flow appears to be benign and tranquil. The plunging water creates a turbulent zone of reverse current (a hydraulic) at the downstream base of the dam. A boat can be drawn into the falling water and easily be swamped. The tumbling action will then roll the boat over, submerge it, and push it away from the dam below the surface only to pull it and its occupants back into the falling water as they reach the surface. This continuous action can easily trap the boat and its crew. General safety precautions when working from a boat near dams include:

- If possible, avoid working above, below, or otherwise in proximity to a low-head dam;
- If it is necessary to work in proximity to the upstream side of a low-head dam, work in the lowest flow conditions possible for that water body and have two sources of power (main engine plus auxiliary or twin engines) onboard and running in the event the backup is immediately needed. For waterbodies with slow or low flow, the backup "power" can be oars, if that will be effective;

- Always carry an anchor of adequate size and design securely attached to a length of chain equal to one boat length, and a length of nylon line equal to three to five times the anticipated depth, to stop the vessel and hold it against the flow. This equipment must be ready to deploy in an instant with the end of the line attached to the boat.
- Cutting devices adequate to clear any line that becomes fouled on the boat and threatens its safety must be at the ready. These should include but are not limited to garden loppers, bolt cutters, cable shears, and a hatchet or machete.
- When working in proximity to the downstream side of a low-head dam, completely avoid the hydraulic area at the base of the dam.
- Always follow the directions of posted signs or other markers in the water on either side of the dam.

4.6.3 Canals

Canals are normally highly regulated man-made waterways. Any operator using a boat to transit these conduits of flow must understand the flow system and its hazards. Typically, the water in any given canal system is allocated for some specific use. Regulation may be seasonal or associated with storm runoff. The system may consist of a series of diversions conveying flow to various points of use, and may include flow through tunnels of large diameter pipes, in addition to open channel conveyances. In short, use of boats in these types of flow systems should be avoided, if possible, and only undertaken after the operator and crew have contacted the agency responsible for management and regulation to become familiar with potential hazards built into the system.

4.7 Carbon Monoxide

When docked or rafted with other boats, be aware of exhaust emissions from the other boats. Carbon monoxide is a colorless, odorless gas that can cause dizziness and fainting (as well as more serious symptoms in confined areas). If the work area set-up is conducive to potential carbon monoxide accumulation, safely configure the boat positioning to avoid exposure to carbon monoxide fumes.

4.8 Seasickness

Seasickness is caused when the motion of the boat swaying and pitching disturbs the inner ear organs that enable a human to balance. This movement sets off alarm signals to the brain causing nausea, headache, dizziness, and sometimes vomiting. This condition intensifies with the lack of fresh air and inactivity. Fortunately, medication is available that helps most people by sedating the balancing organs. The medication can cause drowsiness and should be taken with care.

You can often avoid seasickness by staying busy and keeping your mind occupied by taking over the helm or any other activity that will keep you above deck. Look at the horizon rather than the water near the boat. Take deep breaths and drink plenty of water. The worst thing that a person can do is go below deck with no land or horizon to look at. Reading or staring at an object will assuredly bring on the effects of seasickness. If you are seasick lie down on your back with your eyes closed. This will greatly reduce the effects.

4.9 Outer Continental Shelf

Materials, equipment, tools, containers, and other items used in the Outer Continental Shelf that are of such shape or configuration that they are likely to snag or damage fishing devices shall be handled and marked as follows.

- All loose materials, small tools, and other small objects shall be kept in a suitable storage area or a marked container when not in use;
- All cable, chain, or wire segments shall be recovered after use and securely stored until suitable disposal is accomplished;
- Skid-mounted equipment, portable containers, spools, reels, and drums shall be marked with the owner's name before use or transport over offshore waters;
- All markings must clearly identify the owner and must be durable enough to resist the effects of the environmental conditions to which they may be exposed; and
- Minerals Management Service Potential Incident of Noncompliance G-252 stipulates that the above markings cannot be made with chalk, grease pencil or crayon, parking pens, non-waterproof decals, or water-based paints.

5 TRAINING

Employees that perform work from boats shall be trained to, and shall be familiar with the safety related work practices described in this SOP. Training records shall be kept in the employees training file for the term of their employment.

6 REFERENCES

U.S. Coast Guard. 2018. "The Official Website of the U.S. Coast Guard's Boating Safety Division." Accessed online at: http://www.uscgboating.org/regulations/index.php?m=r. January 2018.

National Safe Boating Council. 2018. "Downloadable Resources." Accessed online at: http://www.safeboatingcouncil.org/downloadable-resources. January 2018.

Boat-Ed. 2017. *The Florida Boater's Guide: A Handbook of Boating Laws and Responsibilities*.

U.S. Fish and Wildlife Service. 2014. "Fish and Wildlife Service Occupational Safety and Health, Part 241, Safety Operations." September 17, 2014.

Nautical Know How, Inc., 2016. "Boat Safe.com." Accessed online at: http://www.boatsafe.com/.

Revision Log

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01	Removed reference to Scheduled Review Date and updated copyright year.	D. Sheppard	Oct-2019

ecology and environment, inc. Global Environmental Specialists	Standard Operating Procedure	HS 5.8	
		Revision: 01	
		Date:	October 2019
		Page:	1 of 7

Title: Hand and Portable Power Tools

Prepared by: David Sheppard	Reviewed by: Tom Siener

1 SCOPE AND APPLICATION

The scope of this Standard Operating Procedure (SOP) is to provide safe use practices for hand and portable power tools. This SOP applies to all work activities where hand and portable power tools are used by Ecology and Environment (E & E) employees.

2 DEFINITIONS AND ACRONYMS

CFR	Code of Federal Regulations
E & E	Ecology and Environment, Inc.
hand tool	Hand operated tools that do not require a power source.
OSHA	Occupational Safety and Health Administration
PPE	personal protective equipment
Portable Power Tool	Hand operated tools that require a power source (e.g., electric and pneumatic).
SOP	Standard Operating Procedure. SOPs are written instructions documenting routine or repetitive activities followed by E & E. The development and use of SOPs facilitates consistency in the quality and integrity of E & E services and products.

3 RESPONSIBILITIES

E & E is responsible for providing training and equipment to their employees to enable them to safely execute the tasks described in this SOP. Employees are responsible for following the procedures described in this document and are authorized to stop any work task or operation where their safety or the safety of others are at risk.

4 PROCEDURE

4.1 General Tool Safety

Hand and portable powered tools are very useful, but they can present hazards if not properly maintained or used by workers. Employees must be properly trained to recognize hazards and safe use practices of commonly used tools. General tool safety guidelines include:

- Always follow the manufacturer's guidelines and recommendations;
- Use the tool for its intended purpose (do not use a wrench to hammer);
- Inspect all tools prior to use and periodically throughout the work task;

- Maintain and properly store tools;
- Never point tools at other workers;
- Hand tools to other workers. Do not toss tools;
- Secure tools when working at elevate heights;
- Always perform cutting tasks in a direction away from your body;
- Ensure proper footing on work surfaces and securely grip the tool;
- Maintain proper posture to avoid tool slippage or excess stress on body;
- Secure work piece with vise or clamp to allow both hands to operate tool;
- Do not wear loose-fitting clothing or jewelry that can be caught in rotating tools;
- Wear proper personal protective equipment (PPE);
- Do not use defective or damaged tools. Remove them from service and tag out to prevent others from using the tool;
- Do not carry power tools by the power cord;
- Inspect power and extension cords prior to each use and before they are plugged into an energy source;
- Place power and extension cords in a manner than does not create a trip hazard;
- Make sure the tool is properly guarded. Do not use tools in the absence of guards if the tool is designed with guards;
- Use ground-fault circuit interrupters outdoors and in wet or damp environments;
- Never leave a tool unattended where an unapproved person could access it; and
- Ensure that portable electric powered tools meet the electrical requirements of Occupational Safety and Health Administration (OSHA) 29 Code of Federal Regulations (CFR) 1910 Subpart S.

4.2 Guarding Portable Powered Tools

An employee shall ensure that all guards are in place and operable at all times when a tool is in use. Guards shall comply with the American National Standards Institute B15.1 standard. Guards are designed to protect the operator from contact with the point of operation, in-running nip points, rotating parts, and flying chips and sparks. Guards shall not be disabled in any fashion. All tools shall be used with the correct shield, guard, or attachment recommended by the manufacturer. Appendix A presents guarding requirements for lawn mowing equipment that is frequently used at E & E office locations.

4.3 Constant Pressure Switches and Throttle Controls

All hand-held powered circular saws that have a blade diameter greater than 2 inches, electric, hydraulic or pneumatic chain saws, and percussion tools without positive accessory holding means shall be equipped with a constant pressure switch or control that will shut off the power when the pressure is released. All hand-held gasoline-powered chain saws or weed-whackers shall be equipped with a constant pressure throttle control that will shut off the power when pressure is released. The operating control on hand-held power tools shall be located to minimize the possibility of accidental operation, if such accidental operation would constitute a hazard to employees.

4.4 Broken or Defective Tools

Use of any tool that does not comply with applicable requirements of this program is prohibited and shall be identified as unsafe by tagging or locking the controls to render them inoperable. Such tool shall be identified as unsafe either by tagging according to OSHA 29 CFR 1910.145 or locking the controls to render them inoperable or be physically removed from its place of operation. The tool should be repaired according to manufacturer's specifications or discarded. Minor tool maintenance may be performed by E & E employees but shall be limited to routine wear part replacement (e.g., worn drill bits and saw blades). Power tools shall be unplugged from their power source prior to minor maintenance activities.

4.5 Personal Protective Equipment

As part of the hazard assessment process for operating hand and power tools, PPE will be chosen and used according to OSHA 29 CFR 1910 Subpart I and the E & E PPE Program. Typical PPE includes safety glasses, gloves, hard hats, and hearing protection. Additional PPE, such as face shields to protect against flying debris or dust masks to prevent inhalation of airborne particulate, may be required and shall be determined as part of the pre-task hazard assessment.

5 TRAINING

Employees that use hand or portable power tools shall be trained and shall be familiar with the safety-related work practices described in this SOP. Training records shall be kept in the employees training file for the term of their employment.

6 REFERENCES

U. S. Department of Labor, Occupational Safety and Health Administration (OSHA). 2002. OSHA 3080: Hand and Power Tools, (Revised).

Revision Log

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00	New Issue	N/A	Jan-2018
01	Removed reference to Scheduled Review Date and updated copyright year.	D. Sheppard	Oct-2019

APPENDIX A
POWERED LAWN MOWERS

Powered Lawn Mowers

Power lawnmowers shall be guarded in accordance with the machine guarding requirements in Occupational Safety and Health Administration (OSHA) 29 Code of Federal Regulations (CFR) 1910.212 (general requirements for all machines).

- ✓ All power-driven chains, belts, and gears shall be so positioned to prevent the operator's accidental contact therewith, during normal starting, mounting, and operation of the machine.
- ✓ A shutoff device shall be provided to stop operation of the motor or engine. This device shall require manual and intentional reactivation to restart the motor or engine.
- ✓ All positions of the operating controls shall be clearly identified.
- ✓ The word "Caution" or similar wording shall be clearly visible at the engine starting point on self-propelled mowers.
- ✓ Be sure the operating control(s) is in neutral before starting the engine.

Walk-Behind and Riding Rotary Mowers

- ✓ The mower blade shall be enclosed except on the bottom and the enclosure shall extend to or below the lowest blade.
- ✓ The word "Caution" or stronger wording shall be placed on the mower at or near each mower hazard.
- ✓ Blade(s) shall stop rotating from the manufacturer's specified maximum speed within 15 seconds after declutching, or shutting off power.
- ✓ In a multiple piece blade, the means of fastening the cutting members to the body of the blade or disc shall be so designed that they will not become worn to a hazardous condition before the cutting members themselves are worn beyond use.

Walk-Behind Rotary Mowers

- ✓ The horizontal angle of the opening(s) in the blade enclosure, intended for the discharge of grass, shall not contact the operator area.
- ✓ There shall be one of the following at all openings in the blade enclosure intended for the discharge of grass:
    - o A minimum unobstructed horizontal distance of 3 inches from the end of the discharge chute to the blade tip circle.

- o A rigid bar fastened across the discharge opening, secured to prevent removal without the use of tools. The bottom of the bar shall be no higher than the bottom edge of the blade enclosure.

- ✓ The highest point(s) of the front of the blade enclosure, except discharge openings, shall be such that any line extending a maximum of 15° downward from the horizontal toward the blade shaft axis (axes) shall not intersect the horizontal plane within the blade tip circle.
- ✓ The mower handle shall be fastened to the mower to prevent loss of control by unintentional uncoupling while in operation.
- ✓ A safety latch shall be provided for the mower handle in the normal operating position(s). The safety latch shall not be subject to unintentional disengagement during normal operation of the mower. The safety latch shall not allow the center or the handle grips to come closer than 17 inches horizontally behind the closest path of the mower blade(s) unless manually disengaged.
- ✓ Wheel drive disengaging controls, except dead man controls, shall move opposite to the direction of the vehicle motion in order to disengage the drive. Dead man controls shall automatically interrupt power to a drive when the operator's actuating force is removed, and may operate in any direction to disengage the drive.

Riding Rotary Motors

- ✓ The highest point(s) of all openings in the blade enclosure front shall be limited by a vertical angle of opening of 15° and a maximum distance of 1.25 inches above the lowest cutting point of the blade in the lowest blade position.
- ✓ Opening(s) shall be placed so that grass or debris will not discharge directly toward any part of an operator seated in a normal operator position. To prevent undesired discharge, note the following:
  - o Ensure a minimum unobstructed horizontal distance of 6 inches from the end of the discharge chute to the blade tip circle.
  - o Fasten a rigid bar across the discharge opening and secure to prevent removal without the use of tools. The bottom of the bar shall be no higher than the bottom edge of the blade enclosure.
- ✓ Mowers shall be provided with stops to prevent jackknifing or locking of the steering mechanism.
- ✓ Vehicle stopping means shall be provided.

Title: Excavation and Trenching

Prepared by: Bill Sass	Reviewed by: David Sheppard

1 Scope and Application

This Standard Operating Procedure (SOP) has been established to protect Ecology & Environment, Inc. (E & E) employees and their representatives from the hazards associated with excavation and trenching activities.

This SOP is based on the Occupational Safety and Health Administration (OSHA) construction safety standards published in Title 29 of the Code of Federal Regulations Part 1926, Subpart P (29 CFR 1926 Subpart P). It applies to E & E fieldwork where excavation equipment is used that results in open excavations, trenches, and/or exploratory test pits. E & E personnel do not operate heavy equipment used for excavation and trenching, but they may conduct work on projects where these activities are taking place by an E & E subcontractor, client contractor, or site responsible party contractor.

2 Definitions and Acronyms

Benching (benching system) a method of protecting employees from cave-ins by excavating the sides of an excavation to form one or a series of horizontal levels or steps, usually with vertical or near-vertical surfaces between levels.

Competent Person one who is capable of identifying existing and predictable hazards in the surroundings, or working conditions which are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them.

CP Competent Person

Excavation any manmade cut, cavity, trench, or depression in an earth surface, formed by earth removal.

Exploratory test pit an excavation, usually open for only a short time, used to examine subsurface soil and/or buried waste for the purpose of visual delineation of subsurface contamination and/or buried waste and/or collection of soil and/or waste samples.

SHASP Health and Safety Plan

Hazardous atmosphere an atmosphere which by reason of being explosive, flammable, poisonous, corrosive, oxidizing, irritating, oxygen deficient, toxic, or otherwise harmful, may cause death, illness, or injury.

LEL Lower explosive limit

LFL	Lower flammability limit
OSHA	Occupational Safety and Health Administration
Protective system	a method of protecting employees from cave-ins, from material that could fall or roll from an excavation face or into an excavation, or from the collapse of adjacent structures. Protective systems include support systems, sloping and benching systems, shield systems, and other systems that provide the necessary protection.
Shield (Shield system)	a structure that is able to withstand the forces imposed on it by a cave-in and thereby protect employees within the structure. Shields can be permanent structures or can be designed to be portable and moved along as work progresses. Additionally, shields can be either pre-manufactured or job-built in accordance with 1926.652(c)(3) or (c)(4). Shields used in trenches are usually referred to as "trench boxes" or "trench shields."
Shoring (Shoring system)	a structure such as a metal hydraulic, mechanical or timber shoring system that supports the sides of an excavation and which is designed to prevent cave-ins.
Sloping (Sloping system)	a method of protecting employees from cave-ins by excavating to form sides of an excavation that are inclined away from the excavation so as to prevent cave-ins. The angle of incline required to prevent a cave-in varies with differences in such factors as the soil type, environmental conditions of exposure, and application of surcharge loads.
Support system	a structure such as underpinning, bracing, or shoring, which provides support to an adjacent structure, underground installation, or the sides of an excavation.
Trench	a narrow excavation (in relation to its length) made below the surface of the ground. In general, the depth is greater than the width, but the width of a trench (measured at the bottom) is not greater than 15 feet (4.6 m). If forms or other structures are installed or constructed in an excavation to reduce the dimension measured from the forms or structure to the side of the excavation to 15 feet (4.6 m) or less (measured at the bottom of the excavation), the excavation is also considered to be a trench.

3 Introduction

Trenching and excavation activities are associated with a variety of potential physical and health hazards. The greatest physical hazards to employees is the potential for cave-ins if working in the trench or excavation. E & E prohibits their employees from entering any trench or excavation greater than 4 feet in depth without taking additional precautions. In cases where E & E employees are required to enter trenches or excavations that are greater than 4 feet in depth, the Daily Excavation Checklist must be completed by E & E's CP and any condition identified as non-compliant on the form must be remediated prior to entering the trench or excavation. The Daily Excavation Checklist is attached at the end of this SOP. E & E employees are also prohibited from working in any excavation regardless of depth when equipment or other material (e.g., piping, trench boxes) are being installed in the excavation. Other physical hazards include falling into an unprotected excavation when working near the leading edge, the presence of mobile equipment within or near the excavation, and potentially encountering underground utilities. Hazardous atmospheres in an excavation can result from volatile contaminants in the soil within the excavation, fumes from equipment staged in or adjacent to the excavation, or from piping or vessels within an excavation. E & E's goal is to protect its employees from these and other hazards on sites where excavations and trenching occurs.

4 Safety Requirements

4.1 Pre-planning

Excavation work requires pre-planning. While E & E employees do not operate equipment and participate in construction/remediation activities, they often work on sites where their subcontractors or contractors from regulatory agencies or other entities are undertaking these activities. Given these circumstances and the potential that E & E employees could potentially enter an excavation for tasks such a sample collection or collecting measurements, E & E will have a competent person (CP) on all sites while excavation/trenching is occurring. The CP will have the necessary experience and training to fulfill this role. While the organization that is conducting the excavation and construction work is directly responsible for ensuring compliance with the OSHA standard, E & E's CP will be familiar with and verify that their subcontractor has addressed the applicable excavation safety requirements.

Prior to engaging in all field activities, E & E staff will prepare a site-specific health and safety plan (SHASP) in compliance with E & E's Corporate Health and Safety Program. This SHASP will cover all tasks conducted by E & E staff, including working in and around excavations.

Another hazard associated with excavations is the potential to hit underground utility lines (e.g., water lines, sewer, electric, gas, communications) and pipes (petroleum, fuel lines, etc.). Prior to initiating excavation the entity actually conducting the excavation is required by law to have underground utilities located. Location will require a call to the state "Call Before You Dig" number (i.e., 811) and/or contracting with a private locating surface that utilizes technologies such as ground penetrating radar to detect buried utilities and pipes. E & E's CP should verify that underground utility location has been completed prior to their subcontractor initiating excavation operations.

Additionally, project personnel should evaluate the presence of surface hazards that could impact the excavation or be impacted by the excavation such as walls or buildings, sidewalks or roads, tools and equipment, vehicles, or spoils piles. These hazards might need to be removed from the excavation area or be supported in some way to prevent damage or collapse.

4.2 Access and Egress

Personnel entering an excavation four feet deep or more will verify that a safe means of access and egress (e.g., stairway, ladder or ramp) is in place and that these structures are located no more than 25 feet from personnel in the excavation at any given time.

4.2.1 Working Around Heavy Equipment and Vehicular Traffic

E & E staff working within an excavation and around heavy equipment and vehicular traffic will wear high visibility clothing (e.g., vests) and hard hats. While in an excavation, employees shall be cognizant of all activities in and around the excavation. Employees will avoid being near or under loads being handling or suspended by equipment. The unpredictable failure of system used to control these loads can cause serious injury or death. Additionally, equipment moving close to the edge of an excavation at the surface can cause a collapse or cause the equipment to fall into the excavation. There should be visual and physical barriers in place to prevent this from occurring.

4.3 Hazardous Atmospheres

Exposure monitoring using real-time instrumentation will be conducted by E & E employees entering an excavation greater than four feet deep where there is a potential for oxygen deficiency (<19.5% oxygen), a flammable or explosive condition (>10 % LEL/LFL), or toxic atmospheres. Monitoring equipment required and action levels for each potential contaminant will be identified in the SHASP. Where appropriate, engineering controls will be used to eliminate hazardous atmospheres. Where oxygen-deficient, flammable, or toxic atmospheres exist, E & E employees will don appropriate respiratory protection and chemical protective clothing as prescribed in the SHASP. Where employees enter excavations with hazardous atmospheres, appropriate emergency rescue equipment and rescue personnel will be available.

4.4 Water Accumulation

Water in an excavation can saturate the soil and cause instability of the excavation wall. It can also make it difficult for employees to move from one place to another or to exit the excavation.

E & E employees will not enter an excavation with standing water. Efforts will be made using appropriate grading, diking, or other methods to prevent surface runoff from entering the excavation. The CP will conduct an inspection of the excavation after rain events and activities that cause ground vibrations. No employee will enter the excavation until the CP determines that it is safe for entry.

4.5 Adjacent Structure Stability

Where the stability of adjoining buildings, walls, or other structures is endangered by excavation operations, support systems such as shoring, bracing, or underpinning shall be provided to ensure the stability of such structures for the protection of employees. Sidewalks, pavements, and appurtenant structures shall not be undermined unless a support system or another method of protection is provided to protect employees from the possible collapse of such structures.

4.6 Loose Rock or Soil

Conditions related to weather, soil moisture content, and vibration could create a hazard in excavations by causing loose rock or soil to fall from the excavation wall. Employees will be protected from this condition by appropriate method, which may include scaling, ice removal, benching, barricading, rock bolting, wire mesh, or other means. Additionally, excavated material will be staged a minimum of two feet from the edge of the excavation. No employee will enter the excavation until the CP determines that it is safe for entry.

4.7 Inspections

The CP will conduct inspections of the excavation areas daily, after rain events, and after other activities or events, as appropriate, to determine whether unsafe conditions exist. Inspections will include the excavation itself, areas adjacent to the excavation, and protective systems. These areas will be evaluated for potential cave-ins, issues with protective systems, hazardous atmospheres, or other conditions that pose a potential hazard to employees. No employee will enter the excavation until the CP determines that it is safe for entry. If unsafe conditions arise (i.e., real-time air monitoring results change from safe to unsafe atmospheres) when employees are in the excavation, the employees will be instructed to immediately vacate the excavation.

4.8 Walkways

Walkways shall be provided where employees or equipment are required or permitted to cross over excavations. Guardrails which comply with 1926.502(b) shall be provided where walkways are 6 feet (1.8 m) or more above lower levels.

5 Protective Systems

Where there is a potential for cave-ins in an excavation employees will be protected using systems such as sloping and/or benching the sides, supporting the sides, or providing shielding between the hazard and the employee. Individual site conditions will be evaluated by the excavation company in agreement with E & E's CP for the most appropriate system to protect employees.

5.1 Sloping and Benching

Sloping and benching options employed by the excavation company will be evaluated by the company's CP. Where E & E employees are expected to enter an excavation, E & E's CP will verify the appropriateness of the system. No employee will enter the excavation until the CP determines that it is safe for entry. Sloping and benching designs will be in accordance with 1926.652(b) and Subpart P, Appendices A and B.

5.2 Support Systems (General)

Where structures adjacent to an excavation (e.g., buildings, walls, sidewalks, pavements) support systems, such as shoring, bracing, or underpinning will be used by the excavation contractor to ensure stability of the structures for the protection of workers entering the excavation. Where support structures are used, E & E's CP will verify the appropriateness of the system and E & E employees will not enter the excavation until the CP determines that it is safe for entry. Support systems will be designed in accordance with 1926.652(c) through 1926.652(e) and Subpart P, Appendices A, C, and D.

5.3 Shield Systems

Excavation shield systems will not be subjected to loads exceeding what they were designed to withstand and installed in a manner that restricts movement should it be subjected to sudden loads.

6 References

U.S. Army Corps of Engineers (USACE). 2014. Safety and Health Requirements, Manual No. 385-1-1, Section 25 – Excavation and Trenching, 30 November 2014.

U.S. Department of Labor, Occupational Safety and Health Administration (OSHA). 2015. Trenching and Excavation Safety, OSHA 2226-10R 2015.

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00	New Issue	N/A	Jan-2018
01	Removed reference to Scheduled Review Date and updated copyright year.	D. Sheppard	Oct=2019

DAILY EXCAVATION CHECKLIST

Client		**Date**	
Project Name		**Ambient Temperature**	
Project Location		**Wind Direction**	
Job Number		**Safety Representative**	
Excavation Depth/Width		**Soil Classification**	
Protective System Used			
Activities In Excavation			
Competent Person(s)			

***NOTE:* Any items marked *NO* on this form *MUST* be remediated prior to any employees entering the excavation.**

YES	NO	N/A	DESCRIPTION
General			
☐	☐	☐	Employees protected from cave-ins and loose rock/soil that could roll into the excavation.
☐	☐	☐	Spoils, materials and equipment set back at least 2 feet from the edge of the excavation.
☐	☐	☐	Protective systems are adequate and in good condition.
☐	☐	☐	Barriers provided at all remotely located excavations, wells, pits, shafts, etc.
☐	☐	☐	Surface encumbrances removed or supported.
☐	☐	☐	Areas on faces of sloped or benched sides above scheduled work areas within excavation are free of excavation work that could affect the safety of employees in the excavation.
☐	☐	☐	Adequate signs posted and barricades provided.
☐	☐	☐	Training (toolbox meeting) conducted w/ employees prior to entering excavation.
☐	☐	☐	Vehicles or equipment parked or stored a safe distance away from edge of excavation.
Utilities			
☐	☐	☐	All buried utilities (both public and private) located and marked.
☐	☐	☐	Overhead lines located, noted and reviewed with the excavator operator.
☐	☐	☐	Utility locations reviewed with equipment operator(s), and precautions taken to ensure contact/damage does not occur.
☐	☐	☐	Utilities crossing the excavation supported and protected from falling materials.
☐	☐	☐	Underground installations protected, supported or removed when excavation is open.
Wet Conditions			
☐	☐	☐	Precautions taken to protect employees from water accumulation (continuous dewatering).
☐	☐	☐	Surface water or runoff diverted /controlled to prevent accumulation in the excavation.
☐	☐	☐	Inspection made after every rainstorm or other hazard increasing occurrence.
Hazardous Atmospheres			
☐	☐	☐	Air in the excavation tested for oxygen deficiency, combustibles, other contaminants.
☐	☐	☐	Oxygen concentrations at least 19.5%; LEL <10%; and all vapors/gases below the lowest occupational exposure limit (OEL).
☐	☐	☐	If NO to above: Is ventilation effective in maintaining atmospheres with adequate oxygen (19.5% or greater); and/or LEL <10%; and/or contains hazardous substances below OEL?
☐	☐	☐	Ventilation effective to provide ambient oxygen levels above 19.5% **(If NO, employees must use a supplied air respirator).**
☐	☐	☐	Ventilation effective to reduce LEL below 10% **(If NO, employees may not enter excavation).**
☐	☐	☐	Ventilation effective to reduce hazardous substance concentrations below the OEL **(If NO, employees must use appropriate type of respiratory protection).**
☐	☐	☐	Emergency equipment available where hazardous atmospheres could or do exist.
☐	☐	☐	Safety harness and lifeline used.
Entry & Exit			
☐	☐	☐	Exit (i.e. ladder, sloped wall) no further than 25 feet from ANY employee.
☐	☐	☐	Ladders secured and extend 3 feet above the edge of the trench.
☐	☐	☐	Wood ramps constructed of uniform material thickness, cleated together at the bottom.
☐	☐	☐	Employees protected from cave-ins when entering or exiting the excavation.

Community Air Monitoring Plans

Introduction

Community Air Monitoring Plan (CAMP) programs require real-time monitoring for particulates (i.e., dust) and/or volatile organic compounds (VOCs) at the upwind and downwind perimeters and adjacent to the nearest commercial or residential structure within the work area when certain activities are in progress at a site. The CAMP is not intended for use in establishing action levels for worker respiratory protection. Rather, its intent is to provide protection for residents within the designated work area and the downwind community (e.g., off-site potential receptors including adjacent and other nearby residences and local pedestrians not involved with the subject work activities) from potential airborne contaminant releases as a direct result of remedial investigation or construction activities. The action levels specified herein require monitoring and, when necessary, corrective actions to abate emissions, and/or shutdown work. Additionally, the CAMP helps to confirm that work activities did not spread contamination off-site through the air.

Reliance on the CAMP should not preclude simple, common-sense measures, including visual observations, to keep dust or odors at a minimum around the work areas.

Particulate Monitoring, Response Levels, and Actions

Particulate concentrations shall be monitored continuously with temporary particulate monitoring stations at the upwind and downwind perimeters of the work zone (most often at the property parcel boundary), as well as at the door or window of an on-site commercial or residential structure nearest the intrusive activities. In addition, upwind and downwind particulate monitoring will occur at temporary soil staging areas and when a contaminated soil stockpile is not covered.

Particulate monitoring shall be performed using real-time monitoring equipment capable of measuring particulate matter less than 10 micrometers in size (PM-10) and capable of determining a 15-minute time-weighted average by integrating over a period of 15 minutes for comparison to the airborne particulate action level. The equipment shall be equipped with a visual and/or audible alarm to indicate exceedance of the action level. In addition, the potential for fugitive dust migration shall be visually assessed during all work activities.

In addition, the following activity requirements apply:

- Dust monitoring (both real time and documentation monitoring) shall be conducted by a designated person with communication to the project manager, resident engineer, and contractor whenever intrusive activities (such as excavation) are performed.

- Air monitoring equipment will be operated by personnel trained in the use of the specific equipment provided. A log of the location, time, type, and value of each reading will be maintained.

- A written copy of the real time air monitoring results for each work day will be kept and shall include an appropriately scaled map of the work area depicting monitoring locations, wind direction and other appropriate symbols.

- If the downwind or on-site PM-10 particulate level is 100 µg/m^3 greater than background (upwind perimeter location) during any 15-minute period, or if airborne dust is observed leaving the work area, then dust suppression techniques must be employed. Work may continue with dust suppression techniques provided that downwind or on-site PM-10 particulate levels do not exceed 150 µg/m^3 above the upwind level and provided that no visible dust is migrating from the work area.

- If, after implementation of dust suppression techniques, downwind or on-site PM-10 particulate levels are greater than 150 µg/m^3 above the upwind level, work must be stopped, and work activities must be reevaluated. Work can resume if dust suppression measures and other controls are successful in reducing the downwind or on-site PM-10 particulate concentration to within 150 µg/m^3 of the upwind level and in preventing visible dust migration.

Dust monitoring locations will be determined on at least a daily basis and are subject to change throughout the day based on actual field conditions such as wind direction, the location of excavation activities, and the location of the nearest downwind receptor.

Volatile Organic Compound Monitoring, Response Levels, and Actions

Periodic monitoring for VOCs will be required during both intrusive and non-intrusive activities (such the collection of groundwater samples from monitoring wells) for sites with significant VOC contamination. "Periodic" monitoring during sample collection might reasonably consist of taking a reading upon arrival at a sample location, monitoring while opening a well cap, monitoring during well baling/purging, and taking a reading prior to leaving a sample location. In some instances, depending upon the proximity of potentially exposed individuals and anticipated contaminant concentrations, continuous monitoring may be required during sampling activities. Examples of such situations include groundwater sampling at contaminated wells along busy urban street, in the midst of a public park, or adjacent to a residence.

For intrusive activities such as drilling and direct push sampling, VOCs must be monitored at the downwind perimeter of the immediate work area (i.e., the exclusion zone) at intervals of no more than 30 minutes. Upwind concentrations should be measured at the start of each workday and periodically thereafter to establish background conditions. VOC monitoring work should be performed using equipment appropriate to measure the types of contaminants known or suspected to be present. For example, for total organic vapor concentrations, a photo-ionization detector (PID) should be used. For specific contaminants, gas detector tubes or gas-specific meters may be employed. The equipment should be calibrated at least daily for the contaminant(s) of concern or for an appropriate surrogate.

VOC Response Levels:

- If the sustained ambient air concentration of total organic vapors at the downwind perimeter of the work area or exclusion zone exceeds 1 part per million (ppm) above background, work activities must be temporarily halted and monitoring continued. If the total organic vapor level readily decreases (per instantaneous readings) below 1 ppm over background, work activities can resume with continuous monitoring.

- If sustained total organic vapor levels at the downwind perimeter of the work area or exclusion zone persist at levels in excess of 1 ppm over background but less than 5 ppm, work activities must be halted, the source of vapors identified, corrective actions taken to abate emissions, and monitoring continued. After these steps, work activities can resume provided that the total organic vapor level 100 feet downwind of the exclusion zone or half the distance to the nearest potential receptor or residential/commercial structure, whichever is less - but in no case less than 20 feet, is below 1 ppm.

- If the organic vapor level is above 5 ppm at the perimeter of the work area, activities must be shutdown and mitigative measures implemented before work can continue.

All readings will be recorded in the health and safety field notebook and/or specific daily monitoring forms developed for a project.

Appendix D

PFAS Guidance and Protocols

NEW YORK STATE OF OPPORTUNITY | Department of Environmental Conservation

SAMPLING, ANALYSIS, AND ASSESSMENT OF PER- AND POLYFLUOROALKYL SUBSTANCES (PFAS)

Under NYSDEC's Part 375 Remedial Programs

April 2023

www.dec.ny.gov

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New York State of Opportunity | Department of Environmental Conservation

ERRATA SHEET for

SAMPLING, ANALYSIS, AND ASSESSMENT OF PER- AND POLYFLUOROALKYL SUBSTANCES (PFAS) Under NYSDEC's Part 375 Remedial Programs Issued January 17, 2020

Citation and Page Number	Current Text	Corrected Text	Date
Title of Appendix I, page 32	Appendix H	Appendix I	2/25/2020
Document Cover, page 1	Guidelines for Sampling and Analysis of PFAS	Sampling, Analysis, and Assessment of Per- and Polyfluoroalkyl Substances (PFAS) Under NYSDEC's Part 375 Remedial Programs	9/15/2020
Data Assessment and Application to Site Cleanup Page 3	Until such time as Ambient Water Quality Standards (AWQS) and Soil Cleanup Objectives (SCOs) for PFOA and PFOS are published	Until such time as Soil Cleanup Objectives (SCOs) for PFOA and PFOS are published	3/28/2023
Water Sample Results Page 3	PFOA and PFOS should be further assessed and considered as potential contaminants of concern in groundwater or surface water if PFOA or PFOS is detected in any water sample at or above 10 ng/L (ppt) and is determined to be attributable to the site, either by a comparison of upgradient and downgradient levels, or the presence of soil source areas, as defined below.	NYSDEC has adopted ambient water quality guidance values for PFOA and PFOS. Groundwater samples should be compared to the human health criteria of 6.7 ng/l (ppt) for PFOA and 2.7 ng/l (ppt) for PFOS. These guidance values also include criteria for surface water for PFOS applicable for aquatic life, which may be applicable at some sites. Drinking water sample results should be compared to the NYS maximum contaminant level (MCL) of 10 ng/l (ppt).Analysis to determine if PFOA and PFOS concentrations are attributable to the site should include a comparison between upgradient and downgradient levels, and the presence of soil source areas, as defined below.	3/28/2023
Soil Sample Results Page 3	Soil cleanup objectives for PFOA and PFOS have been proposed in an upcoming revision to 6 NYCRR Part 375-6. Until SCOs are in effect, the following are to be used as guidance values:	NYSDEC will delay adding soil cleanup objectives for PFOA and PFOS to 6 NYCRR Part 375-6 until the PFAS rural soil background study has been completed. Until SCOs are in effect, the following are to be used as guidance values:	3/28/2023
Protection of Groundwater Page 3	PFOA (ppb) 1.1 PFOS (ppb) 3.7	PFOA (ppb) 0.8 PFOS (ppb) 1.0	3/28/2023

Citation and Page Number	Current Text	Corrected Text	Date
Footnote 2 Page 3	The movement of PFAS in the environment is being aggressively researched at this time; that research will eventually result in more accurate models for the behaviors of these chemicals. In the meantime, DEC has calculated the guidance value for the protection of groundwater using the same procedure used for all other chemicals, as described in Section 7.7 of the Technical Support Document (http://www.dec.ny.gov/docs/remediation_hudson_pdf/techsuppdoc.pdf).	The Protection of Groundwater values are based on the above referenced ambient groundwater guidance values. Details on that calculation are available in the following document, prepared for the February 2022 proposed changes to Part 375 (https://www.dec.ny.gov/docs/remediation_hudson_pdf/part375techsupport.pdf). The movement of PFAS in the environment is being aggressively researched at this time; that research will eventually result in more accurate models for the behaviors of these chemicals. In the meantime, DEC has calculated the guidance value for the protection of groundwater using the same procedure used for all other chemicals, as described in Section 7.7 of the Technical Support Document (http://www.dec.ny.gov/docs/remediation_hudson_pdf/techsuppdoc.pdf).	3/28/2023
Testing for Imported Soil Page 4	If the concentrations of PFOA and PFOS in leachate are at or above 10 ppt (the Maximum Contaminant Levels established for drinking water by the New York State Department of Health), then the soil is not acceptable.	If the concentrations of PFOA and PFOS in leachate are at or above the ambient water quality guidance values for groundwater, then the soil is not acceptable.	3/28/2023
Routine Analysis, page 9	"However, laboratories analyzing environmental samples…PFOA and PFOS in drinking water by EPA Method 537, 537.1 or ISO 25101."	"However, laboratories analyzing environmental samples…PFOA and PFOS in drinking water by EPA Method 537, 537.1, ISO 25101, or Method 533."	9/15/2020
Additional Analysis, page 9, new paragraph regarding soil parameters	None	"In cases where site-specific cleanup objectives for PFOA and PFOS are to be assessed, soil parameters, such as Total Organic Carbon (EPA Method 9060), soil pH (EPA Method 9045), clay content (percent), and cation exchange capacity (EPA Method 9081), should be included in the analysis to help evaluate factors affecting the leachability of PFAS in site soils."	9/15/2020

Citation and Page Number	Current Text	Corrected Text	Date
Data Assessment and Application to Site Cleanup Page 10	Until such time as Ambient Water Quality Standards (AWQS) and Soil Cleanup Objectives (SCOs) for PFAS are published, the extent of contaminated media potentially subject to remediation should be determined on a case-by-case basis using the procedures discussed below and the criteria in DER-10. Target levels for cleanup of PFAS in other media, including biota and sediment, have not yet been established by the DEC.	Until such time as Ambient Water Quality Standards (AWQS) and Soil Cleanup Objectives (SCOs) for PFOA and PFOS are published, the extent of contaminated media potentially subject to remediation should be determined on a case-by-case basis using the procedures discussed below and the criteria in DER-10. Preliminary target levels for cleanup of PFOA and PFOS in other media, including biota and sediment, have not yet been established by the DEC.	9/15/2020
Water Sample Results Page 10	PFAS should be further assessed and considered as a potential contaminant of concern in groundwater or surface water (…) If PFAS are identified as a contaminant of concern for a site, they should be assessed as part of the remedy selection process in accordance with Part 375 and DER-10.	PFOA and PFOS should be further assessed and considered as potential contaminants of concern in groundwater or surface water (…) If PFOA and/or PFOS are identified as contaminants of concern for a site, they should be assessed as part of the remedy selection process in accordance with Part 375 and DER-10.	9/15/2020

Citation and Page Number	Current Text	Corrected Text	Date
Soil Sample Results, page 10	"The extent of soil contamination for purposes of delineation and remedy selection should be determined by having certain soil samples tested by Synthetic Precipitation Leaching Procedure (SPLP) and the leachate analyzed for PFAS. Soil exhibiting SPLP results above 70 ppt for either PFOA or PFOS (individually or combined) are to be evaluated during the cleanup phase."	"Soil cleanup objectives for PFOA and PFOS will be proposed in an upcoming revision to 6 NYCRR Part 375-6. Until SCOs are in effect, the following are to be used as guidance values. " [Interim SCO Table] "PFOA and PFOS results for soil are to be compared against the guidance values listed above. These guidance values are to be used in determining whether PFOA and PFOS are contaminants of concern for the site and for determining remedial action objectives and cleanup requirements. Site-specific remedial objectives for protection of groundwater can also be presented for evaluation by DEC. Development of site-specific remedial objectives for protection of groundwater will require analysis of additional soil parameters relating to leachability. These additional analyses can include any or all the parameters listed above (soil pH, cation exchange capacity, etc.) and/or use of SPLP. As the understanding of PFAS transport improves, DEC welcomes proposals for site-specific remedial objectives for protection of groundwater. DEC will expect that those may be dependent on additional factors including soil pH, aqueous pH, % organic carbon, % Sand/Silt/Clay, soil cations: K, Ca, Mg, Na, Fe, Al, cation exchange capacity, and anion exchange capacity. Site-specific remedial objectives should also consider the dilution attenuation factor (DAF). The NJDEP publication on DAF can be used as a reference: https://www.nj.gov/dep/srp/guidance/rs/daf.pdf. "	9/15/2020

Citation and Page Number	Current Text	Corrected Text	Date
Testing for Imported Soil Page 11	Soil imported to a site for use in a soil cap, soil cover, or as backfill is to be tested for PFAS in general conformance with DER-10, Section 5.4(e) for the PFAS Analyte List (Appendix F) using the analytical procedures discussed below and the criteria in DER-10 associated with SVOCs. If PFOA or PFOS is detected in any sample at or above 1 µg/kg, then soil should be tested by SPLP and the leachate analyzed for PFAS. If the SPLP results exceed 10 ppt for either PFOA or PFOS (individually) then the source of backfill should be rejected, unless a site-specific exemption is provided by DER. SPLP leachate criteria is based on the Maximum Contaminant Levels proposed for drinking water by New York State's Department of Health, this value may be updated based on future Federal or State promulgated regulatory standards. Remedial parties have the option of analyzing samples concurrently for both PFAS in soil and in the SPLP leachate to minimize project delays. Category B deliverables should be submitted for backfill samples, though a DUSR is not required.	Testing for PFAS should be included any time a full TAL/TCL analyte list is required. Results for PFOA and PFOS should be compared to the applicable guidance values. If PFOA or PFOS is detected in any sample at or above the guidance values then the source of backfill should be rejected, unless a site-specific exemption is provided by DER based on SPLP testing, for example. If the concentrations of PFOA and PFOS in leachate are at or above 10 ppt (the Maximum Contaminant Levels established for drinking water by the New York State Department of Health), then the soil is not acceptable. PFOA, PFOS and 1,4-dioxane are all considered semi-volatile compounds, so composite samples are appropriate for these compounds when sampling in accordance with DER-10, Table 5.4(e)10. Category B deliverables should be submitted for backfill samples, though a DUSR is not required.	9/15/2020

Citation and Page Number	Current Text	Corrected Text	Date
Footnotes	None	[1] TOP Assay analysis of highly contaminated samples, such as those from an AFFF (aqueous film-forming foam) site, can result in incomplete oxidation of the samples and an underestimation of the total perfluoroalkyl substances. [2] The movement of PFAS in the environment is being aggressively researched at this time; that research will eventually result in more accurate models for the behaviors of these chemicals. In the meantime, DEC has calculated the soil cleanup objective for the protection of groundwater using the same procedure used for all other chemicals, as described in Section 7.7 of the Technical Support Document (http://www.dec.ny.gov/docs/remediation_hudson_pdf/techsuppdoc.pdf).	9/15/2020
Additional Analysis, page 9	In cases… soil parameters, such as Total Organic Carbon (EPA Method 9060), soil…	In cases… soil parameters, such as Total Organic Carbon (Lloyd Kahn), soil…	1/8/2021
Appendix A, General Guidelines, fourth bullet	List the ELAP-approved lab(s) to be used for analysis of samples	List the ELAP- certified lab(s) to be used for analysis of samples	1/8/2021
Appendix E, Laboratory Analysis and Containers	Drinking water samples collected using this protocol are intended to be analyzed for PFAS by ISO Method 25101.	Drinking water samples collected using this protocol are intended to be analyzed for PFAS by EPA Method 537, 537.1, 533, or ISO Method 25101	1/8/2021
Water Sample Results Page 9	"In addition, further assessment of water may be warranted if either of the following screening levels are met: a. any other individual PFAS (not PFOA or PFOS) is detected in water at or above 100 ng/L; or b. total concentration of PFAS (including PFOA and PFOS) is detected in water at or above 500 ng/L"	Deleted	6/15/2021

Citation and Page Number	Current Text	Corrected Text	Date
Routine Analysis, Page XX	Currently, New York State Department of Health's Environmental Laboratory Approval Program (ELAP)… criteria set forth in the DER's laboratory guidelines for PFAS in non-potable water and solids (Appendix H - Laboratory Guidelines for Analysis of PFAS in Non-Potable Water and Solids).	Deleted	5/31/2022
Analysis and Reporting, Page XX	As of October 2020, the United States Environmental Protection Agency (EPA) does not have a validated method for analysis of PFAS for media commonly analyzed under DER remedial programs (non-potable waters, solids). DER has developed the following guidelines to ensure consistency in analysis and reporting of PFAS.	Deleted	5/31/2022
Routine Analysis, Page XX	LC-MS/MS analysis for PFAS using methodologies based on EPA Method 537.1 is the procedure to use for environmental samples. Isotope dilution techniques should be utilized for the analysis of PFAS in all media.	EPA Method 1633 is the procedure to use for environmental samples.	
Soil Sample Results, Page XX	Soil cleanup objectives for PFOA and PFOS will be proposed in an upcoming revision to 6 NYCRR Part 375-6	Soil cleanup objectives for PFOA and PFOS have been proposed in an upcoming revision to 6 NYCRR Part 375-6	
Appendix A	"Include in the text… LC-MS/MS for PFAS using methodologies based on EPA Method 537.1"	"Include in the text ….EPA Method 1633"	
Appendix A	"Laboratory should have ELAP certification for PFOA and PFOS in drinking water by EPA Method 537, 537.1, EPA Method 533, or ISO 25101"	Deleted	
Appendix B	"Samples collected using this protocol are intended to be analyzed for PFAS using methodologies based on EPA Method 537.1"	"Samples collected using this protocol are intended to be analyzed for PFAS using EPA Method 1633"	

Citation and Page Number	Current Text	Corrected Text	Date
Appendix C	"Samples collected using this protocol are intended to be analyzed for PFAS using methodologies based on EPA Method 537.1"	"Samples collected using this protocol are intended to be analyzed for PFAS using EPA Method 1633"	
Appendix D	"Samples collected using this protocol are intended to be analyzed for PFAS using methodologies based on EPA Method 537.1"	"Samples collected using this protocol are intended to be analyzed for PFAS using EPA Method 1633"	
Appendix G		Updated to include all forty PFAS analytes in EPA Method 533	
Appendix H		Deleted	
Appendix I	Appendix I	Appendix H	
Appendix H	"These guidelines are intended to be used for the validation of PFAS analytical results for projects within the Division of Environmental Remediation (DER) as well as aid in the preparation of a data usability summary report."	"These guidelines are intended to be used for the validation of PFAS using EPA Method 1633 for projects within the Division of Environmental Remediation (DER)."	
Appendix H	"The holding time is 14 days…"	"The holding time is 28 days…"	
Appendix H, Initial Calibration	"The initial calibration should contain a minimum of five standards for linear fit…"	"The initial calibration should contain a minimum of six standards for linear fit…"	
Appendix H, Initial Calibration	Linear fit calibration curves should have an R^2 value greater than 0.990.	Deleted	
Appendix H, Initial Calibration Verification	Initial Calibration Verification Section	Deleted	
Appendix H	secondary Ion Monitoring Section	Deleted	
Appendix H	Branched and Linear Isomers Section	Deleted	

NEW YORK STATE OF OPPORTUNITY | Department of Environmental Conservation

Sampling, Analysis, and Assessment of Per- and Polyfluoroalkyl Substances (PFAS) Under NYSDEC's Part 375 Remedial Programs

Objective

New York State Department of Environmental Conservation's Division of Environmental Remediation (DER) performs or oversees sampling of environmental media and subsequent analysis of PFAS as part of remedial programs implemented under 6 NYCRR Part 375. To ensure consistency in sampling, analysis, reporting, and assessment of PFAS, DER has developed this document which summarizes currently accepted procedures and updates previous DER technical guidance pertaining to PFAS.

Applicability

All work plans submitted to DEC pursuant to one of the remedial programs under Part 375 shall include PFAS sampling and analysis procedures that conform to the guidelines provided herein.

As part of a site investigation or remedial action compliance program, whenever samples of potentially affected media are collected and analyzed for the standard Target Analyte List/Target Compound List (TAL/TCL), PFAS analysis should also be performed. Potentially affected media can include soil, groundwater, surface water, and sediment. Based upon the potential for biota to be affected, biota sampling and analysis for PFAS may also be warranted as determined pursuant to a Fish and Wildlife Impact Analysis. Soil vapor sampling for PFAS is not required.

Field Sampling Procedures

DER-10 specifies technical guidance applicable to DER's remedial programs. Given the prevalence and use of PFAS, DER has developed "best management practices" specific to sampling for PFAS. As specified in DER-10 Chapter 2, quality assurance procedures are to be submitted with investigation work plans. Typically, these procedures are incorporated into a work plan, or submitted as a stand-alone document (e.g., a Quality Assurance Project Plan). Quality assurance guidelines for PFAS are listed in Appendix A - Quality Assurance Project Plan (QAPP) Guidelines for PFAS.

Field sampling for PFAS performed under DER remedial programs should follow the appropriate procedures outlined for soils, sediments, or other solids (Appendix B), non-potable groundwater (Appendix C), surface water (Appendix D), public or private water supply wells (Appendix E), and fish tissue (Appendix F).

QA/QC samples (e.g. duplicates, MS/MSD) should be collected as specified in DER-10, Section 2.3(c). For sampling equipment coming in contact with aqueous samples only, rinsate or equipment blanks should be collected. Equipment blanks should be collected at a minimum frequency of one per day per site or one per twenty samples, whichever is more frequent.

Analysis and Reporting

The investigation work plan should describe analysis and reporting procedures, including laboratory analytical procedures for the methods discussed below. As specified in DER-10 Section 2.2, laboratories should provide a full Category B deliverable. In addition, a Data Usability Summary Report (DUSR) should be prepared by an independent, third-party data validator. Electronic data submissions should meet the requirements provided at: https://www.dec.ny.gov/chemical/62440.html.

DER has developed a *PFAS Analyte List* (Appendix G) for remedial programs to understand the nature of contamination at sites. It is expected that reported results for PFAS will include, at a minimum, all the compounds listed. If lab and/or matrix specific issues are encountered for any analytes, the DER project manager, in consultation with the DER chemist, will make case-by-case decisions as to whether certain analytes may be temporarily or permanently discontinued from analysis at each site. As with other contaminants that are analyzed for at a site, the *PFAS Analyte List* may be refined for future sampling events based on investigative findings.

Routine Analysis

EPA Method 1633 is the procedure to use for environmental samples. Reporting limits for PFOA and PFOS in aqueous samples should not exceed 2 ng/L. Reporting limits for PFOA and PFOS in solid samples should not exceed 0.5 µg/kg. Reporting limits for all other PFAS in aqueous and solid media should be as close to these limits as possible. If laboratories indicate that they are not able to achieve these reporting limits for the entire *PFAS Analyte List*, site-specific decisions regarding acceptance of elevated reporting limits for specific PFAS can be made by the DER project manager in consultation with the DER chemist. Data review guidelines were developed by DER to ensure data comparability and usability (Appendix H - Data Review Guidelines for Analysis of PFAS in Non-Potable Water and Solids).

Additional Analysis

Additional laboratory methods for analysis of PFAS may be warranted at a site, such as the Synthetic Precipitation Leaching Procedure (SPLP) and Total Oxidizable Precursor Assay (TOP Assay).

In cases where site-specific cleanup objectives for PFOA and PFOS are to be assessed, soil parameters, such as Total Organic Carbon (Lloyd Kahn), soil pH (EPA Method 9045), clay content (percent), and cation exchange capacity (EPA Method 9081), should be included in the analysis to help evaluate factors affecting the leachability of PFAS in site soils.

SPLP is a technique used to determine the mobility of chemicals in liquids, soils and wastes, and may be useful in determining the need for addressing PFAS-containing material as part of the remedy. SPLP by EPA Method 1312 should be used unless otherwise specified by the DER project manager in consultation with the DER chemist.

Impacted materials can be made up of PFAS that are not analyzable by routine analytical methodology. A TOP Assay can be utilized to conceptualize the amount and type of oxidizable PFAS which could be liberated in the environment, which approximates the maximum concentration of perfluoroalkyl substances that could be generated if all polyfluoroalkyl substances were oxidized. For example, some polyfluoroalkyl substances may degrade or transform to form perfluoroalkyl substances (such as PFOA or PFOS), resulting in an increase in perfluoroalkyl substance concentrations as contaminated groundwater moves away from a source. The TOP Assay converts, through oxidation, polyfluoroalkyl substances (precursors) into perfluoroalkyl substances that can be detected by routine analytical methodology.[1]

[1] TOP Assay analysis of highly contaminated samples, such as those from an AFFF (aqueous film-forming foam) site, can result in incomplete oxidation of the samples and an underestimation of the total perfluoroalkyl substances.

Commercial laboratories have adopted methods which allow for the quantification of targeted PFAS in air and biota. The EPA's Office of Research and Development (ORD) is currently developing methods which allow for air emissions characterization of PFAS, including both targeted and non-targeted analysis of PFAS. Consult with the DER project manager and the DER chemist for assistance on analyzing biota/tissue and air samples.

Data Assessment and Application to Site Cleanup

Until such time as Soil Cleanup Objectives (SCOs) for PFOA and PFOS are published, the extent of contaminated media potentially subject to remediation should be determined on a case-by-case basis using the procedures discussed below and the criteria in DER-10. Preliminary target levels for cleanup of PFOA and PFOS in other media, including biota and sediment, have not yet been established by the DEC.

Water Sample Results

NYSDEC has adopted ambient water quality guidance values for PFOA and PFOS. Groundwater samples should be compared to the human health criteria of 6.7 ng/l (ppt) for PFOA and 2.7 ng/l (ppt) for PFOS. These human health criteria should also be applied to surface water that is used as a water supply. This guidance also includes criteria for surface water for PFOS applicable for aquatic life, which may be applicable at some sites. Drinking water sample results should be compared to the NYS maximum contaminant level (MCL) of 10 ng/l (ppt). Analysis to determine if PFOA and PFOS concentrations are attributable to the site should include a comparison between upgradient and downgradient levels, and the presence of soil source areas, as defined below.

If PFOA and/or PFOS are identified as contaminants of concern for a site, they should be assessed as part of the remedy selection process in accordance with Part 375 and DER-10.

Soil Sample Results

NYSDEC will delay adding soil cleanup objectives for PFOA and PFOS to 6 NYCRR Part 375-6 until the PFAS rural soil background study has been completed. Until SCOs are in effect, the following are to be used as guidance values:

Guidance Values for Anticipated Site Use	PFOA (ppb)	PFOS (ppb)
Unrestricted	0.66	0.88
Residential	6.6	8.8
Restricted Residential	33	44
Commercial	500	440
Industrial	600	440
Protection of Groundwater[2]	0.8	1.0

PFOA and PFOS results for soil are to be compared against the guidance values listed above. These guidance values are to be used in determining whether PFOA and PFOS are contaminants of concern for the site and for determining remedial action objectives and cleanup requirements. Site-specific remedial objectives for protection of groundwater can also be presented for evaluation by DEC. Development of site-specific remedial objectives for protection of groundwater will require analysis of additional soil parameters relating to leachability. These

[2] The Protection of Groundwater values are based on the above referenced ambient groundwater guidance values. Details on that calculation are available in the following document, prepared for the February 2022 proposed changes to Part 375 (https://www.dec.ny.gov/docs/remediation_hudson_pdf/part375techsupport.pdf). The movement of PFAS in the environment is being aggressively researched at this time; that research will eventually result in more accurate models for the behaviors of these chemicals. In the meantime, DEC has calculated the guidance value for the protection of groundwater using the same procedure used for all other chemicals, as described in Section 7.7 of the Technical Support Document (http://www.dec.ny.gov/docs/remediation_hudson_pdf/techsuppdoc.pdf).

additional analyses can include any or all the parameters listed above (soil pH, cation exchange capacity, etc.) and/or use of SPLP.

As the understanding of PFAS transport improves, DEC welcomes proposals for site-specific remedial objectives for protection of groundwater. DEC will expect that those may be dependent on additional factors including soil pH, aqueous pH, % organic carbon, % Sand/Silt/Clay, soil cations: K, Ca, Mg, Na, Fe, Al, cation exchange capacity, and anion exchange capacity. Site-specific remedial objectives should also consider the dilution attenuation factor (DAF). The NJDEP publication on DAF can be used as a reference: https://www.nj.gov/dep/srp/guidance/rs/daf.pdf.

Testing for Imported Soil

Testing for PFAS should be included any time a full TAL/TCL analyte list is required. Results for PFOA and PFOS should be compared to the applicable guidance values. If PFOA or PFOS is detected in any sample at or above the guidance values then the source of backfill should be rejected, unless a site-specific exemption is provided by DER based on SPLP testing, for example. If the concentrations of PFOA and PFOS in leachate are at or above the ambient water quality guidance values for groundwater, then the soil is not acceptable.

PFOA, PFOS and 1,4-dioxane are all considered semi-volatile compounds, so composite samples are appropriate for these compounds when sampling in accordance with DER-10, Table 5.4(e)10. Category B deliverables should be submitted for backfill samples, though a DUSR is not required.

Appendix A - Quality Assurance Project Plan (QAPP) Guidelines for PFAS

The following guidelines (general and PFAS-specific) can be used to assist with the development of a QAPP for projects within DER involving sampling and analysis of PFAS.

General Guidelines in Accordance with DER-10

- Document/work plan section title – Quality Assurance Project Plan
- Summarize project scope, goals, and objectives
- Provide project organization including names and resumes of the project manager, Quality Assurance Officer (QAO), field staff, and Data Validator
  - The QAO should not have another position on the project, such as project or task manager, that involves project productivity or profitability as a job performance criterion
- List the ELAP certified lab(s) to be used for analysis of samples
- Include a site map showing sample locations
- Provide detailed sampling procedures for each matrix
- Include Data Quality Usability Objectives
- List equipment decontamination procedures
- Include an "Analytical Methods/Quality Assurance Summary Table" specifying:
  - Matrix type
  - Number or frequency of samples to be collected per matrix
  - Number of field and trip blanks per matrix
  - Analytical parameters to be measured per matrix
  - Analytical methods to be used per matrix with minimum reporting limits
  - Number and type of matrix spike and matrix spike duplicate samples to be collected
  - Number and type of duplicate samples to be collected
  - Sample preservation to be used per analytical method and sample matrix
  - Sample container volume and type to be used per analytical method and sample matrix
  - Sample holding time to be used per analytical method and sample matrix
- Specify Category B laboratory data deliverables and preparation of a DUSR

Specific Guidelines for PFAS

- Include in the text that sampling for PFAS will take place
- Include in the text that PFAS will be analyzed by EPA Method 1633
- Include the list of PFAS compounds to be analyzed (*PFAS Analyte List*)
- Include the laboratory SOP for PFAS analysis
- List the minimum method-achievable Reporting Limits for PFAS
  - Reporting Limits should be less than or equal to:
    - Aqueous – 2 ng/L (ppt)
    - Solids – 0.5 µg/kg (ppb)
- Include the laboratory Method Detection Limits for the PFAS compounds to be analyzed
-
- Include detailed sampling procedures
  - Precautions to be taken
  - Pump and equipment types
  - Decontamination procedures
  - Approved materials only to be used
- Specify that regular ice only will be used for sample shipment
- Specify that equipment blanks should be collected at a minimum frequency of 1 per day per site for each matrix

Appendix B - Sampling Protocols for PFAS in Soils, Sediments and Solids

General

The objective of this protocol is to give general guidelines for the collection of soil, sediment and other solid samples for PFAS analysis. The sampling procedure used should be consistent with Sampling Guidelines and Protocols – Technological Background and Quality Control/Quality Assurance for NYS DEC Spill Response Program – March 1991 (http://www.dec.ny.gov/docs/remediation_hudson_pdf/sgpsect5.pdf), with the following limitations.

Laboratory Analysis and Containers

Samples collected using this protocol are intended to be analyzed for PFAS using EPA Method 1633.

The preferred material for containers is high density polyethylene (HDPE). Pre-cleaned sample containers, coolers, sample labels, and a chain of custody form will be provided by the laboratory.

Equipment

Acceptable materials for sampling include stainless steel, HDPE, PVC, silicone, acetate, and polypropylene. Additional materials may be acceptable if pre-approved by New York State Department of Environmental Conservation's Division of Environmental Remediation.

No sampling equipment components or sample containers should come in to contact with aluminum foil, low density polyethylene, glass, or polytetrafluoroethylene (PTFE, Teflon™) materials including sample bottle cap liners with a PTFE layer.

A list of acceptable equipment is provided below, but other equipment may be considered appropriate based on sampling conditions.

- stainless steel spoon
- stainless steel bowl
- steel hand auger or shovel without any coatings

Equipment Decontamination

Standard two step decontamination using detergent (Alconox is acceptable) and clean, PFAS-free water will be performed for sampling equipment. All sources of water used for equipment decontamination should be verified in advance to be PFAS-free through laboratory analysis or certification.

Sampling Techniques

Sampling is often conducted in areas where a vegetative turf has been established. In these cases, a pre-cleaned trowel or shovel should be used to carefully remove the turf so that it may be replaced at the conclusion of sampling. Surface soil samples (e.g. 0 to 6 inches below surface) should then be collected using a pre-cleaned, stainless steel spoon. Shallow subsurface soil samples (e.g. 6 to ~36 inches below surface) may be collected by digging a hole using a pre-cleaned hand auger or shovel. When the desired subsurface depth is reached, a pre-cleaned hand auger or spoon shall be used to obtain the sample.

When the sample is obtained, it should be deposited into a stainless steel bowl for mixing prior to filling the sample containers. The soil should be placed directly into the bowl and mixed thoroughly by rolling the material into the middle until the material is homogenized. At this point the material within the bowl can be placed into the laboratory provided container.

Sample Identification and Logging

A label shall be attached to each sample container with a unique identification. Each sample shall be included on the chain of custody (COC).

Quality Assurance/Quality Control

- Immediately place samples in a cooler maintained at 4 ± 2º Celsius using ice
- Collect one field duplicate for every sample batch, minimum 1 duplicate per 20 samples. The duplicate shall consist of an additional sample at a given location
- Collect one matrix spike / matrix spike duplicate (MS/MSD) for every sample batch, minimum 1 MS/MSD per 20 samples. The MS/MSD shall consist of an additional two samples at a given location and identified on the COC
- Request appropriate data deliverable (Category B) and an electronic data deliverable

Documentation

A soil log or sample log shall document the location of the sample/borehole, depth of the sample, sampling equipment, duplicate sample, visual description of the material, and any other observations or notes determined to be appropriate. Additionally, care should be performed to limit contact with PFAS containing materials (e.g. waterproof field books, food packaging) during the sampling process.

Personal Protection Equipment (PPE)

For most sampling Level D PPE is anticipated to be appropriate. The sampler should wear nitrile gloves while conducting field work and handling sample containers.

Field staff shall consider the clothing to be worn during sampling activities. Clothing that contains PTFE material (including GORE-TEX®) or that have been waterproofed with PFAS materials should be avoided. All clothing worn by sampling personnel should have been laundered multiple times.

Appropriate rain gear (PVC, polyurethane, or rubber rain gear are acceptable), bug spray, and sunscreen should be used that does not contain PFAS. Well washed cotton coveralls may be used as an alternative to bug spray and/or sunscreen.

PPE that contains PFAS is acceptable when site conditions warrant additional protection for the samplers and no other materials can be used to be protective. Documentation of such use should be provided in the field notes.

Appendix C - Sampling Protocols for PFAS in Monitoring Wells

General

The objective of this protocol is to give general guidelines for the collection of groundwater samples for PFAS analysis. The sampling procedure used should be consistent with Sampling Guidelines and Protocols – Technological Background and Quality Control/Quality Assurance for NYS DEC Spill Response Program – March 1991 (http://www.dec.ny.gov/docs/remediation_hudson_pdf/sgpsect5.pdf), with the following limitations.

Laboratory Analysis and Container

Samples collected using this protocol are intended to be analyzed for PFAS using EPA Method 1633.

The preferred material for containers is high density polyethylene (HDPE). Pre-cleaned sample containers, coolers, sample labels, and a chain of custody form will be provided by the laboratory.

Equipment

Acceptable materials for sampling include: stainless steel, HDPE, PVC, silicone, acetate, and polypropylene. Additional materials may be acceptable if pre-approved by New York State Department of Environmental Conservation's Division of Environmental Remediation.

No sampling equipment components or sample containers should come in contact with aluminum foil, low density polyethylene, glass, or polytetrafluoroethylene (PTFE, Teflon™) materials including plumbers tape and sample bottle cap liners with a PTFE layer.

A list of acceptable equipment is provided below, but other equipment may be considered appropriate based on sampling conditions.

- stainless steel inertia pump with HDPE tubing
- peristaltic pump equipped with HDPE tubing and silicone tubing
- stainless steel bailer with stainless steel ball
- bladder pump (identified as PFAS-free) with HDPE tubing

Equipment Decontamination

Standard two step decontamination using detergent (Alconox is acceptable) and clean, PFAS-free water will be performed for sampling equipment. All sources of water used for equipment decontamination should be verified in advance to be PFAS-free through laboratory analysis or certification.

Sampling Techniques

Monitoring wells should be purged in accordance with the sampling procedure (standard/volume purge or low flow purge) identified in the site work plan, which will determine the appropriate time to collect the sample. If sampling using standard purge techniques, additional purging may be needed to reduce turbidity levels, so samples contain a limited amount of sediment within the sample containers. Sample containers that contain sediment may cause issues at the laboratory, which may result in elevated reporting limits and other issues during the sample preparation that can compromise data usability. Sampling personnel should don new nitrile gloves prior to sample collection due to the potential to contact PFAS containing items (not related to the sampling equipment) during the purging activities.

Sample Identification and Logging

A label shall be attached to each sample container with a unique identification. Each sample shall be included on the chain of custody (COC).

Quality Assurance/Quality Control

- Immediately place samples in a cooler maintained at 4 ± 2º Celsius using ice
- Collect one field duplicate for every sample batch, minimum 1 duplicate per 20 samples. The duplicate shall consist of an additional sample at a given location
- Collect one matrix spike / matrix spike duplicate (MS/MSD) for every sample batch, minimum 1 MS/MSD per 20 samples. The MS/MSD shall consist of an additional two samples at a given location and identified on the COC
- Collect one equipment blank per day per site and minimum 1 equipment blank per 20 samples. The equipment blank shall test the new and decontaminated sampling equipment utilized to obtain a sample for residual PFAS contamination. This sample is obtained by using laboratory provided PFAS-free water and passing the water over or through the sampling device and into laboratory provided sample containers
- Additional equipment blank samples may be collected to assess other equipment that is utilized at the monitoring well
- Request appropriate data deliverable (Category B) and an electronic data deliverable

Documentation

A purge log shall document the location of the sample, sampling equipment, groundwater parameters, duplicate sample, visual description of the material, and any other observations or notes determined to be appropriate. Additionally, care should be performed to limit contact with PFAS containing materials (e.g. waterproof field books, food packaging) during the sampling process.

Personal Protection Equipment (PPE)

For most sampling Level D PPE is anticipated to be appropriate. The sampler should wear nitrile gloves while conducting field work and handling sample containers.

Field staff shall consider the clothing to be worn during sampling activities. Clothing that contains PTFE material (including GORE-TEX®) or that have been waterproofed with PFAS materials should be avoided. All clothing worn by sampling personnel should have been laundered multiple times.

Appropriate rain gear (PVC, polyurethane, or rubber rain gear are acceptable), bug spray, and sunscreen should be used that does not contain PFAS. Well washed cotton coveralls may be used as an alternative to bug spray and/or sunscreen.

PPE that contains PFAS is acceptable when site conditions warrant additional protection for the samplers and no other materials can be used to be protective. Documentation of such use should be provided in the field notes.

Appendix D - Sampling Protocols for PFAS in Surface Water

General

The objective of this protocol is to give general guidelines for the collection of surface water samples for PFAS analysis. The sampling procedure used should be consistent with Sampling Guidelines and Protocols – Technological Background and Quality Control/Quality Assurance for NYS DEC Spill Response Program – March 1991 (http://www.dec.ny.gov/docs/remediation_hudson_pdf/sgpsect5.pdf), with the following limitations.

Laboratory Analysis and Container

Samples collected using this protocol are intended to be analyzed for PFAS using EPA Method 1633.

The preferred material for containers is high density polyethylene (HDPE). Pre-cleaned sample containers, coolers, sample labels, and a chain of custody form will be provided by the laboratory.

Equipment

Acceptable materials for sampling include: stainless steel, HDPE, PVC, silicone, acetate, and polypropylene. Additional materials may be acceptable if pre-approved by New York State Department of Environmental Conservation’s Division of Environmental Remediation.

No sampling equipment components or sample containers should come in contact with aluminum foil, low density polyethylene, glass, or polytetrafluoroethylene (PTFE, Teflon™) materials including sample bottle cap liners with a PTFE layer.

A list of acceptable equipment is provided below, but other equipment may be considered appropriate based on sampling conditions.

- stainless steel cup

Equipment Decontamination

Standard two step decontamination using detergent (Alconox is acceptable) and clean, PFAS-free water will be performed for sampling equipment. All sources of water used for equipment decontamination should be verified in advance to be PFAS-free through laboratory analysis or certification.

Sampling Techniques

Where conditions permit, (e.g. creek or pond) sampling devices (e.g. stainless steel cup) should be rinsed with site medium to be sampled prior to collection of the sample. At this point the sample can be collected and poured into the sample container.

If site conditions permit, samples can be collected directly into the laboratory container.

Sample Identification and Logging

A label shall be attached to each sample container with a unique identification. Each sample shall be included on the chain of custody (COC).

Quality Assurance/Quality Control

- Immediately place samples in a cooler maintained at 4 ± 2º Celsius using ice
- Collect one field duplicate for every sample batch, minimum 1 duplicate per 20 samples. The duplicate shall consist of an additional sample at a given location
- Collect one matrix spike / matrix spike duplicate (MS/MSD) for every sample batch, minimum 1 MS/MSD per 20 samples. The MS/MSD shall consist of an additional two samples at a given location and identified on the COC
- Collect one equipment blank per day per site and minimum 1 equipment blank per 20 samples. The equipment blank shall test the new and decontaminated sampling equipment utilized to obtain a sample for residual PFAS contamination. This sample is obtained by using laboratory provided PFAS-free water and passing the water over or through the sampling device and into laboratory provided sample containers
- Request appropriate data deliverable (Category B) and an electronic data deliverable

Documentation

A sample log shall document the location of the sample, sampling equipment, duplicate sample, visual description of the material, and any other observations or notes determined to be appropriate. Additionally, care should be performed to limit contact with PFAS containing materials (e.g. waterproof field books, food packaging) during the sampling process.

Personal Protection Equipment (PPE)

For most sampling Level D PPE is anticipated to be appropriate. The sampler should wear nitrile gloves while conducting field work and handling sample containers.

Field staff shall consider the clothing to be worn during sampling activities. Clothing that contains PTFE material (including GORE-TEX®) or that have been waterproofed with PFAS materials should be avoided. All clothing worn by sampling personnel should have been laundered multiple times.

Appropriate rain gear (PVC, polyurethane, or rubber rain gear are acceptable), bug spray, and sunscreen should be used that does not contain PFAS. Well washed cotton coveralls may be used as an alternative to bug spray and/or sunscreen.

PPE that contains PFAS is acceptable when site conditions warrant additional protection for the samplers and no other materials can be used to be protective. Documentation of such use should be provided in the field notes.

Appendix E - Sampling Protocols for PFAS in Private Water Supply Wells

General

The objective of this protocol is to give general guidelines for the collection of water samples from private water supply wells (with a functioning pump) for PFAS analysis. The sampling procedure used should be consistent with Sampling Guidelines and Protocols – Technological Background and Quality Control/Quality Assurance for NYS DEC Spill Response Program – March 1991 (http://www.dec.ny.gov/docs/remediation_hudson_pdf/sgpsect5.pdf), with the following limitations.

Laboratory Analysis and Container

Drinking water samples collected using this protocol are intended to be analyzed for PFAS by EPA Method 537, 537.1, 533, or ISO Method 25101. The preferred material for containers is high density polyethylene (HDPE). Pre-cleaned sample containers, coolers, sample labels, and a chain of custody form will be provided by the laboratory.

Equipment

Acceptable materials for sampling include stainless steel, HDPE, PVC, silicone, acetate, and polypropylene. Additional materials may be acceptable if pre-approved by New York State Department of Environmental Conservation's Division of Environmental Remediation.

No sampling equipment components or sample containers should come in contact with aluminum foil, low density polyethylene, glass, or polytetrafluoroethylene (PTFE, Teflon™) materials (e.g. plumbers tape), including sample bottle cap liners with a PTFE layer.

Equipment Decontamination

Standard two step decontamination using detergent (Alconox is acceptable) and clean, PFAS-free water will be performed for sampling equipment. All sources of water used for equipment decontamination should be verified in advance to be PFAS-free through laboratory analysis or certification.

Sampling Techniques

Locate and assess the pressure tank and determine if any filter units are present within the building. Establish the sample location as close to the well pump as possible, which is typically the spigot at the pressure tank. Ensure sampling equipment is kept clean during sampling as access to the pressure tank spigot, which is likely located close to the ground, may be obstructed and may hinder sample collection.

Prior to sampling, a faucet downstream of the pressure tank (e.g., washroom sink) should be run until the well pump comes on and a decrease in water temperature is noted which indicates that the water is coming from the well. If the homeowner is amenable, staff should run the water longer to purge the well (15+ minutes) to provide a sample representative of the water in the formation rather than standing water in the well and piping system including the pressure tank. At this point a new pair of nitrile gloves should be donned and the sample can be collected from the sample point at the pressure tank.

Sample Identification and Logging

A label shall be attached to each sample container with a unique identification. Each sample shall be included on the chain of custody (COC).

Quality Assurance/Quality Control

- Immediately place samples in a cooler maintained at 4 ± 2º Celsius using ice
- Collect one field duplicate for every sample batch, minimum 1 duplicate per 20 samples. The duplicate shall consist of an additional sample at a given location
- Collect one matrix spike / matrix spike duplicate (MS/MSD) for every sample batch, minimum 1 MS/MSD per 20 samples. The MS/MSD shall consist of an additional two samples at a given location and identified on the COC
- If equipment was used, collect one equipment blank per day per site and a minimum 1 equipment blank per 20 samples. The equipment blank shall test the new and decontaminated sampling equipment utilized to obtain a sample for residual PFAS contamination. This sample is obtained by using laboratory provided PFAS-free water and passing the water over or through the sampling device and into laboratory provided sample containers.
- A field reagent blank (FRB) should be collected at a rate of one per 20 samples. The lab will provide a FRB bottle containing PFAS free water and one empty FRB bottle. In the field, pour the water from the one bottle into the empty FRB bottle and label appropriately.
- Request appropriate data deliverable (Category B) and an electronic data deliverable
- For sampling events where multiple private wells (homes or sites) are to be sampled per day, it is acceptable to collect QC samples at a rate of one per 20 across multiple sites or days.

Documentation

A sample log shall document the location of the private well, sample point location, owner contact information, sampling equipment, purge duration, duplicate sample, visual description of the material, and any other observations or notes determined to be appropriate and available (e.g. well construction, pump type and location, yield, installation date). Additionally, care should be performed to limit contact with PFAS containing materials (e.g. waterproof field books, food packaging) during the sampling process.

Personal Protection Equipment (PPE)

For most sampling Level D PPE is anticipated to be appropriate. The sampler should wear nitrile gloves while conducting field work and handling sample containers.

Field staff shall consider the clothing to be worn during sampling activities. Clothing that contains PTFE material (including GORE-TEX®) or that have been waterproofed with PFAS materials should be avoided. All clothing worn by sampling personnel should have been laundered multiple times.

Appendix F - Sampling Protocols for PFAS in Fish

This appendix contains a copy of the current SOP developed by the Division of Fish and Wildlife (DFW) entitled "General Fish Handling Procedures for Contaminant Analysis" (Ver. 8). This SOP should be followed when collecting fish for contaminant analysis. Note, however, that the Bureau of Ecosystem Health will not be supplying bags or tags. All supplies are the responsibility of the collector

Procedure Name: General Fish Handling Procedures for Contaminant Analysis

Number: FW-005

Purpose: This procedure describes data collection, fish processing and delivery of fish collected for contaminant monitoring. It contains the chain of custody and collection record forms that should be used for the collections.

Organization: Environmental Monitoring Section
Bureau of Ecosystem Health
Division of Fish and Wildlife (DFW)
New York State Department of Environmental Conservation (NYSDEC)
625 Broadway
Albany, New York 12233-4756

Version: 8

Previous Version Date: 21 March 2018

Summary of Changes to this Version: Updated bureau name to Bureau of Ecosystem Health. Added direction to list the names of all field crew on the collection record. Minor formatting changes on chain of custody and collection records.

Originator or Revised by: Wayne Richter, Jesse Becker

Date: 26 April 2019

Quality Assurance Officer and Approval Date: Jesse Becker, 26 April 2019

NEW YORK STATE
DEPARTMENT OF ENVIRONMENTAL CONSERVATION

GENERAL FISH HANDLING PROCEDURES FOR CONTAMINANT ANALYSES

A. Original copies of all continuity of evidence (i.e., Chain of Custody) and collection record forms must accompany delivery of fish to the lab. A copy shall be directed to the Project Leader or as appropriate, Wayne Richter. All necessary forms will be supplied by the Bureau of Ecosystem Health. Because some samples may be used in legal cases, it is critical that each section is filled out completely. Each Chain of Custody form has three main sections:

1. The top box is to be filled out **and signed** by the person responsible for the fish collection (e.g., crew leader, field biologist, researcher). This person is responsible for delivery of the samples to DEC facilities or personnel (e.g., regional office or biologist).

2. The second section is to be filled out **and signed** by the person responsible for the collections while being stored at DEC, before delivery to the analytical lab. This may be the same person as in (1), but it is still required that they complete the section. Also important is the **range of identification numbers** (i.e., tag numbers) included in the sample batch.

3. Finally, the bottom box is to record any transfers between DEC personnel and facilities. Each subsequent transfer should be **identified, signed, and dated**, until laboratory personnel take possession of the fish.

B. The following data are required on each **Fish Collection Record** form:

1. Project and Site Name.

2. DEC Region.

3. All personnel (and affiliation) involved in the collection.

4. Method of collection (gill net, hook and line, etc.)

5. Preservation Method.

C. The following data are to be taken on each fish collected and recorded on the **Fish Collection Record** form:

1. Tag number - Each specimen is to be individually jaw tagged at time of collection with a unique number. Make sure the tag is turned out so that the number can be read without opening the bag. Use tags in sequential order. For small fish or composite samples place the tag inside the bag with the samples. The Bureau of Ecosystem Health can supply the tags.

2. Species identification (please be explicit enough to enable assigning genus and species). Group fish by species when processing.

3. Date collected.

4. Sample location (waterway and nearest prominent identifiable landmark).

5. Total length (nearest mm or smallest sub-unit on measuring instrument) and weight (nearest g or

smallest sub-unit of weight on weighing instrument). Take all measures as soon as possible with calibrated, protected instruments (e.g. from wind and upsets) and prior to freezing.

6. Sex - fish may be cut enough to allow sexing or other internal investigation, but do not eviscerate. Make any incision on the right side of the belly flap or exactly down the midline so that a left-side fillet can be removed.

D. General data collection recommendations:

1. It is helpful to use an ID or tag number that will be unique. It is best to use metal striped bass or other uniquely numbered metal tags. If uniquely numbered tags are unavailable, values based on the region, water body and year are likely to be unique: for example, R7CAY11001 for Region 7, Cayuga Lake, 2011, fish 1. If the fish are just numbered 1 through 20, we have to give them new numbers for our database, making it more difficult to trace your fish to their analytical results and creating an additional possibility for errors.

2. Process and record fish of the same species sequentially. Recording mistakes are less likely when all fish from a species are processed together. Starting with the bigger fish species helps avoid missing an individual.

3. If using Bureau of Ecosystem Health supplied tags or other numbered tags, use tags in sequence so that fish are recorded with sequential Tag Numbers. This makes data entry and login at the lab and use of the data in the future easier and reduces keypunch errors.

4. Record length and weight as soon as possible after collection and before freezing. Other data are recorded in the field upon collection. An age determination of each fish is optional, but if done, it is recorded in the appropriate "Age" column.

5. For composite samples of small fish, record the number of fish in the composite in the Remarks column. Record the length and weight of each individual in a composite. All fish in a composite sample should be of the same species and members of a composite should be visually matched for size.

6. Please submit photocopies of topographic maps or good quality navigation charts indicating sampling locations. GPS coordinates can be entered in the Location column of the collection record form in addition to or instead for providing a map. These records are of immense help to us (and hopefully you) in providing documented location records which are not dependent on memory and/or the same collection crew. In addition, they may be helpful for contaminant source trackdown and remediation/control efforts of the Department.

7. When recording data on fish measurements, it will help to ensure correct data recording for the data recorder to call back the numbers to the person making the measurements.

E. Each fish is to be placed in its own individual plastic bag. For small fish to be analyzed as a composite, put all of the fish for one composite in the same bag but use a separate bag for each composite. It is important to individually bag the fish to avoid difficulties or cross contamination when processing the fish for chemical analysis. Be sure to include the fish's tag number inside the bag, preferably attached to the fish with the tag number turned out so it can be read. Tie or otherwise secure the bag closed. **The Bureau of Ecosystem Health will supply the bags.** If necessary, food grade bags may be procured from a suitable vendor (e.g., grocery store). It is preferable to redundantly label each bag with a manila tag tied between the knot and the body of the bag. This tag should be labeled with the project name, collection location, tag number, collection date, and fish species. If scales are collected, the scale envelope should be labeled with the same information.

F. Groups of fish, by species, are to be placed in one large plastic bag per sampling location. **The Bureau of Ecosystem Health will supply the larger bags.** Tie or otherwise secure the bag closed. Label the site bag with a manila tag tied between the knot and the body of the bag. The tag should contain: project, collection location, collection date, species and **tag number ranges**. Having this information on the manila tag enables lab staff to know what is in the bag without opening it.

G. Do not eviscerate, fillet or otherwise dissect the fish unless specifically asked to. If evisceration or dissection is specified, the fish must be cut along the exact midline or on the right side so that the left side fillet can be removed intact at the laboratory. If filleting is specified, the procedure for taking a standard fillet (SOP PREPLAB 4) must be followed, including removing scales.

H. Special procedures for PFAS: Unlike legacy contaminants such as PCBs, which are rarely found in day to day life, PFAS are widely used and frequently encountered. Practices that avoid sample contamination are therefore necessary. While no standard practices have been established for fish, procedures for water quality sampling can provide guidance. The following practices should be used for collections when fish are to be analyzed for PFAS:

    No materials containing Teflon.
    No Post-it notes.
    No ice packs; only water ice or dry ice.
    Any gloves worn must be powder free nitrile.
    No Gore-Tex or similar materials (Gore-Tex is a PFC with PFOA used in its manufacture).
    No stain repellent or waterproof treated clothing; these are likely to contain PFCs.
    Avoid plastic materials, other than HDPE, including clipboards and waterproof notebooks.
    Wash hands after handling any food containers or packages as these may contain PFCs. Keep pre-wrapped food containers and wrappers isolated from fish handling.
    Wear clothing washed at least six times since purchase.
    Wear clothing washed without fabric softener.
    Staff should avoid cosmetics, moisturizers, hand creams and similar products on the day of sampling as many of these products contain PFCs (Fujii et al. 2013). Sunscreen or insect repellent should not contain ingredients with “fluor” in their name. Apply any sunscreen or insect repellent well downwind from all materials. Hands must be washed after touching any of these products.

I. All fish must be kept at a temperature <45° F (<8° C) immediately following data processing. As soon as possible, freeze at -20° C ± 5° C. Due to occasional freezer failures, daily freezer temperature logs are required. The freezer should be locked or otherwise secured to maintain chain of custody.

J. In most cases, samples should be delivered to the Analytical Services Unit at the Hale Creek field station. Coordinate delivery with field station staff and send copies of the collection records, continuity of evidence forms and freezer temperature logs to the field station. For samples to be analyzed elsewhere, non-routine collections or other questions, contact Wayne Richter, Bureau of Ecosystem Health, NYSDEC, 625 Broadway, Albany, New York 12233-4756, 518-402-8974, or the project leader about sample transfer. Samples will then be directed to the analytical facility and personnel noted on specific project descriptions.

K. A recommended equipment list is at the end of this document.

NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION
DIVISION OF FISH AND WILDLIFE
FISH COLLECTION RECORD

Project and Site Name ____________________ DEC Region ____________

Collections made by (include all crew) ____________________

Sampling Method: ☐Electrofishing ☐Gill netting ☐Trap netting ☐Trawling ☐Seining ☐Angling ☐Other ____________

Preservation Method: ☐Freezing ☐Other ____________ Notes (SWFDB survey number): ____________

FOR LAB USE ONLY- LAB ENTRY NO.	COLLECTION OR TAG NO.	SPECIES	DATE TAKEN	LOCATION	AGE	SEX &/OR REPROD. CONDIT	LENGTH ( )	WEIGHT ( )	REMARKS

richter: revised 2011, 5/7/15, 10/4/16, 3/20/17; becker: 3/23/17, 4/26/19

NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION
CHAIN OF CUSTODY

I, ______________________________, of ____ collected the
(Print Name) (Print Business Address)

following on ____________________, 20____ from ____
(Date) (Water Body)

in the vicinity of ____
(Landmark, Village, Road, etc.)

Town of ____, in _________________________________ County.

Item(s) ____

____

Said sample(s) were in my possession and handled according to standard procedures provided to me prior to collection. The sample(s) were placed in the custody of a representative of the New York State Department of Environmental Conservation on ____________________________________, 20______.

____ ______________________________
Signature Date

I, __________________________________, received the above mentioned sample(s) on the date specified and assigned identification number(s) ____ to the sample(s). I have recorded pertinent data for the sample(s) on the attached collection records. The sample(s) remained in my custody until subsequently transferred, prepared or shipped at times and on dates as attested to below.

_______________________________________ ___________________
Signature Date

SECOND RECIPIENT (Print Name)	TIME & DATE	PURPOSE OF TRANSFER
SIGNATURE	UNIT	
THIRD RECIPIENT (Print Name)	TIME & DATE	PURPOSE OF TRANSFER
SIGNATURE	UNIT	
FOURTH RECIPIENT (Print Name)	TIME & DATE	PURPOSE OF TRANSFER
SIGNATURE	UNIT	
RECEIVED IN LABORATORY BY (Print Name)	TIME & DATE	REMARKS
SIGNATURE	UNIT	
LOGGED IN BY (Print Name)	TIME & DATE	ACCESSION NUMBERS
SIGNATURE	UNIT	

NOTICE OF WARRANTY

By signature to the chain of custody (reverse), the signatory warrants that the information provided is truthful and accurate to the best of his/her ability. The signatory affirms that he/she is willing to testify to those facts provided and the circumstances surrounding the same. Nothing in this warranty or chain of custody negates responsibility nor liability of the signatories for the truthfulness and accuracy of the statements provided.

HANDLING INSTRUCTIONS

On day of collection, collector(s) name(s), address(es), date, geographic location of capture (attach a copy of topographic map or navigation chart), species, number kept of each species, and description of capture vicinity (proper noun, if possible) along with name of Town and County must be indicated on reverse.

Retain organisms in manila tagged plastic bags to avoid mixing capture locations. Note appropriate information on each bag tag.

Keep samples as cool as possible. Put on ice if fish cannot be frozen within 12 hours. If fish are held more than 24 hours without freezing, they will not be retained or analyzed.

Initial recipient (either DEC or designated agent) of samples from collector(s) is responsible for obtaining and recording information on the collection record forms which will accompany the chain of custody. This person will seal the container using packing tape and writing his signature, the time and the date across the tape onto the container with indelible marker. Any time a seal is broken, for whatever purpose, the incident must be recorded on the Chain of Custody (reason, time, and date) in the purpose of transfer block. Container then is resealed using new tape and rewriting signature, with time and date.

EQUIPMENT LIST

Scale or balance of appropriate capacity for the fish to be collected.

Fish measuring board.

Plastic bags of an appropriate size for the fish to be collected and for site bags.

Individually numbered metal tags for fish.

Manila tags to label bags.

Small envelops, approximately 2” x 3.5”, if fish scales are to be collected.

Knife for removing scales.

Chain of custody and fish collection forms.

Clipboard.

Pens or markers.

Paper towels.

Dish soap and brush.

Bucket.

Cooler.

Ice.

Duct tape.

New York State of Opportunity | Department of Environmental Conservation

Appendix G – PFAS Analyte List

Group	Chemical Name	Abbreviation	CAS Number
Perfluoroalkyl sulfonic acids	Perfluorobutanesulfonic acid	PFBS	375-73-5
	Perfluoropentanesulfonic acid	PFPeS	2706-91-4
	Perfluorohexanesulfonic acid	PFHxS	355-46-4
	Perfluoroheptanesulfonic acid	PFHpS	375-92-8
	Perfluorooctanesulfonic acid	PFOS	1763-23-1
	Perfluorononanesulfonic acid	PFNS	68259-12-1
	Perfluorodecanesulfonic acid	PFDS	335-77-3
	Perfluorododecanesulfonic acid	PFDoS	79780-39-5
Perfluoroalkyl carboxylic acids	Perfluorobutanoic acid	PFBA	375-22-4
	Perfluoropentanoic acid	PFPeA	2706-90-3
	Perfluorohexanoic acid	PFHxA	307-24-4
	Perfluoroheptanoic acid	PFHpA	375-85-9
	Perfluorooctanoic acid	PFOA	335-67-1
	Perfluorononanoic acid	PFNA	375-95-1
	Perfluorodecanoic acid	PFDA	335-76-2
	Perfluoroundecanoic acid	PFUnA	2058-94-8
	Perfluorododecanoic acid	PFDoA	307-55-1
	Perfluorotridecanoic acid	PFTrDA	72629-94-8
	Perfluorotetradecanoic acid	PFTeDA	376-06-7
Per- and Polyfluoroether carboxylic acids	Hexafluoropropylene oxide dimer acid	HFPO-DA	13252-13-6
	4,8-Dioxa-3H-perfluorononanoic acid	ADONA	919005-14-4
	Perfluoro-3-methoxypropanoic acid	PFMPA	377-73-1
	Perfluoro-4-methoxybutanoic acid	PFMBA	863090-89-5
	Nonafluoro-3,6-dioxaheptanoic acid	NFDHA	151772-58-6
Fluorotelomer sulfonic acids	4:2 Fluorotelomer sulfonic acid	4:2-FTS	757124-72-4
	6:2 Fluorotelomer sulfonic acid	6:2-FTS	27619-97-2
	8:2 Fluorotelomer sulfonic acid	8:2-FTS	39108-34-4
Fluorotelomer carboxylic acids	3:3 Fluorotelomer carboxylic acid	3:3 FTCA	356-02-5
	5:3 Fluorotelomer carboxylic acid	5:3 FTCA	914637-49-3
	7:3 Fluorotelomer carboxylic acid	7:3 FTCA	812-70-4
Perfluorooctane sulfonamides	Perfluorooctane sulfonamide	PFOSA	754-91-6
	N-methylperfluorooctane sulfonamide	NMeFOSA	31506-32-8
	N-ethylperfluorooctane sulfonamide	NEtFOSA	4151-50-2
Perfluorooctane sulfonamidoacetic acids	N-methylperfluorooctane sulfonamidoacetic acid	N-MeFOSAA	2355-31-9
	N-ethylperfluorooctane sulfonamidoacetic acid	N-EtFOSAA	2991-50-6
Perfluorooctane sulfonamide ethanols	N-methylperfluorooctane sulfonamidoethanol	MeFOSE	24448-09-7
	N-ethylperfluorooctane sulfonamidoethanol	EtFOSE	1691-99-2

Group	Chemical Name	Abbreviation	CAS Number
Ether sulfonic acids	9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid (F-53B Major)	9Cl-PF3ONS	756426-58-1
	11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (F-53B Minor)	11Cl-PF3OUdS	763051-92-9
	Perfluoro(2-ethoxyethane) sulfonic acid	PFEESA	113507-82-7

Appendix H - Data Review Guidelines for Analysis of PFAS in Non-Potable Water and Solids

General

These guidelines are intended to be used for the validation of PFAS using EPA Method 1633 for projects within the Division of Environmental Remediation (DER). Data reviewers should understand the methodology and techniques utilized in the analysis. Consultation with the end user of the data may be necessary to assist in determining data usability based on the data quality objectives in the Quality Assurance Project Plan. A familiarity with the laboratory's Standard Operating Procedure may also be needed to fully evaluate the data. If you have any questions, please contact DER's Quality Assurance Officer, Dana Barbarossa, at dana.barbarossa@dec.ny.gov.

Preservation and Holding Time

Samples should be preserved with ice to a temperature of less than 6°C upon arrival at the lab. The holding time is 28 days to extraction for aqueous and solid samples. The time from extraction to analysis for aqueous samples is 28 days and 40 days for solids.

Temperature greatly exceeds 6ºC upon arrival at the lab*	Use professional judgement to qualify detects and non-detects as estimated or rejected
Holding time exceeding 28 days to extraction	Use professional judgement to qualify detects and non-detects as estimated or rejected if holding time is grossly exceeded

*Samples that are delivered to the lab immediately after sampling may not meet the thermal preservation guidelines. Samples are considered acceptable if they arrive on ice or an attempt to chill the samples is observed.

Initial Calibration

The initial calibration should contain a minimum of six standards for linear fit and six standards for a quadratic fit. The relative standard deviation (RSD) for a quadratic fit calibration should be less than 20%.

The low-level calibration standard should be within 50% - 150% of the true value, and the mid-level calibration standard within 70% - 130% of the true value.

%RSD >20%	J flag detects and UJ non detects

Continuing Calibration Verification

Continuing calibration verification (CCV) checks should be analyzed at a frequency of one per ten field samples. If CCV recovery is very low, where detection of the analyte could be in question, ensure a low level CCV was analyzed and use to determine data quality.

CCV recovery <70 or >130%	J flag results

Blanks

There should be no detections in the method blanks above the reporting limits. Equipment blanks, field blanks, rinse blanks etc. should be evaluated in the same manner as method blanks. Use the most contaminated blank to evaluate the sample results.

Blank Result	Sample Result	Qualification
Any detection	<Reporting limit	Qualify as ND at reporting limit
Any detection	>Reporting Limit and >10x the blank result	No qualification
>Reporting limit	>Reporting limit and <10x blank result	J+ biased high

Field Duplicates

A blind field duplicate should be collected at rate of one per twenty samples. The relative percent difference (RPD) should be less than 30% for analyte concentrations greater than two times the reporting limit. Use the higher result for final reporting.

RPD >30%	Apply J qualifier to parent sample

Lab Control Spike

Lab control spikes should be analyzed with each extraction batch or one for every twenty samples. In the absence of lab derived criteria, use 70% - 130% recovery criteria to evaluate the data.

Recovery <70% or >130% (lab derived criteria can also be used)	Apply J qualifier to detects and UJ qualifier to non detects

Matrix Spike/Matrix Spike Duplicate

One matrix spike and matrix spike duplicate should be collected at a rate of one per twenty samples. Use professional judgement to reject results based on out of control MS/MSD recoveries.

Recovery <70% or >130% (lab derived criteria can also be used)	Apply J qualifier to detects and UJ qualifier to non detects of parent sample only
RPD >30%	Apply J qualifier to detects and UJ qualifier to non detects of parent sample only

Extracted Internal Standards (Isotope Dilution Analytes)

Problematic analytes (e.g. PFBA, PFPeA, fluorotelomer sulfonates) can have wider recoveries without qualification. Qualify corresponding native compounds with a J flag if outside of the range.

Recovery <50% or >150%	Apply J qualifier
Recovery <25% or >150% for poor responding analytes	Apply J qualifier
Isotope Dilution Analyte (IDA) Recovery <10%	Reject results

Signal to Noise Ratio

The signal to noise ratio for the quantifier ion should be at least 3:1. If the ratio is less than 3:1, the peak is discernable from the baseline noise and symmetrical, the result can be reported. If the peak appears to be baseline noise and/or the shape is irregular, qualify the result as tentatively identified.

Reporting Limits

If project-specific reporting limits were not met, please indicate that in the report along with the reason (e.g. over dilution, dilution for non-target analytes, high sediment in aqueous samples).

Peak Integrations

Target analyte peaks should be integrated properly and consistently when compared to standards. Ensure branched isomer peaks are included for PFAS where standards are available. Inconsistencies should be brought to the attention of the laboratory or identified in the data review summary report.

Appendix E

Historic Boring Logs and Well Construction Diagrams

NEW MONITORING WELLS
(installed by NYSDEC)

MONITORING WELL CONSTRUCTION LOG

DRILLING SUMMARY

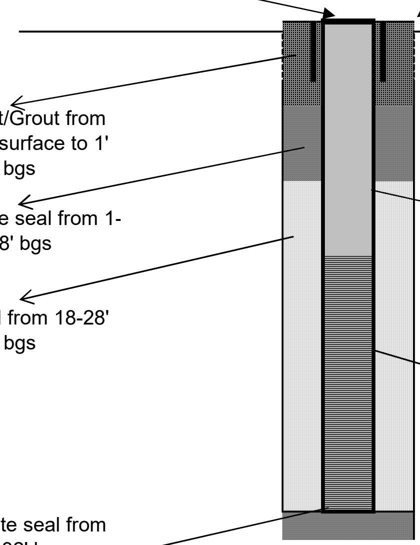
Geologist:
Daniel Sheldon

Drilling Company:
SJB/Empire Geo Serv. Inc.

Driller:
Daniel Delude

Rig Make/Model:
Diedrich D-50

Date:
12/21/2020



NOT TO SCALE

GEOLOGIC LOG

Depth (ft.)	Description
	See boring log

WELL DESIGN

CASING MATERIAL	SCREEN MATERIAL	FILTER MATERIAL
Surface: Steel Flush Mount Casing	Type: 2" Schedule 40 PVC	Type: No. 0 SAND Setting: 18'-28' bgs
Monitor: Schedule 40 PVC	Slot Diameter: 0.010"	*SEAL MATERIAL*
	Setting: 21' - 26' bgs	Type: Bentonite Setting: 28'- 32' bgs Setting: 1'- 18' bgs Type: Cement Grout Setting: 0' - 1' bgs

COMMENTS:

The contractor was directed to install the borehole to a total depth of 30.0' bgs. All soils were screened with a PID meter and checked for olfactory and visual evidence of contamination. All PID readings were noted. A well was constructed of schedule 40 PVC piping and 0.010" slot diameter screen, with a bottom bentonite seal from 32.0 to 28.0 feet, with a sand pack from 28.0 to 18.0 feet, with a bentonite seal from 18 to 1 feet, and slurry mix from 1 foot to ground surface. The well was completed at grade with a steel flush-mount protective casing.

LEGEND:

- PVC Casing
- #0 Sand
- Bentonite
- Cement Grout
- PVC Screen

CLIENT:	LOCATION:	Project No.
NYSDEC	Mayville	17-013-0289
LiRo Engineers, Inc.	**Monitoring Well Construction Details**	*Well Number:* **MW-02**

LiRo Engineers, Inc.

TEST BORING LOG

PROJECT NAME: Mayville		BORING ID:	MW-02
CLIENT: New York State Department of Environmental Conservation (NYSDEC)		SHEET:	1 of 1
BORING CONTRACTOR: SJB/Empire Geo Serv. Inc.		JOB NO.:	17-013-0289
		LOCATION:	Mayville, NY

GROUNDWATER: 2.5 ' bgs on 12/21/2020					CAS.	SAMPLER	TUBE	GROUND ELEVATION:	TBD
DATE	TIME	LEVEL	TYPE	TYPE		HSA		DATE STARTED:	December 18, 2020
				DIA.		4 1/4"	2" sampler	DATE FINISHED:	December 21, 2020
				WT.				DRILLER:	SJB/Empire Geo Serv. Inc.
				FALL				GEOLOGIST:	Daniel Sheldon
								REVIEWED BY:	

DEPTH FEET	STRATA	"S" NO.	"N" NO.	BLOWS PER 6"		REC% RQD%	COLOR	CONSISTENCY HARDNESS	MATERIAL DESCRIPTION	USCS	PID
				1	1	40%	Dark Brown	Soft	SILT and SAND (0-1.0')	SC	0 ppm
				2	3		Light Brown	Very Loose	SILTY SAND , some medium coarse subangular gravel (1.0-6.0'). Wet at 5.0'.	ML	0 ppm
5											
				2	1	35%					0 ppm
				3	2		Light Brown	Very Loose	Medium to coarse SILTY SAND and Medium GRAVEL (6.0-10.0').	SW-GW	0 ppm
10											
				3	2	85%	Medium Gray	Soft	SILTY CLAY (10.0-20.0'). Moist to very moist.	CL	0 ppm
				2	3						0 ppm
15											
				1	1	70%					0 ppm
				1	2						0 ppm
20											
				1	1	90%	Brown	Loose to Medium Dense	Fine to Medium SAND, trace Gravel and Silt (20.0-26.0'). Wet.	SW	0 ppm
				3	3						0 ppm
				7	5	90%					0 ppm
				6	6						0 ppm
25				5	6	90%					0 ppm
				7	7						0 ppm
				4	4	80%	Gray	Loose to Medium Dense	Wet Fine SILTY SAND (26.0-32.0').	SM	0 ppm
				5	5						0 ppm
				6	6	65%					0 ppm
30				4	7						0 ppm
				5	5	90%					0 ppm
32				4	3						0 ppm
									Boring Completed at 32.0 Feet		
35											

COMMENTS: Well constructed. See well construction log.

PROJECT NO.: 17-013-0289
BORING NO.: MW-02

DRILLING SUMMARY

Geologist: Daniel Sheldon

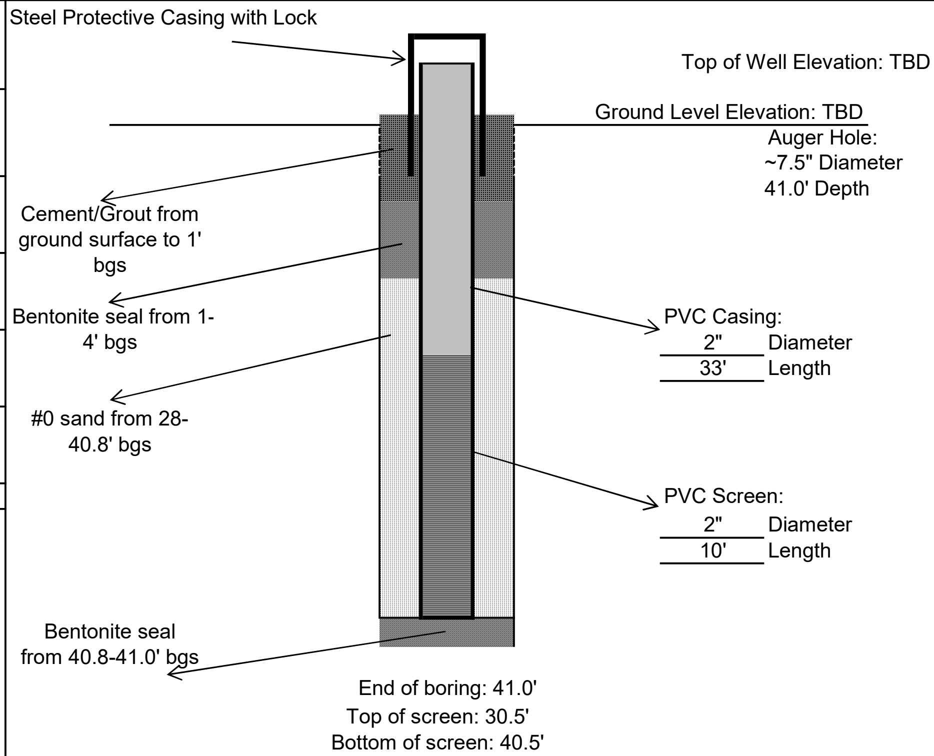
Drilling Company: SJB/Empire Geo Serv. Inc.

Driller: Daniel Delude

Rig Make/Model: Diedrich D-50

Date: 12/22/2020

MONITORING WELL CONSTRUCTION LOG



NOT TO SCALE

GEOLOGIC LOG

Depth (ft.)	Description
	See boring log

WELL DESIGN

CASING MATERIAL	*SCREEN MATERIAL*	*FILTER MATERIAL*
Surface: Steel Protective Casing	Type: 2" Schedule 40 PVC	Type: No. 0 SAND Setting: 28.0'-40.8' bgs
		SEAL MATERIAL
Monitor: Schedule 40 PVC	Slot Diameter: 0.010"	Type: Bentonite Setting: 40.8'- 41.0' bgs Setting: 1'- 28' bgs
	Setting: 30.5' - 40.5' bgs	Type: Cement Grout Setting: 0' - 1' bgs

COMMENTS:

The contractor was directed to install the borehole to a total depth of 40.0' bgs. All soils were screened with a PID meter and checked for olfactory and visual evidence of contamination. All PID readings were noted. A well was constructed of schedule 40 PVC piping and 0.010" slot diameter screen, with a bottom bentonite seal from 40.8 to 41.0 feet, with a sand pack from 40.8 to 28.0 feet, with a bentonite seal from 28 to 1 feet, and slurry mix from 1 foot to ground surface. The well was completed at grade with a steel stick up protective casing and four concrete filled steel bollards.

LEGEND:

- PVC Casing
- #0 Sand
- Bentonite
- Cement Grout
- PVC Screen

CLIENT:	**LOCATION:**	Project No.
NYSDEC	Mayville	17-013-0289
LiRo Engineers, Inc.	**Monitoring Well Construction Details**	*Well Number:* **MW-03**

LiRo Engineers, Inc.

TEST BORING LOG

PROJECT NAME:	Mayville	BORING ID:	MW-03
		SHEET:	1 of 2
CLIENT:	New York State Department of Environmental Conservation (NYSDEC)	JOB NO.:	17-013-0289
BORING CONTRACTOR:	SJB/Empire Geo Serv. Inc.	LOCATION:	Mayville, NY
GROUNDWATER:	11.0 feet bgs on December 22, 2020	GROUND ELEVATION:	TBD
		DATE STARTED:	December 21, 2020
		DATE FINISHED:	December 22, 2020
		DRILLER:	SJB/Empire Geo Serv. Inc.
		GEOLOGIST:	Daniel Sheldon
		REVIEWED BY:	

DATE	TIME	LEVEL	TYPE		CAS.	SAMPLER	TUBE
				TYPE		HSA	
				DIA.		4 1/4"	2" sampler
				WT.			
				FALL			

DEPTH FEET	STRATA	"S" NO.	"N" NO.	BLOWS PER 6"		REC% RQD%	COLOR	CONSISTENCY HARDNESS	MATERIAL DESCRIPTION	USCS	PID
				2	6	65%	Brown	Medium Dense	FILL, sand, gravel, brick, wood (0.0-1.5')	Fill	0 ppm
				9	9						0 ppm
				6	6	65%	Light Brown	Medium Dense	Medium to coarse SILTY SAND and Medium GRAVEL (1.5-5.0'). Wet at 2'.	SW-GW	0 ppm
				5	5						0 ppm
5											0 ppm
				3	4	60%	Gray	Stiff to Very Stiff	SANDY SILT, Trace Clay (5.0-15.0'). Moist to Very Moist.	SM	0 ppm
				6	5						0 ppm
											0 ppm
											0 ppm
10											0 ppm
				6	11	75%					0 ppm
				11	12						0 ppm
											0 ppm
											0 ppm
15											0 ppm
				3	2	70%	Gray	Medium Stiff	SANDY CLAY (15.0-29.5'). Slighty Moist to Moist.	CL	NA
				4	4						NA
											NA
											NA
20											NA
				2	2	60%					NA
				3	4						NA
											NA
											NA
25											NA
				1	2	80%					NA
				2	3						NA
				3	2	100%					NA
				3	2						NA
30				WH	2	100%					NA
				2	6		Dark Brown	Medium Dense	SAND and GRAVEL, trace Silt (29.5-40.5'). Wet.	SW-GW	NA
				2	4	60%					NA
				5	8						NA
				4	4	80%					NA
35				8	10						NA

COMMENTS:	Well constructed. See well construction log.	PROJECT NO.:	17-013-0289
	NA: PID inoperable.	BORING NO.:	MW-03

LiRo Engineers, Inc.

TEST BORING LOG

PROJECT NAME: Mayville		BORING ID:	MW-03
CLIENT: New York State Department of Environmental Conservation (NYSDEC)		SHEET:	2 of 2
BORING CONTRACTOR: SJB/Empire Geo Serv. Inc.		JOB NO.:	17-013-0289
		LOCATION:	Mayville, NY

GROUNDWATER:					CAS.	SAMPLER	TUBE	GROUND ELEVATION:	TBD
DATE	TIME	LEVEL	TYPE	TYPE		HSA		DATE STARTED:	December 21, 2020
				DIA.		4 1/4"	2" sampler	DATE FINISHED:	December 22, 2020
				WT.				DRILLER:	SJB/Empire Geo Serv. Inc.
				FALL				GEOLOGIST:	Daniel Sheldon
								REVIEWED BY:	

DEPTH FEET	STRATA	"S" NO.	"N" NO.	BLOWS PER 6"		REC% RQD%	COLOR	CONSISTENCY HARDNESS	MATERIAL DESCRIPTION	USCS	PID
				2	6	60%	Brown	Medium Dense	SAND and GRAVEL, trace Silt (29.5 -40.5'). Wet.	SW-GW	NA
				9	11						NA
				1	14	70%					NA
				15	12						NA
40				6	7	90%					NA
				9	7						NA
									Boring completed at 41.0 feet.		
45											

COMMENTS: Well constructed. See well construction log.
NA: PID inoperable.

PROJECT NO.: 17-013-0289
BORING NO.: MW-03

DRILLING SUMMARY	MONITORING WELL CONSTRUCTION LOG

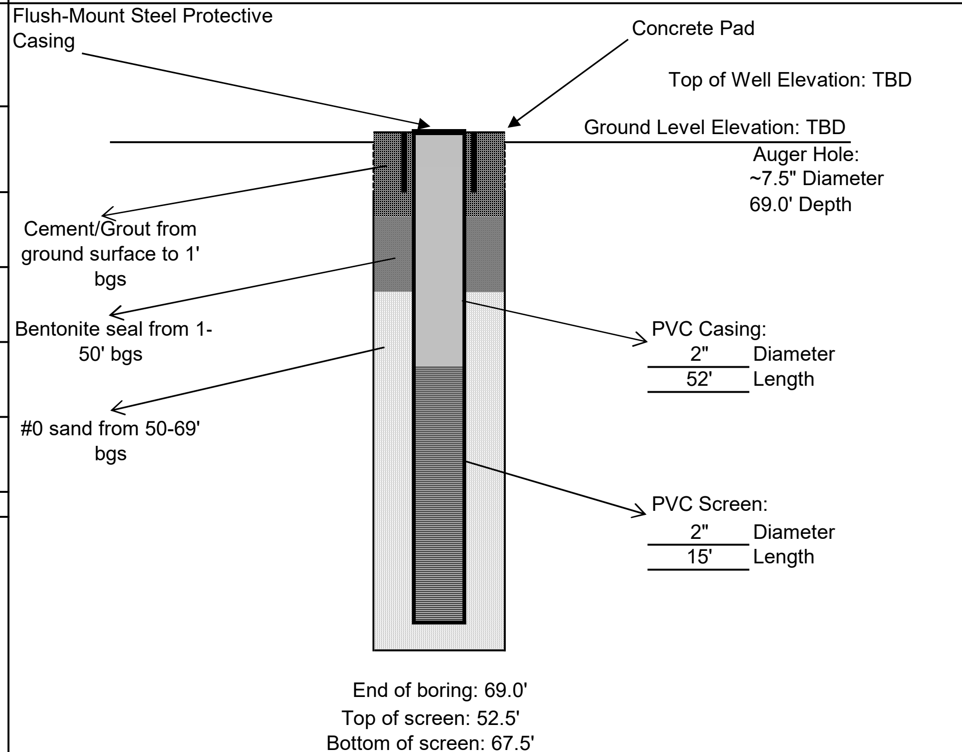
Geologist: Daniel Sheldon

Drilling Company: SJB/Empire Geo Serv. Inc.

Driller: Daniel Delude

Rig Make/Model: Diedrich D-50

Date: 12/28/2020



GEOLOGIC LOG

Depth (ft.)	Description
	See boring log

NOT TO SCALE

WELL DESIGN

CASING MATERIAL		*SCREEN MATERIAL*	*FILTER MATERIAL*	
Surface:	Steel Flush Mount Casing	Type: 2" Schedule 40 PVC	Type: No. 0 SAND	Setting: 50.0'-67.5' bgs
			SEAL MATERIAL	
Monitor:	Schedule 40 PVC	Slot Diameter: 0.010"	Type: Bentonite	Setting: 1.0'- 50.0' bgs
		Setting: 52.5' - 67.5' bgs	Type: Cement Grout	Setting: 0' - 1' bgs

COMMENTS:

The contractor was directed to install the borehole to a total depth of 68.0' bgs. All soils were screened with a PID meter and checked for olfactory and visual evidence of contamination. All PID readings were noted. A well was constructed of schedule 40 PVC piping and 0.010" slot diameter screen, with a with a sand pack from 67.5 to 50.0 feet, with a bentonite seal from 1.0 to 50.0 feet, and slurry mix from 1 foot to ground surface. The well was completed at grade with a a steel flush-mount protective casing.

LEGEND:

- PVC Casing
- #0 Sand
- Bentonite
- Cement Grout
- PVC Screen

CLIENT:	LOCATION:	Project No.
NYSDEC	Mayville	17-013-0289
LiRo Engineers, Inc.	**Monitoring Well Construction Details**	*Well Number:* **MW-04**

LiRo Engineers, Inc.	TEST BORING LOG
	BORING ID: MW-04
PROJECT NAME: Mayville	SHEET: 1 of 1
CLIENT: New York State Department of Environmental Conservation (NYSDEC)	JOB NO.: 17-013-0289
BORING CONTRACTOR: SJB/Empire Geo Serv. Inc.	LOCATION: Mayville, NY

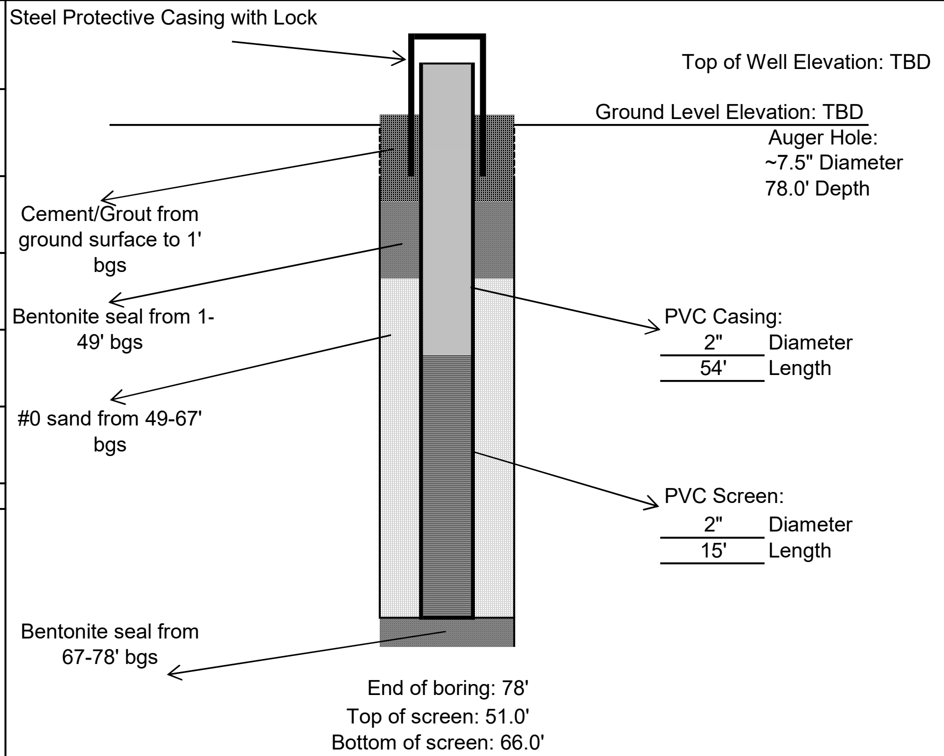
GROUNDWATER:					CAS.	SAMPLER	TUBE	GROUND ELEVATION:	TBD
DATE	TIME	LEVEL	TYPE	TYPE		HSA		DATE STARTED:	December 23, 2020
				DIA.		4 1/4"	2" sampler	DATE FINISHED:	December 23, 2020
				WT.				DRILLER:	SJB/Empire Geo Serv. Inc.
				FALL				GEOLOGIST:	Daniel Sheldon
								REVIEWED BY:	

DEPTH FEET	STRATA	"S" NO.	"N" NO.	BLOWS PER 6"		REC% RQD%	COLOR	CONSISTENCY HARDNESS	MATERIAL DESCRIPTION	USCS	PID
0-50	No Samples Collected 0-50.0 Feet.										
50											
				12	16	90%	Brown to Gray	Medium Dense to Dense	SAND and GRAVEL, some Silt. Few silt and clay seams (50.0-66.0'). Wet.	SW-GW	0 ppm
				24	16						0 ppm
				17	16	100%					0 ppm
				23	17						0 ppm
55				9	10	100%					0 ppm
				13	14						0 ppm
				6	9	80%					0 ppm
				10	11						0 ppm
				11	11	90%					0 ppm
60				12	15						0 ppm
				6	12	65%					0 ppm
				13	17						0 ppm
				18	16	70%					0 ppm
				21	23						0 ppm
65				12	24	70%					0 ppm
				22	26						0 ppm
				36	31	75%	Gray	Very Dense	SILTSTONE fragments in a clayey silt matrix, some sand (66.0-68.0'). Very moist	GC	0 ppm
				29	30						0 ppm
				18	50/3	90%	Dark Gray	Very Dense	Weathered SILTSTONE (68.0-69.0'). Moist.	Bedrock	0 ppm
70											0 ppm
									Boring completed at 69.0 feet.		

COMMENTS: Well constructed. See well construction log.

PROJECT NO.: 17-013-0289
BORING NO.: MW-04

DRILLING SUMMARY	MONITORING WELL CONSTRUCTION LOG
Geologist: Daniel Sheldon	
Drilling Company: SJB/Empire Geo Serv. Inc.	
Driller: Daniel Delude	
Rig Make/Model: Diedrich D-50	
Date: 12/30/2020	



GEOLOGIC LOG

Depth (ft.)	Description
	See boring log

WELL DESIGN

NOT TO SCALE

CASING MATERIAL		*SCREEN MATERIAL*	*FILTER MATERIAL*	
Surface:	Steel Protective Casing	Type: 2" Schedule 40 PVC	Type: No. 0 SAND	Setting: 49'-67' bgs
			SEAL MATERIAL	
Monitor:	Schedule 40 PVC	Slot Diameter: 0.010"	Type: Bentonite	Setting: 67'- 78' bgs Setting: 1'- 49' bgs
		Setting: 51' - 66' bgs	Type: Cement Grout	Setting: 0' - 1' bgs

COMMENTS:

The contractor was directed to install the borehole to a total depth of 74.0' bgs. All soils were screened with a PID meter and checked for olfactory and visual evidence of contamination. All PID readings were noted. A well was constructed of schedule 40 PVC piping and 0.010" slot diameter screen, with a bottom bentonite seal from 67 to 74 feet, with a sand pack from 67 to 49 feet, with a bentonite seal from 49 to 1 feet, and slurry mix from 1 foot to ground surface. The well was completed at grade with a steel stick up protective casing and four concrete filled steel bollards.

LEGEND:

- PVC Casing
- #0 Sand
- Bentonite
- Cement Grout
- PVC Screen

CLIENT:	LOCATION:	Project No.
NYSDEC	Mayville	17-013-0289
LiRo Engineers, Inc.	**Monitoring Well Construction Details**	*Well Number:* **MW-05**

LiRo Engineers, Inc.

TEST BORING LOG

BORING ID:	MW-05
SHEET:	1 of 3
JOB NO.:	17-013-0289
LOCATION:	Mayville, NY
GROUND ELEVATION:	TBD
DATE STARTED:	December 29, 2020
DATE FINISHED:	December 30, 2020
DRILLER:	SJB/Empire Geo Serv. Inc.
GEOLOGIST:	Daniel Sheldon
REVIEWED BY:	

PROJECT NAME: Mayville
CLIENT: New York State Department of Environmental Conservation (NYSDEC)
BORING CONTRACTOR: SJB/Empire Geo Serv. Inc.
GROUNDWATER: 4.0 feet bgs on December 29, 2020

DATE	TIME	LEVEL	TYPE		CAS.	SAMPLER	TUBE
				TYPE		HSA	
				DIA.		4 1/4"	2" sampler
				WT.			
				FALL			

DEPTH FEET	STRATA	"S" NO.	"N" NO.	BLOWS PER 6"		REC% RQD%	COLOR	CONSISTENCY HARDNESS	MATERIAL DESCRIPTION	USCS	PID
				4	13	40%	Brown	Medium Dense	FILL, gravel and sand (0.0-4.5')	Fill	0 ppm
				11	7						0 ppm
				3	3	35%					0 ppm
				3	6						0 ppm
5				3	6	70%					0 ppm
				4	4		Brown	Medium Dense	SAND and GRAVEL, trace Silt. Wet. (4.5-8.0'). Wet at 4'.	SW-GW	0 ppm
				2	4	75%					0 ppm
				3	3						0 ppm
				1	1	35%	Dark Brown	Very Loose to Medium Dense	Fine to Medium SAND, trace Silt, some Gravel (8.0-11.5'). Wet.	SP	0 ppm
10				1	1						0 ppm
				3	6	90%					0 ppm
				9	8						0 ppm
				9	13	80%	Gray	Medium Dense	Fine SILTY SAND, trace Clay (11.5-14.0'). Very moist to wet.	SM	0 ppm
				15	13						0 ppm
15				1	2	80%	Gray	Soft to Very Soft	SANDY CLAY (14.0-30.0'). Slighty Moist to Moist.	CL	0 ppm
				3	10						0 ppm
				4	7	90%					0 ppm
				7	6						0 ppm
				2	2	60%					0 ppm
20				3	6						0 ppm
				1	4	50%					0 ppm
				4	4						0 ppm
				3	4	70%					0 ppm
				3	4						0 ppm
25				1	1	80%					0 ppm
				2	2						0 ppm
				WH	4	90%					0 ppm
				3	3						0 ppm
				WH	1	100%					0 ppm
30				2	4						0 ppm
				WR	WH	90%	Dark Brown	Loose to Medium Dense	SAND and GRAVEL, trace Silt (30.0-37.0'). Wet.	SW-GW	0 ppm
32				2	3						0 ppm
				6	9	85%					0 ppm
				10	10						0 ppm
35				7	7	70%					0 ppm

COMMENTS: Well constructed. See well construction log.

PROJECT NO.: 17-013-0289
BORING NO.: MW-05

LiRo Engineers, Inc.	**TEST BORING LOG**
	BORING ID: MW-05
PROJECT NAME: Mayville	**SHEET:** 2 of 3
CLIENT: New York State Department of Environmental Conservation (NYSDEC)	**JOB NO.:** 17-013-0289
BORING CONTRACTOR: SJB/Empire Geo Serv. Inc.	**LOCATION:** Mayville, NY

GROUNDWATER:					CAS.	SAMPLER	TUBE		
DATE	TIME	LEVEL	TYPE	TYPE		HSA		GROUND ELEVATION:	TBD
				DIA.		4 1/4"	2" sampler	DATE STARTED:	December 29, 2020
				WT.				DATE FINISHED:	December 30, 2020
				FALL				DRILLER:	SJB/Empire Geo Serv. Inc.
								GEOLOGIST:	Daniel Sheldon
								REVIEWED BY:	

DEPTH FEET	STRATA	"S" NO.	"N" NO.	BLOWS PER 6"		REC% RQD%	COLOR	CONSISTENCY HARDNESS	MATERIAL DESCRIPTION	USCS	PID
				9	10	70%	Dark Brown	Medium Dense	SAND and GRAVEL, trace Silt (30.0-37.0'). Wet.	SW-GW	0 ppm
				10	11	80%					0 ppm
				8	10		Gray	Medium Stiff to Soft	SILTY CLAY, trace fine Sand (37.0-49.0'). Slightly moist.	CL	0 ppm
				2	2	80%					0 ppm
40				4	4						0 ppm
				1	2	85%					0 ppm
				4	4						0 ppm
				4	4	90%					0 ppm
				3	4						0 ppm
45				WH	2	80%					0 ppm
				2	2						0 ppm
				2	3	90%					0 ppm
				4	4						0 ppm
				1	4	90%					0 ppm
50				5	13		Dark Brown	Medium Dense	SAND and GRAVEL, trace Silt (49.0-58.0'). Wet.	SW-GW	0 ppm
				4	6	95%					0 ppm
				7	10						0 ppm
				8	9	100%					0 ppm
				11	12						0 ppm
55				9	10	100%					0 ppm
				13	13						0 ppm
				7	7	70%					0 ppm
				4	6						0 ppm
				6	12	100%	Gray	Medium Stiff to Stiff	SANDY SILT, trace Clay (58.8-66.0'). Wet.	ML	0 ppm
60				9	8						0 ppm
				6	6	90%					0 ppm
				6	6						0 ppm
				6	6	90%					0 ppm
				8	12						0 ppm
65				5	3	100%					0 ppm
				3	3						0 ppm
				4	5	80%	Gray	Medium Stiff to Stiff	CLAYEY SILT, trace fine sand (66.0-78.0'). Slightly moist to moist.	MH	0 ppm
				5	5						0 ppm
				1	2	100%					0 ppm
70				3	5						0 ppm

COMMENTS: Well constructed. See well construction log.

PROJECT NO.: 17-013-0289
BORING NO.: MW-05

LiRo Engineers, Inc.

TEST BORING LOG

BORING ID:	MW-05
SHEET:	3 of 3
JOB NO.:	17-013-0289
LOCATION:	Mayville, NY
GROUND ELEVATION:	TBD
DATE STARTED:	December 29, 2020
DATE FINISHED:	December 30, 2020
DRILLER:	SJB/Empire Geo Serv. Inc.
GEOLOGIST:	Daniel Sheldon
REVIEWED BY:	

PROJECT NAME: Mayville
CLIENT: New York State Department of Environmental Conservation (NYSDEC)
BORING CONTRACTOR: SJB/Empire Geo Serv. Inc.

GROUNDWATER:					CAS.	SAMPLER	TUBE
DATE	TIME	LEVEL	TYPE	TYPE		HSA	
				DIA.		4 1/4"	2" sampler
				WT.			
				FALL			

DEPTH FEET	STRATA	"S" NO.	"N" NO.	BLOWS PER 6"		REC% RQD%	COLOR	CONSISTENCY HARDNESS	MATERIAL DESCRIPTION	USCS	PID
				WH	4	80%	Gray	Medium Stiff	CLAYEY SILT, trace fine sand (66.0-78.0'). Slightly moist to moist.	MH	0 ppm
				4	5						0 ppm
				2	4	90%					0 ppm
				5	7						0 ppm
75				WH	2	70%					0 ppm
				3	2						0 ppm
				WH	3	100%					0 ppm
				3	5						0 ppm
									Boring completed at 78.0 feet		
80											

COMMENTS: Well constructed. See well construction log.

PROJECT NO.: 17-013-0289
BORING NO.: MW-05

DRILLING SUMMARY	MONITORING WELL CONSTRUCTION LOG

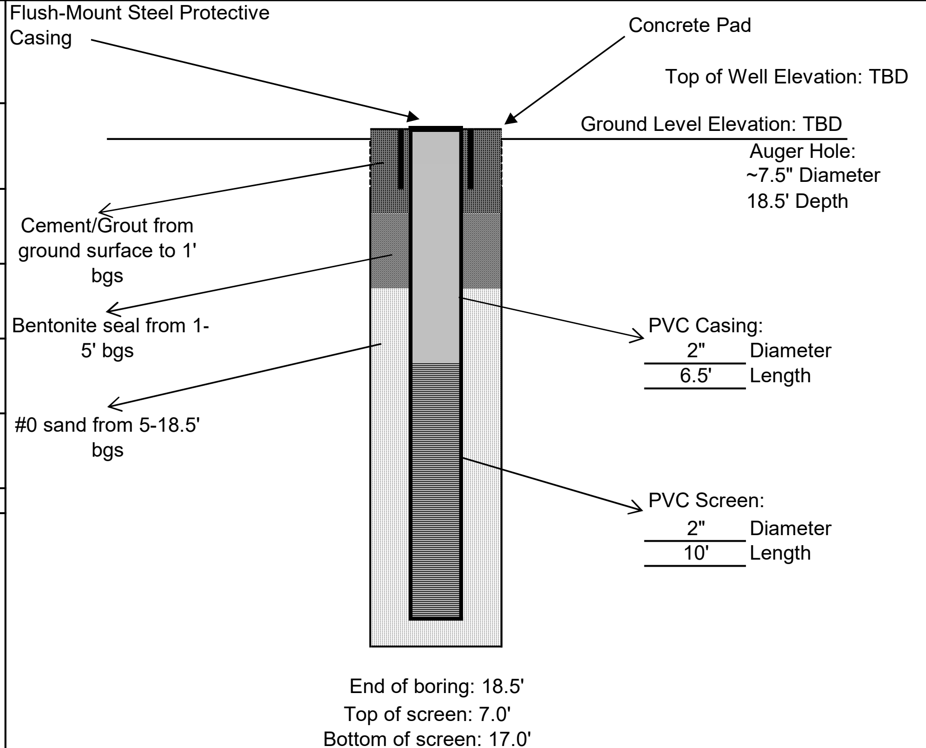
Geologist: Daniel Sheldon

Drilling Company: SJB/Empire Geo Serv. Inc.

Driller: Daniel Delude

Rig Make/Model: Diedrich D-50

Date: 1/5/2021



GEOLOGIC LOG

Depth (ft.)	Description
	See boring log

WELL DESIGN

NOT TO SCALE

CASING MATERIAL	*SCREEN MATERIAL*	*FILTER MATERIAL*
Surface: Steel Flush Mount Casing	Type: 2" Schedule 40 PVC	Type: No. 0 SAND Setting: 5 to 18.5' bgs
		SEAL MATERIAL
Monitor: Schedule 40 PVC	Slot Diameter: 0.010"	Type: Bentonite Setting: 1.0'- 5.0' bgs
	Setting: 7' - 17' bgs	Type: Cement Grout Setting: 0' - 1' bgs

COMMENTS:

The contractor was directed to install the borehole to a total depth of 18.0' bgs. All soils were screened with a PID meter and checked for olfactory and visual evidence of contamination. All PID readings were noted. A well was constructed of schedule 40 PVC piping and 0.010" slot diameter screen, with a with a sand pack from 5.0 to 18.5 feet, with a bentonite seal from 1.0 to 5.0 feet, and slurry mix from 1 foot to ground surface. The well was completed at grade with a a steel flush-mount protective casing.

LEGEND:

- PVC Casing
- #0 Sand
- Bentonite
- Cement Grout
- PVC Screen

CLIENT:	LOCATION:	Project No.
NYSDEC	Mayville	17-013-0289
LiRo Engineers, Inc.	**Monitoring Well Construction Details**	*Well Number:* **MW-06**

LiRo Engineers, Inc.	TEST BORING LOG
	BORING ID: MW-06
PROJECT NAME: Mayville	SHEET: 1 of 1
CLIENT: New York State Department of Environmental Conservation (NYSDEC)	JOB NO.: 17-013-0289
BORING CONTRACTOR: SJB/Empire Geo Serv. Inc.	LOCATION: Mayville, NY

GROUNDWATER: 5.5 Ft bgs					CAS.	SAMPLER	TUBE	GROUND ELEVATION:	TBD
DATE	TIME	LEVEL	TYPE	TYPE		HSA		DATE STARTED:	January 4, 2021
				DIA.		4 1/4"	2" sampler	DATE FINISHED:	January 4, 2021
				WT.				DRILLER:	SJB/Empire Geo Serv. Inc.
				FALL				GEOLOGIST:	Daniel Sheldon
								REVIEWED BY:	

DEPTH FEET	STRATA	"S" NO.	"N" NO.	BLOWS PER 6"		REC% RQD%	COLOR	CONSISTENCY HARDNESS	MATERIAL DESCRIPTION	USCS	PID
				WH	2	60%	Brown to Dark Brown	Medium Stiff to Stiff	SANDY SILT with some angular coarse Gravel (0.0-8.0'). Wet at 5.5 feet.	ML	0 ppm
				4	8						0 ppm
				2	9	70%					0 ppm
				4	6						0 ppm
5				2	2	60%					0 ppm
				7	6						0 ppm
				2	8	45%					0 ppm
				6	7						0 ppm
				9	7	20%	Brown to Light Brown	Medium Dense	Coarse angular GRAVEL, some Silt, trace Clay (8.0-12.0'). Moist.	GM	0 ppm
10				4	5						0 ppm
				4	7	60%					0 ppm
				14	12						0 ppm
				9	13	100%	Olive Gray	Hard	SANDY SILT with some angular gravel (12.0-17.0'). Dry.	ML	0 ppm
				17	24						0 ppm
15				28	17	70%					0 ppm
				21	32						0 ppm
				22	50/3	90%					0 ppm
							Gray	Very Dense	Weathered SILTSTONE (17.0-18.5'). Dry.	Bedrock	0 ppm
				50/4		100%					0 ppm
20									Boring completed at 18.5 feet.		
25											
30											
35											

COMMENTS: Well constructed. See well construction log.

PROJECT NO.: 17-013-0289
BORING NO.: MW-06

LiRo Engineers, Inc.

TEST BORING LOG

BORING ID:	SB-06A
SHEET:	1 of 1
JOB NO.:	17-013-0289
LOCATION:	Mayville, NY
GROUND ELEVATION:	TBD
DATE STARTED:	January 5, 2021
DATE FINISHED:	January 5, 2021
DRILLER:	SJB/Empire Geo Serv. Inc.
GEOLOGIST:	Daniel Sheldon
REVIEWED BY:	

PROJECT NAME: Mayville
CLIENT: New York State Department of Environmental Conservation (NYSDEC)
BORING CONTRACTOR: SJB/Empire Geo Serv. Inc.

GROUNDWATER:

DATE	TIME	LEVEL	TYPE		CAS.	SAMPLER	TUBE
				TYPE		HSA	
				DIA.		4 1/4"	2" sampler
				WT.			
				FALL			

DEPTH FEET	STRATA	"S" NO.	"N" NO.	BLOWS PER 6"		REC% / RQD%	COLOR	CONSISTENCY HARDNESS	MATERIAL DESCRIPTION	USCS	PID
									No Samples Collected 0-18 Feet.		
18											
19				23	50/2	90%	Gray	Very Dense	Weathered SILTSTONE	Bedrock	0 ppm
									Boring completed at 18.7 feet.		

COMMENTS: Bedrock confirmation boring completed in vicinity of well MW-06.

PROJECT NO.: 17-013-0289
BORING NO.: SB-06A

DRILLING SUMMARY	MONITORING WELL CONSTRUCTION LOG

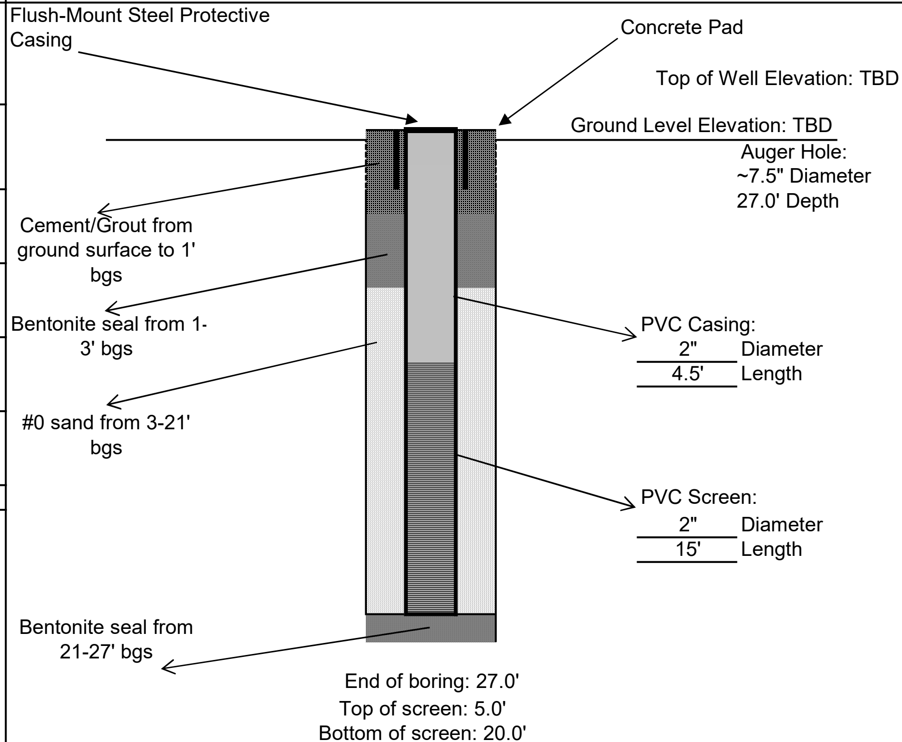
Geologist: Daniel Sheldon

Drilling Company: SJB/Empire Geo Serv. Inc.

Driller: Daniel Delude

Rig Make/Model: Diedrich D-50

Date: 1/4/2021



GEOLOGIC LOG

Depth (ft.)	Description
	See boring log

WELL DESIGN

NOT TO SCALE

CASING MATERIAL	*SCREEN MATERIAL*	*FILTER MATERIAL*
Surface: Steel Flush Mount Casing	Type: 2" Schedule 40 PVC	Type: No. 0 SAND Setting: 3-21' bgs
		SEAL MATERIAL
Monitor: Schedule 40 PVC	Slot Diameter: 0.010"	Type: Bentonite Setting: 21'- 27' bgs Setting: 1'- 3' bgs
	Setting: 5' - 20' bgs	Type: Cement Grout Setting: 0' - 1' bgs

COMMENTS:

The contractor was directed to install the borehole to a total depth of 26.0' bgs. All soils were screened with a PID meter and checked for olfactory and visual evidence of contamination. All PID readings were noted. A well was constructed of schedule 40 PVC piping and 0.010" slot diameter screen, with a bottom bentonite seal from 21.0 to 27.0 feet, with a sand pack from 3.0 to 21.0 feet, with a bentonite seal from 1.0 to 3.0 feet, and slurry mix from 1 foot to ground surface. The well was completed at grade with a steel flush mount casing.

LEGEND:

- PVC Casing
- #0 Sand
- Bentonite
- Cement Grout
- PVC Screen

CLIENT:	LOCATION:	Project No.
NYSDEC	Mayville	17-013-0289
LiRo Engineers, Inc.	**Monitoring Well Construction Details**	*Well Number:* **MW-07**

LiRo Engineers, Inc.	TEST BORING LOG

PROJECT NAME: Mayville		BORING ID:	MW-07
CLIENT: New York State Department of Environmental Conservation (NYSDEC)		SHEET:	1 of 1
BORING CONTRACTOR: SJB/Empire Geo Serv. Inc.		JOB NO.:	17-013-0289
		LOCATION:	Mayville, NY

GROUNDWATER: 9.7 Ft bgs on January 4, 2012					CAS.	SAMPLER	TUBE	GROUND ELEVATION:	TBD
DATE	TIME	LEVEL	TYPE	TYPE		HSA		DATE STARTED:	December 31, 2020
				DIA.		4 1/4"	2" sampler	DATE FINISHED:	December 31, 2020
				WT.				DRILLER:	SJB/Empire Geo Serv. Inc.
				FALL				GEOLOGIST:	Daniel Sheldon
								REVIEWED BY:	

DEPTH FEET	STRATA	"S" NO.	"N" NO.	BLOWS PER 6"		REC% RQD%	COLOR	CONSISTENCY HARDNESS	MATERIAL DESCRIPTION	USCS	PID
				2	3	40%	Brown to Dark Brown	Medium Dense to Loose	FILL, reworked Gravel, silty sand, and clay. Trace brick, asphalt, and slag. (0-16.0'). Wet at 6 feet.	Fill	0 ppm
				12	15						0 ppm
				6	26	35%					0 ppm
				8	2						0 ppm
5				1	1	15%					0 ppm
				WH							0 ppm
				WH	1	70%					0 ppm
				WH							0 ppm
				WH	1	40%					0 ppm
10				1	2						0 ppm
				1	1	25%					0 ppm
				1	1						0 ppm
				1	2	80%					0 ppm
				2	3						0 ppm
15				9	3	70%					0 ppm
				10	6						0 ppm
				11	3	75%	Olive Gray	Stiff to Very Stiff	SILTY SAND with some angular Gravel (16.0-20.0'). Dry.	SM	0 ppm
				11	12						0 ppm
				4	7	50%					0 ppm
20				15	13						0 ppm
				7	10	70%	Grayish Brown	Very Stiff to Hard	CLAYEY SILT and coarse GRAVEL (20.0-27.0'). Very moist.	GM	0 ppm
				15	12						0 ppm
				11	16	65%					0 ppm
				14	57						0 ppm
25				13	12	60%					0 ppm
				50/5							0 ppm
27				32	50/1	100%					0 ppm
									Boring completed at 27.0 feet		
30											
35											

COMMENTS:	Well constructed. See well construction log.	PROJECT NO.:	17-013-0289
		BORING NO.:	MW-07

EXISTING OR FORMER WELLS - MORRIS STREET AREA

Sweatman Farm Well

Sweatman Farm Well
DECOMMISSIONED

VILLAGE OF MAYVILLE
NEW YORK
RECEIVED
JAN 24 1996

Village of Mayville
Water Department
PO Box 188
Mayville, NY 14757

Town of Chautauqua, Chaut. Cty, NY

8" ID Test Well
Sweatman Farm
Morris Street, Mayville, NY

Contractor: Ehmke Well Drillers
104 Main Street
Silver Creek, NY

Driller: George Ehmke
Helper: Steve Czerniak
Chris Dobbs

Depth: 185' to bottom of 8" hole
Bed Rock: 130'6"

Casing: 133'4" of new 8-5/8"OD
Schedule # 40

Shale Rock: 130'6" to 185'

Screen: 6" ID X 6-5/8"OD
steel fabricated with
torch-cut beveled slots
8 ft. in length.

Screen Set: 126'4" to 134'4"
with flared top and closed
bail bottom.

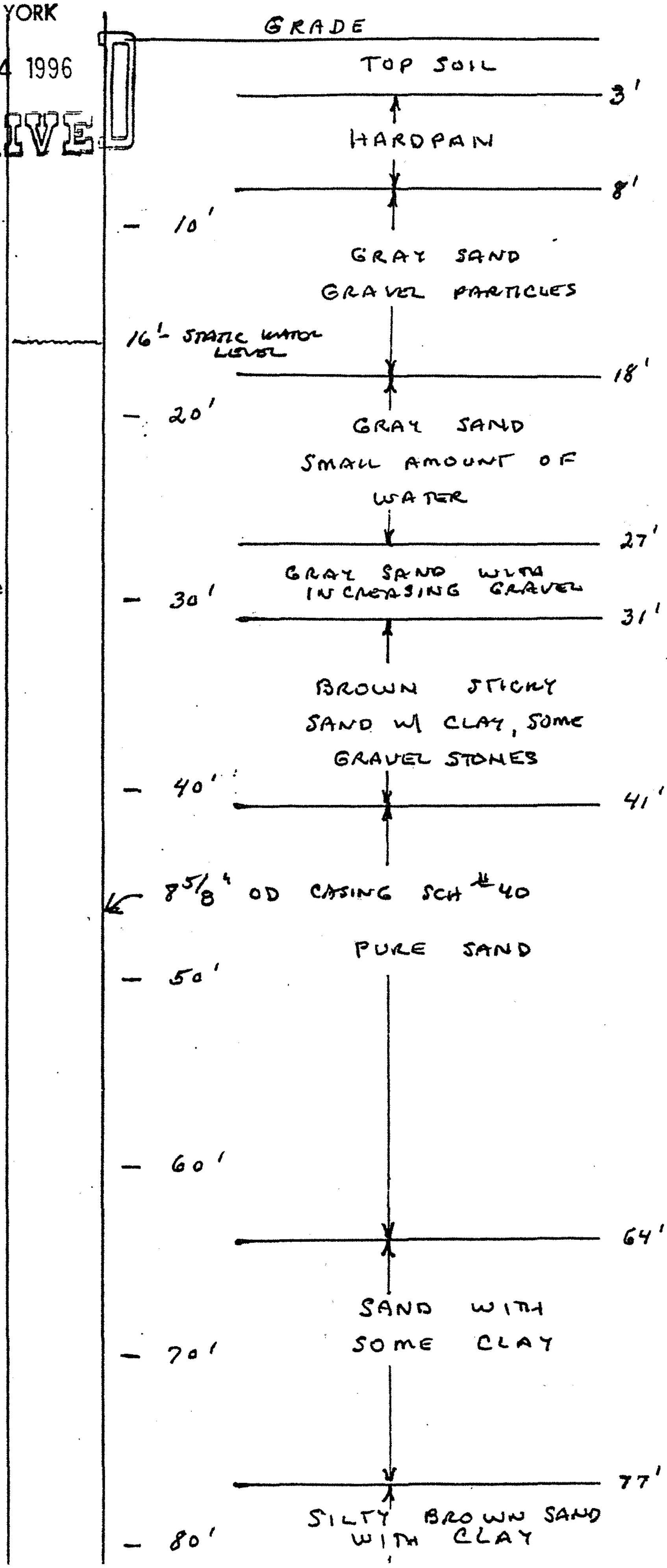
Hole backfilled and tamped at
the top of fill (134'4")

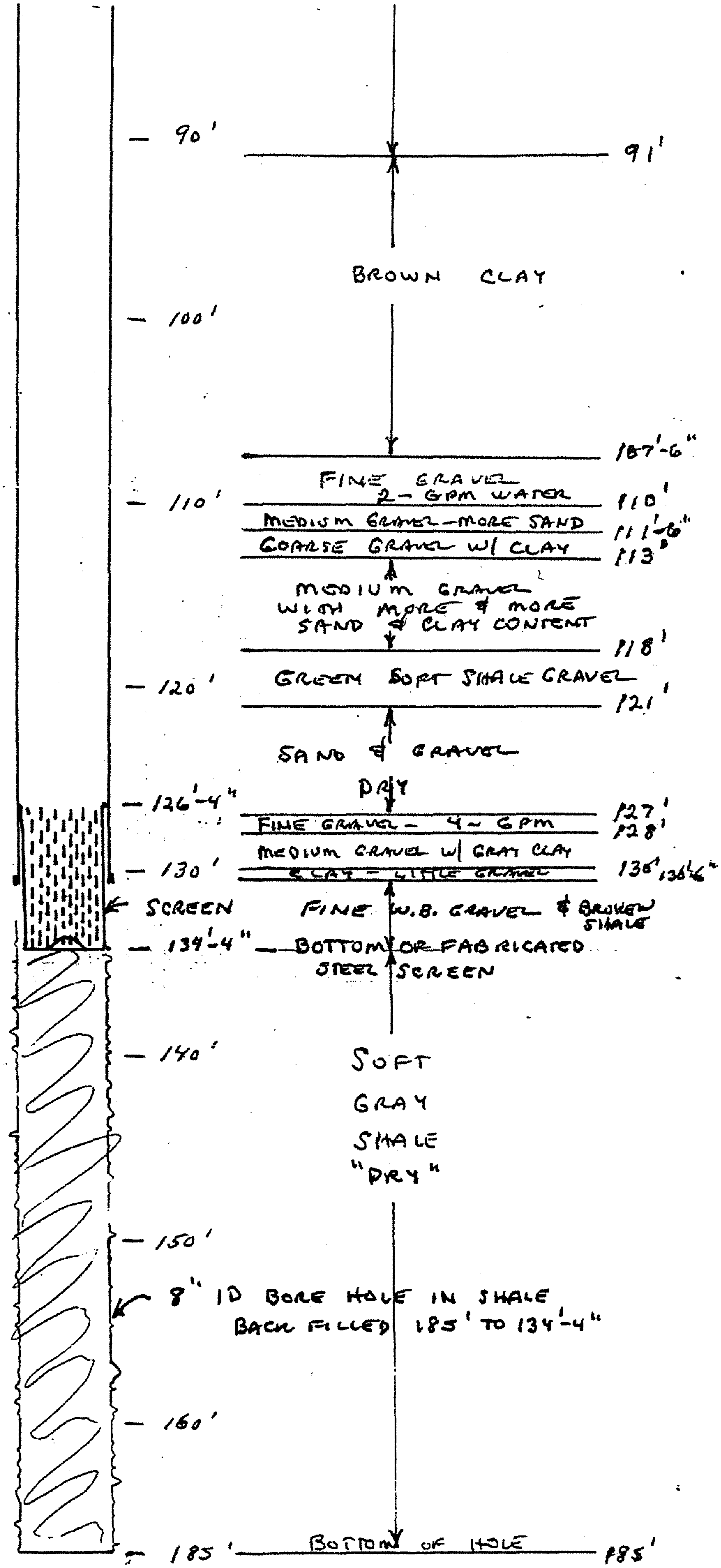
Well pump tested Jan. 8, 1996
with vertical turbine pump

Flow: 49 GPM at 70' pumping
level:

Static Level: 16'

Drilled Oct. 21, 1995
thru Jan, 12, 1996





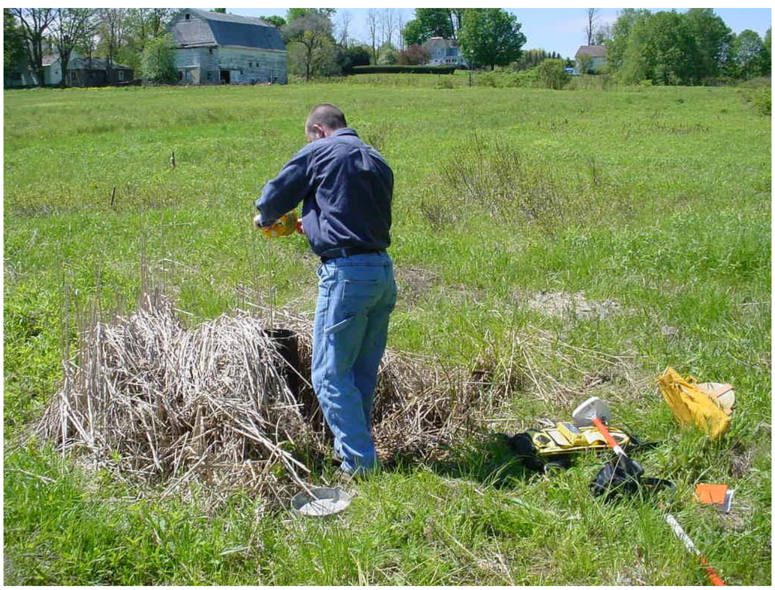
VERTICAL SCALE
1/8" = 1'

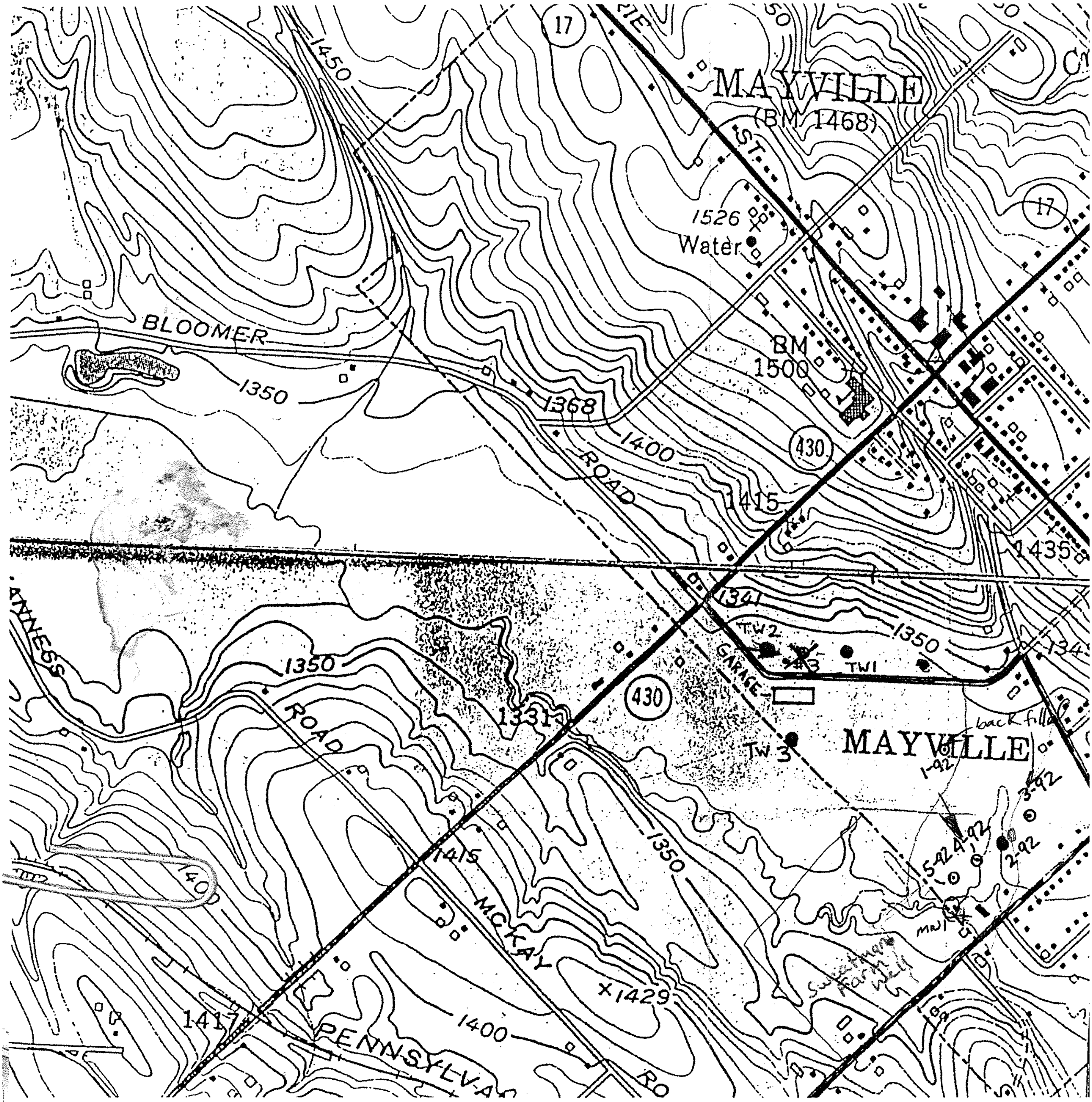
Test well located on old Sweatman Farm

8" steel casing
TOC 1.75' above ground
Total depth 136.9' below TOC
Water level 23.4' below TOC
Original depth of well 134.3' b.g.
Screen: 6" slotted steel 130-134.3'
GPS location: 42.2413936^{o} N lat,
79.506278^{o} W long

Water is ponded around well casing; depression is ~1' deep and ~ 5 to 6' in dia. around well

CCDOH recommends this well casing be pulled and the well properly plugged and abandoned.





MAYVILLE
(BM 1468)
1526
Water
BM
1500
BLOOMER
1350
1368
1400
ROAD
430
1415
1435
1341
TW2
TW1
TW3
GARAGE
1350
1331
MAYVILLE
back fill
1-92
3-92
2-92
4-92
5-92
MW1
Swatham Farm Well
ROAD
1415
MCKAY
1429
1400
1417
PENNSYLVA
1450
17

North Chautauqua Lake Sewer District (NCLSD)
Water Pollution Control Plant (2 Clark Street)
- Water Supply Well

WATER SUPPLY WELL (NCLSD)

North Chautauqua Lake Sewer District
Mayville, N. Y. 2 CLARK STREET
(Town of Chautauqua N.Y.)

Driller: Ronald Metzger
Helper: Fritz Ehmke

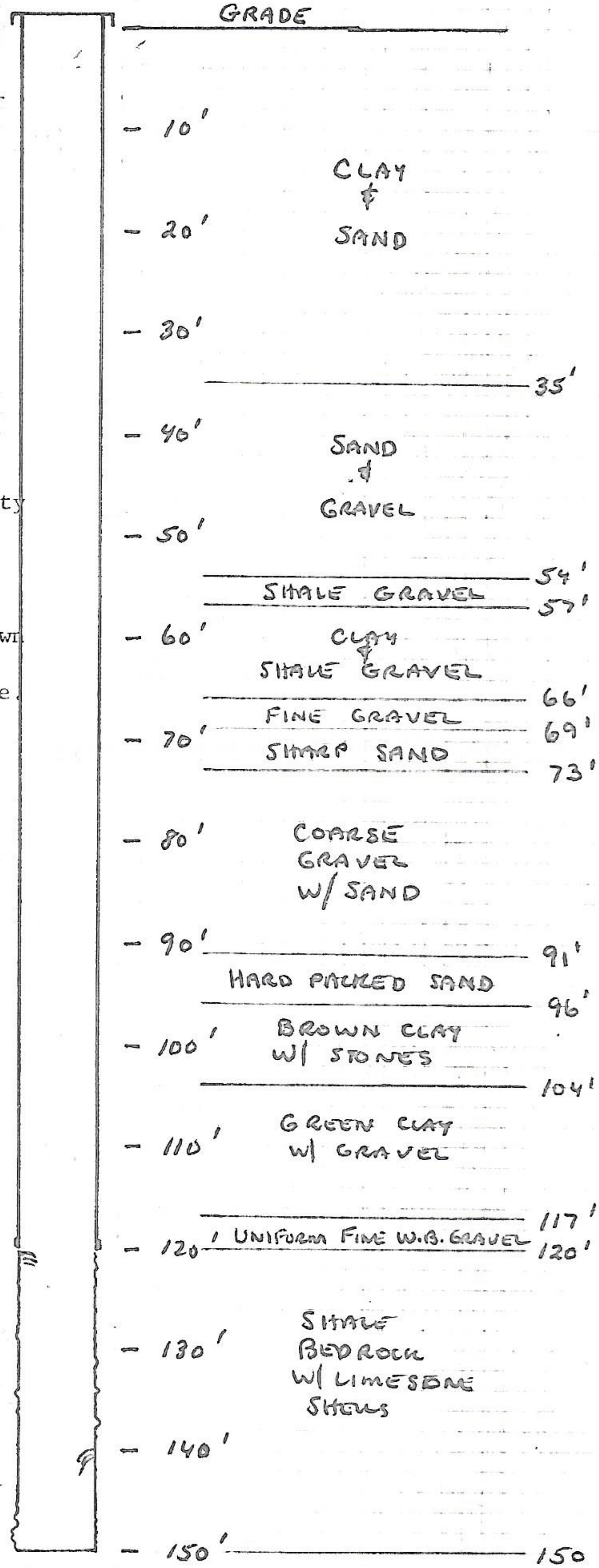
Depth: 150 ft.
Casing: 121 ft. of new 8" ID
Bedrock: 120 ft. below grade
Veins: 120 ft. in gravel top of rock
140 ft. in bedrock

Pump Test: 8-7-80 8 hrs. duration
Flow Rate: 32 GPM at 47 ft. pumping level
20 GPM at 31 ft. pumping level

Well completed: August 7, 1980

Recommendation: 3/4 HP, 5 stage high capacity 230 volt, 3 wire submersible type water pump having a 40 ft. pump setting in the well.

Specific capacity: 2 GPM per foot of drawdown
Static Level: 10 feet above grade*
* Well freeflows 5+ GPM 8" above grade.



EHMKE WELL DRILLERS INC.
Box 4, 104 Main Street
Silver Creek, N.Y. 14136
934-2658

EHMKE WELL DRILLERS Silver Creek

EHMKE WELL DRILLERS, INC.
104 Main Street
SILVER CREEK, NEW YORK 14136
Area Code 716 934-2658

WELL DEPTH: 150 feet

REPORT OF PUMPING TEST DATE: August 7, 1980

OWNER: North Chautauqua Lake Sewer Dist.
PO Box 167, 1 Clark Street
Mayville, N. Y. 14757

LOCATION: Sewage Treatment Plant
Mayville, N. Y.

WELL # 1 FOREMAN: Michael Raczka DURATION OF TEST: 8 Hours

TYPE WELL: [XX] Gravel [XX] New [XX] Open Hole [ ] Gravel-packed [ ] Developed
[XX] Rock [ ] Old [ ] Screened [ ] Natural-pack [ ] Perforated

CASINGS: Length: 121 ft. (Outer) 8" I.D. 8-5/8" O.D. Grouted: [ ] Yes
(Inner) ______ I.D. ______ O.D. [XX] No

~~SCREENS: [ ] Telescope Size ______ [ ] Stainless steel [ ] Everdur Bronze
[ ] Std. Pipe Size ______ [ ] Low-carbon steel [ ] Armco galv. iron
[ ] Slotted Casing ______ [ ] Red Brass [ ] Plastic
Screen I.D. ______ Screen O.D. ______ Length ______ Overall ______
[ ] Sump casing ______ [ ] Closed bail bottom [ ] Lead Packer top
[ ] Flush tube ______ to ______ [ ] Weld ring top to ______ casing.
[ ] K Packer top Slot size: ______~~

TYPE PUMP: [ ] Turbine [XX] Submersible [ ] Suction DISCHARGE: 2" pipe
Orifice: 1-3/8"

DEPTH READING DEVICE: [ ] Altitude gauge [XX] Electric probe
TOP OF SCREEN @ ______ TOP OF BOWLS @ 100 ft.
STATIC WATER LEVEL Freeflowing WATER SAMPLE TAKEN BY ______

	TIME OF DAY	BACK PRESS	ORIFICE	GPM	ALTITUDE	WATER LEVEL	OBS.HOLE
-7-80	12:29 PM	0"	1-3/8"	0		Static	
	12:30	18"	"	32.75		25'	
	12:45	18"	"	32.75		35'	
	1:00	18"	"	32.75		40'	
	1:30	18"	"	32.75		42'	
	2:00	18"	"	32.75		45'	
	2:30	18"	"	32.75		45'	
	3:00	18"	"	32.75		45'	
	3:30	18"	"	32.75		45'	
	4:00	18"	"	32.75		46'	
	4:30	18"	"	32.75		47'	
	5:00	17"	"	31.75		47'	
	5:30	17"	"	31.75		47'	
	6:00	17"	"	31.75		47'	
	6:30	7"	"	20.3		40'	close discharge down
	7:00	7"	"	20/3		32'	
	7:30	7"	"	20.3		31'	
	8:00	7"	"	20.3		31'	
	8:30	7"	"	20.3		31'	

End of test.

Specific capacity of the well is approximaeely 2GPM per foot of drawdown.

[signature]

Well 1-92

LOG OF BORING 1-92 (DECOMMISSIONED)

LOCATION: Hayville, NY
SURFACE ELEVATION: 1331 Feet MSL

DATE DRILLED: 3/31-4/2/92
TOTAL DEPTH OF HOLE: 87.0 Feet

DRILLING METHOD: 8 in. Hollow Stem Auger
WATER LEVEL ATD: Feet

WELL CONSTRUCTION	DEPTH (FT)	SAMPLE NUMBER	BLOWS/FT	GRAPHIC LOG	MATERIALS DESCRIPTION
	0–5				Brown SAND and GRAVEL and boulders.
	5–10				Brown SAND.
	10–15				Gray silty SAND.
	15–50				Gray silty CLAY.
	50–53				Gray SAND w/ trace gravel.
	53–57				Gray SAND.
	57–59				Gray coarse SAND.
	59–75				Gray silty SAND.
	75–85				Gray silty SAND and GRAVEL; did not appear to yield significant water.
	85–87				Gray CLAY.
					Boring terminated in this strata.
					Test boring backfilled.

Depth scale: 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100

Figure F.5

7

VILLAGE OF MAYVILLE, N. Y.
TEST WELL 1-92 * TW 1-92

0 - 5'	Yellowish Brown Sandy Silt
5 - 35'	Gray Silty Clay
35 - 36'	Gray Silty Clay and Small Gravel Mixed In
36 - 37'	Fine Gray-Brown Sand Heaving Up Hole
37 - 39'	Gray Sand-Fine Gravel Heaving Up
39 - 41'	Brown Sand and Small Amount of Gravel Heaving Up
41 - 42'	Brown Sand - Little Amount of Gravel Increasing Clay
42 - 54'	Gray Clay
54 - 56'	Silty Gray Medium Sand Mixed With Fine - Coarse Gravel. Clay Balls Mixed in Also.
56 - 58'	Gray Coarse Sand and Fine to Medium Gravel
58 - 60'	Silty Gray Sand, Coarse Sand, Fine and Medium Gravel
60 - 61'	Some Large Gravel Heaving Up Hole
61 - 62'	Gray Clay With Medium Sand With Fine Gravel Mixed In
62 - 63'	Silty Gray Clay
63 - 63.5'	Gray Clay

* At Location of Boring 2-92

8" casing slotted between 55 and 60 ft

installed mid-1992 by Moody and Associates

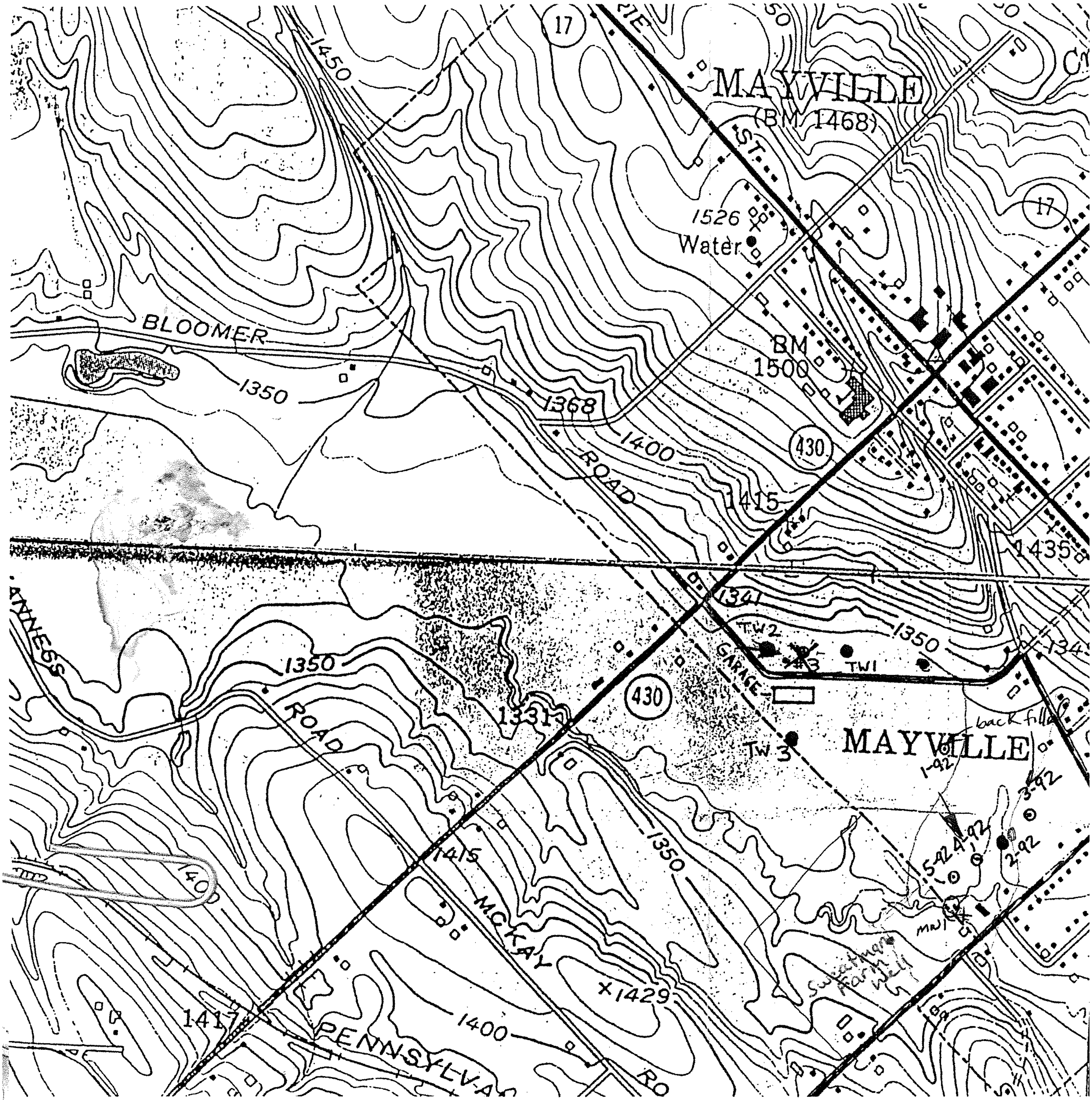
2006

TW 1-92 located at edge of ball field in Gravit Park north of DPW.

8" steel casing
TOC 1.7' above ground
Total depth 59.9' below TOC
Water level 16.75' below TOC
Original depth of well ~60 b.g.
Screen: 8" casing slotted 55-60'
GPS location: 42.2450223° N lat, 79.5024574° W long

CCDOH recommends this well casing be pulled and the well properly plugged and abandoned

.


MAYVILLE
(BM 1468)
17
1450
1526
Water
BLOOMER
1350
1368
BM
1500
1400
ROAD
430
1415
1435
1341
TW2
TW1
1350
GARAGE
TW 3
MAYVILLE
back fill
1-92
3-92
2-92
4-92
5-92
1350
1331
430
ROAD
1350
1415
MCKAY
1429
1400
1417
PENNSYLVA

Well 2-92

LOG OF BORING 2-92 (DECOMMISSIONED)

LOCATION: Mayville, NY
SURFACE ELEVATION: 1330.57 Feet NSL
DATE DRILLED: 4/26-4/28/92
TOTAL DEPTH OF HOLE: 100 Feet
DRILLING METHOD: 8 In. Hollow Stem Auger
WATER LEVEL ATD: 14 Feet

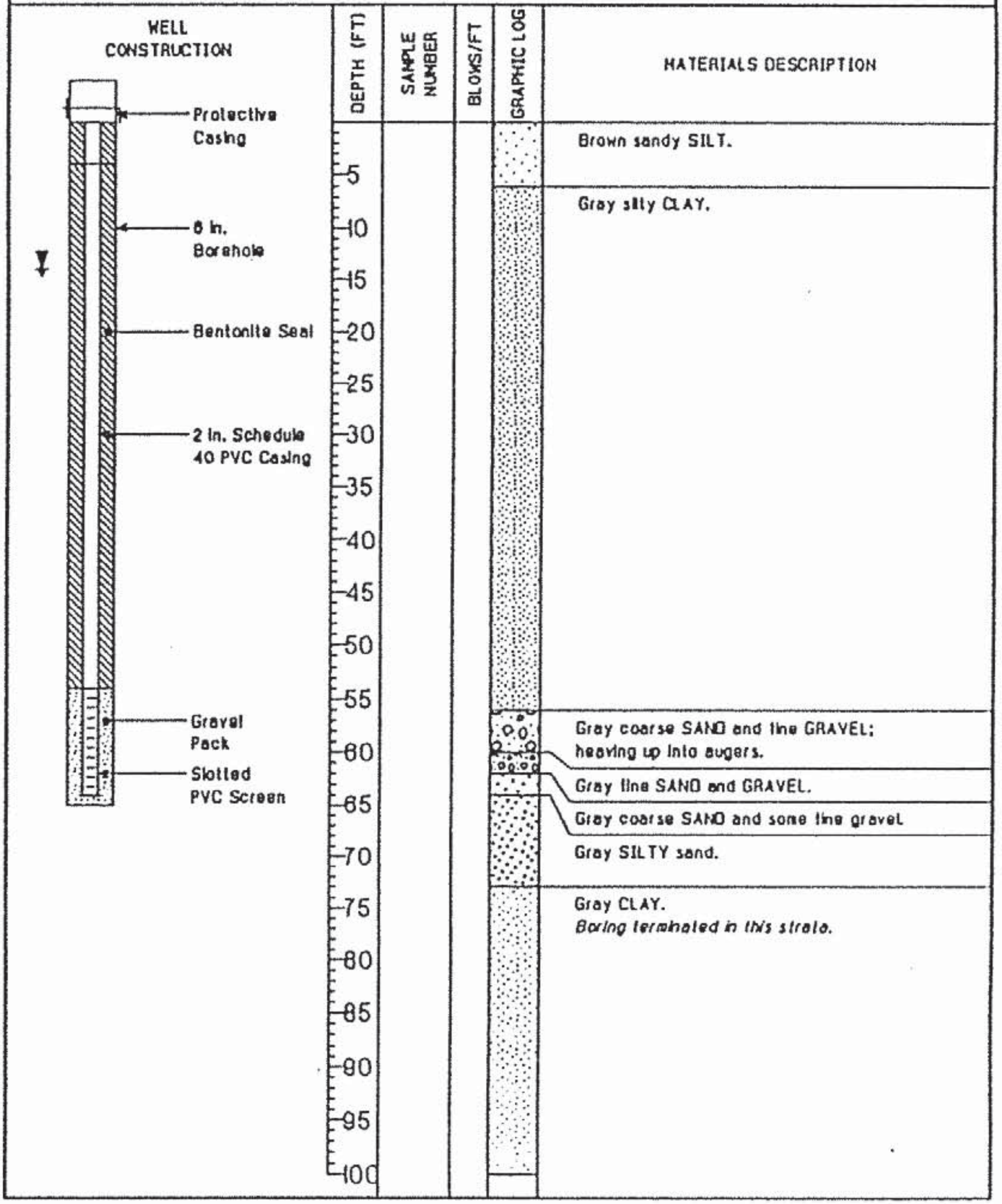


Figure F.6

MAYVILLE, NEW YORK Moody + Assoc.

TEST WELL 2-92 MW 2-92

May 26 - 28, 1992

DEPTH - (Ft.)	GEOLOGIC LOG
0 - 6'	Brown sandy silt
6 - 56'	Gray silty clay
56 - 60'	Gray coarse sand and fine gravel; heaving up into augers
60 - 62'	Gray fine sand and gravel
62 - 64'	Gray coarse sand and some fine gravel
64 - 73'	Gray silty sand
73 - 100'	Gray clay

Installed 2" PVC monitoring point; screened interval 54 to 64 feet with gravel pack and bentonite seal.

Interval from 56 to 64 feet has potential for ground water development.

Static Water Level: 14 feet.

2006

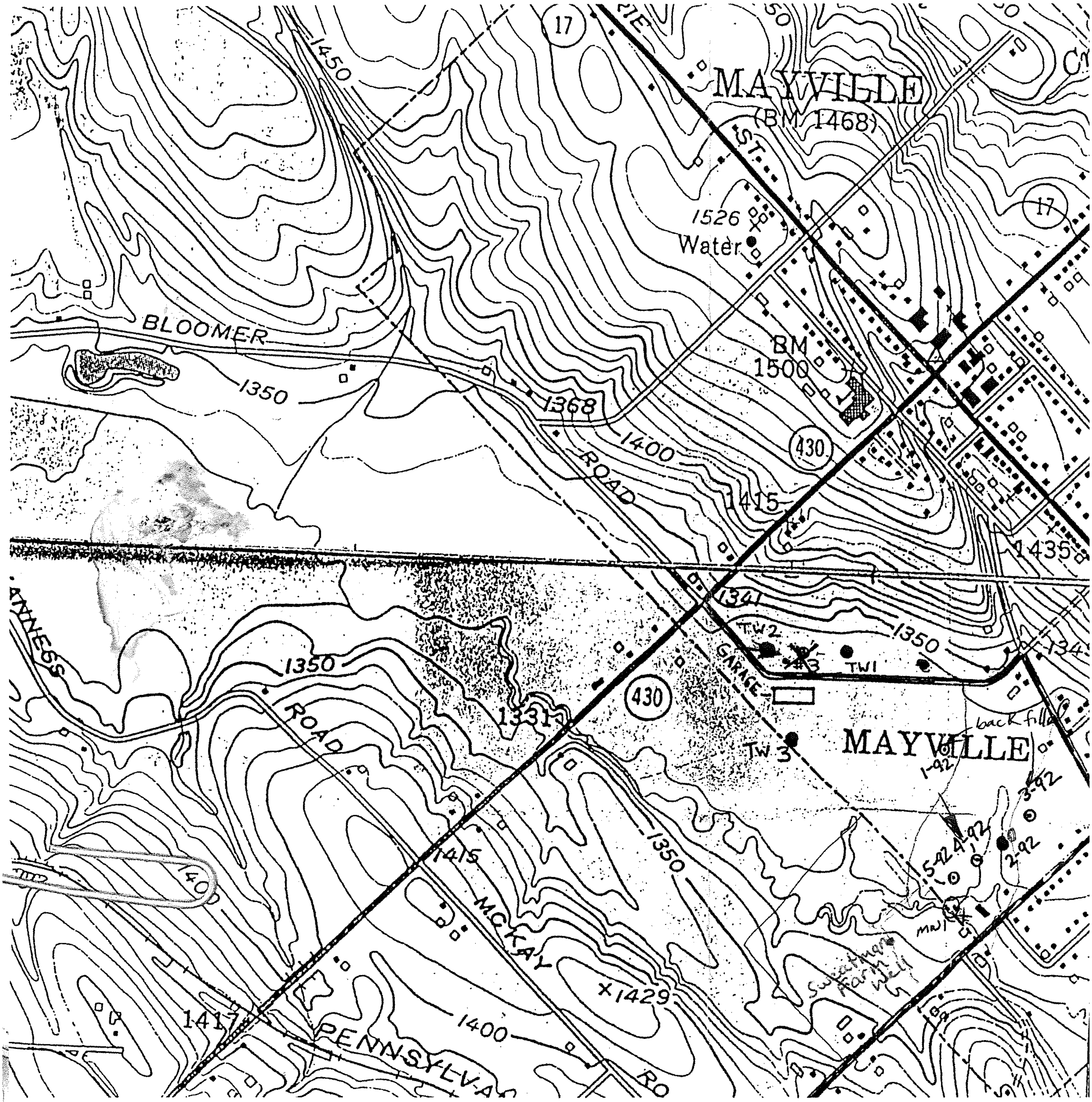
MW 2-92 located 7.25 ft east of TW 1-92

Top of steel protective casing 1.8' above ground

Total measurable depth 5.5' below TOC
Original depth of well ~64' b.g.
Screen: 2" PVC 54-64'
GPS location: 42.2450911° N lat, -79.5024786° W long

PVC casing is broken and well has filled in with sediment, stagnant water is present in well.

CCDOH recommends this well be properly plugged and abandoned.


MAYVILLE
(BM 1468)
1526
Water
BLOOMER
1350
1368
BM
1500
1400
ROAD
430
1415
1435
1341
TW2
TW1
GARAGE
1350
1331
430
TW3
MAYVILLE
back fill
1-92
3-92
2-92
4-92
5-92
MW1
Swatchman Farm Well
ROAD
1350
1400
1415
MCKAY
1429
1417
1400
PENNSYLVA
17
17

Well 3-92

LOG OF BORING 3-92 (DECOMMISSIONED)

LOCATION: Mayville, NY

DATE DRILLED: 5/28-5/29/92

DRILLING METHOD: 8 in. Hollow Stem Auger

SURFACE ELEVATION: 1331 Feet MSL

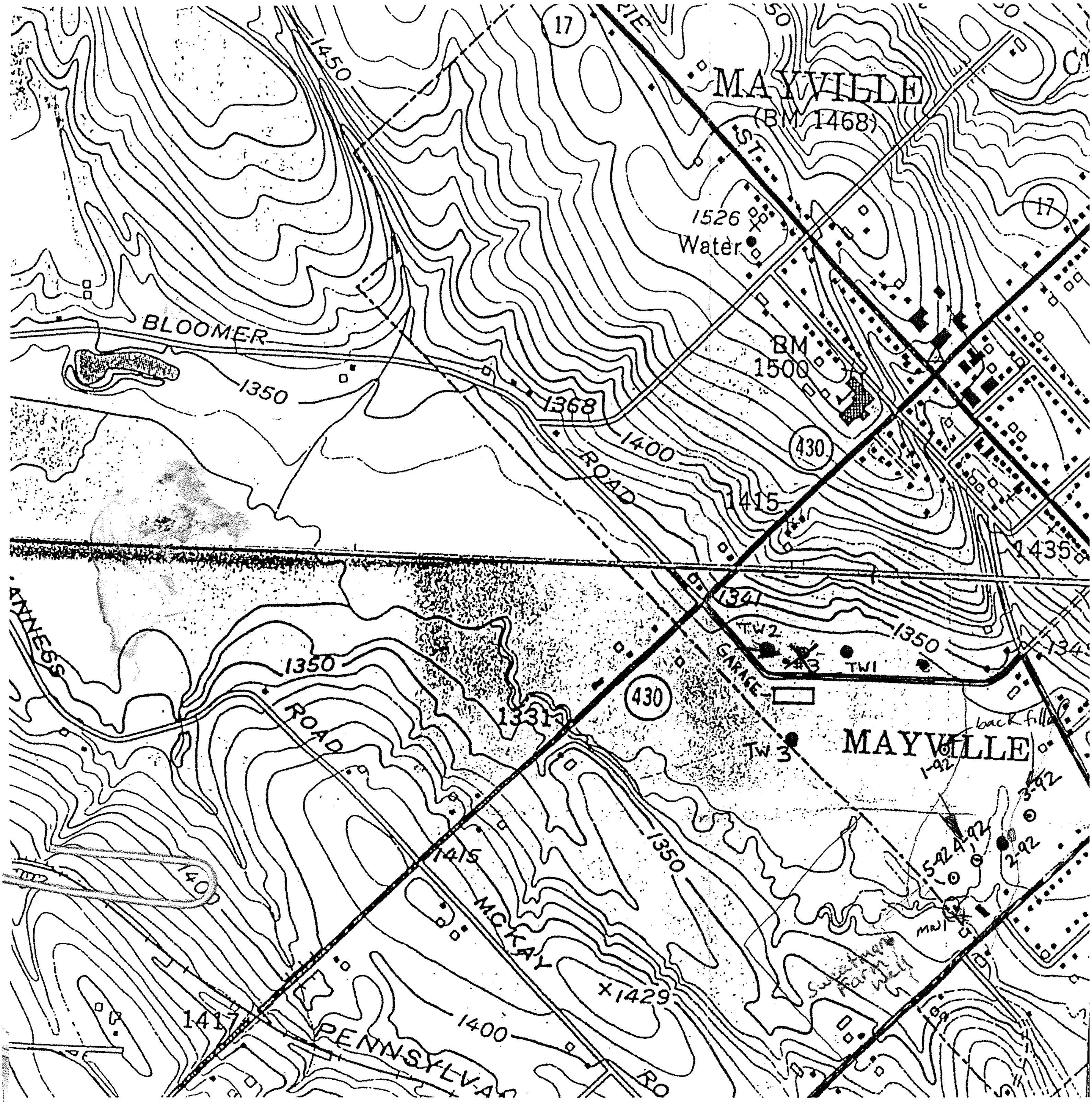
TOTAL DEPTH OF HOLE: 100 Feet

WATER LEVEL ATD: Feet

WELL CONSTRUCTION	DEPTH (FT)	SAMPLE NUMBER	BLOWS/FT	GRAPHIC LOG	MATERIALS DESCRIPTION
					Brown sandy SILT.
					Gray silty SAND.
					Gray silty CLAY.
					Gray fine SAND.
					Brown SAND and GRAVEL; heaving up into augers.
					Brown SAND and GRAVEL w/ increasing clay content.
					Gray silty CLAY. *Boring terminated in this strata.* *Test boring backfilled.*

Depth scale (ft): 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100

Figure F.7


MAYVILLE
(BM 1468)
17
1526
Water
BLOOMER
1350
1368
1400
ROAD
BM
1500
430
1415
1435
1341
TW2
TW1
1350
GARAGE
1350
430
1331
TW3
MAYVILLE
ROAD
backfill
1-92
3-92
2-92
5-92
4-92
MW1
1415
1350
MCKAY
Swatchman Farm Well
x1429
1400
1417
PENNSYLVA
1400
ANNESS

Well 4-92

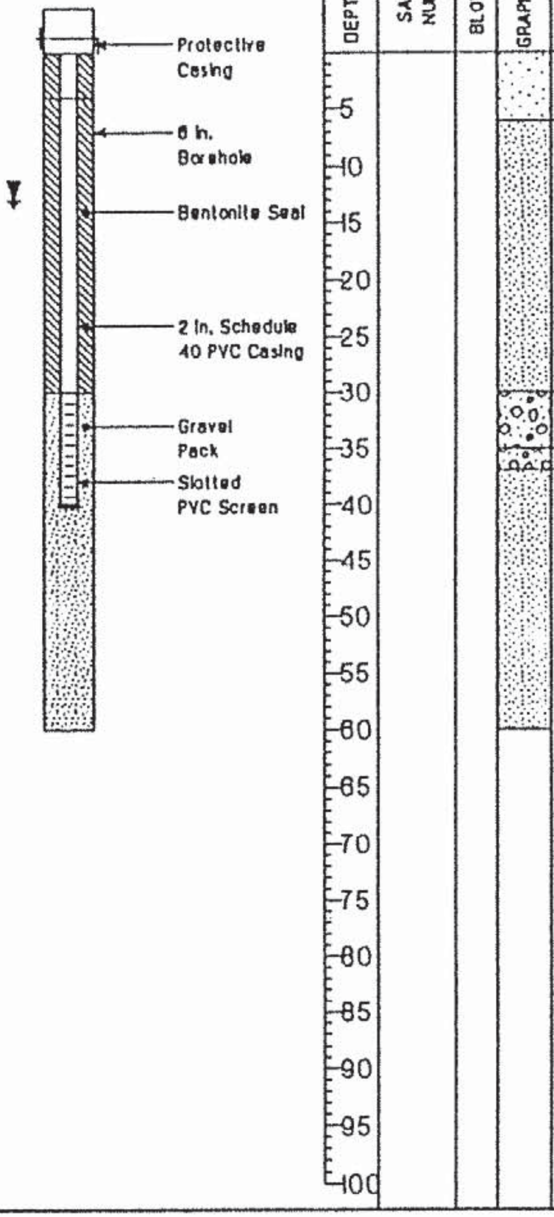
LOG OF BORING 4-92 (DECOMMISSIONED)

LOCATION: Mayville, NY
SURFACE ELEVATION: 1330.95 Feet MSL

DATE DRILLED: 8/1/92
TOTAL DEPTH OF HOLE: 60 Feet

DRILLING METHOD: 8 in. Hollow Stem Auger
WATER LEVEL ATD: 13 Feet

WELL CONSTRUCTION	DEPTH (FT)	SAMPLE NUMBER	BLOWS/FT	GRAPHIC LOG	MATERIALS DESCRIPTION



Brown sandy SILT.

Gray silty CLAY.

Brown SAND and GRAVEL; this interval "takes" water.

Brown SAND and GRAVEL, w/ predominantly clay.

Gray silty CLAY.

Boring terminated in this strata.

Figure F.8

MAYVILLE, NEW YORK – Moody + Assoc.

TEST WELL 4-92 MW 4-92

June 1, 1992

DEPTH (Ft.)	GEOLOGIC LOG
0 - 6'	Brown sandy silt
6 - 30'	Gray silty clay
30 - 35'	Brown sand and gravel; this interval "takes" water
35 - 37'	Brown sand and gravel with predominantely clay
37 - 60'	Gray silty clay

Installed 2" PVC monitoring point; screened interval from 30 to 40 feet with gravel pack and bentonite seal.

Static Water Level: 13 Feet

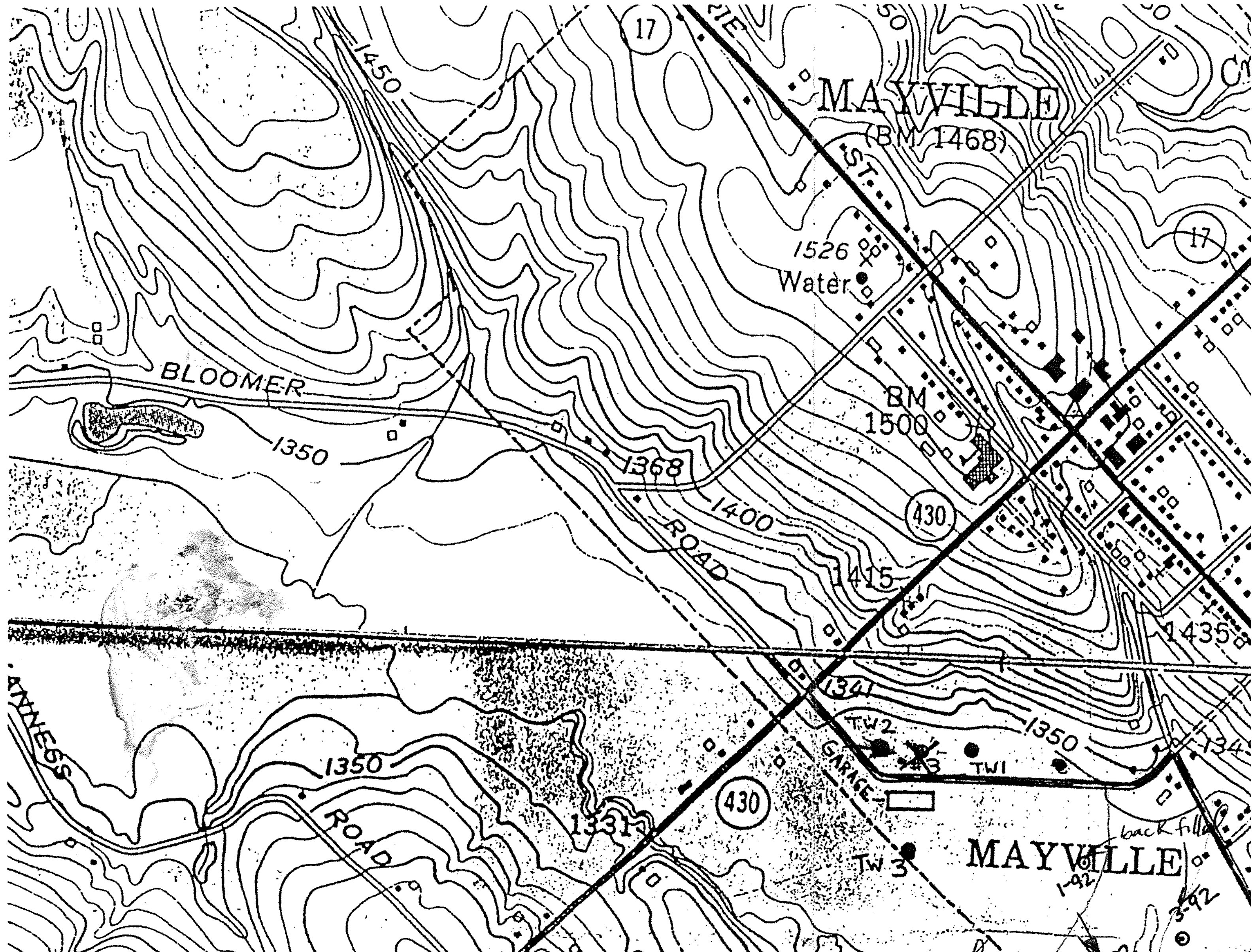
2006

MW 4-92 located behind DPW shop and new storage building.

2" PVC casing with 4" protective steel casing. Outer protective casing is loose.

TOC (2" PVC) 3.1' above ground
Total depth 36.7' below TOC
Water level 17.6' below TOC
Original depth of well ~40' b.g.
Screen: 2"PVC 30-40'
GPS location: 42.2447789° N lat, 79.5031475° W long

CCDOH recommends this well be properly plugged and abandoned.



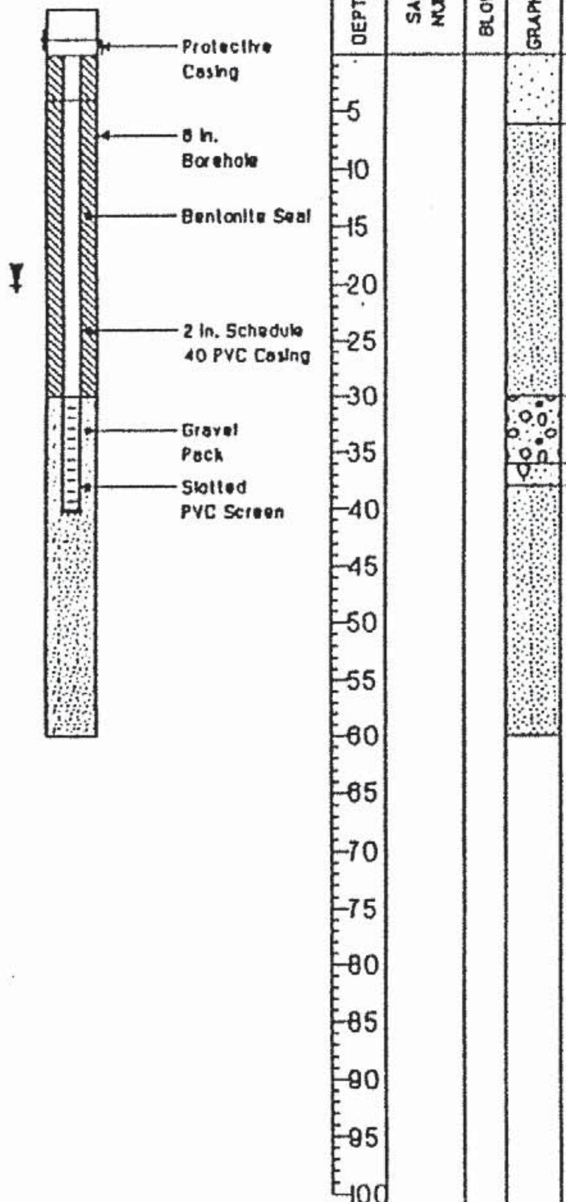
MAYVILLE
(BM 1468)
17
1450
1526
Water
BLOOMER
1350
1368
BM
1500
1400
ROAD
430
1415
1435
1341
TW2
TW1
TW3
GARAGE
1350
1331
430
ROAD
MAYVILLE
back fill
1-92
3-92
2-92
4-92
5-92
MW1
1350
1415
MCKAY
1429
1400
1417
PENNSYLVA
ANNESS
Swatman Farm Well

Well 5-92

LOG OF BORING 5-92 (DECOMMISSIONED)

LOCATION: Mayville, NY
SURFACE ELEVATION: 1330.89 Feet MSL
DATE DRILLED: 6/2/92
TOTAL DEPTH OF HOLE: 60 Feet
DRILLING METHOD: 8 in. Hollow Stem Auger
WATER LEVEL ATD: 20 Feet

WELL CONSTRUCTION	DEPTH (FT)	SAMPLE NUMBER	BLOWS/FT	GRAPHIC LOG	MATERIALS DESCRIPTION



Brown sandy SILT.

Gray silty CLAY.

Brown SAND and GRAVEL.

Gray silty CLAY w/brown SAND and GRAVEL.

Gray silty CLAY.

Boring terminated in this strata.

Figure F.9

MAYVILLE, NEW YORK Moody + Assoc.

TEST WELL 5-92 MW 5-92

June 2, 1992

DEPTH (Ft.)	GEOLOGIC LOG
0 - 6'	Brown sandy silt
6 - 30'	Gray silty clay
30 - 36'	Brown sand and gravel
36 - 38'	Gray silty clay with brown sand and gravel
38 - 60'	Gray silty clay

Installed 2" PVC monitoring point; screened interval from 30 to 40 feet with gravel pack and bentonite seal.

Static Water level: 20 Feet (?)

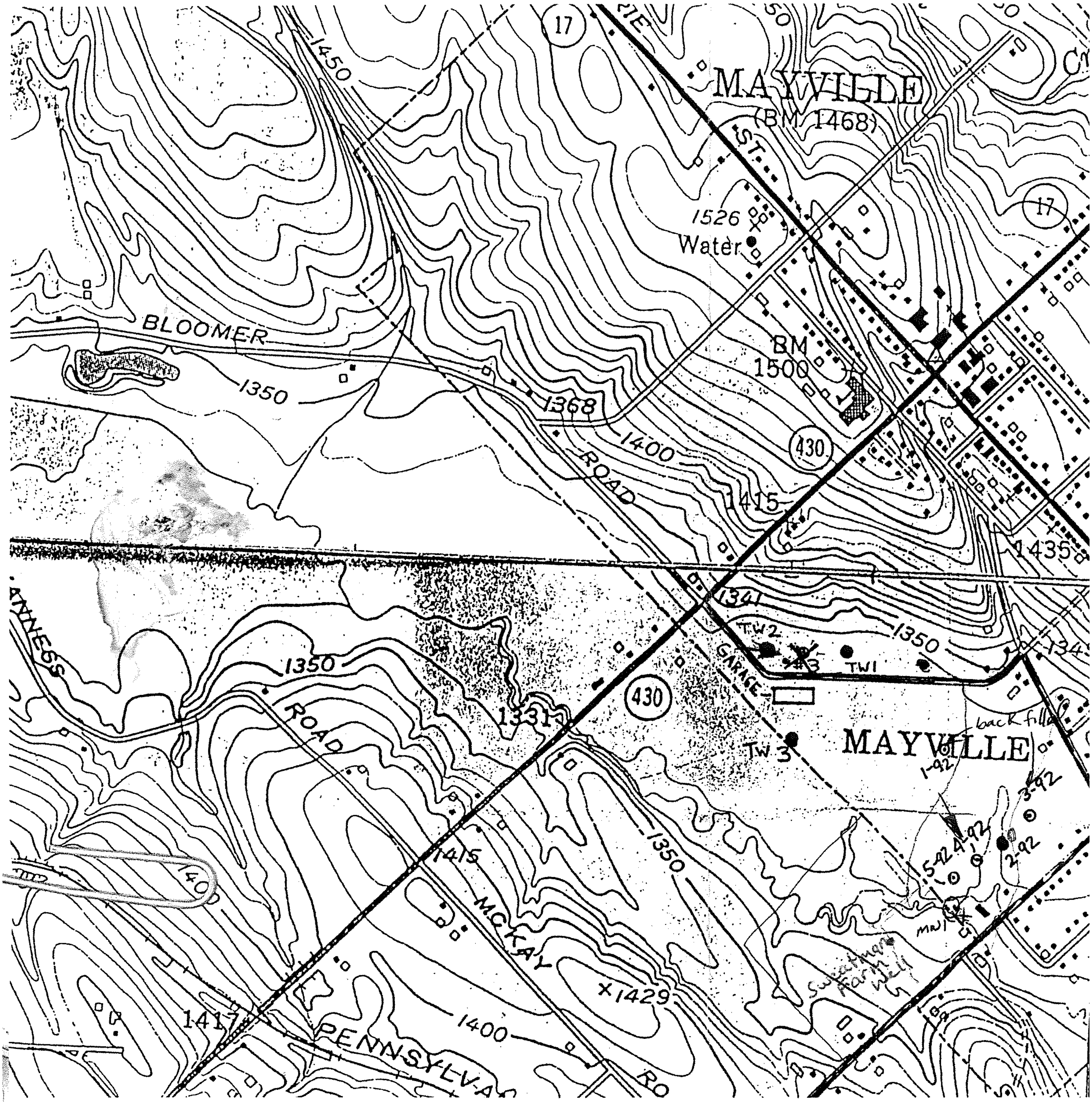
2006

MW 5-92 located in edge of woods behind DPW shop.

2" PVC casing with no protective steel casing.

TOC 2.9' above ground
Total depth 42.0' below TOC
Water level 16.9' below TOC
Original depth of well ~40' b.g.
Screen: 2" PVC 30-40'
GPS location: 42.2445036° N lat, 79.5038895 ° W long

CCDOH recommends this well be properly plugged and abandoned.


MAYVILLE
(BM 1468)
17
1450
1526
Water
BLOOMER
1350
1368
BM
1500
1400
ROAD
430
1415
1435
1341
TW2
TW1
TW3
GARAGE
1350
1331
MAYVILLE
back fill
1-92
3-92
2-92
4-92
5-92
MW1
ROAD
1415
MCKAY
1350
1400
1429
1417
PENNSYLVA
RO
Swatman Farm Well

Well MW-1

LOG OF BORING MW-1

LOCATION: Mayville, NY 95 Morris Street

DATE DRILLED: 11/04/91

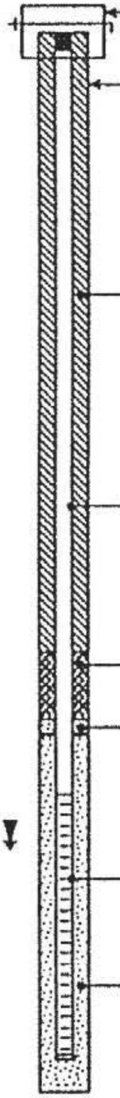
DRILLING METHOD: 8 in. Hollow Stem Auger

SURFACE ELEVATION: 1327.45 Feet MSL

TOTAL DEPTH OF HOLE: 40.0 Feet

WATER LEVEL ATD: 30.8 Feet

WELL CONSTRUCTION



SAMPLE NUMBER	BLOWS/FT
1	12
2	8
3	7
4	13
5	13
6	10
7	5
8	7
9	8
10	5
11	7
12	4
13	4
14	8
15	WR
16	11
17	17
18	11
19	20
20	12

DEPTH (FT): 5, 10, 15, 20, 25, 30, 35, 40

MATERIALS DESCRIPTION

- Dry, dark brown TOP SOIL overlying tan SILT w/little fine sand and a trace of fine gravel.
- Moist, medium brown, firm, plastic CLAYEY SILT, contains 2" fine sand lense.
- Moist, gray, firm, plastic CLAY and SILT.
- Wet, gray, firm, plastic CLAYEY SILT.
- Wet, gray, firm, plastic SILTY CLAY.
- Wet, gray, firm, plastic CLAYEY SILT.
- Wet, gray, firm, plastic SILTY CLAY.
- Wet, gray, firm to soft, plastic CLAY w/some to little silt.
- Wet, gray, firm, plastic CLAYEY SILT.
- Wet, gray, firm to soft, plastic CLAY w/some to little silt.
- Wet, grey, fine to medium SAND w/trace of fine gravel. WR=Sampler penetrates with weight of rod.
- No recovery from sample #17 after 2 attempts.
- Wet, gray, fine to coarse SAND w/little fine gravel.
- Wet, gray, fine to coarse SAND w/trace of large gravel. **
- Wet, gray, firm to soft, plastic CLAY w/some to little silt. *Boring terminated in this strata.*

Note: Samples from 2 to 28 ft consist of pebble free lake sediments.

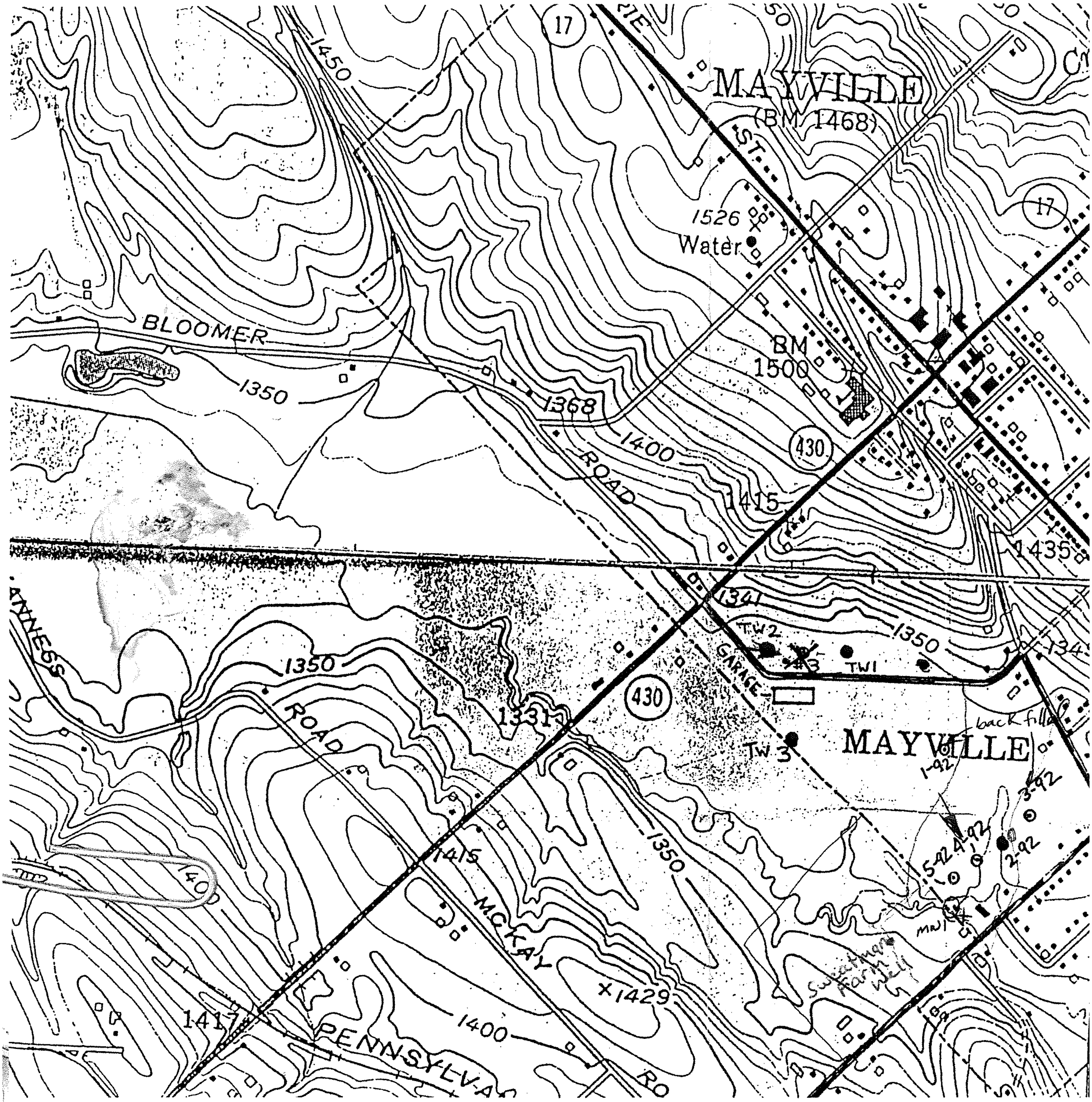
Figure F.4

MW-1 is located on hill next to PW-2 (Caisson well).

2" dia. Sch 40 PVC w/4" steel protective casing.

TOC 1.4' above ground
Total depth 39.0' below TOC
Water level 14.37' below TOC
Original depth of well 38.8' b.g.
Screen: 2" PVC 28.8-38.8'
GPS location: 42.2428772^{o} N lat, 79.5038213^{o} W long

This well was drilled as part of the AWWARF project under direction of CCDOH and SUNY Fredonia. It is part of the WaterNETwork of monitoring wells used for evaluating long-term groundwater trends throughout county. This well was properly constructed and grouted following strict procedures.


MAYVILLE
(BM 1468)
17
1526
Water
BLOOMER
1350
1368
BM
1500
1400
ROAD
430
1415
1435
1341
TW2
TW1
1350
GARAGE
1350
430
1331
TW3
MAYVILLE
ROAD
1415
MCKAY
1350
1400
1429
1417
PENNSYLVA
1400
back fill
1-92
3-92
2-92
4-92
5-92
MW1
Swatman Farm Well

EXISTING OR FORMER WELLS - PATTERSON STREET AREA

Wells TW-1 and TW-2

MAYVILLE, NEW YORK Moody + Assoc.

TEST WELL #1 TW 1 (DECOMMISSIONED)

DEPTH (ft.)	DESCRIPTION
0 - 13	Top soil, brown sandy clay and gravel
13 - 33	Fine gray silty clay
33 - 52	Brown clay, sand and fine gravel
52 - 58	Hard packed brown sand and gravel
58 - 60	Gray shale with streaks of clay
60 - 62	Gray sandy shale

Bailed well after pulling 8-inch back to 51 feet. Bailed water level down and well recovered at a rate of 20 gpm. S. W. L. 18 feet from ground level.

TEST WELL #2 TW 2

DEPTH (ft.)	DESCRIPTION
0 - 17	Brown sandy clay and fine gravel
17 - 37	Gray silty clay
37 - 38	Brown sand and gravel (making water at 37 feet. S. W. L. 24 feet.
38 - 45	Gray clay some gravel
45 - 49	Brown sand and gravel, little bit of clay.
49 - 55	Brown sand and gravel heaved at 54 ft.
55 - 56	Clay and boulders
56 - 69	Brown sand and gravel all sizes, little bits of clay
69 - 70	Gray silty clay

Top of 6-inch slotted pipe screen 55 feet from ground level.
Total length of screen - 15 feet.
Top of slots - 58 feet from ground level.
Eleven feet of slots exposed.
Bottom one foot blank.
T. D. 70 feet from ground level.
S. W. L. 22 feet T. O. C.

TW2

cc: Mayor
Board
File

Moody and ASSOCIATES, Inc.
GROUND WATER RESOURCE SPECIALISTS

PROFESSIONAL GROUND WATER
AND
ENVIRONMENTAL SERVICES

SINCE 1891

Executive Office
R.D. 4, Box 412, Cotton Road
Meadville, PA 16335
(814) 724-4970

August 23, 1989

VILLAGE OF MAYVILLE
3 South Erie Street
P. O. Box 188
Mayville, New York 14757-0188

ATTN.: Mr. Chet Crandall

RE: LETTER REPORT ON RESULTS
OF TEST WELL DRILLING

Dear Chet:

The following letter report addresses work completed in July and August regarding test well drilling and pump testing for the Village of Mayville. Work was performed under Moody proposal No. 89-MP-079 and this report (with soon to follow lab analyses) signifies completion of the work.

SUMMARY

1. A total of two (2) 8-inch test wells were installed by cable tool method.

2. The first test well (TW #1) was located ±300 feet east of Village Production Well #3 (PW #3). Formation encountered during drilling TW #1 showed no potential for groundwater development. Bedrock was encountered at 62 feet.

3. Test Well #2 (TW #2) was then drilled ±300 feet west of PW #3. Significant sand and gravel was encountered from a depth of 56 to 69 feet. 6" casing

4. TW #2 was developed to remove fine sand, clay and silt from the formation.

5. TW #2 was pump tested over a 48-hour period at a final pumping rate of 84 gpm with a pumping level of 50' 3".

6. We believe that based on this, a new production well, pumping by itself, would be capable of producing anywhere from 100 to 150 gpm (144,000 to 216,000 gpd), on a long-term bais. Larger drafts of 200 gpm may be obtained on a short-term basis.

7. A water level recorder was placed on TW #2 to monitor the effect of pumping PW #3. During what appears to be an 8-hour pumping cycle for PW #3, TW #2 showed it's water level dropping about 1½ feet during this pumping period. The TW #2 water level would recover after this cycle. Because of this interference, a new production well located at the TW #2 site would reduce the amount of water pumped from itself and PW #3 if both were pumped concurrently. Although we cannot determine the exact combined yield, we believe that both wells pumping at the same time would produce a combined gpm of 250 maximum and a minimum of 125 gpm. If a well is located here, only actual pumping would determine the long-term combined flow from these two wells.

8. Attached are well construction details that a new production well located here would require.

9. The formation logs of the wells show that the sand and gravel aquifer thins slightly from PW #3 to TW #2 and is virtually non-existent at TW #1.

   Therefore, it is recommended future test well drilling should be conducted across the road and a minimum of 300 feet south of PW #3 into the valley.

10. Lab results will be forwarded to you around August 25, 1989 as we receive them.

We have appreciated the opportunity to work with the Village on this project and we want to thank you for all of your assistance on this job.

Please don't hesitate to call if you have questions or desire clarification.

Very Truly Yours,

MOODY AND ASSOCIATES, INC.

William R Gough

William R. Gough, C. P. G.
Senior Geologist

WRG/dh

Enclosure

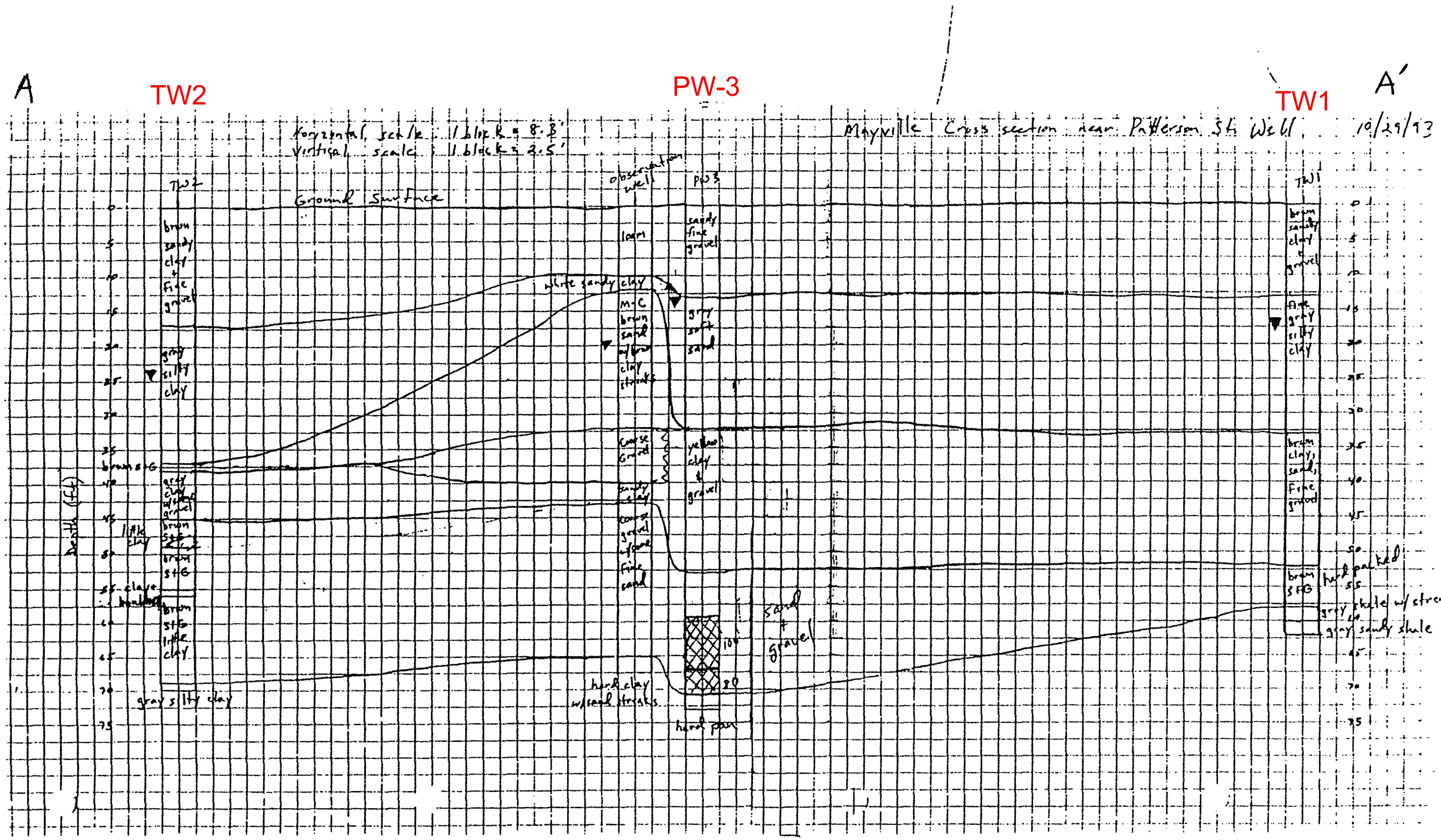


Figure F.13: Cross section A - A' from Figure F.1 in the vicinity of well 3.

TW 1 located 300' east of PW 3

8" steel casing

TOC 2.4' above ground
Total depth 45.6' below TOC
Water level 19.5' below TOC
Original depth of well ~51' b.g.
Screen: none
GPS location: 42.2482934º N lat, 79.5066233º W long

CCDOH recommends this well be properly plugged and abandoned.

TW 2 located ~200 ft west of PW 3

8" steel casing

TOC 0.7' above ground
Total depth 69.0' below TOC
Water level 16.7' below TOC
Original depth of well ~70' b.g.
Screen: 6" slotted steel 58-69'
GPS location: 42.2481832° N lat, 79.5087782° W long

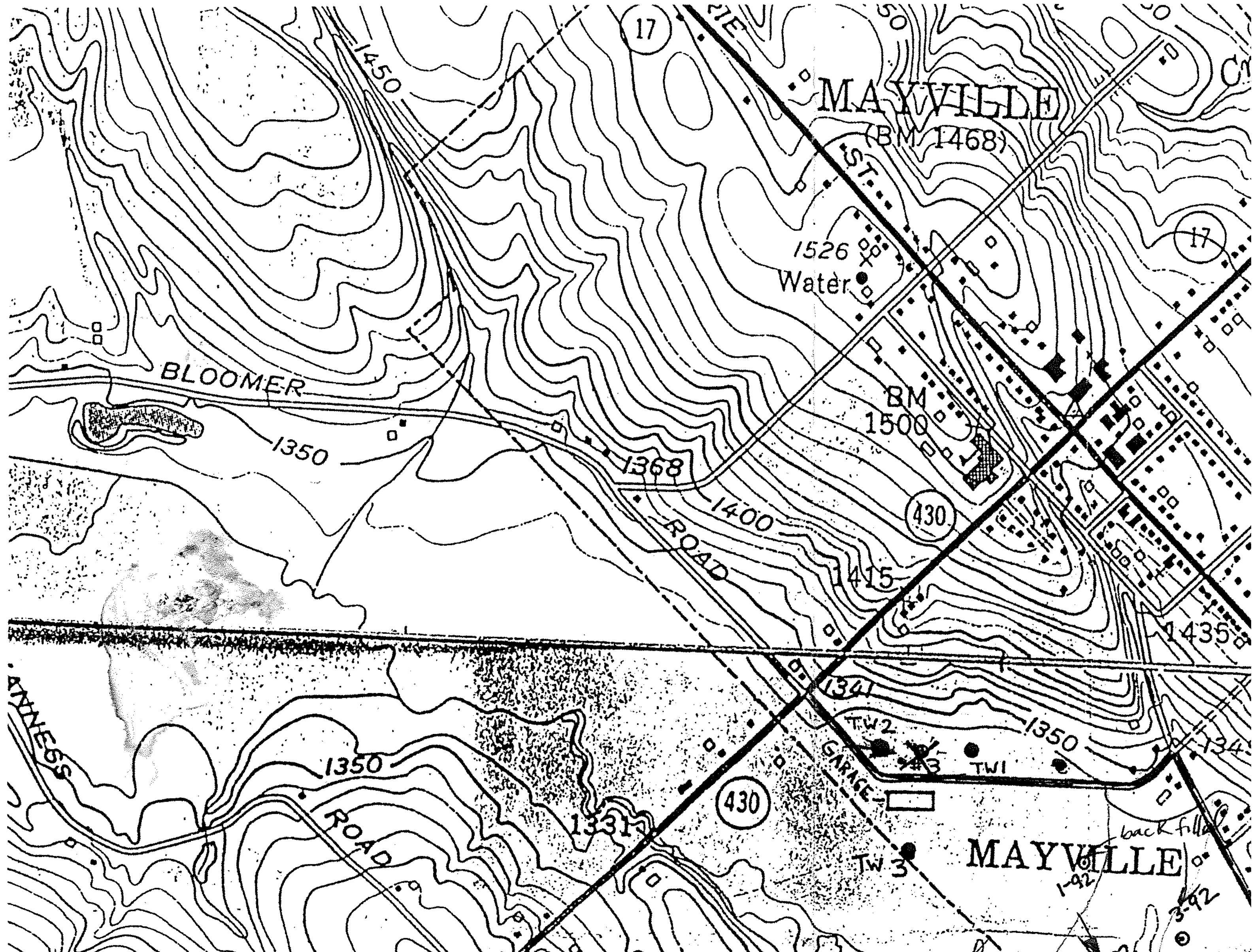
CCDOH recommends that the casing of this well be extended so it is at least 18" above ground and that a locking cap be installed.

This well has multiple purposes:

1) It can be used as a monitoring well during pumping tests of PW 3 (Patterson St. well) since it is in the same aquifer.

2) It will be added to the CCDOH/SUNY Fredonia WaterNET program and will be monitored monthly to evaluate long-term groundwater trends in the same aquifer tapped by PW 3.

3) Long-term aquifer data will aid in troubleshooting problems in PW 3 (e.g. is the aquifer depleted or has the well screen of PW 3 plugged, etc.).

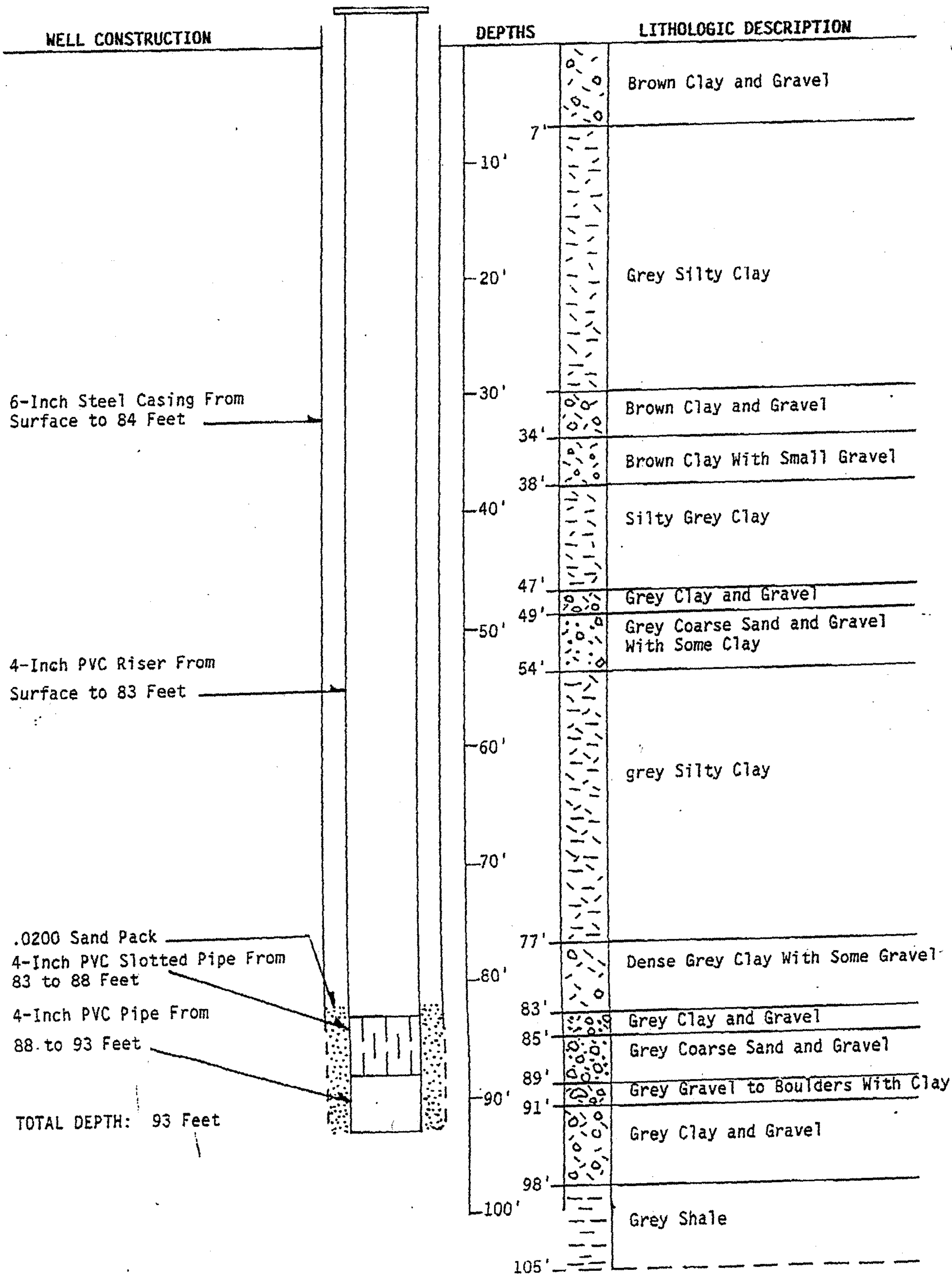

MAYVILLE
(BM 1468)
17
1450
1526
Water
BLOOMER
1350
1368
BM
1500
1400
ROAD
430
1415
1435
1341
TW2
TW1
GARAGE
1350
1331
TW3
MAYVILLE
back fill
1-92
3-92
2-92
4-92
5-92
MW1
ROAD
1415
MCKAY
1350
1400
1429
1417
PENNSYLVA
1400
RO

Well TW-3

FIGURE 1

VILLAGE OF MAYVILLE, NEW YORK

TEST WELL NO. 3 TW 3 (DECOMMISSIONED)



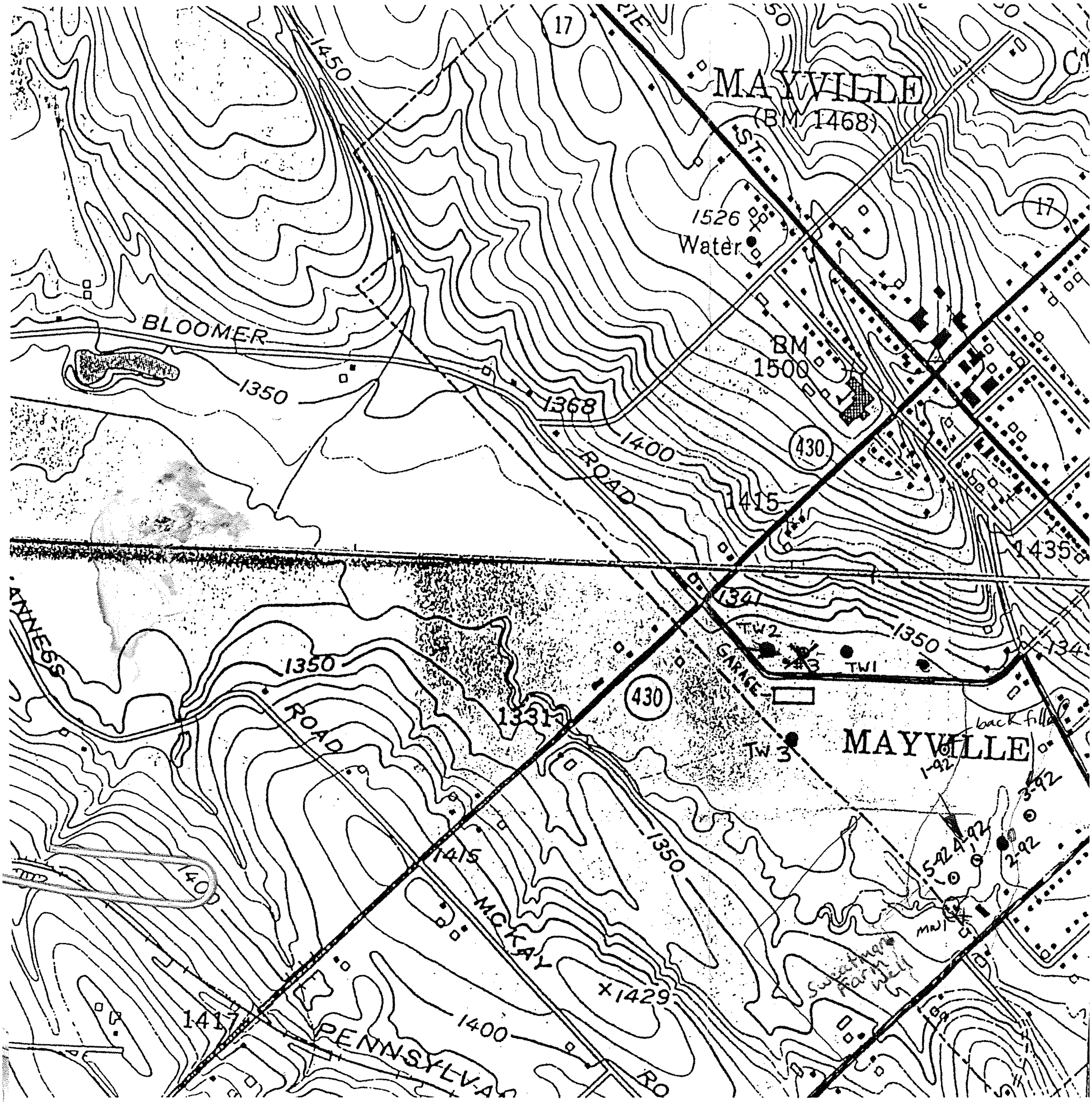
TW 3 located behind Town of Chautauqua DPW.

4" PVC well inside of 6" steel casing

TOC (steel) 2.4' above ground
Total depth 89.2' below TOC
Water level 14.0' below TOC
Original depth of well 93' b.g.
Screen: 4" slotted PVC 83-88'
GPS location: 42.2467667º N lat, 79.508425º W long

CCDOH recommends this well be properly plugged and abandoned.

This well has been monitored monthly since 2001 as part of the WaterNET program. However due to the proximity of potential contaminants, it is best if this well be decommissioned.


MAYVILLE
(BM 1468)
17
1526
Water
BLOOMER
1350
1368
BM
1500
1400
ROAD
430
1415
1435
1341
TW2
TW3
TW1
1350
GARAGE
430
1331
Tw 3
MAYVILLE
back fill
1-92
3-92
2-92
4-92
5-92
MW1
1350
ROAD
1415
MCKAY
1400
×1429
1417
PENNSYLVA
1400
RO

EXISTING WELLS - MAPLE DRIVE EAST AREA

Well OW-2

SUBSURFACE INVESTIGATION LOG

BORING NO. **OW-2**

Project No. **1964.001.002**

PROJECT INFORMATION		DRILLING INFORMATION	
Project:	Mayville Water System improvement Project	**Drilling Co:**	Nature Way Environmental
Client:	Village of Mayville	**Driller:**	Jeremy Leckrome
Site Location:	Northeast Aquifer Area	**Rig Type:**	Versa-Sonic
Job No:	1964.001.002	**Drilling Method(s):**	Rotosonic
Project Manager:	Greg V. Lesniak	**Hammer Wt/Drop:**	Sonic
Logged By:	Greg V. Lesniak	**Hammer Type:**	Sonic
Dates Drilled:	5/30/2018	**Borehole Diam:**	6-inch **Total Depth:** 80'

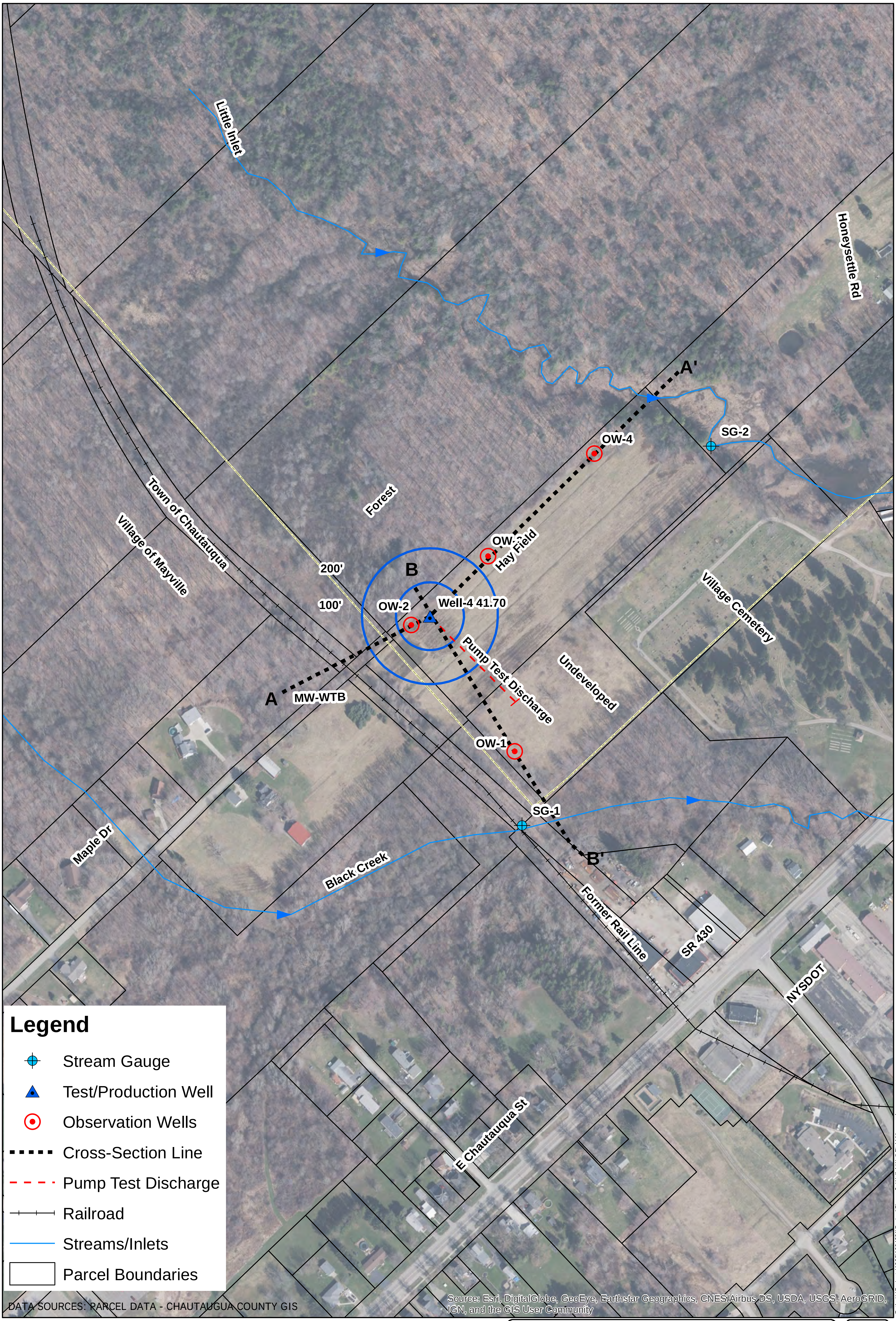
LOCATION INFORMATION				WELL INFORMATION			
Horiz. Datum:		**Latitude:**	$42^0$15' 45.14"	**Ground Elevation:**		**Screen Type/Diam:**	PVC Slotted/4"
Vert. Datum:		**Longitude:**	79^0'30' 4.95"	**TOC Elevation:**		**Slot Size:**	0.02"

Barton & Loguidice, D.P.C. **VILLAGE OF MAYVILLE** BORING NO: OW-2

Depth	Sample Type	USCS	Description	Sample No.	Sample Int.	Recovery	Rate ft/min	N or RQD %	Lithology	Notes / *Well Construction*
0–4	Sonic Core	SP	Brown m/c SAND, some f/m Gravel, trace Silt and Clay, moist		0-10'	10'			Lacustrine	*Steel stickup 3.9'*; SWL 1' ags (1.6' btoic) measured on June 7, 2018 8:15am
4.5–14		ML	Gray cohesive, matrix supported SILT, little f Sand, occasional Silty Clay lenses, very moist							
14–20	Sonic Core	ML	Gray cohesive, matrix supported SILT, some m/c Gravel, trace clay and f Sand, moist		10-20'	10'			Glacial Till	*Bentonite grout seal*

Depth	Sample Type	USCS	Description	Sample No.	Sample Int.	Recovery	Rate ft/min	N or RQD %	Lithology	Notes / *Well Construction*
20–30	Sonic Core	ML	Same as above with more varied Clay content with depth		20-30'	12'			Glacial Till	*Bentonite grout seal*
30–32	Sonic Core	ML			30-40'	10'			Glacial Till	*Bentonite grout seal*
32–36	Sonic Core	ML	Gray SILT, few f/m Sand, reddish lenses of f Sand, very moist to wet		30-40'	10'			Glacial Till	*Bentonite grout seal*
36–39	Sonic Core	SW	Gray cohesive, matrix supported SILT, some m/c Gravel, trace clay and f Sand, moist		30-40'	10'			Glacial Till	*Bentonite Chips*
39–40	Sonic Core	SW	Gray loose m/c SAND, some f/m Gravel, occasional c Gravel, wet (gravel is subrounded to rounded, with siltstone, chert, gniess, sandstone, quartzite)		30-40'	10'			Glacial Till / Glaciofluvial - outwash	*Bentonite Chips*
40–49	Sonic Core	SW			40-50'	10'			Glaciofluvial - outwash	*Bentonite Chips*
49–50	Sonic Core	SW	Gray c SAND, little f/m Gravel, wet		40-50'	10'			Glaciofluvial - outwash	*Bentonite Chips*

Depth	Sample Type	USCS	Description	Sample No.	Sample Int.	Recovery	Rate ft/min	N or RQD %	Lithology	Notes / *Well Construction*
50–52	Sonic Core	SW	Same as above		50-60'	10'			Glaciofluvial - outwash	*Bentonite Chips*
52–56	Sonic Core	GW	Gray m/c GRAVEL, little c Sand, trace silt), wet		50-60'	10'			Glaciofluvial - outwash	*Bentonite Chips*
56–60	Sonic Core	GW	Same as above, no silt, appears washed, no fines in the coarse sand and gravel matrix		50-60'	10'			Glaciofluvial - outwash	*Natural Pack*
60–64	Sonic Core	GW	(Same as above)		60-70'	7'			Glaciofluvial - outwash	*4" diameter slotted screen Screen slot 0.02"*; 14.5 gpm/ft specific capacity June 2018
64–70	Sonic Core	GW	c GRAVEL, few Cobbles, appears washed, no fines in gravel matrix, no sample 68-70' possibly due to cobbles not entering core barrel.		60-70'	7'			Glaciofluvial - outwash	
70–73.5	Sonic Core	SW	Gray m/c SAND, transition to c SAND at 72.5', wet		70-80'	10'			Glaciofluvial - outwash	*Borehole collapsed as casing removed*
73.5–78	Sonic Core	GW	m/c GRAVEL, trace m/c Sand, wet		70-80'	10'			Glaciofluvial - outwash	
78–80	Sonic Core	SW	Gray c SAND, some m Gravel, wet Boring Terminated @ 80 ft bgs		70-80'	10'			Glaciofluvial - outwash	



Barton & Loguidice

1 inch = 250 feet

Village of Mayville
Well - 4
Well-Field Map
Chautauqua County 3/23/2020 New York

Figure 2
Project No. 1964.001

WELL DEVELOPMENT LOGS

WELL DEVELOPMENT LOG

LiRo Engineers, Inc.

Project Title: NYSDEC I&R - Mayville

Well Number: **MW-02**

Site Name: Mayville

Date: 1/4/2021-1/6/2021

Staff: AK, MK

A). Total casing and screen length in feet: 26.00

B). Water level below top of casing in feet: 0 *Artesian Overflow

C). Number of feet standing water [A-B]: 26

D). Volume of water/foot of casing (gal.): 0.17

E). Volume of water in casing (gal. [CxD]: 4.42

F). Volume of water to remove (gal.) [Ex5]: 22.10

G). Volume of water actually removed (gal.): 185.00

Well ID	Volume (gal/ft)
1"	0.04
2" (circled)	0.17
3"	0.38
4"	0.66
5"	1.04
6"	1.50
8"	2.60

H). Explanation/Reason if F ≠ G: Attempting to get turbidity below 50 NTU

I). Pumping/Extraction Method: ☐ Bailer ☐ Peristaltic ☐ Whale ☐ Grundfos ☑ Other: Waterra

J). Development Flow/Extraction Rates: 0.8 gpm (Average)

PURGE DATA

1/4/2021 Time	Temperature (˚C)	pH	ORP (mV)	Conductivity (ms/cm)	Turbidity (NTU)	Dissolved Oxygen (mg/L)	Dissolved Oxygen %	Appearance
11:40	8.69	8.41	269	0.441	>1000	20.73	178.2	very turbid
11:46	9.34	8.42	249	0.438	>1000	3.86	33.7	very turbid
11:54	9.96	8.44	234	0.438	>1000	0.00	0.0	very turbid
11:59	10.12	8.44	223	0.437	>1000	34.84	310	very turbid
12:12	10.08	8.45	221	0.437	>1000	9.78	88.9	very turbid
12:59	9.15	8.41	230	0.441	>1000	5.89	49.9	very turbid
13:05	9.84	8.41	223	0.440	>1000	4.13	36.5	very turbid

Comments: Well is under artesian pressure. Actual water level is unknown.

WELL DEVELOPMENT LOG

LiRo Engineers, Inc.

Project Title: NYSDEC I&R - Mayville

Well Number: **MW-02**

Site Name: Mayville

Date: 1/4/2021-1/6/2021

Staff: AK, MK

PURGE DATA

1/4/2021 Time	Temperature (˚C)	pH	ORP (mV)	Conductivity (ms/cm)	Turbidity (NTU)	Dissolved Oxygen (mg/L)	Dissolved Oxygen %	Appearance
13:12	9.93	8.41	211	0.439	>1000	0.00	0.0	very turbid
13:19	10.19	8.40	206	0.437	>1000	0.00	0.0	very turbid
13:25	10.26	8.40	198	0.438	>1000	0.00	0.0	very turbid
13:30	10.33	8.34	199	0.436	>1000	0.00	0.0	very turbid
13:36	10.26	8.38	200	0.437	>1000	0.00	0.0	very turbid
13:41	10.26	8.38	201	0.435	>1000	0.00	0.0	very turbid
13:46	10.27	8.39	202	0.436	>1000	1.96	17.1	very turbid
13:52	10.33	8.39	203	0.435	>1000	0.00	0.0	very turbid
13:57	10.36	8.39	204	0.435	>1000	0.00	0.0	very turbid
14:03	10.38	8.39	205	0.437	>1000	4.29	38.1	very turbid
14:09	10.29	8.39	206	0.436	>1000	0.00	0.0	very turbid
14:15	10.33	8.39	207	0.438	>1000	0.00	0.0	very turbid
14:21	10.32	8.40	208	0.438	>1000	5.28	47.1	very turbid
14:28	10.20	8.40	209	0.441	>1000	0.00	0.0	very turbid
14:34	10.29	8.39	210	0.440	>1000	5.49	49.0	very turbid
14:41	10.21	8.39	211	0.440	>1000	0.00	0.0	very turbid
14:48	10.29	8.39	212	0.439	>1000	1.60	15.1	very turbid
14:54	10.30	8.39	213	0.441	>1000	0.00	0.0	very turbid
15:00	10.27	8.39	182	0.440	>1000	0.00	0.0	very turbid
15:06	10.28	8.39	177	0.440	>1000	0.00	0.0	very turbid
15:13	10.28	8.39	172	0.441	994	3.93	34.6	very turbid

Comments: Well is under artesian pressure. Actual water level is unknown.

WELL DEVELOPMENT LOG

LiRo Engineers, Inc.

Project Title: NYSDEC I&R - Mayville

Well Number: **MW-02**

Site Name: Mayville

Date: 1/4/2021-1/6/2021

Staff: AK, MK

PURGE DATA

Time	Temperature (˚C)	pH	ORP (mV)	Conductivity (ms/cm)	Turbidity (NTU)	Dissolved Oxygen (mg/L)	Dissolved Oxygen %	Appearance
15:19	10.32	8.39	178	0.441	>1000	6.12	54.6	very turbid
15:25	10.33	8.39	183	0.440	>1000	0.00	0.0	very turbid
15:31	10.30	8.39	186	0.440	>1000	0.00	0.0	very turbid
15:37	10.27	8.39	188	0.440	812	5.30	47.3	turbid
15:45	10.29	8.39	188	0.440	865	5.38	47.2	turbid
15:51	10.28	8.39	189	0.441	1000	0.00	0.0	very turbid
1/6/2021								
8:41	1.50	8.59	265	0.359	768	0.00	0.0	turbid
8:50	5.21	8.65	260	0.509	>1000	0.00	0.0	very turbid
9:00	7.84	8.39	265	0.484	789	0.00	0.0	very turbid

Comments: Well is under artesian pressure. Actual water level is unknown.

WELL DEVELOPMENT LOG

LiRo Engineers, Inc.

Project Title: NYSDEC I&R - Mayville

Well Number: **MW-03**

Site Name: Mayville

Date: 12/30/2020-1/4/2021

Staff: AK, MK

A). Total casing and screen length in feet: 43.00

B). Water level below top of casing in feet: 10.41

C). Number of feet standing water [A-B]: 32.59

D). Volume of water/foot of casing (gal.): 0.17

E). Volume of water in casing (gal. [CxD]: 5.54

Well ID	Volume (gal/ft)
1"	0.04
2"	0.17
3"	0.38
4"	0.66
5"	1.04
6"	1.50
8"	2.60

F). Volume of water to remove (gal.) [Ex5]: 27.70

G). Volume of water actually removed (gal.): 335.00

H). Explanation/Reason if F ≠ G: Attempting to get turbidity below 50 NTU

I). Pumping/Extraction Method: ☑ Bailer ☐ Peristaltic ☐ Whale ☐ Grundfos ☑ Other: Waterra

J). Development Flow/Extraction Rates: 0.5 gpm (Average)

PURGE DATA

12/30/2020 Time	Temperature (˚C)	pH	ORP (mV)	Conductivity (ms/cm)	Turbidity (NTU)	Dissolved Oxygen (mg/L)	Dissolved Oxygen %	Appearance
11:03	8.42	10.04	100	0.651	639	0.84	7.2	slightly turbid
12:13	8.68	8.56	121	0.452	693	2.65	23.0	very turbid
12:20	9.44	8.53	87	0.554	882	0.29	2.5	very turbid
13:05	8.95	8.35	115	0.572	>1000	9.46	81.6	very turbid
13:16	8.23	8.25	122	0.173	747	7.55	63.8	very turbid
13:24	8.79	8.28	129	0.525	>1000	5.36	46.3	very turbid
13:47	8.99	8.34	130	0.572	>1000	4.95	42.9	very turbid

Comments: Well developed with a bailer on 12/30 and then a Waterra pump on 12/31-1/4.

WELL DEVELOPMENT LOG

LiRo Engineers, Inc.

Project Title: NYSDEC I&R - Mayville

Well Number: **MW-03**

Site Name: Mayville

Date: 12/30/2020-1/4/2021

Staff: AK, MK

PURGE DATA

Time	Temperature (˚C)	pH	ORP (mV)	Conductivity (ms/cm)	Turbidity (NTU)	Dissolved Oxygen (mg/L)	Dissolved Oxygen %	Appearance
13:55	8.99	8.34	130	0.572	>1000	4.97	43.1	very turbid
14:15	9.05	8.40	139	0.572	>1000	3.53	30.6	very turbid
14:30	9.12	8.39	136	0.571	>1000	3.35	29.2	very turbid
15:15	8.72	8.39	133	0.568	>1000	2.44	20.4	very turbid
15:24	8.30	8.27	134	0.354	>1000	3.01	25.7	very turbid
15:40	7.83	8.44	146	0.497	>1000	1.67	14.1	very turbid
15:48	9.06	8.36	142	0.569	>1000	0.00	0.0	very turbid
12/31/2020								
8:55	6.03	8.88	169	0.602	>1000	42.43	341.5	very turbid
9:00	7.25	6.63	174	0.605	>1000	15.19	126.8	very turbid
9:08	8.41	8.41	176	0.576	>1000	6.20	52.3	very turbid
9:28	7.35	8.26	179	0.584	>1000	0.53	4.5	very turbid
9:37	7.95	8.43	202	0.576	>1000	0.00	0.0	very turbid
9:46	8.48	8.37	222	0.579	>1000	1.52	13.0	very turbid
9:55	8.55	8.37	219	0.571	>1000	3.10	26.6	very turbid
10:01	8.85	8.37	218	0.570	986.0	0.00	0.0	very turbid
10:08	8.95	8.37	218	0.569	852.0	0.26	2.2	very turbid
10:22	8.76	8.36	217	0.572	731.0	4.55	39.2	very turbid
10:29	9.04	8.35	221	0.562	814	4.51	39.1	very turbid
10:36	9.03	8.35	223	0.57	>1000	4.66	40.4	very turbid
10:48	9.07	8.36	219	0.572	324	0	0	slightly turbid

Comments: Well developed with a bailer on 12/30 and then a Waterra pump on 12/31-1/4.

WELL DEVELOPMENT LOG

LiRo Engineers, Inc.

Project Title: NYSDEC I&R - Mayville

Well Number: **MW-03**

Site Name: Mayville

Date: 12/30/2020-1/4/2021

Staff: AK, MK

PURGE DATA

Time	Temperature (˚C)	pH	ORP (mV)	Conductivity (ms/cm)	Turbidity (NTU)	Dissolved Oxygen (mg/L)	Dissolved Oxygen %	Appearance
10:59	9.11	8.36	222	0.565	1000	4.28	37.3	very turbid
11:04	9.14	8.35	222	0.571	941.0	4.91	42.6	very turbid
11:11	9.16	8.36	221	0.572	1000.0	4.90	43.2	very turbid
11:16	9.15	8.36	226	0.508	>1000	4.05	55.2	very turbid
11:22	9.32	8.34	225	0.570	>1000	2.54	22.2	very turbid
11:31	9.15	8.33	219	0.569	>1000	4.72	41.6	very turbid
11:34	8.99	8.41	234	0.459	>1000	3.71	32.3	very turbid
11:42	9.24	8.37	223	0.570	>1000	4.80	41.8	very turbid
11:46	9.32	8.35	228	0.567	>1000	0.00	0.0	very turbid
11:58	9.34	8.34	227	0.568	>1000	4.34	37.9	very turbid
12:04	9.29	8.34	226	0.568	>1000	0.00	0.0	very turbid
12:10	9.22	8.34	230	0.569	>1000	0.00	0.0	very turbid
12:16	9.36	8.34	236	0.569	>1000	4.31	37.7	very turbid
12:22	9.32	8.33	234	0.593	>1000	0.00	0.0	very turbid
12:28	9.35	8.34	231	0.570	1000	4.59	46.1	very turbid
12:32	9.33	8.34	233	0.571	485	0.00	0.0	slightly turbid
14:17	7.11	8.26	250	0.594	830	26.93	223.1	very turbid
14:39	7.98	8.34	248	0.546	329	3.61	30.8	slightly turbid
15:13	8.44	8.44	249	0.582	302	1.75	15.0	slightly turbid
1/4/2021								
9:04	6.44	8.37	272	0.601	>1000	6.05	49.3	very turbid

Comments: Well developed with a bailer on 12/30 and then a Waterra pump on 12/31-1/4.

WELL DEVELOPMENT LOG

LiRo Engineers, Inc.

Project Title: NYSDEC I&R - Mayville

Well Number: **MW-03**

Site Name: Mayville

Date: 12/30/2020-1/4/2021

Staff: AK, MK

PURGE DATA

Time	Temperature (˚C)	pH	ORP (mV)	Conductivity (ms/cm)	Turbidity (NTU)	Dissolved Oxygen (mg/L)	Dissolved Oxygen %	Appearance
9:09	7.99	8.36	269	0.585	>1000	2.16	18.1	very turbid
9:15	8.57	8.36	269	0.580	>1000	5.11	44.3	very turbid
9:21	8.82	8.35	268	0.575	>1000	0.00	0.0	very turbid
9:26	8.88	8.33	270	0.575	>1000	6.05	67.8	very turbid
9:33	8.73	8.39	268	0.576	908	0.00	0.0	very turbid
9:36	8.94	8.37	270	0.579	698	0.00	0.0	turbid
9:41	9.08	8.35	272	0.578	424	5.85	50.7	turbid
9:45	8.34	8.41	269	0.578	334	6.06	51.4	slightly turbid
9:55	9.09	8.37	273	0.573	>1000	5.12	44.4	very turbid
10:00	9.25	8.36	270	0.575	>1000	0.00	0.0	very turbid
10:05	9.30	8.37	271	0.576	>1000	0.00	0.0	very turbid
10:08	9.40	8.36	272	0.575	>1000	0.00	0.0	very turbid

Comments: Well developed with a bailer on 12/30 and then a Waterra pump on 12/31-1/4.

WELL DEVELOPMENT LOG

LiRo Engineers, Inc.

Project Title: NYSDEC I&R - Mayville

Well Number: **MW-04**

Site Name: Mayville

Date: 1/6/2021

Staff: AK

A). Total casing and screen length in feet: 67.10

B). Water level below top of casing in feet: 9.22

C). Number of feet standing water [A-B]: 57.88

D). Volume of water/foot of casing (gal.): 0.17

E). Volume of water in casing (gal. [CxD]: 9.84

F). Volume of water to remove (gal.) [Ex5]: 49.20

G). Volume of water actually removed (gal.): 220.00

Well ID	Volume (gal/ft)
1"	0.04
2" (circled)	0.17
3"	0.38
4"	0.66
5"	1.04
6"	1.50
8"	2.60

H). Explanation/Reason if F ≠ G: Attempting to get turbidity below 50 NTU

I). Pumping/Extraction Method: ☐ Bailer ☐ Peristaltic ☐ Whale ☐ Grundfos ☑ Other: Waterra

J). Development Flow/Extraction Rates: 0.8 gpm (Average)

PURGE DATA

Time	Temperature (˚C)	pH	ORP (mV)	Conductivity (ms/cm)	Turbidity (NTU)	Dissolved Oxygen (mg/L)	Dissolved Oxygen %	Appearance
10:30	6.77	9.35	-348	0.474	498	11.05	90.6	slightly turbid
10:37	7.42	9.24	-331	0.576	>1000	2.80	23.5	very turbid
10:49	7.65	8.77	-286	0.564	>1000	0.00	0.0	very turbid
10:57	7.52	8.42	-225	0.577	>1000	2.04	17.2	very turbid
11:03	8.31	8.38	-178	0.59	>1000	3.00	25.6	very turbid
11:27	8.52	8.37	-146	0.581	>1000	1.59	13.6	very turbid
11:52	8.18	8.37	-142	0.581	>1000	0.80	7.2	very turbid

Comments:

WELL DEVELOPMENT LOG

LiRo Engineers, Inc.

Project Title: NYSDEC I&R - Mayville

Well Number: **MW-04**

Site Name: Mayville

Date: 1/6/2021

Staff: AK

PURGE DATA

Time	Temperature (˚C)	pH	ORP (mV)	Conductivity (ms/cm)	Turbidity (NTU)	Dissolved Oxygen (mg/L)	Dissolved Oxygen %	Appearance
12:17	8.06	8.35	-102	0.578	706	1.34	11.4	turbid
12:43	8.01	8.33	-46	0.577	509	1.41	12.0	slightly turbid
13:08	8.21	8.32	-24	0.581	290	1.71	14.5	slightly turbid
13:33	8.46	8.35	-44	0.578	200	0.00	0.0	clear
13:58	8.45	8.35	-24	0.578	178	0.00	0.0	clear
14:23	8.10	8.36	-88	0.576	180	0.70	6.2	clear
14:48	7.18	8.36	-83	0.567	433	2.56	21.3	slightly turbid

Comments:

WELL DEVELOPMENT LOG

LiRo Engineers, Inc.

Project Title: NYSDEC I&R - Mayville

Well Number: **MW-05**

Site Name: Mayville

Date: 1/7/2021

Staff: AK

A). Total casing and screen length in feet: 65.00

B). Water level below top of casing in feet: 9.08

C). Number of feet standing water [A-B]: 55.92

D). Volume of water/foot of casing (gal.): 0.17

E). Volume of water in casing (gal. [CxD]: 9.51

F). Volume of water to remove (gal.) [Ex5]: 47.53

G). Volume of water actually removed (gal.): 200.00

Well ID	Volume (gal/ft)
1"	0.04
2"	0.17
3"	0.38
4"	0.66
5"	1.04
6"	1.50
8"	2.60

H). Explanation/Reason if F ≠ G: Attempting to get turbidity below 50 NTU

I). Pumping/Extraction Method: ☐ Bailer ☐ Peristaltic ☐ Whale ☐ Grundfos ☑ Other: Waterra

J). Development Flow/Extraction Rates: 0.65 gpm (Average)

PURGE DATA

Time	Temperature (˚C)	pH	ORP (mV)	Conductivity (ms/cm)	Turbidity (NTU)	Dissolved Oxygen (mg/L)	Dissolved Oxygen %	Appearance
9:46	1.99	8.32	229	0.190	997	31.19	236.4	very turbid
9:52	7.64	8.92	-34	0.227	>1000	0.00	0.0	very turbid
10:02	8.11	8.84	-27	0.213	>1000	0.00	0.0	very turbid
10:09	8.48	8.78	-8	0.206	>1000	2.54	21.7	very turbid
10:17	8.72	8.75	-2	0.204	>1000	3.97	34.2	very turbid
10:48	8.71	8.79	-51	0.201	>1000	32.11	276.1	very turbid
11:16	7.35	8.84	11	0.127	529	0.19	1.6	turbid

Comments:

WELL DEVELOPMENT LOG

LiRo Engineers, Inc.

Project Title: NYSDEC I&R - Mayville

Well Number: **MW-05**

Site Name: Mayville

Date: 1/7/2021

Staff: AK

PURGE DATA

Time	Temperature (˚C)	pH	ORP (mV)	Conductivity (ms/cm)	Turbidity (NTU)	Dissolved Oxygen (mg/L)	Dissolved Oxygen %	Appearance
11:44	8.62	8.86	-49	0.202	>1000	1.72	14.8	very turbid
12:!3	8.43	8.84	-31	0.200	>1000	1.26	10.8	very turbid
13:22	7.37	8.73	-55	0.204	>1000	1.97	20.7	very turbid
13:50	8.10	8.81	-26	0.205	>1000	19.88	168.2	very turbid
14:18	8.45	8.84	-66	0.198	>1000	20.19	172.0	very turbid
14:47	8.26	8.81	-42	0.201	>1000	4.66	39.7	very turbid
15:16	8.20	8.88	-82	0.199	>1000	4.10	34.8	very turbid

Comments:

WELL DEVELOPMENT LOG

LiRo Engineers, Inc.

Project Title: NYSDEC I&R - Mayville

Well Number: **MW-06**

Site Name: Mayville

Date: 1/8/2021

Staff: AK

A). Total casing and screen length in feet: 14.70

B). Water level below top of casing in feet: 3.70

C). Number of feet standing water [A-B]: 11.00

D). Volume of water/foot of casing (gal.): 0.17

E). Volume of water in casing (gal. [CxD]: 1.87

F). Volume of water to remove (gal.) [Ex5]: 9.35

G). Volume of water actually removed (gal.): 50.00

Well ID	Volume (gal/ft)
1"	0.04
2" (circled)	0.17
3"	0.38
4"	0.66
5"	1.04
6"	1.50
8"	2.60

H). Explanation/Reason if F ≠ G: Attempting to get turbidity below 50 NTU

I). Pumping/Extraction Method: ☐ Bailer ☐ Peristaltic ☐ Whale ☐ Grundfos ☑ Other: Waterra

J). Development Flow/Extraction Rates: 0.4 gpm (Average)

PURGE DATA

Time	Temperature (˚C)	pH	ORP (mV)	Conductivity (ms/cm)	Turbidity (NTU)	Dissolved Oxygen (mg/L)	Dissolved Oxygen %	Appearance
8:48	2.55	8.62	-295	0.282	>1000	26.16	170.7	very turbid
9:00	7.04	8.31	-207	0.178	>1000	0.00	0.0	very turbid
9:16	7.65	7.83	-143	0.155	>1000	0.23	1.9	very turbid
9:41	8.19	7.18	-46	0.128	>1000	19.34	164	very turbid
10:05	7.85	7.06	-37	0.127	>1000	5.90	49.6	very turbid
10:30	7.91	7.05	-7	0.125	>1000	2.41	20.3	very turbid
10:54	7.66	7.01	44	0.102	>1000	1.95	16.5	very turbid

Comments:

WELL DEVELOPMENT LOG

LiRo Engineers, Inc.

Project Title: NYSDEC I&R - Mayville

Well Number: **MW-07**

Site Name: Mayville

Date: 1/8/2021

Staff: AK

A). Total casing and screen length in feet: 20.30

B). Water level below top of casing in feet: 8.61

C). Number of feet standing water [A-B]: 11.69

D). Volume of water/foot of casing (gal.): 0.17

E). Volume of water in casing (gal. [CxD]: 1.99

F). Volume of water to remove (gal.) [Ex5]: 9.94

G). Volume of water actually removed (gal.): 60.00

Well ID	Volume (gal/ft)
1"	0.04
2" (circled)	0.17
3"	0.38
4"	0.66
5"	1.04
6"	1.50
8"	2.60

H). Explanation/Reason if F ≠ G: Attempting to get turbidity below 50 NTU

I). Pumping/Extraction Method: ☐ Bailer ☐ Peristaltic ☐ Whale ☐ Grundfos ☑ Other: Waterra

J). Development Flow/Extraction Rates: 0.4 gpm (Average)

PURGE DATA

Time	Temperature (˚C)	pH	ORP (mV)	Conductivity (ms/cm)	Turbidity (NTU)	Dissolved Oxygen (mg/L)	Dissolved Oxygen %	Appearance
11:27	5.12	7.92	88	5.49	>1000	0.65	5.2	very turbid
11:41	7.82	8.30	-72	5.49	>1000	32.07	274.8	very turbid
12:14	8.53	8.30	-88	5.65	>1000	9.74	85.5	very turbid
12:44	9.17	8.35	-105	5.69	>1000	4.4	3.5	very turbid
13:16	8.84	8.34	-104	5.67	>1000	0.00	0.0	very turbid
13:42	9.45	8.40	-98	5.68	737	0.00	0.0	very turbid
14:09	8.95	8.53	-87	5.56	89.1	9.32	83.1	clear
14:37	9.13	8.60	-93	5.58	257	5.21	46.0	clear

Comments:

WELL PURGING/SAMPLING LOGS

WELL PURGE LOG

LiRo Engineers, Inc.

Project Title: NYSDEC I&R - Mayville

Well Number: **MW-02**

Site Name: Mayville

Date: 1/12/2021

Staff: AK, BW

Time: 9:15 (sample collected)

A). Total casing and screen length in feet: 26.00

B). Water level below top of casing in feet: 0 (artesian flow)

C). Number of feet standing water [A-B]: 26

D). Volume of water/foot of casing (gal.): 0.17

E). Volume of water in casing (gal. [CxD]: 4.42

F). Volume of water to remove (gal.) [Ex3]: 13.26

G). Volume of water actually removed (gal.): N/A

Well ID	Volume (gal/ft)
1"	0.04
2" (circled)	0.17
3"	0.38
4"	0.66
5"	1.04
6"	1.50
8"	2.60

H). Explanation/Reason if F ≠ G: Parameters stabilized

I). Pumping/Extraction Method: ☐ Bailer ☑ Peristaltic ☐ Whale ☐ Grundfos ☐ Other ___________

J). Purge/Sampling Flow/Extraction Rates: 0.1 gpm (Average) Sampling Flow/Extraction Rate: 0.1 gpm (Average)

PURGE DATA

Time	Temperature (˚C)	pH	ORP (mV)	Conductivity (ms/cm)	Turbidity (NTU)	Dissolved Oxygen (mg/L)	Dissolved Oxygen %	Appearance
8:55	5.52	8.82	112	0.520	106	8.24	67.0	clear
9:00	9.21	8.21	128	0.509	39.8	0.00	0.0	clear
9:05	10.28	8.20	128	0.473	30.9	0.00	0.0	clear
9:10	**10.34**	**8.31**	**127**	**0.472**	**21.9**	**0.00**	**0.0**	**clear**

Comments: Well experiencing artesian conditions and flowed after opening. Actual water volume removed from well is unknown.
Bold readings are parameters recorded immediately before sample collection.
Low flow pump used to purge, well sampled after parameters stabilized.

Sampling ID: MW-02

Sampling Parameters: (check one)

☑ PFAs

☐ PFAs & 1,4-Dioxane

☐ TCL VOCs, SVOCs, Pesticides, Herbicides, PCBs, TAL Metals, Cyanide, PFAs & 1,4-Dioxane

☐ Other (list parameters below) ___________

WELL PURGE LOG

LiRo Engineers, Inc.

Project Title: NYSDEC I&R - Mayville

Well Number: **MW-03**

Site Name: Mayville

Date: 1/12/2021

Staff: AK, BW

Time: 9:50 (sample collected)

A). Total casing and screen length in feet: 42.60

B). Water level below top of casing in feet: 9.75

C). Number of feet standing water [A-B]: 32.85

D). Volume of water/foot of casing (gal.): 0.17

E). Volume of water in casing (gal. [CxD]: 5.58

F). Volume of water to remove (gal.) [Ex3]: 16.75

G). Volume of water actually removed (gal.): 1.50

Well ID	Volume (gal/ft)
1"	0.04
2"	0.17
3"	0.38
4"	0.66
5"	1.04
6"	1.50
8"	2.60

H). Explanation/Reason if F ≠ G: Parameters stabilized

I). Pumping/Extraction Method: ☐ Bailer ☑ Peristaltic ☐ Whale ☐ Grundfos ☐ Other ___________

J). Purge/Sampling Flow/Extraction Rates: 0.1 gpm (Average)

Sampling Flow/Extraction Rate: 0.1 gpm (Average)

PURGE DATA

Time	Temperature (˚C)	pH	ORP (mV)	Conductivity (ms/cm)	Turbidity (NTU)	Dissolved Oxygen (mg/L)	Dissolved Oxygen %	Appearance
9:30	7.39	8.31	142	0.573	215	7.43	62.8	clear
9:35	8.55	8.34	143	0.592	283	3.32	9.9	clear
9:40	9.16	8.33	141	0.592	304	3.65	31.8	clear
9:45	**9.03**	**8.31**	**142**	**0.587**	**247**	**15.93**	**46.1**	**clear**

Comments:

Bold readings are parameters recorded immediately before sample collection.

Low flow pump used to purge, well sampled after parameters stabilized.

Sampling ID: MW-03

Sampling Parameters: (check one)

☑ PFAs

☐ PFAs & 1,4-Dioxane

☐ TCL VOCs, SVOCs, Pesticides, Herbicides, PCBs, TAL Metals, Cyanide, PFAs & 1,4-Dioxane

☐ Other (list parameters below)

WELL PURGE LOG

LiRo Engineers, Inc.

Project Title: NYSDEC I&R - Mayville

Well Number: **MW-04**

Site Name: Mayville

Date: 1/12/2021

Staff: AK, BW

Time: 10:55
(sample collected)

A). Total casing and screen length in feet: 67.10

B). Water level below top of casing in feet: 9.30

C). Number of feet standing water [A-B]: 57.8

D). Volume of water/foot of casing (gal.): 0.17

E). Volume of water in casing (gal. [CxD]: 9.83

F). Volume of water to remove (gal.) [Ex3]: 29.48

G). Volume of water actually removed (gal.): 2.00

Well ID	Volume (gal/ft)
1"	0.04
2"	0.17
3"	0.38
4"	0.66
5"	1.04
6"	1.50
8"	2.60

H). Explanation/Reason if F ≠ G: Parameters stabilized

I). Pumping/Extraction Method: ☐ Bailer ☑ Peristaltic ☐ Whale ☐ Grundfos ☐ Other ___________

J). Purge/Sampling Flow/Extraction Rates: 0.1 gpm (Average)   Sampling Flow/Extraction Rate: 0.1 gpm (Average)

PURGE DATA

Time	Temperature (˚C)	pH	ORP (mV)	Conductivity (ms/cm)	Turbidity (NTU)	Dissolved Oxygen (mg/L)	Dissolved Oxygen %	Appearance
10:30	6.64	9.19	55	0.462	341	3.44	28.2	clear
10:35	7.90	9.43	-3	0.496	365	0.00	0.0	clear
10:40	9.01	9.65	-57	0.460	408	0.00	0.0	clear
10:45	9.06	8.81	-17	0.565	403	0.00	0.0	slightly turbid
10:50	**9.19**	**8.41**	**-9**	**0.639**	**565**	**0.00**	**0.0**	**slightly turbid**

Comments:

Bold readings are parameters recorded immediately before sample collection.

Low flow pump used to purge, well sampled after parameters stabilized.

Sampling ID: MW-04

Sampling Parameters: (check one)

☑ PFAs

☐ PFAs & 1,4-Dioxane

☐ TCL VOCs, SVOCs, Pesticides, Herbicides, PCBs, TAL Metals, Cyanide, PFAs & 1,4-Dioxane

☐ Other (list parameters below)

WELL PURGE LOG

LiRo Engineers, Inc.

Project Title: NYSDEC I&R - Mayville

Well Number: **MW-05**

Site Name: Mayville

Date: 1/12/2021

Staff: AK, BW

Time: 12:00
(sample collected)

A). Total casing and screen length in feet: 67.80

B). Water level below top of casing in feet: 9.09

C). Number of feet standing water [A-B]: 58.71

D). Volume of water/foot of casing (gal.): 0.17

E). Volume of water in casing (gal. [CxD]: 9.98

F). Volume of water to remove (gal.) [Ex3]: 29.94

G). Volume of water actually removed (gal.): 2.00

Well ID	Volume (gal/ft)
1"	0.04
2"	0.17
3"	0.38
4"	0.66
5"	1.04
6"	1.50
8"	2.60

H). Explanation/Reason if F ≠ G: Parameters stabilized

I). Pumping/Extraction Method: ☐ Bailer ☑ Peristaltic ☐ Whale ☐ Grundfos ☐ Other ___________

J). Purge/Sampling Flow/Extraction Rates: 0.1 gpm (Average)

Sampling Flow/Extraction Rate: 0.1 gpm (Average)

PURGE DATA

Time	Temperature (˚C)	pH	ORP (mV)	Conductivity (ms/cm)	Turbidity (NTU)	Dissolved Oxygen (mg/L)	Dissolved Oxygen %	Appearance
11:15	8.15	8.65	112	0.252	330	0.00	0.0	clear
11:20	9.32	8.70	103	0.245	290	0.00	0.0	clear
11:25	10.08	8.82	80	0.225	234	0.00	0.0	clear
11:30	10.05	8.81	72	0.224	231	0.00	0.0	clear
11:35	**10.07**	**8.80**	**67**	**0.223**	**242**	**0.00**	**0.0**	**clear**

Comments: MS/MSD and duplicate sample taken at this location.
Bold readings are parameters recorded immediately before sample collection.
Low flow pump used to purge, well sampled after parameters stabilized.

Sampling ID: MW-05

Sampling Parameters: (check one)

☐ PFAs

☐ PFAs & 1,4-Dioxane

☑ TCL VOCs, SVOCs, Pesticides, Herbicides, PCBs, TAL Metals, Cyanide, PFAs & 1,4-Dioxane

☐ Other (list parameters below)
____

WELL PURGE LOG

LiRo Engineers, Inc.

Project Title: NYSDEC I&R - Mayville

Well Number: **MW-06**

Site Name: Mayville

Date: 1/12/2021

Staff: AK, BW

Time: 13:40
(sample collected)

A). Total casing and screen length in feet: 16.00

B). Water level below top of casing in feet: 4.40

C). Number of feet standing water [A-B]: 11.6

D). Volume of water/foot of casing (gal.): 0.17

E). Volume of water in casing (gal. [CxD]: 1.97

F). Volume of water to remove (gal.) [Ex3]: 5.92

G). Volume of water actually removed (gal.): 2.50

Well ID	Volume (gal/ft)
1"	0.04
2" (circled)	0.17
3"	0.38
4"	0.66
5"	1.04
6"	1.50
8"	2.60

H). Explanation/Reason if F ≠ G: Parameters stabilized

I). Pumping/Extraction Method: ☐ Bailer ☑ Peristaltic ☐ Whale ☐ Grundfos ☐ Other ___________

J). Purge/Sampling Flow/Extraction Rates: 0.1 gpm (Average) Sampling Flow/Extraction Rate: 0.1 gpm (Average)

PURGE DATA

Time	Temperature (˚C)	pH	ORP (mV)	Conductivity (ms/cm)	Turbidity (NTU)	Dissolved Oxygen (mg/L)	Dissolved Oxygen %	Appearance
13:05	6.89	8.46	34	0.216	249	21.10	173.9	clear
13:10	9.17	7.30	-103	0.168	>1000	2.25	19.6	very turbid
13:15	9.18	7.23	-97	0.157	934	1.30	11.3	very turbid
13:20	9.22	7.06	-82	0.138	591	0.00	0.0	turbid
13:25	9.26	6.82	-61	0.128	250	0.00	0.0	slightly turbid
13:30	**9.26**	**6.81**	**-61**	**0.126**	**196**	**0.00**	**0.0**	**clear**

Comments:
Bold readings are parameters recorded immediately before sample collection.
Low flow pump used to purge, well sampled after parameters stabilized.

Sampling ID: MW-06

Sampling Parameters: (check one)

☐ PFAs

☐ PFAs & 1,4-Dioxane

☑ TCL VOCs, SVOCs, Pesticides, Herbicides, PCBs, TAL Metals, Cyanide, PFAs & 1,4-Dioxane

☐ Other (list parameters below)
____

WELL PURGE LOG

LiRo Engineers, Inc.

Project Title: NYSDEC I&R - Mayville

Well Number: **MW-07**

Site Name: Mayville

Date: 1/12/2021

Staff: AK, BW

Time: 14:50
(sample collected)

A). Total casing and screen length in feet: 20.00

B). Water level below top of casing in feet: 9.09

C). Number of feet standing water [A-B]: 10.91

D). Volume of water/foot of casing (gal.): 0.17

E). Volume of water in casing (gal. [CxD]: 1.85

F). Volume of water to remove (gal.) [Ex3]: 5.56

G). Volume of water actually removed (gal.): 2.00

Well ID	Volume (gal/ft)
1"	0.04
2" (circled)	0.17
3"	0.38
4"	0.66
5"	1.04
6"	1.50
8"	2.60

H). Explanation/Reason if F ≠ G: Parameters stabilized

I). Pumping/Extraction Method: ☐ Bailer ☑ Peristaltic ☐ Whale ☐ Grundfos ☐ Other ___________

J). Purge/Sampling Flow/Extraction Rates: 0.1 gpm (Average)

Sampling Flow/Extraction Rate: 0.1 gpm (Average)

PURGE DATA

Time	Temperature (˚C)	pH	ORP (mV)	Conductivity (ms/cm)	Turbidity (NTU)	Dissolved Oxygen (mg/L)	Dissolved Oxygen %	Appearance
14:15	8.10	7.93	-45	5.75	470	50.00	434.6	turbid
14:20	9.85	8.30	-93	5.64	824	0.00	0.0	very turbid
14:25	10.30	8.40	-101	5.65	>1000	0.00	0.0	very turbid
14:30	10.40	8.45	-116	5.69	>1000	0.95	8.7	very turbid
14:35	**10.67**	**8.48**	**-127**	**5.72**	**>1000**	**0.36**	**3.3**	**very turbid**

Comments:
Bold readings are parameters recorded immediately before sample collection.
Low flow pump used to purge, well sampled after parameters stabilized.

Sampling ID: MW-07

Sampling Parameters: (check one)

☐ PFAs

☐ PFAs & 1,4-Dioxane

☑ TCL VOCs, SVOCs, Pesticides, Herbicides, PCBs, TAL Metals, Cyanide, PFAs & 1,4-Dioxane

☐ Other (list parameters below)
____