



Remedial Investigation Work Plan

Haverstraw Chair Factory Site
(30 Liberty and 87 Main Street Parcels)
Haverstraw, New York

November 2024
(Revised ~~June~~ August 2025)

Prepared for:

Haverstraw Community Chair Factory LLC
1046 New York Avenue, Suite A
Huntington Station, New York 11746

Prepared by:

**Roux Environmental Engineering
and Geology, D.P.C.**
2558 Hamburg Turnpike, Suite 300
Buffalo, New York 14218

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Certification

I, Thomas H. Forbes, certify that I am currently a NYS registered professional engineer and that this November 2024 (revised ~~June-August~~ 2025) Remedial Investigation (RI) Work Plan for the Haverstraw Chair Factory Site was prepared in accordance with applicable statutes and regulations and in substantial conformance with the DER Technical Guidance for Site Investigation and Remediation (DER-10).

<u>Thomas H. Forbes, P.E.</u>		
NYS Professional Engineer #070950-1	Date	Signature

It is a violation of Article 145 of New York State Education Law for any person to alter this document in any way without the express written verification of adoption by any New York State licensed engineer in accordance with Section 7209(2), Article 145, New York State Education Law.

LIST OF ACRONYMS

ACM	Asbestos Containing Material
AST	Aboveground Storage Tank
BCA	Brownfield Cleanup Agreement
BCP	Brownfield Cleanup Program
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CAMP	Community Air Monitoring Plan
C/D	Construction and Demolition
CFR	Code of Federal Regulation
COC	Certificate of Completion
CP	Commissioner Policy
DER	Division of Environmental Remediation
DUSR	Data Usability Summary Report
EC	Engineering Control
ELAP	Environmental Laboratory Approval Program
FBGS	Feet Below Ground Surface
FER	Final Engineering Report
FOP	Field Operating Procedure
GWQS/GV	Groundwater Quality Standards/Guidance Values
HASP	Health and Safety Plan
IC	Institutional Control
IRM	Interim Remedial Measure
LQG	Large Quantity Generator
LUST	Leaking Underground Storage Tank
MECP	Master Erosion Control Plan
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
NYSDEL	New York State Department of Labor
NYCRR	New York Codes, Rules, and Regulations
O&M	Operations and Maintenance
OM&M	Operation, Maintenance, and Monitoring
OSHA	Occupational Safety and Health Administration
PAHs	Polycyclic Aromatic Hydrocarbons
PCB	Polychlorinated Biphenyl
PFAS	Per- and Polyfluoroalkyl Substances
PID	Photoionization Detector
PPM	Parts Per Million

PRR	Periodic Review Report
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
RAO	Remedial Action Objective
RAWP	Remedial Action Work Plan
RCRA	Resource Conservation and Recovery Act
REC	Recognized Environmental Condition
RI	Remedial Investigation
ROD	Record of Decision
RP	Remedial Party
SCG	Standards, Criteria, and Guidelines
SCO	Soil Cleanup Objective
SMP	Soil Management Plan
SSAL	Site-Specific Action Limit
SVOC	Semi-Volatile Organic Compound
TAL	Target Analyte List
TCL	Target Compound List
TCLP	Toxicity Characteristic Leachate Procedure
TIC	Tentatively Identified Compound
USEPA	United States Environmental Protection Agency
UST	Underground Storage Tank
VOC	Volatile Organic Compound

1. Introduction

This document presents the proposed scope of work and implementation procedures for completion of a Remedial Investigation (RI) at the Haverstraw Chair Factory Site (Site), located at 30 Liberty and 87 Main Street, Haverstraw, New York (see **Figure 1** and **Figure 2**).

The Applicant, Haverstraw Community Chair Factory LLC, acting as a Volunteer, has elected to pursue cleanup and redevelopment of the Site under the New York State Brownfield Cleanup Program (BCP), and has submitted a BCP Application to the New York State Department of Environmental Conservation (NYSDEC) in conjunction with this Work Plan. The planned redevelopment is to construct an approximately 682,000 square foot mixed-use residential with commercial spaces building that will include a main lobby, a shipping and receiving mailing area, commercial spaces, resident amenity spaces, and associated parking areas. The RI will be completed by Roux Environmental Engineering and Geology, DPC (Roux), on behalf of the Applicants. The work will be completed in accordance with NYSDEC DER-10 guidelines (Ref. 6), 6NYCRR Part 375 regulations and the site-specific Brownfield Cleanup Agreement (BCA).

1.1 Site Background

The BCP Site consists of two portions of legal parcels totaling approximately 4.53-acres, including a 3.68-acre parcel addressed at 30 Liberty Street and a 0.85-acre parcel addressed at 87 Main Street, Haverstraw, New York. The BCP Site is currently undeveloped with building debris staged in the associated parking lots.

As part of this project Roux completed a historical record research, including reviews of Sanborn Fire Insurance Maps, and municipal records for additional information relative to the Site. From at least 1892 through 1902, the eastern portion of the Property was covered by the Hudson River. By 1921, this portion of the Site was developed with a manufacturing structure indicating fill material was utilized to build up the land. The Site was utilized for manufacturing operations including brick manufacturing, chair manufacturing and a refinery from at least 1921 through 1994. By 2006 all manufacturing buildings were demolished. Demolition debris from the former manufacturing and refinery buildings was observed in large piles throughout the undeveloped portions of the Property. The unknown origin and contents of the fill material used to build up the land, the long history of manufacturing and the associated demolition debris represent a Recognized Environmental Condition (REC) for the Site.

Previous environmental investigations completed at the Site have identified elevated levels of polycyclic aromatic hydrocarbons (PAHs), residual petroleum, and metals exceeding Parts 375 Restricted-Residential Soil Cleanup Objectives (RRSCOs). Details of the previous investigations are presented in **Section 2.6** below and the reports are provided in **Appendix B**.

1.2 Project Objectives

For sites entering the BCP at the point of investigation, NYSDEC requires completion of the RI detailed in this Work Plan. The primary objectives of this RI/IRM are to:

- Collect additional media samples, under appropriate quality assurance/quality control criteria, to better delineate the nature and extent of contamination.
- Assess the groundwater flow direction and groundwater quality conditions at the Site.

- Determine if the concentrations of constituents of concern in site media pose potential unacceptable risks to human health and the environment.
- Provide the data needed to evaluate potential remedial measures and determine appropriate actions to address potential risks.

As part of the RI, sampling data will be used to evaluate whether remedial alternatives can meet the objectives. The intended uses of these data dictate the confidence levels. Two data confidence levels will be employed in the RI: screening level data and definitive level data. In general, screening level confidence will apply to field measurements, including PID measurements, groundwater elevation measurements, and field analyses (i.e., pH, temperature, dissolved oxygen, specific conductivity, and turbidity). Definitive level confidence will apply to samples for chemical analysis. The applicability of these levels of data will be further specified in the Quality Assurance Project Plan (QAPP) in **Section 4**. Sampling and analytical acceptance and performance criteria such as precision, accuracy, representativeness, comparability, completeness, and sensitivity, are defined in the QAPP.

1.3 Project Organization and Responsibilities

The Applicant, Haverstraw Community Chair Factory LLC has applied to the New York State BCP as a Volunteer, i.e., non-polluter, per ECL§27-1405. Roux will complete the RI and manage the brownfield cleanup, on behalf of the Applicant. Roux will also be responsible for verifying and certifying that the brownfield remedial action was completed in conformance with the approved work plans and NYSDEC DER-10 requirements.

Roux personnel as well as subcontractors for this project have not been determined at this time. Once pricing is secured, subcontract agreements are in place, and a field schedule determined, résumés for the selected project team will be provided to the Department, if requested. Roux's Project Manager's résumé, however, has been included in **Appendix A**. The table below presents the planned project team.

Company	Role	Name	Contact Information
Haverstraw Community Chair Factory LLC	Applicant contact	Dylan Salmons	(856) 371-1857
Roux	Principal Scientist /Project Officer	Mike Lesakowski	(716) 856-0599
Roux	Principal Engineer	Thomas H. Forbes, P.E.	(716) 856-0599
TBD	Analytical Testing	TBD	TBD
TBD	Drilling Services	TBD	TBD
TBD	Excavation Services	TBD	TBD
Data Validation Services	DUSR	TBD	TBD

2. Site Description

2.1 General

The Site, currently vacant/underutilized land (see **Figure 2**), is located in a suburban portion of Rockland County, comprised of approximately 4.53 acres along the Hudson River off of the Allison Avenue, Liberty Street, Front Street, and Main Street area in the planned development district of the Village of Haverstraw in Rockland County, New York. The Site sits within a highly developed residential, commercial, and recreational area of the Village of Haverstraw. To the north, the Site is bordered by parts of the Hudson River and Bowline Point Park; to the south of the Site sits Emerline Park; east of the Site is the Hudson River; on the west, the Site is bordered by residential homes, a church, library, and a post office.

2.2 Site Topography and Drainage

The Site is relatively level with surface elevations approximately 10 feet above mean sea level with topographic relief generally sloping towards the north and east. The surface of the Site is covered with thick vegetation. Precipitation (i.e., rain or melting snow) is likely to move with topographic relief. Shallow groundwater flow is likely to be affected by various cycles of development and filling, as well as utilities and foundation installation.

2.3 Geology and Hydrogeology

2.3.1 Overburden

According to the United States Department of Agriculture (USDA) Web soil survey (**Ref. 1**), Site soils are characterized as Hinckley loamy sand (HcD), Udorthents - wet substratum (Uw), and urban land (Ux). The HcD soil type is characterized as 85 percent urban land and 15 percent minor components; the Uw soil type is characterized as 80 percent urban land and 20 percent minor components; the Ux soil type is characterized as 75 percent urban land and 25 percent minor components. The Site's soil consists of an upper layer of fill, which overlies native sands/silts and gray clay. The native clay appears to form a continuous layer between approximately 5 and 15 feet below ground surface.

Groundwater is generally encountered between 1 and 7 feet below ground surface. Given the proximity to the Hudson River, groundwater depth and direction of flow are tidally influenced; however, unless indicated otherwise, an assumption has been made that the gradient of groundwater flow follows the surface topography of the Site and immediate surrounding area's subsurface features, such as excavations, utilities, and localized fill conditions. Monitoring wells will be installed during the investigation to assess groundwater flow and quality.

2.3.2 Bedrock

Based on the bedrock geologic map of Rockland County, the Site is located within the Piedmont Province, and the Newark Lowlands physiographic region. This region is characterized by low-contrasting topographic relief composed of sedimentary rock that is broken by northerly trending ridges that generally parallel the Hudson River. The Site is situated over the Newark Group/Basin, north of the Palisades Sill diabase and east of the Ramapo Fault Line, within an area of diabase (dark-gray to black, fine-textured igneous rock composed mainly of feldspar and pyroxene) and basalt (finer-grained igneous rock with the same mineral composition of diabase), conglomerate with dolostone and metaquartzite clasts, mudstone,

siltstone and arkosic sandstone. Sedimentary rocks within the Site are of the Brunswick Formation of the Newark Group/Basin, and primarily consist of sandstone, shale and conglomerate. These sedimentary deposits are dated to the Mesozoic Era, primarily forming during the late Triassic to early Jurassic Period. Igneous intrusions of the Brunswick Formation, such as the diabase ridge, occurred during the Triassic Age, and were generally adjacent to the Hudson River. Structurally, the bedrock formations strike in a north-south direction. Depth to and type of bedrock below the Site has not yet been determined. Further site investigation would be required to confirm the type and depth of bedrock.

2.3.3 Hydrogeology

Groundwater resources in the area surrounding the Site include a shallow, sandy aquifer comprising stratified drift deposits along the tidal marsh at the shore of the Hudson River, and a deeper bedrock groundwater aquifer that is isolated from the shallow aquifer. The shallow aquifer is not used as a source of potable water because of poor water quality (e.g. high salinity). The deeper bedrock aquifer is used as a source of potable water. Regional groundwater flow is likely to the east towards the Hudson River or north towards the man-made bay. Locally, groundwater may be influenced by subsurface features, such as excavations, utilities, and localized fill conditions. Monitoring wells will be installed during the RI to assess groundwater flow and quality.

2.4 Utilities and Groundwater Use

The subject property has access to all major public and private utilities, including potable water, sanitary and storm sewers, electric, and natural gas. New York State Electric and Gas (NYSEG) Corporation utilities are in the right-of-way along Allison, Broad, and Liberty Street.

Groundwater at the Site is assigned Class "GA" by 6NYCRR Part 701.15. Currently, there are no deed restrictions on the use of groundwater at the Site; however, there are no groundwater supply wells on the property. Regionally, groundwater in the area has not been developed for industrial, agriculture, or public supply purposes. Municipal potable water service is provided on- and off-site.

2.5 Wetlands

A Fish and Wildlife Resource Impact Assessment will be conducted as part of the remedial investigation, including a delineation of potential wetland areas on the BCP Site.

2.6 Previous Investigations

A summary of the investigation that has occurred at the Site is presented below, included in **Appendix B** and the investigation location with areas of concern shown in **Figure 3**.

2.6.1 Phase I Environmental Site Assessment

A Phase I Environmental Site Assessment (ESA) completed by Hillman Consulting dated March of 2023 identified recognized environmental concerns (RECs) at the Site.

From at least 1892 through 1902, the eastern portion of the Property was covered by the Hudson River. By 1921, this portion of the Site was developed with a manufacturing structure indicating fill material was utilized to build up the land. The Site was utilized for manufacturing operations including brick manufacturing, chair manufacturing and a refinery from at least 1921 through 1994. By 2006 all

manufacturing buildings were demolished. Demolition debris from the former manufacturing and refinery buildings was observed in large piles throughout the undeveloped portions of the Property. The unknown origin and contents of the fill material used to build up the land, the long history of manufacturing and the associated demolition debris represent a Recognized Environmental Condition (REC) for the Site.

2.6.2 Phase II Investigation (October 2024)

Roux Environmental Engineering and Geology, D.P.C. (Roux) completed test pit investigation on the Site in May 2024, which was summarized in the October 2024 Phase II Investigation report. Fifteen soil borings (designated as TP-1 through TP-15) were advanced at the Site on May 30, 2024.

Twelve samples (TP-2 (0-2 ft), TP-3 (0-2 ft), TP-4 (0-2 ft), TP-5 (4-5 ft), TP-6 (2-4 ft), TP-7 (5-7 ft), TP-8 (0-2 ft), TP-11 (2.5-5 ft), TP-12 (4-6 ft), TP-13 (5-7 ft), TP-14 (0-1.5 ft), and TP-15 (3-5 ft)) were submitted for chemical analysis of PAHs and Resource and Recovery Act (RCRA) metals. Select samples were also submitted for volatile organic compounds (VOCs). Results of the investigation are summarized below:

- Urban fill materials were identified across the Site to depths ranging from 0.25 fbgs to greater than 10 fbgs.
- Seven different PAHs were identified at various concentrations exceeding USCOs, RRSCOs, CSCOs, and ISCOs at TP-2 (0-2 ft), TP-11 (2.5-5 ft), and TP-14 (0-1.5 ft).
- Metals, including arsenic, barium, chromium, lead, mercury, and selenium, were identified exceeding USCOs, RRSCOs, CSCOs, and ISCOs at TP-5 (4-5 ft), TP-6 (2-4 ft), TP-7 (5-7 ft), TP-8 (0-2 ft), TP-11 (2.5-5 ft), TP-13 (5-7 ft), TP-14 (0-1.5 ft), and TP-15 (3-5 ft).
 - Arsenic was detected exceeding its ISCO (16 mg/kg) at TP-7 (28.8 mg/kg); barium was detected exceeding its CSCO (400 mg/kg) at TP-7 (1,040 mg/kg); chromium was detected exceeding its USCO (31 mg/kg) at TP-7 (47.3 mg/kg); lead was detected exceeding its USCO (64 mg/kg) at TP-5 (71.2 mg/kg), TP-8 (73.5 mg/kg), TP-11 (134 mg/kg), TP-13 (78 mg/kg), TP-14 (262 mg/kg), TP-15 (83.9 mg/kg), exceeding its RRSCO (400 mg/kg) at TP-6 (402 mg/kg), and exceeding its CSCO (1,000 mg/kg) at TP-7 (1,510 mg/kg); mercury was detected exceeding its USCO (0.18 mg/kg) at TP-11 (0.21 mg/kg), TP-14 (0.55 mg/kg), exceeding its RRSCO (0.81 mg/kg) at TP-6 (0.9 mg/kg), and exceeding its ISCO (5.7 mg/kg) at TP-7 (10.4 mg/kg); and selenium was detected exceeding its USCO (31 mg/kg) at TP-7 (47.3 mg/kg).
- VOCs were not detected at concentrations above laboratory detection limits for any of the twelve test pits.

3. Remedial Investigation Scope of Work

The RI scope of work is focused on defining the nature and extent of contamination on-site, delineating the extent of known contamination, identifying the source(s) of contamination, defining chemical constituent migration pathways, qualitatively assessing human health and ecological risks (if necessary), and obtaining data of sufficient quantity and quality to perform the alternatives analysis report. Any deviation from the remedial investigation will require notification to NYSDEC and approval by NYSDEC before being implemented.

Field team personnel will collect environmental samples in accordance with the rationale and protocols described in the QAPP in **Section 4**. The United States Environmental Protection Agency (USEPA) and NYSDEC-approved sample collection and handling techniques will be used. Samples for chemical analysis will be analysed in accordance with USEPA SW-846 methodology with an equivalent Category B deliverable package to meet the definitive-level data requirements. Analytical results will be evaluated by a third-party data validation expert in accordance with provisions described in the QAPP. Data submittals will be provided to the NYSDEC in accordance with the most current electronic data deliverables (EDD) protocols.

During intrusive RI activities, a Community Air Monitoring Plan (CAMP) will be followed. The CAMP is consistent with the requirements for community air monitoring at remediation sites as established by the NYSDOH and NYSDEC. Accordingly, it follows procedures and practices outlined under NYSDEC's DER-10 (May 2010) Appendix 1A (NYSDOH's Generic Community Air Monitoring Plan) and Appendix 1B (Fugitive Dust and Particulate Monitoring).

The investigation approach is described below. **Figure 4** shows the planned RI sample locations. **Table 1** summarizes the planned Sampling and Analytical Program (SAP)

3.1 Pre-Investigation Activities

3.1.1 Utility Clearance

Prior to any intrusive activities, Dig Safely New York (Call 811) will be contacted by the site contractor a minimum of three business days in advance of the work and informed of the intent to perform excavation work at the Site. If underground utilities are present on the property and are anticipated to interfere with intrusive activities, the Applicants and the NYSDEC will be contacted to discuss mitigating measures.

3.2 Soil/Fill Investigation

A soil/fill investigation will be completed across the Site to further assess whether additional impact exists beyond the limits of, and to assess the extent of, known historical contamination. The soil/fill investigation will include the collection of surface and subsurface soil/fill samples. The soil/fill investigation will consist of test pits, soil borings, and surface samples to allow for characterization of surface and subsurface soil/fill material and sample collection.

3.2.2 Surface Soil/Fill Investigation

Eight surface soil/fill samples (SS-1 through SS-8) will be collected from select areas across the Site, co-located with monitoring well locations as shown on **Figure 4**. The samples will be collected from 0 to 2

inches below the vegetative cover to allow for assessment of human exposure via incidental soil ingestion, inhalation of soil, or dermal contact with soil.

3.2.3 Surface Soil/Fill Sample Collection and Analysis

The surface soil samples will be analysed in accordance with the sampling and analysis plan (see **Table 1**). Specifically, all ~~eight~~^{ten} surface soil samples will be analysed for Target Compound List (TCL) volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs), Target Analyte List (TAL) metals, TCL polychlorinated biphenyls (PCBs), TCL pesticides and herbicides, 1,4-dioxane, and per- and polyfluoroalkyl substances (PFAS). If elevated PID readings (i.e., sustained above 10 parts per million, (ppm)) are noted during field screening, laboratory analysis may be expanded to include additional VOCs samples in consultation with the NYSDEC. The soil/fill samples will be analysed in accordance with USEPA SW 846 methodology with equivalent Category B deliverables to allow for independent third-party data usability assessment.

3.2.4 Subsurface Soil/Fill Investigation

Supplemental subsurface soil/fill exploratory locations will be advanced across the Site to further delineate the extent of known contamination, identify the presence of historic urban fill, and determine if other impacts requiring remediation are present at the Site, as further discussed below.

3.2.4.1 Test Pit Investigation

As shown on **Figure 4**, fifteen supplemental test pits, identified as TP-16 through TP-30, will be completed across the Site to further characterize subsurface soil/fill and native material. Test pits will be excavated to a depth where native soil is encountered and to at least 15 fbg, or to equipment refusal, whichever occurs first. Excavated native materials will be segregated from non-native material and will be placed back into the excavation to its original location to avoid co-mingling of native and non-native material to an achievable extent. If gross contaminated material (GCM) is encountered at any point during the excavation process, that material will be separated and staged on poly or containerized until subsequent waste characterization sampling occurs to determine proper disposal means; otherwise, excavated material shall be returned back into the excavation in reverse order of removal. Roux will oversee the test pit investigation work and create a test pit excavation log (including photographs) for each investigation location. FOP 065.1 in **Appendix E** provides a sample test pit excavation log. Real time air and particulate monitoring will be conducted during intrusive activities using a PID and particulate monitor in accordance with the CAMP.

All soil samples will be field screened for the presence of total volatile organics using a calibrated PID with a 10.6 eV lamp, as a procedure for ensuring the health and safety of personnel at the Site, and to identify potential impacts in soil samples for laboratory analysis. Upon reaching the completion depth of each location, field visual/olfactory and PID results will be reviewed, and sample intervals will be determined.

3.2.4.2 Soil Boring Investigation

Eight soil borings (which will subsequently be converted to monitoring well locations), identified as MW-1 through MW-8, will be advanced, in the proposed areas shown on **Figure 4**, to collect soil samples and allow for the installation of monitoring wells. Soil borings will be advanced to an estimated depth of up to 20 fbg, or at a minimum of ten feet into the upper water bearing zone, or until equipment refusal.

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 where wells will be installed will be placed in sealed New York State Department of Transportation (NYSDOT)-approved drums and labelled for subsequent characterization and disposal. Additional information is provided in **Section 3.6** below.

Roux will oversee the investigation work and create a field borehole log (including photographs) for each investigation location. FOP 047.0 in **Appendix E** provides a sample field borehole log. Real time air and particulate monitoring will be conducted during intrusive activities using a PID and particulate monitor in accordance with the CAMP.

All soil samples will be field screened for the presence of volatile organics using a calibrated PID with a 10.6 eV lamp, as a procedure for ensuring the health and safety of personnel at the Site, and to identify potential impacts in soil samples for laboratory analysis. Upon reaching the completion depth of each location, field visual/olfactory and PID results will be reviewed, and sample intervals will be determined.

If boring location modifications are required based on field conditions, such a deviation would require notification to the NYSDEC and approval by the NYSDEC before being implemented.

3.2.5 Subsurface Soil/Fill Sample Collection and Analysis

Table 1 summarizes the proposed RI sample collection and analytical program. The soil/fill samples will be collected to further delineate the horizontal and vertical extent of the known contamination and determine if other impacts requiring remediation are present at the Site.

The sample interval identified as the most impacted (i.e., greatest PID scan result and/or visual/olfactory evidence of impact) at investigation locations will be selected for laboratory analysis. If either the impacts are ubiquitous from grade to final depth or no impacts were identified, the soil/fill directly above water table will be selected for analysis. If the impacts are ubiquitous from grade to final depth or no impacts were identified, and water is not encountered at a particular sample location, the sample interval will be selected based on the professional discretion of the field personnel and in consultation with the NYSDEC. If differentiable impacts are noted during the investigation, additional samples will be collected such that representative samples from all fill/soil types are collected to determine the nature and extent of contamination. Field personnel are afforded the full discretion and authority to sample differential impacts as necessary.

Subsurface soil/fill sampling will be completed in accordance with the Sampling and Analysis Plan shown on **Table 1**. Specifically, thirty-six subsurface soil samples from two distinct lithology zones (soil/fill material and native soils) will be screened, sampled and analysed as follows:

- Soil/Fill material from Test Pits and Soil Borings
 - Soil/fill material in eight-ten of the fifteen test pits and all eight soil borings will be analysed for full suite parameters that include TCL plus CP-51 VOCs, TCL SVOCs, TAL metals, TCL PCBs, TCL pesticides and herbicides, 1,4-dioxane, and PFAS; the remaining seven-five of fifteen test pits will be sampled for known contaminants, which include TAL metals and pH.
- Native soil from Test Pits and Soil Borings

- Native soil in eight-ten of the fifteen test pits and all eight soil borings will be analysed for full suite parameters that include TCL plus CP-51 VOCs, TCL SVOCs, TAL metals, TCL PCBs, TCL pesticides and herbicides, 1,4-dioxane, and PFAS; the remaining seven-five of fifteen test pits will be sampled for known contaminants, which include TAL metals and pH.

En-core samplers will be used to collect VOC soil samples from pit sidewalls from varying depths greater than 6-inches below ground surface from within the impacted depth range, based on field observations in accordance with Roux's Surface and Subsurface Soil Sampling Procedures. If the test pit is greater than 4 feet in depth, it will not be entered for sampling; in this event, collect samples using the backhoe bucket, then fill sample containers from the center of the bucket using the stainless steel sampling equipment (i.e., spoon, spade, trowel etc.). Remaining samples will be collected and placed into pre-cleaned laboratory provided sample bottles, cooled to 4°C in the field, and transported under chain-of-custody command to a NYSDOH Environmental Laboratory Approval Program (ELAP)-certified analytical laboratory.

Additional step-out test pits may be excavated 10 feet away from each delineation sample with additional samples being collected and placed on "hold" with the laboratory, pending the results of the initial samples. If the step-out samples do not meet RRSCOs, it will be considered whether it is more cost and time effective to return to the Site for additional delineation sampling, or to collect post-excavation samples as needed during remedial excavation activities.

Up to eight waste characterization soil/fill samples, including one from fill material within each test pit, will be collected during the RI and analyzed for TCLP VOCs, TCLP SVOCs, TCLP metals, PCBs, ignitability, corrosivity, and reactivity to fulfill landfill analytical disposal requirements; the samples will be chosen to represent fill conditions across the Site, to include previously identified fill areas with elevated metal concentrations. Based on the results of the RI soil/fill samples and the waste characterization soil/fill samples, the landfill may allow the waste characterization parameter list to be reduced to the constituents of potential concern (COPCs) if the facility requires additional waste characterization samples based on the estimated disposal volume.

The soil/fill samples will be analysed in accordance with USEPA SW 846 methodology with equivalent Category B deliverables to allow for independent third-party data usability assessment.

3.3 Groundwater Investigation

Eight groundwater monitoring wells, identified as MW-1 through MW-8, will be advanced at the Site to assess groundwater quality data and flow direction. **Figure 4** shows the planned groundwater monitoring well locations. Monitoring well installation and groundwater sample collection details are discussed in the following sections.

3.3.1 Monitoring Well Installation

Monitoring wells will be installed following the advancement of soil borings with a rotary or direct-push drill rig. All non-dedicated drilling tools and equipment will be decontaminated between boring locations using potable tap water and a phosphate-free detergent (e.g., Alconox).

Each well boring will be advanced to a target minimum depth of five feet below the first encountered groundwater estimated depths ranging from 15 to 20 fbg; however, borings may be advanced to greater

depths to define the Site geology or to encounter the water bearing zone if deeper than 20 fbs. Wells will be constructed with 2-inch diameter Schedule (SCH) 40 PVC with a minimum 5-foot flush joint SCH 40 PVC 0.010-inch machine-slotted well screen. Each well screen and attached riser will be placed at the bottom of each borehole and a silica sand filter pack (size #0) will be installed from the base of the well to a maximum of two feet above the top of the screen. A bentonite chip seal will then be installed and allowed to hydrate sufficiently to mitigate the potential for downhole grout contamination. The newly installed monitoring wells will be completed with keyed-alike locks, a lockable J-plug, and a steel flush mounted road box or steel stick-up casing. Concrete will be placed in the boring around the protective casing and sloped away from the casing.

3.3.2 Well Development

After installation, but not within 24 hours, newly installed monitoring wells will be developed in accordance with Roux and NYSDEC protocols. Development of the monitoring wells will be accomplished with dedicated disposable polyethylene bailers via surge and purge methodology. Field parameters including pH, temperature, turbidity, dissolved oxygen (DO), oxidation-reduction potential (ORP) and specific conductance will be measured periodically (i.e., every well volume or as necessary) during development. Field measurements will continue until they become relatively stable. Stability will be defined as variation between measurements of approximately 10 percent or less with no overall upward or downward trend in the measurements. A minimum of three well volumes will be evacuated from each monitoring well during development activities. Should monitoring wells go dry during well development, Roux will allow sufficient time for the well to recharge then continue to purge until three well volumes are evacuated.

Purged groundwater will be containerized in NYSDOT-approved drums and labelled per monitoring well location pending laboratory analytical results. Based on the RI groundwater analytical results and field observations, it will be determined, in consultation with the Department, if the containerized development water is acceptable for surface discharge through carbon or requires subsequent on-site treatment and/or off-site disposal.

3.3.3 Groundwater Sample Collection

Groundwater sampling will be performed at least one week after well development. Prior to groundwater sample collection, static water levels will be measured and recorded from all on-site monitoring wells to facilitate the preparation of a Site-wide isopotential map. Following water level measurement, field personnel will purge and sample monitoring wells using a submersible pump with dedicated pump tubing following low-flow/minimal drawdown purge and sample collection procedures. In the event of pump failure or the saturated unit does not permit the proper implementation of low-flow sampling, a dedicated polyethylene bailer will be used to purge and sample the well. Prior to sample collection via low-flow methodology, groundwater will be evacuated from each well at a low-flow rate (typically less than 0.1 L/min) while maintaining a generally consistent water level. Field measurements for pH, temperature, turbidity, DO, ORP, specific conductance and water level, as well as visual and olfactory field observations will be periodically recorded and monitored for stabilization. Low-flow purging will be considered complete when field parameters stabilize and when turbidity measurements fall below 50 Nephelometric Turbidity Units (NTU) or become stable above 50 NTU regardless of volume purged. Purging via disposable bailer, if necessary, will be considered complete following the removal of three well volumes and field parameter stabilization or to dryness, whichever occurs first. In general, stability is defined as variation between field measurements of 10 percent or less and no overall upward or downward trend in the measurements. Upon stabilization of field parameters, groundwater samples will be collected and analysed as discussed below.

Groundwater sampling methods will conform with protocol acceptable for the collection of the PFAS in accordance with the Department's Guidelines for Sampling and Analysis of PFAS. Sampling personnel will wear nitrile gloves while handling empty sample containers, filling sample containers, sealing sample containers, and placement of samples into sample coolers. It is recommended that clean nitrile gloves be worn while handling sample containers, during the groundwater sampling, and sealing/placement of samples into the laboratory supplied cooler. Sample collection methods that will be implemented during the RI include:

- Submersible Pump with Dedicated Pump Tubing

Monitoring wells will be purged and sampled using a non-dedicated submersible pump and dedicated pump tubing following low-flow (minimal drawdown) purge and sample collection procedures, as described above. Non-dedicated pumps will require decontamination prior to use at each well location and the collection of an equipment blank.

- Polyethylene Disposable Bailer

If low flow is not feasible (e.g., due to depth to groundwater), wells of any depth (up to 100 fbgs) may be purged and sampled using a polyethylene disposable bailer via direct grab. In general, a bottom filling dedicated polyethylene bailer is attached to a length of dedicated hollow-braid polypropylene rope and lowered into the well smoothly and slowly so as not to agitate the groundwater or damage the well. Purging continues until a predetermined volume of water has been removed (typically three well volumes) or to dryness. Measurements for pH, temperature, specific conductance, dissolved oxygen, and turbidity are recorded following removal of each well volume. The well is purged until the readings for indicator parameters stabilize or the well is purged to dryness.

Prior to, and immediately following collection of groundwater samples, field measurements for pH, specific conductance, temperature, dissolved oxygen, turbidity, and water level, as well as visual and olfactory field observations will be recorded. All collected groundwater samples will be placed in pre-cleaned, pre-preserved laboratory provided sample bottles, cooled to 4°C in the field, and transported under chain-of-custody command to a NYSDOH-approved laboratory for analysis.

3.3.4 Groundwater Sample Analyses

As summarized on **Table 1**, each groundwater sample from monitoring wells MW-1 through MW-8 will be sampled for parameters, including TCL plus CP-51 VOCs, TCL SVOCs, TAL metals, TAL dissolved metals, PCBs, pesticides and herbicides. Four of the eight groundwater monitoring wells will also be sampled for emerging contaminants (PFAS and 1,4-dioxane). Groundwater samples will be collected and analysed in accordance with USEPA SW 846 methodology with equivalent NYSDEC Category B deliverables to allow for independent third-party data usability assessment. Samples collected for 1,4-dioxane will be analyzed via EPA Method 8270 Selective Ion Monitoring (SIM) mode and samples collected for PFAS analysis will be analyzed via a modified EPA Method 1633.

3.4 Soil Vapor Investigation

Soil vapor will be investigated at six locations to evaluate the potential for soil vapor intrusion (SVI) risks for future on-site buildings, and to complete a qualitative off-site exposure assessment. Soil boreholes will be advanced to a depth up to approximately 5 fbgs (depending on depth to groundwater observed during the soil borings). One ambient outdoor air sample will also be collected concurrent with the soil vapor samples. Soil vapor sampling probes will be installed in general conformance with the NYSDOH Soil Vapor Intrusion Guidance.

Each soil vapor sampling probe will be installed using specialized stainless steel soil probes. Sampling equipment includes stainless steel sampling screens, ¼-inch inside diameter inert sample tubing and dedicated Summa canisters. The steel rod will be equipped with an anchor point at the driving end of the rod. The anchor point will be connected to the sampling screen and tubing on the inside of the steel rod. Once the steel rod is advanced to the target depth, the steel rod will be retracted, leaving the anchor point, sampling screen and sampling tubing within the borehole annulus. Glass beads (or equivalent) will be poured around the sampling screen in a manner to cover the entire length of the sampling screen. Bentonite or bentonite/soil mixture will be placed above the glass beads to the ground surface to create a seal to prohibit infiltration of ambient air into the sampling area.

Once the sample probes are installed, the probe and tubing will be purged (three volumes) using a syringe and helium tracer gas will be used during the purging phase (in the same manner as recommended for soil vapor intrusion probes) to ensure that the probes are well sealed. Samples will be collected over an approximate 4-hour period. All soil vapor samples will be collected and analysed for VOCs by EPA Method TO-15.

Each canister will be fitted with a sampling valve that uses a critical orifice and mass flow controller to regulate the air flow into the canister for the selected sampling period. The mass flow controller will maintain a relative constant air flow rate throughout the sampling period. Summa canister valves will remain closed until the sample holes are complete and all the canisters are in their respective positions. The valves will then be opened for the designated collection period.

3.4.1 Soil Vapor Sample Analysis

Samples will be collected in laboratory supplied Summa® canisters, and once filled will be transported under chain-of-custody command to a NYSDOH-approved laboratory for analysis of USEPA TCL VOCs in accordance with USEPA Method TO-15. Samples will be analysed in accordance with the NYSDOH Guidance for Evaluating Soil Vapor Intrusion in the State of New York (October 2006, and subsequent revisions). Typically, a minimum reporting limit of one microgram per cubic meter (1 µg/m³) or less is sufficient for most analytes. Field documentation of soil vapor investigation sampling activities will be recorded. The soil vapor samples will be analysed in accordance with USEPA SW 846 methodology with equivalent Category B deliverables to allow for independent third-party data usability assessment.

3.5 Field Specific Quality Assurance/Quality Control Sampling

In addition to the soil/fill and groundwater samples described above, field-specific quality assurance/quality control (QA/QC) samples will be collected and analysed to ensure the reliability of the generated data as described in the QAPP (see **Section 4**) and to support the required third-party data usability assessment effort. Site-specific QA/QC samples will include matrix spikes, matrix spike duplicates (MS/MSDs), blind duplicates, and trip blanks (see **Table 1**).

3.6 Decontamination and Investigation-Derived Waste Management

Every attempt will be made to use dedicated sampling equipment during the RI; however, if non-dedicated equipment is required and/or used, the equipment will be decontaminated, at a minimum, with a non-phosphate detergent (i.e., Alconox®) and potable water mixture, rinsed with distilled water, and air-dried before each use in accordance with Roux's field operating procedures (FOPs) presented in **Appendix E**. Decontaminated sampling equipment will be kept in a clean environment prior to sample collection. Heavy

equipment, such as an excavator and drilling tools, will be decontaminated by the subcontractor as indicated above, as necessary.

RI generated spoils (soil-fill) not exhibiting gross contamination (i.e., visible product, odor, sheen, etc.) will be returned to the location and approximate depth from which it was removed (soil/fill). RI generated monitoring well drilling spoils, groundwater, and decontamination rinse water will be containerized. RI and/or subsequent waste characterization analytical results of investigation-derived waste (IDW) material will be used to determine if spoils/water can be returned to the ground surface, utilized on-site, or require treatment and/or off-site disposal.

IDW materials exhibiting gross contamination will be placed in sealed NYS Department of Transportation (NYSDOT)-approved drums for subsequent characterization and disposal based on the RI results.

All generated IDW drums will be labelled alpha-numerically and include contents, origin, and date of generation using a paint stick marker on two sides and the top of each drum. Drums will be securely staged on-site pending analyses and remedial measures assessment. Field personnel will coordinate the on-site handling and temporary storage of IDW drums, including transportation, characterization sampling, and offsite disposal arrangements, as necessary.

Discarded personal protective equipment (PPE) (i.e., latex gloves, Tyvek, paper towels, etc.) and disposable sampling equipment (i.e., bailers or stainless-steel spoons) will be placed in sealed plastic garbage bags and disposed of as municipal solid waste.

3.7 Site Mapping and Survey

A Site map showing sample points and relevant Site features will be developed during the field investigation. Roux will employ a handheld GPS unit to identify the locations of all soil borings, newly installed wells, and test pits relative to State planar grid coordinates. Monitoring well and subsurface soil investigation location elevations will be measured by Roux's surveyor. An isopotential map showing the general direction of groundwater flow will be prepared based on water level measurements relative to United States Geological Survey (USGS) vertical datum.

3.8 Field Documentation and Reporting

RI field activities will be documented in a Field Activity Daily Log (FADLs) to provide a record of activities conducted at the Site. Entries will be signed and dated at the end of each day of fieldwork (or as produced) by the Field Team Leader. Field notes will include, at a minimum, the: date and time of all entries, names of personnel on-site, weather conditions (temperature, precipitation, etc.), location of activity, and description of activity. Sampling activities will be logged and photographed as necessary to document the activities at the Site. Progress photographs from a set location will be collected to document development activities and intrusive construction activities. Field personnel will, at a minimum, complete the following standard field forms (see **Appendix C**):

- Chain of Custody Form (per selected laboratory)
- Equipment Calibration Log
- FADLs
- Field Borehole/Monitoring Well Log

- Groundwater Field Form
- Investigative-Derived Waste Container Log (if necessary)
- Photographic Log
- Real-Time Air Monitoring Log
- Tailgate Safety Meeting Form
- Test Pit Excavation Log
- Problem Identification Report (as necessary)
- Corrective Measures Report

Real-time community air monitoring will be performed during the RI activities at the Site. ~~A CAMP is included~~ within Roux's HASP (see **HASP Appendix DE**). Any exceedance of CAMP data will be summarized and provided to the NYSDEC and NYSDOH within 24 hours of occurrence; otherwise, CAMP data reports will be provided to NYSDEC and NYSDOH on a weekly basis. Any issues related to CAMP monitoring will be discussed during weekly progress meetings.

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4. Quality Assurance Project Plan

A Quality Assurance Project Plan (QAPP) has been prepared in support of the RI/IRM activities. The QAPP dictates implementation of the investigation tasks delineated in this Work Plan. A Sampling and Analysis Plan (SAP) identifying methods for sample collection, decontamination, handling, and shipping, is provided below.

The QAPP will assure the accuracy and precision of data collection during the Site characterization and data interpretation periods. The QAPP identifies procedures for sample collection to mitigate the potential for cross-contamination, as well as analytical requirements necessary to allow for independent data validation. The QAPP has been prepared in accordance with USEPA's Requirements for Quality Assurance Project Plans for Environmental Data Operations (Ref. 5); the EPA Region II CERCLA Quality Assurance Manual (Ref. 2), and NYSDEC's DER-10 Technical Guidance for Site Investigation and Remediation (May 2010).

4.1 Scope of the QAPP

This QAPP was prepared to provide quality assurance (QA) guidelines to be implemented during the RI/IRM activities. This document may be modified for subsequent phases of investigative work, as necessary. The QAPP provides:

- A means to communicate to the persons executing the various activities exactly what is to be done, by whom, and when.
- A culmination to the planning process that ensures that the program includes provisions for obtaining quality data (e.g., suitable methods of field operations).
- A historical record that documents the investigation in terms of the methods used, calibration standards and frequencies planned, and auditing planned.
- A document that can be used by the Project Manager's and QA Officer to assess if the activities planned are being implemented and their importance for accomplishing the goal of quality data.
- A plan to document and track project data and results.
- Detailed descriptions of the data documentation materials and procedures, project files, and tabular and graphical reports.

The QAPP is primarily concerned with the quality assurance and quality control aspects of the procedures involved in the collection, preservation, packaging, and transportation of samples; field testing; record keeping; data management; chain-of-custody procedures; laboratory analyses; and other necessary matters to assure that the investigation activities, once completed, will yield data whose integrity can be defended.

QA refers to the conduct of all planned and systematic actions necessary to perform satisfactorily all task-specific activities and to provide information and data confidence as a result of such activities. The QA for task-specific activities includes the development of procedures, auditing, monitoring, and surveillance of the performance.

QC refers to the activity performed to determine if the work activities conform to the requirements. This includes activities such as inspections of the work activities in the field (e.g., verification that the items and

materials installed conform to applicable codes and design specifications). QA is an overview monitoring of the performance of QC activities through audits rather than first time inspections.

4.2 QAPP Organization and Responsibility

The principal organizations involved in verifying achievement of data collection goals for the Site include: the NYSDEC, NYSDOH, and Haverstraw Community Chair Factory LLC (Volunteers), Roux (Volunteer's Consultant), the drilling subcontractor(s), the independent environmental laboratory, and the independent third-party data validator. The roles, responsibilities, and required qualifications of these organizations are discussed in the following subsections. Résumés are included in **Appendix A**.

4.2.1 Volunteers

Haverstraw Community Chair Factory LLC will be responsible for complying with the QA requirements as specified herein and for monitoring and controlling the quality of the Brownfield cleanup construction either directly or through their designated environmental consultant and/or legal counsel. The Applicant will also have the authority to select Remedial Action Contractor(s) to assist them in fulfilling these responsibilities. The designated Project Manager is responsible for implementing the project and has the authority to commit the resources necessary to meet project objectives and requirements.

4.2.2 Applicant

Roux is the Environmental Engineer and Scientific Technical Consultant on this project and is responsible for the implementation of the RI Work Plan, including, but not limited to, field operations, laboratory testing, data management, data analysis and reporting. Any one member of Roux's staff may fill more than one of the identified project positions (e.g., field team leader and site safety and health officer). The various quality assurances, field, laboratory, and management responsibilities of key project personnel are defined below.

- *Project Officer (PO):* *Michael Lesakowski*
The PO has the responsibility for ensuring conformance with the BCP program requirements. The PO will report directly to the Applicants and the NYSDEC/NYSDOH Project Managers and is responsible for project oversight. The PO will:
 - o Define project objectives and develop a detailed work plan schedule.
 - o Acquire and apply technical and corporate resources as needed to assure performance within budget and schedule constraints.
 - o Review the work performed on the project to assure its quality, responsiveness, and timeliness.
 - o Certify deliverables before their submission to NYSDEC.
- *Project Manager (PM):* *Michael Lesakowski*
The PM has the responsibility for ensuring that the project meets the Work Plan objectives. The PM will report directly to the Applicants' Project Coordinator and the NYSDEC/NYSDOH Project Managers and is responsible for technical and project oversight. The PM will:
 - o Define project objectives and develop a detailed work plan schedule.
 - o Establish project policy and procedures to address the specific needs of the project as a whole, as well as the objectives of each task.

- o Develop and meet ongoing project and/or task staffing requirements, including mechanisms to review and evaluate each task product.
- o Review the work performed on each task to assure its quality, responsiveness, and timeliness.
- o Review and analyze overall task performance with respect to planned requirements and authorizations.
- o Review all deliverables before their submission to NYSDEC.
- o Develop and meet ongoing project and/or task staffing requirements, including mechanisms to review and evaluate each task product.
- o Ultimately be responsible for the preparation and quality of interim and final reports.
- o Represent the project team at meetings.

- FTL/SSHO: *TBD*

The Field Team Leader (FTL) has the responsibility for implementation of specific project tasks identified at the Site, is responsible for the supervision of project field personnel, subconsultants, and subcontractors. The FTL reports directly to the Project Manager. The FTL will:

- o Define daily work activities.
- o Orient field staff concerning the project's special considerations.
- o Monitor and direct subcontractor personnel.
- o Review the work performed on each task to ensure its quality, responsiveness, and timeliness.
- o Assure that field activities, including sample collection and handling, are carried out in accordance with this QAPP.

For this project the FTL will also serve as the Site Safety and Health Officer (SSHO). As such, they are responsible for implementing the procedures and required components of the Site Health and Safety Plan (HASP), determining levels of protection needed during field tasks, controlling site entry/exit, briefing the field team and subcontractors on site-specific health and safety issues, and all other responsibilities as identified in the HASP.

4.3 Quality Assurance (QA) Responsibilities

The QA Officer will have direct access to corporate executive staff as necessary, to resolve any QA dispute, and is responsible for auditing the implementation of the QA program in conformance with the demands of specific investigations and Roux's policies, and NYSDEC requirements. The QA Officer has sufficient authority to stop work on the investigation as deemed necessary in the event of serious QA issues.

- Project QA Officer: *Lori Riker, P.E.*

Specific function and duties include:

- o Performing QA audits on various phases of the field operations.
- o Reviewing and approving QA plans and procedures.
- o Providing QA technical assistance to project staff.

- o Reporting on the adequacy, status, and effectiveness of the QA program on a regular basis to the Project Manager for technical operations.
- o Responsible for assuring third party data review of all sample results from the analytical laboratory.

4.4 Field Responsibilities

Roux field staff for this project is drawn from a pool of qualified personnel. The Project Manager will use staff to gather and analyze data, and to prepare various task reports and support materials. All of the designated technical team members will be experienced professionals who possess the degree of specialization and technical competence required to effectively and efficiently perform the required work.

4.5 Quality Assurance Objectives for Measurement Data

The overall objectives and criteria for assuring quality for this effort are discussed below. This QAPP addresses how the acquisition and handling of samples and the review and reporting of data will be documented. The objectives of this QAPP are to address the following:

- The procedures to be used to collect, preserve, package, and transport groundwater samples.
- Field data collection.
- Record keeping.
- Data management.
- Chain-of-custody procedures.
- Precision, accuracy, completeness, representativeness, decision rules, comparability, and level of quality control effort conformance for sample analysis and data management by laboratory under EPA analytical methods.

4.6 Level of QC Effort for Sample Parameters

Field blank, method blank, trip blank, field duplicate, laboratory duplicate, laboratory control, standard reference materials (SRM) and matrix spike samples will be analyzed to assess the quality of the data resulting from the field sampling and analytical programs. QC samples are discussed below.

- Field and trip blanks consisting of distilled water will be submitted to the analytical laboratories to provide the means to assess the quality of the data resulting from the field-sampling program. Field (equipment) blank samples are analyzed to check for procedural chemical constituents at the facility that may cause sample contamination. Trip blanks are used to assess the potential for contamination of samples due to contaminant migration during sample shipment and storage.
- Method blank samples are generated within the laboratory and used to assess contamination resulting from laboratory procedures.
- Duplicate samples are analyzed to check for sampling and analytical reproducibility.
- MS/MSD and MS/Duplicate samples provide information about the effect of the sample matrix on the digestion and measurement methodology. Depending on site-specific

circumstances, one MS/MSD or MS/Duplicate should be collected for every 20 or fewer investigative samples to be analyzed for organic and inorganic chemicals of a given matrix (see **Table 1**).

The general level of QC effort will be one field (blind) duplicate and one field blank (when non-dedicated equipment is used) for every 20 or fewer investigative samples of a given matrix. Additional sample volume will also be provided to the laboratory to allow one site-specific MS/MSD or MS/Duplicate for every 20 or fewer investigative samples of a given matrix. One trip blank consisting of distilled, deionized water will be included along with each sample delivery group of aqueous VOC samples. Emerging contaminants sampling will include an equipment blank and a field blank sample to ensure the reliability of the generated data.

4.7 Sampling and Analysis Plan

Methods and protocol to be used to collect environmental samples (i.e., soil and groundwater) for this investigation are described in the Roux Field Operating Procedures (FOPs), summarized on **Table 3**, and presented electronically in **Appendix E**.

The number and types of environmental samples to be collected is summarized on **Table 1**. Sample parameter lists, holding times and sample container requirements are summarized on **Table 2**. The sampling program and related site activities are discussed below. To the extent allowed by existing physical conditions at the facility, sample collection efforts will adhere to the specific methods presented herein. If alternative sampling locations or procedures are implemented in response to facility specific constraints, each will be selected on the basis of meeting data objectives. Such alternatives will be approved by NYSDEC before implementation and subsequently documented for inclusion in the project file.

4.7.1 Custody Procedures

Sample custody is controlled and maintained through the chain-of-custody (COC) procedures. Chain of custody is the means by which the possession and handling of samples will be tracked from the source (field) to their final disposition, the laboratory. A sample is considered to be in a person's custody if it is in the person's possession or it is in the person's view after being in his or her possession or it was in that person's possession and that person has locked it in a vehicle or room. Sample containers will be cleaned and preserved at the laboratory before shipment to the Site. The following section and FOPs for Sampling, Labeling, Storage, and Shipment, located in **Appendix E**, describe procedures for maintaining sample custody from the time samples are collected to the time they are received by the analytical laboratory.

4.7.2 Sample Storage

Samples are stored in secure limited-access areas. Walk-in coolers or refrigerators are maintained at 4°C, $\pm$ 2°C, or as required by the applicable regulatory program. The temperatures of all refrigerated storage areas are monitored and recorded at a minimum of once per day. Deviations of temperature from the applicable range require corrective action, including moving samples to another storage location if necessary.

4.7.3 Sample Custody

Sample custody is defined by this document as when any of the following occur:

- It is in someone's actual possession.
- It is in someone's view after being in his or her physical possession.
- It was in someone's possession and then locked, sealed, or secured in a manner that prevents unsuspected tampering.
- It is placed in a designated and secure area.

Samples are removed from storage areas by the sample custodian or analysts and transported to secure laboratory areas for analysis. Access to the laboratory and sample storage areas is restricted to laboratory personnel and escorted visitors only; all areas of the laboratory are therefore considered secure. If required by the applicable regulatory program, internal chain-of-custody is documented in a log by the person moving the samples between laboratory and storage areas.

Laboratory documentation used to establish COC and sample identification may include the following:

- Field COC forms or other paperwork that arrives with the sample.
- The laboratory COC.
- Sample labels or tags are attached to each sample container.
- Sample custody seals.
- Sample preparation logs (i.e., extraction and digestion information) recorded in hardbound laboratory books that are filled out in legible handwriting, signed, and dated by the chemist.
- Sample analysis logs (e.g., metals, GC/MS, etc.) information recorded in hardbound laboratory books that are filled out in legible handwriting, signed, and dated by the chemist.
- Sample storage log (same as the laboratory COC).
- Sample disposition log, which documents sample disposal by a contracted waste disposal company.

4.7.4 Sample Tracking

All samples are maintained in the appropriate coolers prior to and after analysis. The analysts remove and return their samples as needed. Samples that require internal COC are relinquished to the analysts by the sample custodians. The analyst and sample custodian must sign the original COC relinquishing custody of the samples from the sample custodian to the analyst. When the samples are returned, the analyst will sign the original COC returning sample custody to the sample custodian. Sample extracts are relinquished to the instrumentation analysts by the preparatory analysts. Each preparation department tracks internal COC through their logbooks/spreadsheets.

Any change in the sample during the time of custody will be noted on the COC (e.g., sample breakage or depletion).

4.7.5 Split Sampling

The Department may split any soil or groundwater samples at the Department's expense, during this RI/IRM. Roux personnel will cooperate with the Department to facilitate split sampling, as requested.

4.8 Calibration Procedures and Frequency

This section describes the calibration procedures and the frequency at which these procedures will be performed for both field and laboratory instruments.

4.8.1 Field Instrument Calibration

Quantitative field data to be obtained during groundwater sampling include pH, turbidity, specific conductance, temperature, and depth to groundwater. Quantitative water level measurements will be obtained with an electronic sounder or steel tape, which require no calibration. Quantitative field data to be obtained during soil sampling include screening for the presence of volatile organic constituents using a PID.

FOPs located in **Appendix E** describe the field instruments used to monitor for these parameters and the calibration methods, standards, and frequency requirements for each instrument. Calibration results will be recorded on the appropriate field forms and in the Project Field Book.

4.9 Analytical Procedures

Samples collected during this investigation field sampling activities will be analyzed by a NYSDOH-approved laboratory.

4.9.1 Field Instrument Calibration

Field procedures for collecting and preserving groundwater and soil samples are described in FOPs located in **Appendix E**. A summary of the FOPs is presented on **Table 3**.

4.10 Data Usability Evaluation

Data usability evaluation procedures shall be performed for both field and laboratory operations as described below.

4.10.1 Procedures Used to Evaluate Field Data Usability

Procedures to validate field data for this project will be facilitated by adherence to the FOPs identified in **Appendix E**. The performance of all field activities, calibration checks on all field instruments at the beginning of each day of use, manual checks of field calculations, checking for transcription errors and review of field log books is the responsibility of the Field Team Leader.

4.10.2 Procedures Used to Evaluate Laboratory Data Usability

Data evaluation will be performed by the third-party data validator using the most current methods and quality control criteria from the USEPA's Contract Laboratory Program (CLP) *National Functional Guidelines for Organic Data Review* (Ref. 3), and Contract Laboratory Program, *National Functional Guidelines for Inorganic Data Review* (Ref. 4). The data review guidance will be used only to the extent that it is applicable to the SW-846 methods; SW-846 methodologies will be followed primarily and given preference over CLP when differences occur. Also, results of blanks, surrogate spikes, MS/MSDs, and laboratory control samples will be reviewed/evaluated by the data validator. All sample analytical data for each sample matrix shall be evaluated. The third-party data validation expert will also evaluate the overall

completeness of the data package. Completeness checks will be administered on all data to determine whether deliverables specified in this QAPP are present. The reviewer will determine whether all required items are present and request copies of missing deliverables.

5. Investigation Support Documents

5.1 Health and Safety Protocols

Roux has prepared a Site-Specific Health and Safety Plan (HASP) for use by our employees in accordance with 40 CFR 300.150 of the NCP and 29 CFR 1910.120. The HASP, provided in **Appendix D**, includes the following site-specific information:

- A hazard assessment.
- Training requirements.
- Definition of exclusion, contaminant reduction, and other work zones.
- Monitoring procedures for site operations.
- Safety procedures.
- Personal protective clothing and equipment requirements for various field operations.
- Disposal and decontamination procedures.

The HASP also includes a contingency plan that addresses potential site-specific ~~emergencies,~~ ~~and emergencies and coincides with the~~ Community Air Monitoring Plan (**Appendix F**) that describes required particulate and vapor monitoring to protect the neighboring community during intrusive site investigation and remediation activities.

Health and safety activities will be monitored throughout the field investigation ~~s and IRM~~. A member of the field team will be designated to serve as the on-site Health and Safety Officer throughout the field program. This person will report directly to the Project Manager and the Corporate Health and Safety Coordinator. The HASP will be subject to revision as necessary, based on new information that is discovered during the field investigation and/or remedial activities.

5.1.1 Community Air Monitoring

Real-time community air monitoring will be performed during the RI ~~and IRM~~ activities at the Site. ~~A CAMP is included within Roux's HASP~~ (see **Appendix DE**). Particulate and VOC monitoring will be performed along the downwind perimeter of the work area during RI test pitting, RI boring, ~~IRM and~~ excavation, and soil/fill handling activities in accordance with this plan. The CAMP is consistent with the requirements for community air monitoring at remediation sites as established by the NYSDOH and NYSDEC. Accordingly, it follows procedures and practices outlined under NYSDEC's DER-10 (May 2010) Appendix 1A (NYSDOH's Generic Community Air Monitoring Plan) and Appendix 1B (Fugitive Dust and Particulate Monitoring).

5.2 Citizen Participation Activities

NYSDEC will coordinate and lead community relations throughout the course of the project. Roux will support NYSDEC's community relations activities, as necessary. A Citizen Participation Plan will be prepared by Roux and submitted to NYSDEC under separate cover. The Citizen Participation Plan will follow NYSDEC's Citizen Participation Plans template for Brownfield Cleanup Program sites entering the BCP at the point of site investigation.

6. Reporting and Schedule

Upon completion of the RI fieldwork, a comprehensive RI/AAR will be completed summarizing the RI and ~~IRM~~ tasks completed as described below.

6.1 Remedial Investigation Reporting

The RI section of the RI/AA report will include the following information and documentation, consistent with the NYSDEC's DER-10 Technical Guidance for Site Investigation and Remediation (May 2010).

- Introduction and background;
- A description of the Site and the investigation areas;
- A description of the field procedures and methods used during the RI;
- The collection of geospatial data and presentation of investigation drawings detailing the investigation locations, potential areas of concern based on historical investigations, presence of buildings, utility poles, and subgrade utilities;
- A discussion of the nature and rationale for any significant variances from the scope of work described in this RI Work Plan;
- The data obtained during the RI, considered by Roux to be of useable quality, including geochemical data, field measurements, validated analytical results, etc.;
- For all investigation and emerging contaminants (EC) groundwater sample results that exceed TAL and TCL parameters above the GWQS or contaminant thresholds on the EC checklist sheet, a GIS well map will be produced that shows all public and private drinking water wells within ½ mile of the Site;
- Comparative criteria that may be used to calculate cleanup levels during the AA process, such as NYSDEC's USCOs, NYSDEC's GWQS, and other pertinent regulatory standards or criteria;
- A discussion of contaminant fate and transport. This will provide a description of the hydrologic parameters of the Site, and an evaluation of the lateral and vertical movement of groundwater;
- Conclusions regarding the extent and character of environmental impact in the media being investigated;
- The conclusions of the on-site and off-site qualitative human health and environmental exposure assessment completed in accordance with DER-10; and
- Supporting materials for RI data. These will include boring logs, monitoring well construction diagrams, laboratory analytical reports, and similar information.
- A conceptual site model in accordance with DER-10 requirements if a no further action conclusion is not achieved ~~by the IRM~~.

In addition, Roux will require third-party analytical data review by a qualified, independent data validation expert for the RI and historic investigation data. Specifically, a DUSR will be prepared, with appropriate data qualifiers added to the results. The DUSR will follow NYSDEC format per the NYSDEC's September 1997 DUSR guidelines and May 2010 DER-10 guidance. The DUSR and any necessary qualifications to the data will be appended to the RI report.

6.2 Alternatives Analysis (AA)

An AA is developed to provide a forum for evaluating and selecting a recommended remedial approach, in accordance with DER-10. A list of remedial action objectives will be developed based on findings of the RI

and the requirement for the selected remedial measures to be protective of human health and the environment under the proposed future use scenario. Proposed SCOs for the Site for the contaminants will also be presented based on the proposed future use of the Site. Further, volumes and areas of media potentially requiring additional remediation will be calculated. General response actions will then be delineated to address each of the Site's problem areas. These response actions will form the foundation for the development and screening of applicable remedial alternatives against the following criteria as described in 6NYCRR 375-1.8(f) and DER-10-4.2:

- Overall Protection of Human Health and the Environment
- Compliance with Standards, Criteria, & Guidance (SCGs)
- Long-term Effectiveness & Permanence
- Reduction of Toxicity, Mobility, or Volume
- Short-term Effectiveness
- Implementability
- Cost Effectiveness
- Land Use

In addition, the criteria of community acceptance will be considered based on public comments on the RI/AA Report and proposed remedial action. Following the screening of alternatives, a comparative analysis will be performed against the above criteria. The comparative analysis will allow for better understanding of the relative advantages and disadvantages of each of the alternatives and will facilitate the identification of a recommended remedial approach.

7. Sustainability and Green Remediation

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7.1 Green Remediation Evaluation

NYSDEC's DER-31 Green Remediation requires that green remediation concepts and techniques be considered during all stages of the remedial program, including remedial investigations, with the goal of improving the sustainability of the cleanup and summarizing the net environmental benefit of any implemented green technology.

This section of the RIWP provides a summary of any green remediation evaluations to be completed for the Site during remedial investigations, and as reported in the Site Management Plan (SMP) and Periodic Review Reports (PRRs).

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Best Management Practices (BMPs) and green remediation techniques to be considered for the Site in order to reduce the environmental footprint are further discussed below:

- Increase energy efficiency/minimize total energy use and direct/indirect CO2/greenhouse gas (GHG) emissions to the atmosphere;
- Reduce emissions of air pollutants;
- Minimize habitat disturbance and create or enhance habitat or usable land;
- Conserve natural resources such as soil and water; promote the sequestration of carbon through reforestation or afforestation;
- Minimize fresh water consumption and maximize water reuse during daily operations and treatment processes;
- Prevent long-term erosion, surface runoff, and off-site water quality impacts;
- Prevent unintended soil compaction;
- Minimize waste or implement beneficial use of materials that would otherwise be considered a waste;
- Minimize equipment and truck idling and use sustainably produced biofuels to reduce discharges of pollutants and GHGs to the atmosphere;
- Utilize clean diesel (new or retrofitted) equipment to reduce emissions to the atmosphere;
- Minimize truck travel for disposal to save energy, reduce emissions, reduce localized noise, vibration, and wear and tear on roads;
- Minimize use of heavy equipment to save energy and reduce emissions.

In addition to the implementation of BMPs, the following actions were considered to make the remedy greener and more sustainable:

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- Cleaner and more energy-efficient equipment will be utilized during Operation, Maintenance, and Monitoring (OM&M) activities to the extent practicable.
- Green remediation principles will be applied to any future work plans and/or remedial actions including but not limited to cover system modifications.

7.1.1 Timing of Green Remediation Evaluations

For major remedial system components, green remediation evaluations and corresponding modifications will be undertaken as part of a formal Remedial System Optimization (RSO), or at any time that the Project Manager feels appropriate, (e.g. during significant maintenance events or in conjunction with storm recovery activities).

Modifications resulting from green remediation evaluations will be routinely implemented and scheduled to occur during planned/routine operation and maintenance activities after approval from the DER project manager. The reporting of these modifications will be presented in the PRR.

7.1.2 Remedial Systems

Remedial systems will be operated properly considering the current Site conditions to conserve materials and resources to the greatest extent possible. Consideration will be given to operating rates and use of reagents and consumables. Spent materials will be sent for recycling, as appropriate.

There are no remedial systems operating at the Site.

7.1.3 Building Operations

Structures including buildings and sheds will be operated and maintained to provide for the most efficient operation of the remedy, while minimizing energy, waste generation and water consumption.

There are no buildings operating remedial systems at the Site.

7.1.4 Frequency of System Checks, Sampling and Other Periodic Activities

Transportation to and from the Site, use of consumables in relation to visiting the Site in order to conduct system checks and/or collect samples, and shipping samples to a laboratory for analyses have direct and/or inherent energy costs. The schedule and/or means of these periodic activities have been prepared so that these tasks can be accomplished in a manner that does not impact remedy protectiveness but reduces expenditure of energy or resources.

The following activities have been considered:

- Reduced sampling frequencies: Sampling will be conducted at the frequency described in this SMP.
- Reduced site visits: Site visits will be conducted at the frequency described in the SMP.
- Coordination/consolidation of activities: Activities will be consolidated so as to reduce the frequency of site visits to the extent possible while still completing all requirements specified in the SMP.

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Use of mass transit/carpooling for site visits: Mass transit is limited in the Town of Haverstraw. Carpooling will be utilized when possible.

7.1.5 Metrics and Reporting

Information on energy usage, solid waste generation, transportation and shipping, water usage and land use and ecosystems will be recorded to facilitate and document consistent implementation of green remediation during site management and to identify corresponding benefits. A set of metrics has been developed and will be evaluated over time to ensure that green remediation actions are achieving the desired results.

Metrics specific to the Site include the following:

- Fuel usage for personal vehicles (transportation to/from the Site to complete groundwater sampling and annual inspections);
- Waste generation and disposal (purge water during groundwater sampling); and

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- Fuel usage for waste transportation vehicles (transporting waste purge water from the Site to disposal location).

Metrics will be reported annually in the PRR. Any additional metrics identified throughout site management will also be reported and the Spreadsheets for Environmental Footprint Analysis (SEFA) will be revised.

7.2 Remedial System Optimization

An RSO study will be conducted any time that the NYSDEC or the remedial party requests in writing that an in-depth evaluation of the remedy is needed. An RSO may be appropriate if any of the following occur:

- The remedial actions have not met or are not expected to meet RAOs in the time frame estimated in the Decision Document (DD);
- The management and operation of the remedial system is exceeding the estimated costs;
- The remedial system is not performing as expected or as designed;
- Previously unidentified source material may be suspected;
- Plume shift has potentially occurred;
- Site conditions change due to development, change of use, change in groundwater use, etc.;
- There is an anticipated transfer of the site management to another remedial party or agency; and
- A new and applicable remedial technology becomes available.

An RSO will provide a critique of a Site's conceptual model, give a summary of past performance, document current cleanup practices, summarize progress made toward the Site's cleanup goals, gather additional performance or media specific data and information and provide recommendations for improvements to enhance the ability of the present system to reach RAOs or to provide a basis for changing the remedial strategy.

The RSO study will focus on overall site cleanup strategy, process optimization and management with the intent of identifying impediments to cleanup and improvements to site operations to increase efficiency, cost effectiveness and remedial time frames. Green remediation technology and principles are to be considered when performing the RSO.

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78. Project Schedule

Figure 5 presents a tentative project schedule for the major tasks to be performed in support of the RI Work Plan and RI/AA Report.

89. References

1. United States Department of Agriculture (USDA), Soil Conservation Service. *Soil Survey of Erie County, New York*. December 1986.
2. U.S. Environmental Protection Agency, Region II. *CERCLA Quality Assurance Manual, Revision I*. October 1989.
3. U.S. Environmental Protection Agency. National Functional Guidelines for Organic Data Review (EPA-540/R-94-012), 1994a.
4. U.S. Environmental Protection Agency. National Functional Guidelines for Inorganic Data Review (EPA-540/R-94-013), 1994b.
5. U.S. Environmental Protection Agency. *Requirements for Quality Assurance Project Plans for Environmental Data Operations (EPA QA/R-5)*. October 1998.
6. New York State Department of Environmental Conservation. *DER-10; Technical Guidance for Site Investigation and Remediation*. May 2010.
7. New York State Department of Health, *Soil Vapor Intrusion Guidance*, February 2024.
8. Roux Environmental Engineering and Geology, D.P.C., *Phase II Environmental Investigation Letter Summary Report*. October 2024.

Remedial Investigation Work Plan
Haverstraw Chair Factory Site, Haverstraw, New York

TABLES

1. Summary of Sampling and Analytical Program
2. Sample Container, Volume, Preservative & Holding Time Requirements
3. Summary of Field Operating Procedures



TABLE 1
SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM
HAVERSTRAW CHAIR FACTORY SITE
HAVERSTRAW, NEW YORK

Location	Number of Proposed Locations	Matrix	Parameter ¹								
			TCL plus CP-51 VOCs ²	TCL SVOCs ²	TAL Metals (Total)	TAL Metals (Dissolved)	PCBs	Herbicides	Pesticides	PFAS	Waste Characterization Parameters ⁷
Surface Soil											
Surface Soil (0-2")	8	Soil	8	8	8	8	8	8	8	8	--
Blind Duplicate ³	-	Soil	1	1	1	1	1	1	1	1	--
MS/MSD ³	-	Soil	1	1	1	1	1	1	1	1	--
Surface Soil Subtotal			10	10	10	10	10	10	10	10	0
Subsurface Soil											
Test Pits (Fill Material)	15	Soil	10	15	15	15	10	10	10	10	8
Test Pits (Native Soil)	15	Soil	10	15	15	15	10	10	10	10	--
Soil Borings (MWs) (Fill Material)	8	Soil	8	8	8	8	8	8	8	8	--
Soil Borings (MWs) (Native Soil)	8	Soil	8	8	8	8	8	8	8	8	--
Blind Duplicate ³	-	Soil	2	2	2	2	2	2	2	2	--
MS/MSD ³	-	Soil	2	2	2	2	2	2	2	2	--
Soil Subtotal			40	50	50	50	40	40	40	40	8
Soil Vapor (Method TO-15)											
Soil Vapor	6	Soil Vapor	6	--	--	--	--	--	--	--	--
Outdoor Air	1	Ambient Air	1	--	--	--	--	--	--	--	--
Soil Vapor Subtotal			7	0	0	0	0	0	0	0	0
Groundwater											
Monitoring Well	8	Groundwater	8	8	8	8	8	8	8	4	--
Blind Duplicate ³	-	Groundwater	1	1	1	1	1	1	1	1	--
MS/MSD ³	-	Groundwater	1	1	1	1	1	1	1	1	--
Trip Blank ⁴	-	Water	1	--	--	--	--	--	--	--	--
Equipment Blank ⁵	-	Water	--	--	--	--	--	--	--	1	--
Field Blank ⁶	-	Water	--	--	--	--	--	--	--	1	--
Groundwater Subtotal			11	10	10	10	10	10	10	8	0
Sampling Totals			68	70	70	70	60	60	60	58	8

Notes:

- Analyses will be performed via USEPA SW-846 methodology with equivalent Category B deliverables package.
- Tentatively identified compounds (TICs) and 1,4 Dioxane (soil via USEPA Method 8270 and groundwater via USEPA Method 8270 SIM) will also be reported.
- Blind duplicate and MS/MSD samples will be collected at a frequency of 1 per 20 samples/media collected.
- Trip blanks will be submitted to the laboratory each day aqueous volatile organic samples are collected.
- One equipment blank will be submitted to the laboratory for the six monitoring wells to be sampled.
- Field blanks will be submitted to the laboratory each day groundwater samples are collected.
- Waste characterization parameters are likely to include the following analysis requirements: TCLP VOCs, TCLP SVOCs, TCLP Metals, PCBs, ignitability, corrosivity, and reactivity.

Acronyms:

VOCs = volatile organic compounds SVOCs = semi-volatile organic compounds TCL = Target Compound List
TAL = Target Analyte List
PCBs = Polychlorinated Biphenyls
PFAS = Per- and polyfluoroalkyl substances



TABLE 2
SAMPLE CONTAINER, VOLUME, PRESERVATIVE & HOLDING TIME REQUIREMENTS
HAVERSTRAW CHAIR FACTORY SITE
HAVERSTRAW, NEW YORK

Matrix	Parameter ¹	Method ¹	Container Type	Minimum Volume	Preservation (Cool to 2-4 °C for all samples)	Holding Time from Sample Date
Soil	TCL + CP-51 VOCs	8260B	EnCore/WMG	5 gm / 4 oz.	Cool to 2-4 °C, Zero Headspace	48 - hours / 14 days
	TCL SVOCs	8270C	WMG	16 oz.	Cool to 2-4 °C	14 days extrac./40 days
	TAL Metals ²	6010	WMG	4 oz.	Cool to 2-4 °C	6 months/Hg 28 days
	Pesticides	8081	WMG	8oz	Cool to 2-4 °C	14 days extrac./40 days
	Herbicides	8151	WMG	8oz	Cool to 2-4 °C	14 days extrac./40 days
	PCBs	8082	WMG	4 oz.	Cool to 2-4 °C	14 days extrac./40 days
	PFAS	1633	HDPE/ Polypropylene	2 - 500 mL	Cool to 2-4 °C	14 days
Groundwater	TCL + CP-51 VOCs	8260B	glass vial	3 - 4 oz.	HCl to pH<2, Zero Headspace, Cool to 2-4 °C	14 days
	PFAS	1633	HDPE/ Polypropylene	2 - 500 mL	Cool to 2-4 °C	14 days
	1,4-Dioxane	8270 SIM	8270 SIM	2 - 500 mL	Cool to 2-4 °C	7 days extrac/40 days
	TCL SVOCs	8270C	amber glass	1000 ml	Cool to 2-4 °C	7 days extrac/40 days
	TAL Metals ²	6010	plastic	600 ml	HNO ₃ to pH<2, Cool to 2-4 °C	6 months/Hg 28 days
	Pesticides	8081B	amber glass	1000 ml	Cool to 2-4 °C	14 days extrac./40 days
	Herbicides	8151A	amber glass	1000 ml	Cool to 2-4 °C	14 days extrac./40 days
	PCBs	8082	amber glass	1000 ml	Cool to 2-4 °C	7 days extrac/40 days

References:

1. Test Methods for Evaluating Solid Wastes, USEPA SW-846, Update III, 1991.

Notes:

1. EPA-approved methods published in Reference 1 above may be used. The list of analytes, laboratory method and the method detection limit for each parameter are included in Tables 1 and 2 of the QAPP.

2. Mercury sampling in soil/groundwater via EPA methods 7471/7470 respectively.

Acronyms:

VOCs = Volatile Organic Compounds SVOCs = Semi-Volatile Organic Compounds TCL = Target Compound List

TAL = Target Analyte List WMG = Wide Mouth Glass

PFAS = Per- and Polyfluoroalkyl Substances

TABLE 3
SUMMARY OF FIELD OPERATING PROCEDURES

HAVERSTRAW CHAIR FACTORY SITE
HAVERSTRAW, NEW YORK

FOP No.	Procedure
002.0	Abandonment of Monitoring Wells Procedure
007.0	Calibration and Maintenance of Portable Dissolved Oxygen Meter
008.0	Calibration and Maintenance of Portable Field pH/Eh Meter
009.0	Calibration and Maintenance of Portable Field Turbidity Meter
011.1	Calibration and Maintenance of Portable Photoionization Detector
012.0	Calibration and Maintenance of Portable Specific Conductance Meter
013.0	Composite Sample Collection Procedure for Non-Volatile Organic Analysis
015.0	Documentation Requirements for Drilling and Well Installation
017.0	Drill Site Selection Procedure
018.0	Drilling and Excavation Equipment Decontamination Procedures
021.0	Establishing Horizontal and Vertical Control
022.0	Groundwater Level Measurement
023.1	Groundwater Purging Procedures Prior to Sample Collection
024.1	Groundwater Sample Collection Procedures
024.2	Groundwater Sample Collection Procedures for PFOS & PFOS Sample
026.1	Hollow Stem Auger (HSA) Drilling Procedures
031.2	Low Flow (Minimal Drawdown) Groundwater Purging & Sampling Procedure
032.1	Management of Investigation-Derived Waste (IDW)
033.0	Monitoring Well Construction for Hollow Stem Auger Boreholes
036.0	Monitoring Well Development Procedures
040.1	Non-Disposable and Non-Dedicated Sampling Equipment Decontamination
041.0	Overburden Casing Installation Procedure
046.0	Sample Labeling, Storage and Shipment Procedures
048.0	Screening of Soil Samples for Organic Vapors During Impacted Soil Removal Activities
050.0	Sediment Sample Collection in Shallow Water Procedures
054.2	Soil Description Procedures Using The Visual-Manual Method
057.0	Soil Sample Collection for VOC Analysis - EnCore
063.2	Surface and Subsurface Soil Sampling Procedures
065.1	Test Pit Excavation and Logging Procedures
073.2	Real-Time Air Monitoring During Intrusive Activities
076.0	"Before Going Into the Field" Procedure
079.0	Stockpile Sampling Procedures for Chemical Analysis
080.0	Stockpile & Borrow Source Sampling Procedures for Physical Analysis
082.0	Waste Sampling Procedures
084.0	Calibration and Maintenance of Portable Particulate Meter
085.0	Field Quality Control Procedures

Remedial Investigation Work Plan
Haverstraw Chair Factory Site, Haverstraw, New York

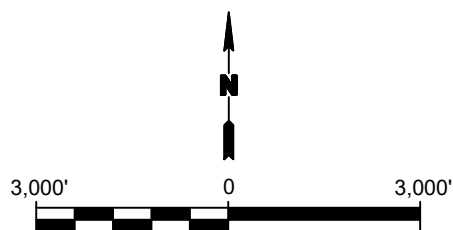
FIGURES

1. Site Location and Vicinity Map
2. Site Plan (Aerial)
3. Investigation Locations & Areas of Concern
4. Planned Remedial Investigation Locations
5. Preliminary Project Schedule

F:\CAD\ROUX\PENNSYLVANIA\Haverstraw\WP\FIGURE 1: SITE LOCATION & VICINITY MAP.DWG



QUADRANGLE LOCATION



BASE MAP: USGS QUADRANGLE HAVERSTRAW, NY 2023

Title:

SITE LOCATION AND VICINITY MAP

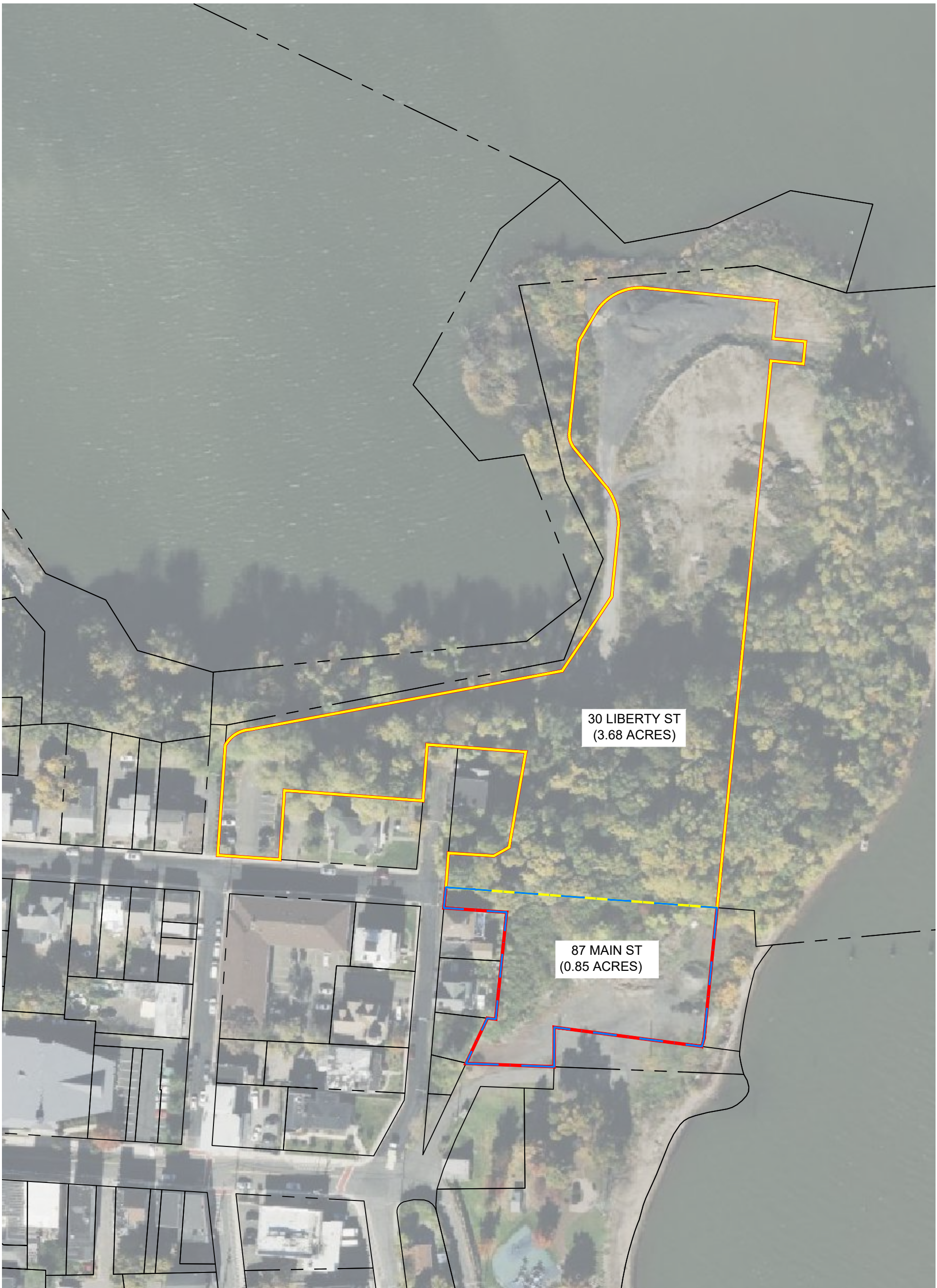
REMEDIAL INVESTIGATION WORK PLAN

HAVERSTRAW CHAIR FACTORY SITE
30 LIBERTY AND 87 MAIN STREET PARCELS

Prepared for:

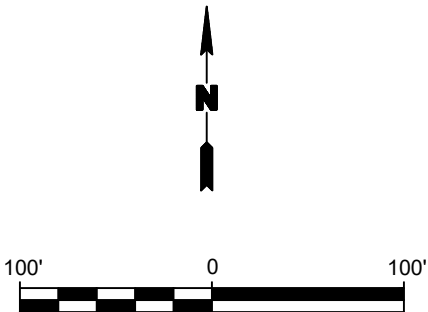
HAVERSTRAW COMMUNITY CHAIR FACTORY LLC

	Compiled by: AEP	Date: 11/5/2024	FIGURE 1
	Prepared by: CNK	Scale: AS SHOWN	
	Project Mgr: NAS	Project: 4375.0004B000	
	File: FIGURE 1: SITE LOCATION & VICINITY MAP.DWG		

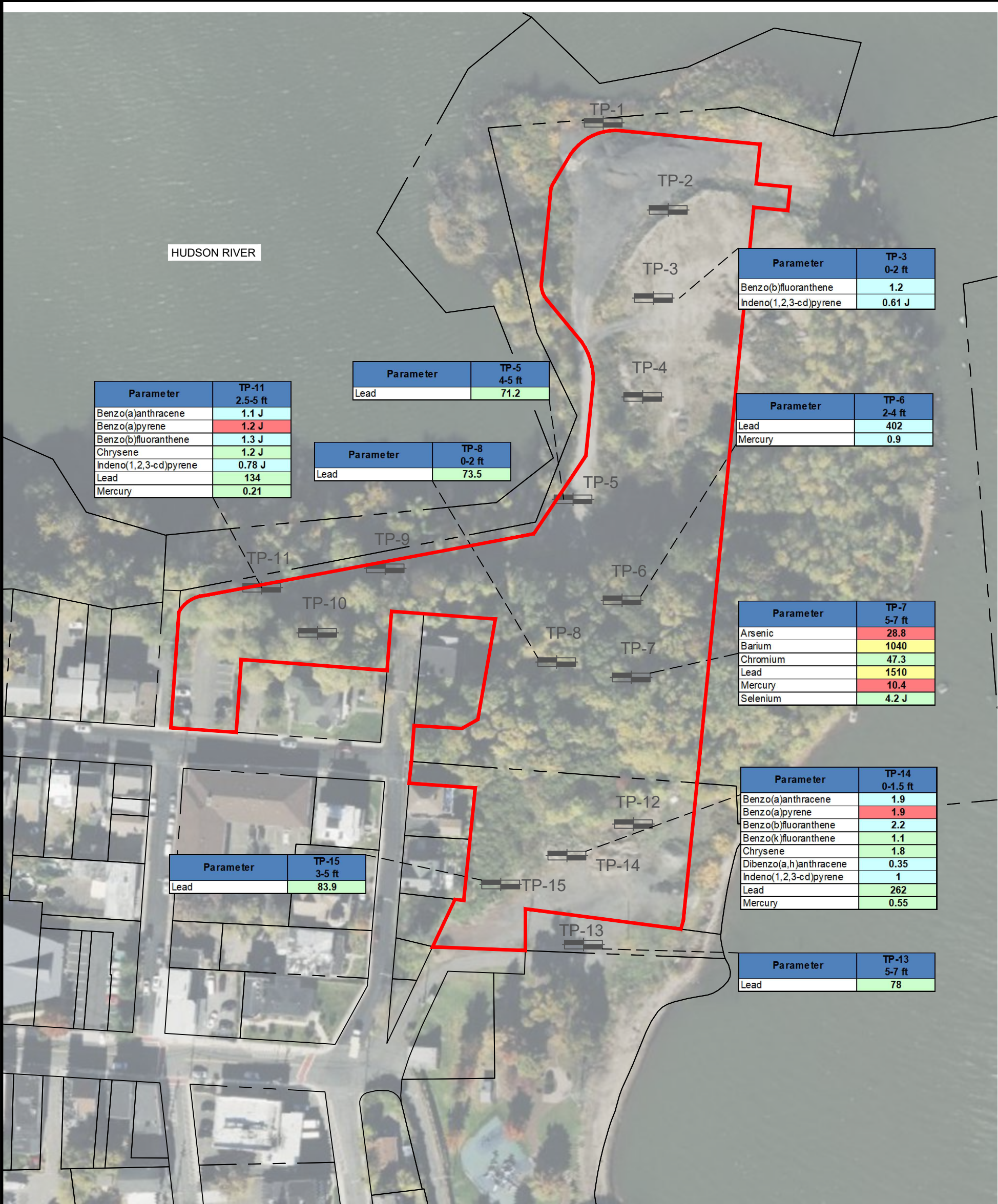


LEGEND:

- BCP BOUNDARY (~4.53 AC)
- PARCEL BOUNDARY
- BCP PORTION OF 87 MAIN ST.
- BCP PORTION OF 30 LIBERTY ST



Title:			
SITE PLAN (AERIAL)			
REMEDIAL INVESTIGATION WORK PLAN			
HAVERSTRAW CHAIR FACTORY SITE			
30 LIBERTY AND 87 MAIN STREET PARCELS			
HAVERSTRAW, NEW YORK			
Prepared for			
HAVERSTRAW COMMUNITY CHAIR FACTORY LLC			
	Compiled by: AEP	Date: 11/5/2024	FIGURE
	Prepared by: CNK	Scale: AS SHOWN	
	Project Mgr: BM	Project: 4375.0004B000	
	File: FIGURE 2; SITE PLAN (AERIAL).DWG		
			2

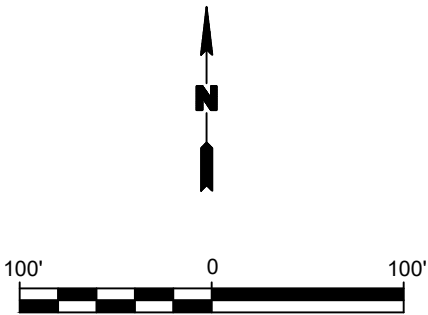


LEGEND:

- BCP BOUNDARY (~4.53 AC)
- PARCEL BOUNDARY
- TEST PIT

Parameter	TP-3 0-2 ft	SAMPLE LOCATION AND DEPTH (FT)
Benzo(b)fluoranthene	1.2	PARAMETER CONCENTRATION IN MILLIGRAMS PER KILOGRAM
Indeno(1,2,3-cd)pyrene	0.61 J	

- Results Exceed Part 375 Unrestricted Use SCOs**
- Results Exceed Part 375 Restricted Residential Use SCOs**
- Results Exceed Part 375 Industrial Use SCOs**
- Results Exceed Part 375 Commercial Use SCOs**



Title:

INVESTIGATION LOCATIONS
& AREAS OF CONCERN
REMEDIAL INVESTIGATION WORK PLAN
HAVERSTRAW CHAIR FACTORY SITE
30 LIBERTY AND 87 MAIN STREET PARCELS
HAVERSTRAW, NEW YORK

Prepared for:

HAVERSTRAW COMMUNITY CHAIR FACTORY LLC

ROUX

Compiled by: AEP
Prepared by: CNK
Project Mgr: BM

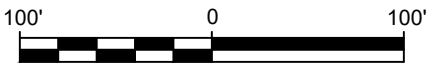
Date: 11/5/2024
Scale: AS SHOWN
Project: 4375.0004B000

FIGURE
3



LEGEND:

- BCP BOUNDARY (~4.53 AC)
- PARCEL BOUNDARY
- TP-1 (15) PREVIOUS TEST PIT (15)
- TP-16 (10; FULL SUITE) PLANNED TEST PIT (10; FULL SUITE)
- TP-25 (5; PAHs + METALS) PLANNED TEST PIT (5; PAHs + METALS)
- MW-1 (8) PLANNED MONITORING WELL / SOIL BORING (8)
- SS-1 (8) PLANNED SURFACE SOIL SAMPLE (8)
- SV-1 (6) PLANNED SOIL VAPOR LOCATION (6)



NOTES:
1. ALL SHOWN SURFACE SOIL (SS) SAMPLES WILL BE COLLECTED FROM THE SAME LOCATION AS THE ADJACENTLY SHOWN MONITORING WELL / SOIL BORING (MW) LOCATION.

Title:

**PLANNED REMEDIAL INVESTIGATION LOCATIONS
REMEDIAL INVESTIGATION WORK PLAN
HAVERSTRAW CHAIR FACTORY SITE**

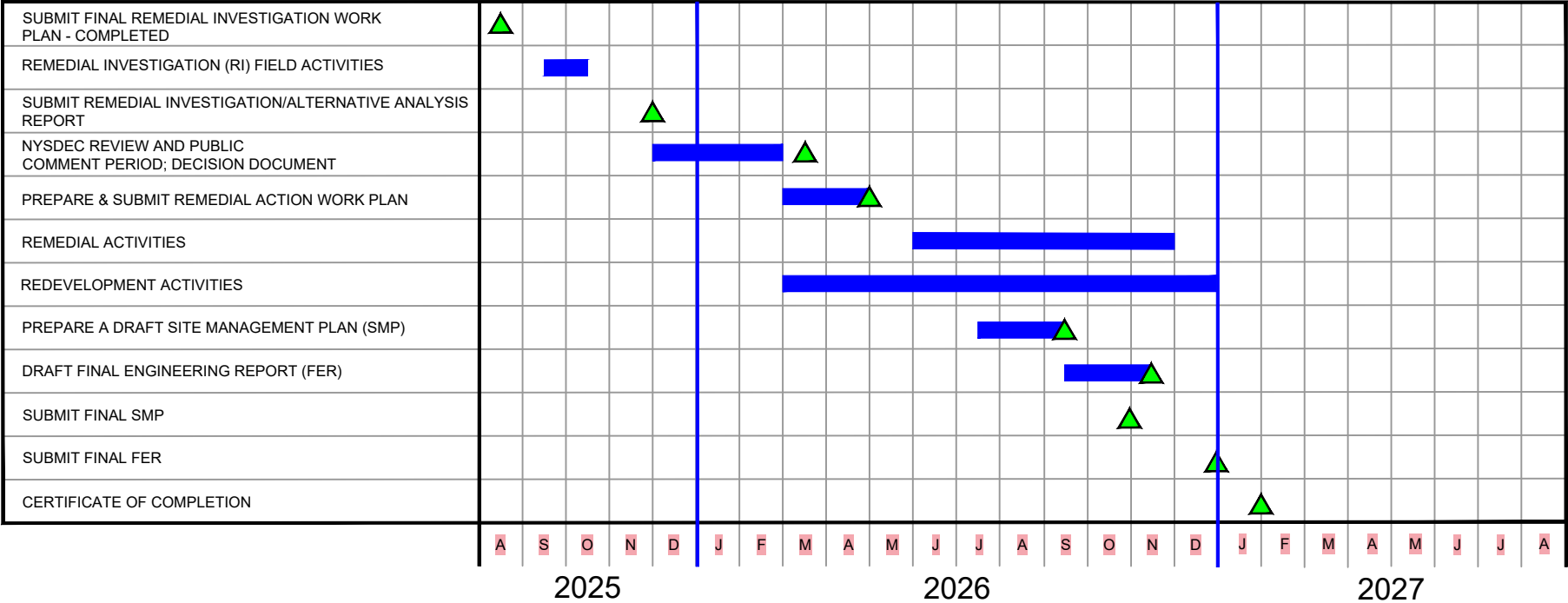
30 LIBERTY AND 87 MAIN STREET PARCELS
HAVERSTRAW, NEW YORK

Prepared for

HAVERSTRAW COMMUNITY CHAIR FACTORY LLC

Compiled by: CNK	Date: MAY 2025	FIGURE 4
Prepared by: CNK	Scale: AS SHOWN	
Project Mgr: BM	Project: 4375.0004B000	
File: HAVERSTRAW-HAVERSTRAW CHAIR FACTORY-INVESTIGATION LOCATIONS & AREAS OF CONCERN-FIGURE 4.DWG		

PROJECT TASKS:



Title:

PROJECT SCHEDULE

REMEDIAL INVESTIGATION WORK PLAN

HAVERSTRAW CHAIR FACTORY SITE

30 LIBERTY AND 87 MAIN STREET PARCELS

HAVERSTRAW, NEW YORK

Prepared for:

HAVERSTRAW COMMUNITY CHAIR FACTORY LLC

ROUX

Compiled by:

Prepared by: JJY

Project Mgr: MAL

File: FIGURE 5; PROJECT SCHEDULE_R2.DWG

Date: JULY 2025

Scale: NA

Project: 4375.0001B000

FIGURE

5

Remedial Investigation Work Plan
Haverstraw Chair Factory Site, Haverstraw, New York

APPENDICES

- A. Professional Profiles
- B. Previous Investigations (*Flash Drive*)
- C. Project Documentation Forms
- D. Health and Safety Plan (HASP) including CAMP
- E. Field Operating Procedures (FOPs)

Remedial Investigation Work Plan
Haverstraw Chair Factory Site, Haverstraw, New York

APPENDIX A

Professional Profiles

EDUCATION

BASc (Civil Engineering) 1992; University of Waterloo, Ontario, Canada
MASc (Environmental Engineering) 1994; University of Guelph, Ontario, Canada

REGISTRATION AND AFFILIATIONS

Professional Engineer, New York
Certified OSHA 40-Hour Hazardous Waste Site Training
Visible Emissions Certification, Received April 1, 2015
Air and Waste Management Association, Niagara Frontier Section Board Member

SUMMARY OF EXPERIENCE

Ms. Riker has over 28 years of environmental and civil engineering experience that has focused on industrial regulatory compliance assistance; Phase I environmental site assessments; Phase II investigations; remedial investigations and alternative analyses under various state and federal cleanup programs; detailed wastewater and industrial process design; and construction administration. Ms. Riker's regulatory compliance experience consists of petroleum bulk storage (PBS) and chemical bulk storage (CBS) auditing and the associated spill prevention reporting; Emergency Planning and Community Right-to-Know Act (EPCRA) Tier II and Toxic Release Inventory (Form R) reporting; Title V air permitting (Title V, State facility, minor facility registrations), compliance reporting, and emission statement preparation; storm water permitting, reporting, Storm Water Pollution Prevention Plans (SWPPPs), and Best Management Practices (BMP) Plans; industrial wastewater design and pretreatment permitting; and hazardous waste auditing, annual reporting, and reduction plans.

REPRESENTATIVE PROJECT EXPERIENCE

July 2023 to Present	Roux Environmental Engineering and Geology, D.P.C.
May 2003 to July 2023	Benchmark Civil/Environmental Engineering & Geology, PLLC
Nov 1997 to May 2002	Malcolm Pirnie, Inc.
Feb 1995 to Oct 1997	ENVIRON Corporation

- Assisted in the RCRA Corrective Measures Study (CMS) for the Former Bethlehem Steel Coke Oven Division Site located in Lackawanna, NY. Duties included preparing work plans for Interim Corrective Measures (ICMs); reviewing analytical data obtained for the solid waste management units (SWMUs) and water courses; reviewing reports/assessments prepared by other consultants retained by NYSDEC and other agencies; and evaluating numerous slag/fill and groundwater remedial alternatives and recommending a final remedial approach in the CMS Report.
- Managing numerous successful NYSDEC BCP projects for former steel plant sites and industrial/commercial properties in western NY. Prepared Remedial Investigation (RI) Work Plans, RI Reports, Interim Remedial Measures (IRM) Work Plans, Remedial Action Work Plans, Final Engineering Reports, Site Management Plans, and annual site inspections and Periodic Review Reports. Contaminants of concern primarily include petroleum, chlorinated solvents, heavy metals, and emerging contaminants.
- Currently serving as environmental consultant for two western NY pharmaceutical manufacturers. Providing on-going wastewater compliance assistance; and developed and updated Spill Prevention Control and Countermeasure (SPCC) Plans and air emissions permits. Assisted with wastewater treatment plant expansion, including sequencing batch reactors and UV disinfection, and NYSDEC

State Pollutant Discharge Elimination System (SPDES) permit modifications for increased flow and new cooling tower water treatment chemicals.

- Currently serving as adjunct environmental compliance specialist for a company that designs and builds vacuum and heat transfer equipment, and a food manufacturing facility. Environmental regulatory auditing, sampling, inspecting, reporting, and training services include: EPCRA Tier II and Form R; NYSDEC Multi-Sector General Permit (MSGP) for Storm Water Discharges Associated with Industrial Activity and the associated SWPPP; PBS and SPCC Plan; hazardous waste management; air permitting; and wastewater pretreatment system assistance.
- Providing/managing on-going environmental compliance assistance to scrap metal recycling facilities in NY and PA including: permitting, sampling, inspection, and reporting requirements under the MSGP for Storm Water Associated with Industrial Activity and SPDES Permits; PBS inspections and preparing SPCC Plans; EPCRA Tier II reporting; preparing landfill disposal application; preparing Water Treatment Chemical notifications; hazardous waste annual reporting; and air permitting modifications, compliance reporting, and annual emission statement preparation.
- Currently serving as a third-party environmental consultant to Delta Sonic Car Wash Systems, Inc. for its NY, PA, and IL gasoline stations and lube oil shops. Providing regulatory support for spills and releases. Performing environmental compliance audits focusing on NYSDEC PBS regulations and preparing SPCC Plans and an overall BMP Plan.
- Providing/managing on-going environmental compliance assistance to industrial facilities including air permit applications and modifications; SPDES/NPDES storm water permitting, BMP Plan/SWPPP preparation, compliance monitoring, and DMR preparation; water withdrawal and sewer metering reports; PBS registration, SPCC Plan preparation, and tank inspection; and annual hazardous waste reporting.
- Assisted with permitting and design of facilities for storage and handling compressed gas in accordance with the NYS Fire Code, and prepared Emergency Action Plans, Fire Prevention Plans, and Hazardous Materials Management Plans required of NFPA 55.
- Provided environmental compliance assistance to NOCO Energy Corp. for its major petroleum distribution terminal and warehouse in Tonawanda, NY and multiple retail gasoline stations in NY and VT. Specific projects include: storm water permitting and preparation of a SWPPP; preparation of SPCC Plans and a Spill Prevention Report (SPR); Title V air permitting assistance and emission statement preparation; EPCRA Form R reporting; review of and recommendations for updating the USCG Facility Response Plan; and permitting and conceptual design for upgrades to a PBS warehouse facility.
- Served as the environmental compliance manager for a porcelain insulator manufacturing facility and completed regulatory reporting requirements including TP550 forms, Form R reports, Tier II reports, hazardous waste reports, storm water permitting, and DMRs.
- Assisted in performing environmental regulatory compliance audits for numerous active industrial facilities. Responsibilities included researching and interpreting applicable environmental regulations and preparing reports to summarize the findings and prioritize corrective measures.
- Assisted with environmental regulatory compliance audits at Gibraltar Steel's New York facilities, and coordinated audits at Gibraltar Steel's other facilities nationwide. The audits covered major existing environmental regulatory programs, as well as applicable local or state regulations and potential upcoming regulatory requirements.
- Prepared PBS and CBS applications for tank registration under NYSDEC's bulk storage programs and prepared the associated SPCC Plans and SPRs for industrial facilities.

LORI E. RIKER, P.E.

- Assisted in preparing an SPCC Plan for General Electric Company's Tonawanda facility. Work included review of numerous federal and state regulations pertaining to PCB-contaminated oil and waste.



PROFESSIONAL PROFILE



CONTACT INFORMATION

Main: (716) 856-0599
Direct: (716) 818-3954
Email: mlesakowski@rouxinc.com
Website: www.rouxinc.com

2558 Hamburg Turnpike
Suite 300
Buffalo, NY 14218

EDUCATION

Master of Science
Environmental Engineering
Science
University at Buffalo, 2008

Bachelor of Science
Biology
State University of New York at
Fredonia, 1994

Michael Lesakowski

Vice President | Principal Scientist | Co-operations Manager

EXPERIENCE SUMMARY

Over 25 years professional experience in environmental engineering, science and consulting at numerous contaminated sites throughout the northeast United States as Vice President (Roux Environmental Engineering and Geology, DPC), President, Principal Scientist, Sr. Project Manager and Project Manager (TurnKey Environmental Restoration, LLC), Executive Vice President, Project Manager and Environmental Scientist (LCS, Inc.) and Environmental Scientist (GZA GeoEnvironmental of NY).

TECHNICAL SPECIALTIES

Expert in all aspects of the New York Brownfield Cleanup Program, including technical assessment and analysis of the site investigation/remedy selection process, and site remediation. Expert in the business of the NY BCP sites, including cost/credit analysis and structured liability transfers of contaminated properties. Mr. Lesakowski has investigated and remediated over 100 NY brownfield projects, including 10 renewable energy redevelopment projects on remediated brownfield sites. He has managed assessments, investigations and remediation projects on properties with a multitude of historic uses (e.g., petroleum storage refineries and terminals, gas stations, automobile dealerships, rail yards, foundries, dry cleaners, steel manufacturing, metallurgical plants, metal plating operations, junk yards), media types (surface and subsurface soil, groundwater, sediments, soil vapor, indoor air, building materials) and contaminants (e.g., volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), heavy metals, per- and polyfluoroalkyl substances (PFAS)). Mr. Lesakowski has managed remediation projects, ranging from simple underground storage tank (UST) removals to large-scale soil excavations, in-situ soil stabilization, and complex groundwater remediation programs, such as biological and/or chemical in-situ groundwater treatment and permeable reactive barriers for VOCs and PFAS.

REPRESENTATIVE PROJECTS

GLR Holdings Site, Niagara Falls, New York

Manager and Principal Investigator/Remediator for Remedial Investigation (RI), Interim Remedial Measure (IRM) and Remedial Alternatives Analysis under the NYSDEC guidance for a former automotive repair facility with significant soil, groundwater and soil vapor chlorinated volatile organic compounds impact. The RI included a hydrogeologic assessment, including soil borings using a hollow stem auger drill rig, installation, development and sampling of groundwater monitoring wells, an on-site and off-site soil vapor assessment and dye test to trace drains and sewers to evaluate potential preferential pathways. The remediation approach included:

- soil excavation and disposal;
- in-situ enhanced biodegradation of groundwater, and,
- The newly constructed building included an active subslab depressurization system to protect the occupants from potential soil vapor intrusion.

The site was redeveloped as a restaurant.



Seneca Market I, LLC Site, Watkins Glen, New York

Manager of Site Investigation and Remediation at a former drycleaner, bus garage and asphalt plant under NYSDEC guidance with significant chlorinated volatile organic compounds impact. The investigation included a hydrogeologic assessment, including soil borings, test pits and monitoring well installation, development and sampling. The remediation approach involved:

- underground storage tank removal;
- in-ground hydraulic lift removal
- hazardous soil excavation and disposal proximate a commercial building;
- enhanced biodegradation of groundwater;
- Groundwater extracted during excavation was treated with granular activated carbon and discharged to the municipal sewer system
- An active subslab depressurization system to protect the occupants from potential soil vapor intrusion; and,
- Portions of the site included an engineered soil cover system.

The Property was redeveloped with an up-scale hotel.

330 Maple Road Site, Amherst, New York

Manager and Principal Investigator/Remediator for a Remedial Investigation/Alternatives Analysis and Remedial Action under NYSDEC guidance for a small-arms shooting range with hazardous lead and semi-volatile organic compounds (SVOCs) in soil. The RI involved collecting over 1,000 soil samples on 26-acre parcel slated for future mixed-use commercial and residential development. Bench-scale testing was completed to select a substrate to treat the characteristic hazardous soil to below toxicity characteristic leaching procedure (TCLP) thresholds. Remedial Action included:

- physical removal of lead shot from the soil matrix;
- in-situ stabilization of characteristically hazardous lead-impacted soil; and,
- Excavation and off-site disposal of lead and SVOC-impacted soil.

The site was remediated to allow for residential re-use.

275 Franklin Street Site

Manager and Principal Investigator/Remediator for a Remedial Investigation/Alternatives Analysis and Remedial Action under NYSDEC guidance at a NYSDEC Brownfield Cleanup Program site formerly used as drycleaner in western New York with significant soil and groundwater chlorinated VOC impacts. The investigation included a hydrogeologic assessment, including soil borings and overburden and bedrock monitoring well installation, development and sampling. Soil was successfully remediated using a combination of soil vapor extraction and excavation and off-site disposal. Groundwater remediation involved in-situ treatment of impacted groundwater at the downgradient property boundary whereby groundwater migrated through a permeable reactive barrier. An active sub-slab depressurization system design and installation is planned in the new building during construction.

Niagara Street and Pennsylvania Avenue Site

Manager and Principal Investigator/Remediator for a Remedial Investigation/Alternatives Analysis and Remedial Action under NYSDEC guidance at a NYSDEC Brownfield Cleanup Program site formerly used as gasoline and service station in Buffalo, New York with significant petroleum impacts. The investigation included a hydrogeologic assessment, including soil borings and overburden monitoring well installation, development and sampling. Remedial Action included:

- Demolition of the former service station building and product dispenser canopy and disposal of construction and demolition debris;
- Removal and recycling of approximately 80 tons of concrete at Iron City in Lackawanna, New York;
- Removal of five underground storage tanks, including all associated dispensing units and underground product piping;
- Excavation of petroleum-impacted soil/fill followed by off-site transportation and disposal a commercial landfill;
- Extraction and treatment of approximately 6,000-gallons of groundwater from the excavation during remediation activities using bag filtration and granular activated carbon and discharge to the municipal sewer; and,
- Placement and compaction of approximately crusher run stone backfill to the approximate pre-existing grade.



1501 College Avenue Site

Manager and Principal Investigator/Remediator for a Remedial Investigation/Alternatives Analysis and Remedial Action under NYSDEC guidance at a NYSDEC Brownfield Cleanup Program site at a former heavy industrial and manufacturing facility in Niagara Falls, New York. The investigation included a hydrogeologic assessment, including soil borings, test pits and overburden monitoring well installation, development and sampling. Remedial Action included:

- Disposal of galbestos roofing and building materials;
- Collection and removal of seven (7) roll-off containers of abandoned drums and containers of off-spec former carbon electrode manufacturing materials;
- Waste petroleum oil was vacuumed out of two abandoned tanker trucks;
- Cleaning and collection of steel ASTs, empty drums and two (2) abandoned tanker trucks and transported off-site with other on-Site scrap metals (i.e., building demolition metals);
- Excavation and disposal of non-hazardous petroleum-impacted soil/fill;
- Excavation of PCB-impacted soil/fill;
- Extraction and storage of approximately 20,000 gallons of impacted water removed from the excavation for solidification and final disposal at a commercial landfill; and,
- A soil cover system across the site.

500 South Union Street Site

Manager and Principal Investigator/Remediator for a Remedial Investigation/Alternatives Analysis and Remedial Action under NYSDEC guidance at a NYSDEC Brownfield Cleanup Program site at a former dry cleaning facility in Spencerport, New York. The investigation included a hydrogeologic assessment, including exterior and interior soil borings, test pits and monitoring well installation, development and sampling, soil vapor testing and hydrogeologic assessment to design the in-situ groundwater treatment program. Remedial Action included:

- Installation of an active subslab depressurization system within the existing building to prevent migration of vapors into the building air;
- In-situ injection of treatment agent at 71 injection points located across the Site to enhance natural biodegradation of cVOCs in groundwater;
- Limited excavation and off-Site disposal of surface soil/fill exceeding commercial use soil cleanup objectives; and,
- Construction and maintenance of a soil cover system consisting of the existing building, pavement (asphalt), sidewalks, and soil cover in all other areas at a minimum of one foot thick over the demarcation layer, to prevent human exposure to remaining contaminated soil/fill remaining at the Site;

The site is currently used as a multi-tenant commercial facility.

Scott Rotary Seals Site

Manager and Principal Investigator/Remediator for a Remedial Investigation/Alternatives Analysis and Remedial Action under NYSDEC guidance at a NYSDEC Brownfield Cleanup Program site at a former petroleum refining facility in Olean, New York. The investigation included a hydrogeologic assessment, including soil borings, test pits and monitoring well installation, development and sampling, as well as subslab vapor/indoor air testing. Remedial Action included:

- Limited excavation and off-Site disposal of shallow grossly contaminated soil to a depth of approximately 6-feet below final grade within the northwest area of the Site, including the building footprint and utility corridors;
- Installation of a soil vapor extraction system to treat grossly contaminated soil in the deeper vadose zone soil/fill from approximately 6-fbgs to the top of the groundwater surface;
- Construction and maintenance of a soil cover system consisting of buildings, pavement (asphalt and concrete), sidewalks, and soil cover in all other areas at a minimum of one foot thick over the demarcation layer, to prevent human exposure to remaining contaminated soil/fill remaining at the Site;



PROFESSIONAL PROFILE

- Installation of an active subslab depressurization system within the newly constructed on-Site building to prevent migration of vapors into the buildings; and,
- Installation of a LNAPL removal system within certain on-Site wells, utilizing absorbent socks.

The site is was redeveloped as a light industrial and commercial facility.

Olean Redevelopment Parcel 2 Site

Manager and Principal Investigator/Remediator for a Remedial Investigation/Alternatives Analysis and Remedial Action under NYSDEC guidance at a NYSDEC Brownfield Cleanup Program site at a former petroleum refining and major storage facility in Olean, New York. The comprehensive investigation, which was completed over three separate sites (Olean Redevelopment Parcels 1,2 and 3) totaling approximate 60-acres, included a hydrogeologic assessment, including soil borings, test pits and monitoring well installation, development and sampling.

As part of the investigation, bench-scale studies were completed to assess treatment of grossly contaminated petroleum soil (GCPS) impacted soil and lead-impacted soil. Soil/fill batches were treated by mixing to simulate landfarming; stabilized with lime, Portland cement, and fly ash (all amendments added at 2% and 5% by weight); and chemically oxidized with hydrogen peroxide (1% and 3% by weight).

Based on the results of the bench-scale treatability studies, four pilot-scale treatability studies were performed: in-situ SVE; ex-situ landfarming; force vented biopiles (FVBP); and, solidification/stabilization. As part of these pilot-scale treatability studies, biofiltration was assessed as component of treatment of the extracted air from the in-situ SVE pilot study and for the FVBP pilot study.

Remedial Action included:

- Approximately 2,715-tons of arsenic contaminated soil/fill, 143-tons of mercury contaminated soil/fill and 638-tons of grossly contaminated petroleum soil (GCPS) was excavated, loaded, and transported off-Site to a commercial landfill;
- Approximately 34,313 linear feet of subsurface metallic product piping (steel, cast iron, lead and copper) was exposed, tapped, evacuated of contents, removed, cleaned and recycled or disposed. An additional 156 linear feet of wood pipe was also exposed, tapped, evacuated of contents, removed, cleaned and disposed off-site. Piping which extended beyond the property boundary was capped and/or grouted at the apparent property line. Approximately 240 cubic yards of GCPS was excavated during piping removal activities and treated on the on-site force-vented biopiles FVBPs and reused as backfill below the cover system;
- Approximately 24, 55-gallon drums were generated from the removal of the abandoned subsurface piping. The contents of the piping included LNAPL, residual pipe scale, and product sludge. The 24 drums (15 non-hazardous and 9 hazardous) were disposed at a commercial landfill. In addition to the drums, approximately 3.5 tons of tank contents that were placed into roll-off containers and solidified with Portland cement due to liquid content were disposed at a commercial landfill. Water extracted from excavations during piping removal was pumped into holding tanks, treated with bag filters and granular activated carbon (GAC) on-site, pumped into a secondary on-Site temporary holding tank, sampled, and discharged to the municipal sanitary sewer with approval under an Industrial Pretreatment Program permit. Approximately 4 drums of wash water generated during holding tank cleaning were disposed at a commercial landfill;
- Design, installation and operation of a SVE system to address GCPS in the deeper soil/fill from approximately 2 to 15 fbg. The SVE system included the installation of 13 SVE wells, associated conveyance piping, and placement of three trailer-mounted SVE blowers. Emissions from the SVE system were controlled using biofilters, which allowed the naturally occurring microbes to bioremediate the air stream and control the nuisance odors from the SVE systems.



- Light non-aqueous phase liquid (NAPL) recovery was completed utilizing hydrocarbon absorbent socks at one well and a product pump at one well. LNAPL thicknesses at these locations has been measured to vary from 0 to 6.5 ft. Recovered product was transferred to properly labeled and sealed 55-gallon drums at the Site for future off-Site disposal.
- A site cover system was constructed to allow for commercial use of the Site. The cover system consists of a minimum of one foot of soil. A portion of the Site is covered with an asphalt road that serves as part of the cover system. The soil cover was placed over a demarcation layer, consisting of orange plastic mesh, and was hydroseeded and fertilized. On-Site drainage ditches were lined with rip-rap.

Olean Redevelopment Parcel 3 Site

Manager and Principal Investigator/Remediator for a Remedial Investigation/Alternatives Analysis and Remedial Action under NYSDEC guidance at a NYSDEC Brownfield Cleanup Program site at a former petroleum refining and major storage facility in Olean, New York. The comprehensive investigation, which was completed over three separate sites (Olean Redevelopment Parcels 1,2 and 3) totaling approximate 60-acres, included a hydrogeologic assessment, including soil borings, test pits and monitoring well installation, development and sampling.

As part of the investigation, bench-scale studies were completed to assess treatment of grossly contaminated petroleum soil (GCPS) impacted soil and lead-impacted soil. Soil/fill batches were treated by mixing to simulate landfarming; stabilized with lime, Portland cement, and fly ash (all amendments added at 2% and 5% by weight); and chemically oxidized with hydrogen peroxide (1% and 3% by weight).

Based on the results of the bench-scale treatability studies, four pilot-scale treatability studies were performed: in-situ SVE; ex-situ landfarming; force vented biopiles (FVBP); and, solidification/stabilization. As part of these pilot-scale treatability studies, biofiltration was assessed as component of treatment of the extracted air from the in-situ SVE pilot study and for the FVBP pilot study.

Remedial Action included:

- Approximately 425-tons of arsenic contaminated soil/fill, 235-tons of GCPS was excavated, loaded, and transported off-Site to a commercial landfill;
- Approximately 7,592-tons of lead contaminated soil/fill was stabilized in-place utilizing Portland cement to treat the soil and render it non-hazardous;
- Approximately 50,667 linear feet of subsurface metallic product piping (steel, cast iron, lead and copper) was exposed, tapped, evacuated of contents, removed, cleaned and recycled or disposed. An additional 232 linear feet of wood pipe was also exposed, tapped, evacuated of contents, removed, cleaned and disposed off-site. Piping which extended beyond the property boundary was capped and/or grouted at the apparent property line. Approximately 2,552 cubic yards of GCPS was excavated during piping removal activities and treated on the on-site FVBPs and reused as backfill below the cover system;
- Approximately 33, 55-gallon drums were generated from the removal of the abandoned subsurface piping. The contents of the piping included LNAPL, residual pipe scale, and product sludge. The 33 drums (21 non-hazardous and 12 hazardous) were disposed at a commercial landfill. In addition to the drums, approximately 4.9 tons of tank contents that were placed into roll-off containers and solidified with Portland cement due to liquid content were disposed at a commercial landfill. Water extracted from excavations during piping removal was pumped into holding tanks, treated with bag filters and granular activated carbon (GAC) on-site, pumped into a secondary on-Site temporary holding tank, sampled, and discharged to the municipal sanitary sewer with approval under an Industrial Pretreatment Program permit. Approximately 6 drums of wash water generated during holding tank cleaning were disposed at a commercial landfill;



- Installation and operation of a SVE system to address GCPS in the deeper soil/fill from approximately 2 to 15 fbgs. The SVE system included the installation of 58 SVE wells, associated conveyance piping, and placement of three trailer-mounted SVE blowers. Emissions from the SVE system were controlled using biofilters, which allowed the naturally occurring microbes to bioremediate the air stream and control the nuisance odors from the SVE systems.
- LNAPL recovery was completed utilizing hydrocarbon absorbent socks;
- A site cover system was constructed to allow for commercial use of the Site. The soil cover was placed over a demarcation layer, consisting of orange plastic mesh, and was hydroseeded and fertilized. On-Site drainage ditches were lined with rip-rap.

The site was redeveloped as a commercial solar power generating facility.

Olean Redevelopment Parcel 1 Site

Manager and Principal Investigator/Remediator for a Remedial Investigation/Alternatives Analysis and Remedial Action under NYSDEC guidance at a NYSDEC Brownfield Cleanup Program site at a former petroleum refining and major storage facility in Olean, New York. The comprehensive investigation, which was completed over three separate sites (Olean Redevelopment Parcels 1,2 and 3) totaling approximate 60-acres, included a hydrogeologic assessment, including soil borings, test pits and monitoring well installation, development and sampling.

As part of the investigation, bench-scale studies were completed to assess treatment of grossly contaminated petroleum soil (GCPS) impacted soil and lead-impacted soil. Soil/fill batches were treated by mixing to simulate landfarming; stabilized with lime, Portland cement, and fly ash (all amendments added at 2% and 5% by weight); and chemically oxidized with hydrogen peroxide (1% and 3% by weight).

Based on the results of the bench-scale treatability studies, four pilot-scale treatability studies were performed: in-situ SVE; ex-situ landfarming; force vented biopiles (FVBP); and, solidification/stabilization. As part of these pilot-scale treatability studies, biofiltration was assessed as component of treatment of the extracted air from the in-situ SVE pilot study and for the FVBP pilot study.

- Approximately 1,652 tons of arsenic contaminated soil/fill, 110 tons of mercury contaminated soil/fill, approximately 357 tons of PCB contaminated soil/fill, and approximately 5,722 tons of PAH (SVOC)-contaminated was excavated, loaded, and transported off-site to a commercial landfill;
- Removal of an ammonia tank, approximately 500-gallon stainless steel vertical UST with no piping; and associated PCB- and ammonia-impacted soil;
- Approximately 49,976 linear feet of subsurface metallic product piping was exposed, tapped, evacuated of contents, removed, cleaned and recycled. An additional approximate 578 tons of GCPS contaminated soil/fill was excavated, loaded, and transported off-site to a commercial landfill;
- Approximately 48, 55-gallon drums were generated during the remedial work, 42 of which were generated from the removal of the abandoned subsurface piping. The contents of the piping included LNAPL, residual pipe scale, and product sludge. Water extracted from excavations during piping removal was pumped into holding tanks, treated with bag filters and granular activated carbon (GAC) on-site, pumped into a secondary on-site temporary holding tank, sampled, and discharged to the municipal sanitary sewer;
- Installation and operation of a SVE system to address GCPS in the soil/fill from approximately 2 to 15 fbgs. The SVE system included the installation of seven SVE wells, associated conveyance piping, and placement of an SVE blower. Emissions from the SVE system were controlled using a biofilter to bioremediate the air stream and control the nuisance odors from the SVE system;
- LNAPL recovery was completed using hydrocarbon absorbent socks and/or manual bailing at six wells and a product skimmer at one well. LNAPL thicknesses at these locations has been measured to vary from 0.3 to 5.05 ft. Recovered product was transferred to properly labeled and sealed 55-gallon drums at the Site for off-site disposal; and,



- Construction and maintenance of a site cover system.

A portion of the site was redeveloped as a hotel.

251 Homer Street Redevelopment Site

Manager and Principal Investigator/Remediator for a Remedial Investigation/Alternatives Analysis and Remedial Action under NYSDEC guidance at a NYSDEC Brownfield Cleanup Program site at a former petroleum refining and major petroleum storage facility in Olean, New York. The investigation included a hydrogeologic assessment, including soil borings, test pits and monitoring well installation, development and sampling. Remedial Action included:

- Removal and recycling of approximately 10,644 linear feet of piping (approx. 97 tons) ranging in diameter from 2-inch to 12-inch. Removal and disposal of 51, 55-gallon drums containing oil, sludge, and scale from within the piping. Extraction, treatment, and discharge of approximately 21,000 gallons of water from within the pipes and perched water encountered during trench excavation under a temporary discharge permit issued by the municipal Wastewater Treatment Plant (WWTP);
- Excavation and off-site disposal of 49,670 tons of grossly contaminated soil (GCS) followed by backfill with clean imported soil. The on-site drainage ditch was converted to a closed 30-inch subsurface drainage pipe as discussed with NYSDEC;
- Excavation and off-site disposal of approximately 2,106 tons of arsenic-impacted soil/fill followed by backfill with clean imported soil;
- Extraction, treatment using granular activated carbon (GAC), and discharge of approximately 250,000 gallons of water encountered during excavation activities under a temporary discharge permit issued by the municipal WWTP;
- Temporary re-routing of Two Mile Creek, followed by excavation of approximately 4,000 tons on-site and 973 tons off-site of Two Mile Creek bed and bank material followed by off-site disposal, and backfilling. The creek bed and banks were restored with stone (creek bottom), and clay and clean soil (creek banks), including biodegradable erosion control blanket, riparian shrubs and hydro-seeding of creek banks;
- Construction and maintenance of a cover system consisting of a minimum 12 inches of clean soil or gravel to prevent human exposure to remaining contaminated soil/fill remaining at the site.

The site was redeveloped as a commercial solar power generating facility.

300 Ohio Street Site

Manager and Principal Investigator/Remediator for a Remedial Investigation/Alternatives Analysis and Remedial Action under NYSDEC guidance at a NYSDEC Brownfield Cleanup Program site at a former petroleum storage and sales facility in Buffalo, New York. The investigation included a hydrogeologic assessment, including soil borings, test pits and monitoring well installation, development and sampling, as well as subslab vapor/indoor air testing. Remedial Action included:

- Excavation and off-site disposal of the underground storage tank (UST) system. A total of sixteen (16) USTs and related piping and appurtenances were uncovered and removed, cleaned of residual contents and transported off-site for recycling as scrap;
- Excavation and off-site disposal of approximately 18,650 tons of grossly contaminated petroleum soil, approximately 220 tons of soil/fill exceeding 500 ppm total PAHs, and approximately 425 tons of soil/fill exceeding Commercial Use SCOs for arsenic and lead;
- Approximately 500 cubic yards (cy) of recyclable concrete and stone generated from the removal of buildings and sign footers/foundations, was crushed on-Site and used for backfill and subsurface grading beneath the cover system; and,
- Construction and maintenance of a cover system consisting a minimum of 12 inches of approved soil/stone material above a demarcation fabric to prevent human exposure to contaminated soil/fill remaining at the site.

A portion of the site was redeveloped as a brewery and restaurant.



229 Homer Street Site

Manager and Principal Investigator/Remediator for a Remedial Investigation/Alternatives Analysis and Remedial Action under NYSDEC guidance at a NYSDEC Brownfield Cleanup Program site at a former petroleum refining and major petroleum storage facility in Olean, New York. The investigation included a hydrogeologic assessment, including soil borings, test pits and monitoring well installation, development, and sampling, as well as a soil vapor intrusion assessment. Remedial Action included:

- Approximately 5,815 tons of grossly contaminated soil GCS-impacted soil/fill was excavated and transported off-site for disposal at a commercial landfill;
- Approximately 1,946 linear feet of subsurface metallic product piping was exposed, tapped, evacuated of contents, removed, cleaned and recycled. Piping which extended beyond the property boundary was capped and/or grouted at the property line.
- Approximately 19 tons of piping was recycled as scrap metal. Cleaning of the pipes generated 4 drums of pipe scale, oil and water, which was transported off-site for incineration.
- Design, installation and operation of an air sparge/soil vapor extraction (AS/SVE) system to address GCS in the deeper soil/fill from approximately 5 to 15 fbs and in the upper 5 ft of the water table (i.e., smear zone). The air sparge portion of the system includes 53 injection wells connected to an air compressor in a climate-controlled trailer via individual 1" polyethylene lines. The SVE system includes 14 extraction wells connected by 2" polyethylene lines to one of two blowers in a separate climate-controlled trailer. Emissions from the SVE system are controlled using a biofilter, which allows naturally occurring microbes to bioremediate the air stream and control the nuisance odors from the AS/SVE system;
- Construction and maintenance of a site cover system.

Former Trico Plant Site

Manager and Principal Investigator/Remediator for a Remedial Investigation/Alternatives Analysis and Remedial Action under NYSDEC guidance at a NYSDEC Brownfield Cleanup Program site at a former manufacturing facility in Buffalo, New York. The investigation included a hydrogeologic assessment, including soil borings, test pits and monitoring well installation, development and sampling, as well as subslab vapor/indoor air testing. Remedial Action included:

- Construction and maintenance of a site cover system.
- In-situ on-site treatment of groundwater contaminated with chlorinated volatile organic compounds (cVOCs);
- Removal of six (6) hydraulic lifts and associated infrastructure and impacted soil/fill;
- Pumping and on-site treatment of water present in the building sub-basement prior to sanitary sewer discharge under a temporary discharge permit;
- Cleaning accessible sump and sewer structures with evidence of potential impacts;
- Removing and properly disposing off-site miscellaneous abandoned regulated waste materials; and abating building components for lead, asbestos, oil staining, PCBs, etc. as required during redevelopment. Building surfaces and features planned to remain with evidence of impacts from historic operations will be encapsulated or sealed;
- Installing an active sub-slab depressurization (ASD) system within the existing buildings; and,
- Maintaining existing cover system in accordance with 6NYCRR Part 375 and NYSDEC DER-10 guidelines. The cover system includes building foundations and asphalt on former Burton Street.

The site is being redeveloped as a mixed-use commercial and residential complex.

Jamison Road Site

Manager and Principal Investigator/Remediator for a Remedial Investigation/Alternatives Analysis and Remedial Action under NYSDEC guidance at a NYSDEC Brownfield Cleanup Program site at an active industrial facility in Elma, New York. The Remedial Investigation was completed across the BCP Site and off-site on adjacent parcels to supplement previous environmental data and delineate or identify areas requiring remediation. Field



activities included soil boring advancement; test pit excavations; surface and near-surface soil/fill sampling; overburden and bedrock monitoring well installation; groundwater and storm water quality sample collection; soil vapor sample collection; and, subslab vapor, indoor air and outdoor air sample collection in six on-site buildings and one off-site building. Hydraulic conductivity testing was also completed in the overburden groundwater zone as well as the bedrock groundwater to assess groundwater transmissivity. Remedial Action included:

- Excavation of 2,430 tons of contaminated soil/fill, which was disposed off-site at a commercial landfill;
- 314 tons of flowable fill proximate to a sewer line was excavated as it was deemed unsuitable due to structural considerations, which was also disposed off-site at commercial landfill;
- Two steel former pipes that ran along the eastern boundary of an on-site building were removed and disposed at a commercial landfill. Approximately 10-gallons of residual hydraulic oil removed from the pipes was transported and recycled off-site;
- Approximately 13,415 cubic yards (CY) of non-impacted soil was excavated for the construction of new buildings. With NYSDEC approval, 12,250 CY of soil was exported for reuse at another site and the remaining soil was reused on-site;
- During overburden soil removal, approximately 1,100,000 gallons of Chlorinated VOC-impacted groundwater was extracted, treated using granular activated carbon, tested, and discharged;
- A former 15" concrete storm sewer was encountered during foundation excavation for new buildings. Approximately 150 gallons of emulsified oil and water were removed using a vacuum truck, transported to an on-site frac tank and later disposed. A portion of the former sewer was removed, and the remaining portion of the sewer was filled in with concrete;
- Installing an active sub-slab depressurization (ASD) system within two new building and two existing buildings;
- As part of the remedial design, a bench-scale treatability study evaluation of media was conducted. The study included four column reactors filled with four different material combinations to determine which most effectively removed CVOCs from the Site groundwater. A proprietary product comprised of granular carbon and zero-valent iron was selected as the treatment medium;
- Implementation of *in-Situ* Chemical Reduction (ISCR) in the form of a permeable reactive barrier (PRB) with two approximate 250-feet long slurry wall legs to direct the groundwater toward the PRB. The slurry walls consist of a homogeneous mixture of soil, bentonite, and water, with a maximum hydraulic conductivity of 1×10^{-6} cm/s. The PRB and slurry wall legs were installed in the northwestern corner of the site to treat groundwater impacted by chlorinated volatile organic compounds;
- Implementation of in-situ phytoremediation using hybrid poplar trees to treat groundwater impacted by 1,4-dioxane. The hybrid poplar trees were planted in two rows in the northwestern corner of the site, upgradient of the PRB; and,
- Installation of an in-line air stripper to remove CVOCs from storm water prior to discharge.

The site has been redeveloped with a mixed-use industrial manufacturing facility and related research and development offices.

1827 Fillmore Site

Manager and Principal Investigator/Remediator for a Remedial Investigation/Alternatives Analysis and Remedial Action under NYSDEC guidance at a NYSDEC Brownfield Cleanup Program site at a former gravel pit filled in with miscellaneous soil/fill and construction and demolition debris in Buffalo, New York located adjacent to two public schools. The Remedial Investigation included a hydrogeologic assessment, including soil borings, test pits and monitoring well installation, development and sampling. As part of the Remedial Investigation, bench-scale studies were completed to assess treatment characteristically hazardous lead-impacted soil. Soil/fill batches were treated by mixing different amendments, including Portland cement and phosphoric acid, at varying percentages by weight. 5% Portland cement was selected as the soil amendment. Remedial action included:

- In-situ stabilization of approximately 3,091 cubic yards of characteristic hazardous lead soil/fill using Portland cement in two remedial areas of concern;
- Excavation and off-site disposal of contaminant source areas, including soil exceeding the site-specific action levels (SSALs) of 3,900 ppm of lead and soil containing total semi-volatile organic compounds (SVOCs) exceeding 500 ppm. Approximately 2,200 tons of soil was removed and disposed off-Site, including 160 tons of soil exceeding the hazardous criteria for lead, which was treated in-situ and rendered non-hazardous prior to disposal; and,



- Construction and maintenance of a soil cover system consisting of a minimum of one foot of soil placed over a demarcation layer, with the upper six inches of soil of sufficient quality to maintain a vegetative layer to prevent human exposure to remaining contaminated soil/fill.

The site is planned to be redeveloped with mixed-use commercial and residential buildings.

3100 Clinton Street Site

Manager and Principal Investigator/Remediator for a Remedial Investigation/Alternatives Analysis and Remedial Action under NYSDEC guidance at a NYSDEC Brownfield Cleanup Program site at a former railyard filled in with miscellaneous soil/fill in West Seneca, New York and located adjacent to a regulated wetland. The Remedial Investigation included a hydrogeologic assessment, including soil borings, test pits and monitoring well installation, development and sampling. Remedial Action included:

- Clearing and grubbing of vegetation, shrubs, and trees to allow remedial excavation activities. Approval to complete work activities within designated wetland areas was received from the United States Army Corps of Engineers and NYSDEC prior to starting work in those areas;
- Excavation and off-site disposal of approximately 45,850 tons (approximately 30,600 cubic yards) of PAH- and metals-impacted soil/fill;
- Excavation and off-site transport to an approved location of a total of 761 loads of surplus native soils which were determined to be structurally unsuitable for redevelopment purposes;
- Excavation and off-site disposal of 5.9 tons of treated/weathered wood (former railroad ties);
- Collection, storage, volume measurement, and discharge of 1,005,000 gallons of groundwater and/or rainwater encountered during remedial activities;
- Backfilling of the excavation area with approximately 172,724 tons of backfill including screened backfill and surge stone. Surge stone was required in areas of the site where natural soils were not suitable for geotechnical requirements of the planned building. In those areas, certain native soils were removed and/or bridged with filter fabric and surge stone was installed beneath compacted gravel.

The site was redeveloped with state-of-the-art food processing protein plant.

351 Franklin Street Site

Manager and Principal Investigator/Remediator for a Remedial Investigation/Alternatives Analysis and Remedial Action under NYSDEC guidance at a NYSDEC Brownfield Cleanup Program site at a former petroleum refining and major storage facility in Olean, New York. The Remedial Investigation included a hydrogeologic assessment, including soil borings, test pits and monitoring well installation, development and sampling. Exterior soil vapor sampling and an interior soil vapor intrusion (SVI) assessment was completed within one on-site building. A pre-design investigation included additional groundwater monitoring wells and gauging/monitoring levels of light non-aqueous phase liquid (LNAPL). As part of the remedial design, bench-scale studies will be completed to assess potential treatment options for grossly-contaminated material (GCM), including assessment of Portland cement and other potential amendments (e.g., lime-kiln dust), at varying percentages by weight.

Remedial actions to be completed include:

- Excavation and reuse of the top one foot of SVOC- and arsenic-impacted soil under the cover system, and disposal of excess material;
- Excavation of non-GCM-impacted soil/fill that resides over the GCM and staging of the material on-site for reuse as backfill under the cover system;
- Excavation and disposal of approximately 16,000 tons of GCM-impacted soil/fill and completion of in-situ solidification (ISS) as needed to address GCM-impacted soil/fill at the water table, followed by backfill and site grading. After the completion of ISS mixing activities, the solidified soil will be allowed to cure for 28 days. After the mixture has cured, core samples will be collected from the solidified soil and post-treatment tests, including unconfined compressive strength (UCS), permeability testing and free liquid testing, will be completed to ensure that the solidified soil meets ISS performance requirements;
- Solidification of excavated soil, as needed, prior to disposal, based on landfill requirements;
- Removal and transfer of abandoned petroleum piping encountered during GCM excavation activities to a recycling



PROFESSIONAL PROFILE

facility and extraction and disposal of piping contents;

- Management of impacted groundwater and stormwater during remedial activities;
- Placement of a cover system across the entire Site;
- Installation of an active sub-slab depressurization (ASD) system in the newly constructed building during construction and completion of SVI sampling;
- Monitoring of groundwater level and LNAPL; and, Removal of LNAPL via bailing or in-well pumps as needed from monitoring wells over time.

The site is planned for a redevelopment as a mixed use commercial and light industrial building.



PROFESSIONAL PROFILE



Thomas H. Forbes, PE

Vice President | Principal Engineer | Co-operations Manager

EXPERIENCE SUMMARY

Mr. Forbes has more than thirty-five years of environmental engineering experience: Vice President, Principal Engineer, and Co-operations Manager at Roux, July 2023 to Present; Principal Engineer and President at Benchmark Civil/Environmental Engineering & Geology, PLLC, June 1998 to July 2023; and Project Engineer, Malcolm Pirnie, Inc., June 1988 to June 1998.

TECHNICAL SPECIALTIES

Mr. Forbes is a registered professional engineer licensed in the States of New York, Ohio, and Pennsylvania. He has over thirty-five years of experience focused on brownfield and hazardous waste site investigation and remediation; petroleum-impacted site remediation; due diligence for environmentally-impaired properties; groundwater and industrial wastewater treatment; and environmental regulatory compliance services. He holds a BS in Chemical Engineering from the University at Buffalo. He is currently a Vice President and Principal Engineer for Roux (2023- present). Mr. Forbes' investigations and cleanups have included well over 250 sites contaminated with a wide range of materials, including per- and polyfluoroalkyl substances (PFAS), chlorinated solvents, polyaromatic hydrocarbons, polychlorinated biphenyls (PCBs), dioxins, heavy metals, cyanide, radioactive isotopes, and petroleum contamination. He has evaluated and successfully implemented cost-saving and innovative treatment technologies on a conventional and design-build basis (e.g., in situ and ex situ physical-chemical, thermal, and biological treatment), as well as removal and containment methods for remediation. Mr. Forbes has also played an instrumental role in extending and improving the New York State Brownfield Cleanup Program (BCP) through voluntary consulting efforts with congressional and senate leaders, as well as the New York State Department of Environmental Conservation (NYSDEC). He has also assisted numerous manufacturing and pharmaceutical clients through the development of strategies, plans, and permit applications necessary to secure and maintain state and federal environmental regulatory compliance.

REPRESENTATIVE PROJECTS

- Project manager for remedial investigation, alternatives analysis, and remedial construction to facilitate redevelopment of over 450-acres of former Bethlehem Steel Corp manufacturing site property encompassing 33 separate Brownfield Cleanup Program (BCP) sites in Lackawanna, New York. Contaminants of concern primarily include petroleum organics, solvents, PCBs, and heavy metals. Currently managing remediation of over 500 acres of additional property under an NYSDEC RCRA Corrective Action Program.
- Expert witness to legal defense team for a former electronic parts manufacturer under suit by Orange County Water District, Fullerton, California for primary drinking water aquifer contamination by chlorinated solvents and emergent organic contaminants. Served as technical consultant during mediation and settlement discussions; prepared expert report and lead technical arguments on behalf of defendant to support claim dismissal.
- Project manager for remediation of spill area soils associated with the Lehigh Valley Railroad Derailment National Priority List (NPL) Site in LeRoy, New York. Developed and implemented a USEPA-approved comprehensive remedial design to address chlorinated solvents in site soils via in situ soil vapor extraction.
- Assisted confidential client's legal counsel negotiate a consent decree with New Mexico Environment Department related to cleanup of chlorinated solvent releases to overburden and the fractured bedrock aquifer from a former manufacturing operation in Albuquerque, NM. Presently assisting in management of in situ groundwater cleanup and monitoring work.

CONTACT INFORMATION

Main: (716) 856- 0599
Direct: (716) 864-1730
Email: tforbes@rouxinc.com
Website: www.rouxinc.com

2558 Hamburg Turnpike
Suite 300
Buffalo, New York 14218

EDUCATION

BS, Chemical Engineering, State
University of New York at
Buffalo, 1988

Graduate of State University of
New York at Buffalo School of
Management Center for
Entrepreneurial Leadership,
2002

Graduate-level courses in
Biological Principles of
Engineering and Hazardous
Waste Management through
the State University of New
York at Buffalo Department of
Environmental Engineering

PROFESSIONAL LICENSES

Professional Engineer: NY, PA,
and OH

- Project Officer for BCP remediation and civil engineering design on a former industrial property to facilitate construction of a 290,000 SF manufacturing building which currently produces a consumer cleaning product for Proctor & Gamble.
- Serve as primary environmental consultant and environmental regulatory compliance manager for a Fortune 500 pharmaceutical manufacturing company in Western New York.
- Assisted in development of an in situ PFAS stabilization pilot test and Remedial Design Work Plan for a western New York Brownfield Cleanup Program Site impacted by suspected firefighting foam practice operations.
- Successfully designed and implemented groundwater pump and treat systems incorporating advanced oxidation processes to remove organic solvents and emerging contaminants at a former municipal landfill and at a former superfund site in central New York.
- Supervised monitoring and remedial measures during redevelopment of the Riverbend Site in Buffalo, New York for a new solar panel and battery system manufacturing operation. Developed a technologically enhanced naturally occurring radioactive material (TENORM) reuse work plan and variance application, which was the first ever employed in New York State. The plan was accepted by New York State, saving tens of millions in disposal costs.
- Served as Project Officer for NYSDEC Brownfield Cleanup Program (BCP) investigation and remediation of 441 Ohio Street, a former freight house located along the Buffalo River. Remedial activities included bank reshaping, hotspot soil/fill removal, and cover system placement to allow redevelopment as a residential apartment building.
- Serving as Project Officer for remedial investigation and cleanup activities at 1176 South Park Avenue, an NYSDEC BCP Site and the location of a former large-scale petroleum storage facility located on the Buffalo River.
- Served as Project Officer for NYSDEC Brownfield Cleanup Program (BCP) investigation and remediation of the former Millard Fillmore Gates Circle hospital complex in Buffalo, New York.
- Project officer for NYSDEC BCP investigation and cleanup of 154 South Ogden Street in concert with construction of the South Buffalo Charter School.
- Project manager for RI/FS, remedial design, and remedial construction at the Sycamore Village Site, a 4-acre New York State Environmental Restoration Program (ERP) site in Buffalo, New York. Responsible for all technical and administrative aspects of the project, involving removal of over 18,000 cubic yards of soil from an impacted residential neighborhood and site restoration.
- Served as project manager and supervising contractor for design-build remedial activities at the Markhams National Priority List (NPL) site in Dayton, NY. Successfully implemented remedial measures leading to USEPA-designated Preliminary Site Closeout status in October 2008 and delisting in 2009.
- Served as project manager representing multiple potential responsible party (PRP)-led remedial construction activities to address heavy metal and chlorinated solvent impacts at the Peter Cooper Landfill NPL site. Responsible for oversight and coordination of RI/FS planning and implementation activities, lead technical contact with USEPA, and remedial measures design and construction. Achieved site closeout in 2011.
- Assisted in the development of a voluntary cleanup plan for remediation of a 120-acre former steel manufacturing site in Buffalo, New York which was contaminated with volatile organic compounds, heavy metals, poly-nuclear aromatic hydrocarbons. Specific assistance involved design of a groundwater remediation system to address VOC and SVOC source area impacts proximate to a residential neighborhood and development and implementation of a Community Air Monitoring Plan involving quantitative monitoring (Summa Canister and respirable particulate analysis) and qualitative monitoring (field instruments).
- Served as Project Manager for RI/FS and cleanup activities related to solvent releases from a former paint and specialty coatings manufacturing facility in Buffalo, New York. The work, carried out under NY State Superfund program, included in situ treatment of soils and groundwater impacted by chlorinated and non-chlorinated volatile organics and heavy metals.
- Currently serving as Project Manager for New York State Voluntary Cleanup efforts for chlorinated solvent cleanup at a former degreasing and electroplating facility in Rochester, NY. Designed and implemented interim remedial measures involving low-profile air stripping and in situ hydrogen infusion.
- Served as Project Manager for multiple EPA Pilot-Grant funded investigations for City of Buffalo Department of Strategic Planning.
- Managed design-build cleanup of former New 7th Street Brownfield Cleanup Program Site in Buffalo, New York. The project involved design-build removal of several hundred tons of petroleum-impacted soil and fill material and preparation of related engineering reports resulting in Certificate of Completion issuance.

- Led remedial efforts for petroleum releases at a Western New York refinery and major oil storage facility, achieving site inactivation within 3 months of the release.
 - Managed spill site investigation and cleanup work including underground storage tank removal work at numerous petroleum and chemical spill sites in Western New York.
 - Led design-build construction of a 5 MGD capacity cooling water pH adjustment system for PVS Chemical Corporation. The project included design of feed forward pH control system, adjustment tank and mixer construction, process, and chemical feed piping modifications to neutralize sulfuric acid discharges. Successfully implemented startup and demonstration testing.
 - Designed a 75 gpm groundwater treatment system and served as quality assurance officer for remedial efforts at the Steelfields site (former LTV Steel/Hanna Furnace Site), Buffalo, New York. The treatment system removes petroleum-based volatile organic and semi-volatile organic compounds prior to discharge to the Buffalo Sewer Authority.
 - Assisted the City of Buffalo Department of Community Development in implementing an emergency PCB-contaminated soil removal effort from a residential neighborhood in Buffalo, New York. Responsibilities included coordination of hazmat excavation contractor and secure landfill, preparation of an emergency excavation and confirmatory sampling plan, and oversight of community air monitoring during the removal work.
 - Performed a Feasibility Study and prepared an Engineering Design Report for remediation of PCB-contaminated soils and sediments at the Columbus McKinnon Corporation, Tonawanda, New York. Responsibilities included detailed evaluation of several remedial processes, completion of design calculations and remedial cost estimates, and preparation of a final report for submission to NYSDEC.
 - Assisted in performance of a Feasibility Study for the West Valley Nuclear Demonstration Site. The Feasibility Study evaluated alternatives for remediation of groundwater contaminated with radioactive isotopes from a former containment area release.
 - Assisted in the design and performed start-up of a groundwater remediation system for Moog, Inc., an aerospace parts manufacturer. The project, performed on a design-build basis, involved preparation of design plans, securing contractor bids for construction, and start-up of the remediation system, which incorporates filtration and air stripping to remove chlorinated volatile organic contaminants from groundwater.
 - Designed and implemented groundwater monitoring well decommissioning procedures for the Love Canal site, Niagara Falls, New York. The project was performed on behalf of NYSDEC and included abandoning monitoring wells no longer used in the Love Canal landfill or in adjoining neighborhoods.
 - Prepared an environmental monitoring plan for remediation of PCB-contaminated sediments in the St. Lawrence River along the General Motors, Inc. Powertrain Division facility in Massena, New York.
 - Assisted in the performance of a Feasibility Study for remediation of volatile organic, PCB and heavy metal-contaminated soils and ground water at the Rochester Fire Academy, Rochester, New York.
- ### PUBLICATIONS/PRESENTATIONS
- Forbes, Thomas H. and Frappa, Richard H. "Innovative Remedial Measures for the Mercury Aircraft Site" Proceedings of the Purdue University 50th Annual Industrial Waste Conference, May 1995.
- Frappa, Richard H., Forbes, Thomas H. and McManus, Anne Marie "A Blast to Remediate" Industrial Wastewater, July/August 1996.
- Forbes, Thomas H. and McManus, Anne Marie "Advanced Oxidation Technology and Application" Proceedings of the University at Buffalo 28th Mid-Atlantic Industrial and Hazardous Waste Conference, July 1996.
- Forbes, Thomas H. et al - "Pay to Throw in Buffalo" Proceedings of 1997 Solid Waste Association of North America annual conference.
- Forbes, T.H. & Werthman, P.H. "Development of Site-Specific Cleanup Levels for Commercial Redevelopment of a Large Former Steel Works," presented at the Brownfields 2000 Conference, Atlantic City NJ, October 2000.
- Forbes, Thomas H. and Frappa, Richard H. "Innovative Remedial Measures Almost 10 Years Later at the Former Mercury Aircraft Site" Proceedings of the National Groundwater Association Northeast Conference, October 2002.
- Forbes, Thomas H. "Ins and Outs of the New York State Brownfield Cleanup Program" Air & Waste Management Association, Niagara Frontier Section, Annual Environmental Seminar (presentation), April 2006.
- Forbes, Thomas H. "Brownfield Redevelopment" Proceedings of Half Moon Seminar's "New York Environmental Compliance for Design Professionals" conference, September 2008.
- Forbes, Thomas H. "New York State Brownfield Cleanup Program Update" Air & Waste Management Association Annual Environmental Seminar (presentation), April 2009.

Remedial Investigation Work Plan
Haverstraw Chair Factory Site, Haverstraw, New York

APPENDIX B

Previous Investigations (*Flash Drive*)

Remedial Investigation Work Plan
Haverstraw Chair Factory Site, Haverstraw, New York

APPENDIX C

Project Documentation Forms



INSPECTOR'S DAILY REPORT

CONTRACTOR					
CLIENT		DATE:			
LOCATION		DAY		JOB NO.	
WEATHER		TEMP	° F	START	END

WORK PERFORMED:

CONTRACTOR ACTIVITIES:

[PUT CONTRACTOR ACTIVITIES HERE, BE SPECIFIC. TYPE OF EQUIPMENT, ACTIVITIES PERFORMED, BY WHOM, LOCATION OF LANDFILL ETC.]

TURNKEY ACTIVITIES:

[PUT ENGINEER ACTIVITIES HERE, BE SPECIFIC. TYPE OF EQUIPMENT, ACTIVITIES AND TESTING PERFORMED, SAMPLES COLLECTED, BY WHOM, LOCATION OF LANDFILL ETC.]

TEST PERFORMED		QA PERSONNEL SIGNATURE			
PICTURES TAKEN	none	REPORT NO.			
VISITORS	none	SHEET	1	OF	



INSPECTOR'S DAILY REPORT

CONTRACTOR							
CLIENT				DATE:			
LOCATION				DAY		JOB NO.	
WEATHER		TEMP	° F	START		END	



INSPECTOR'S DAILY REPORT

MEETINGS HELD & RESULTS:

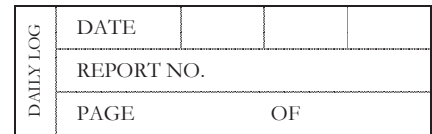
CONTRACTOR'S WORK FORCE AND EQUIPMENT

DESCRIPTION	H	#	DESCRIPTION	H	#	DESCRIPTION	H	#	DESCRIPTION	H	#
Field Engineer						Equipment			Front Loader Ton		
Superintendent			Ironworker			Generators			Bulldozer		
						Welding Equip.			DJ Dump truck		
Laborer-Foreman			Carpenter						Water Truck		
Laborer									Backhoe		
Operating Engineer			Concrete Finisher						Excavator		
						Roller			Pad foot roller		
Carpenter						Paving Equipment					
						Air Compressor					

REMARKS:

REFERENCES TO OTHER FORMS:

SAMPLES COLLECTED:					
SAMPLE NUMBER					
APPROX. LOCATION OF STOCKPILE					
NO. OF STOCKPILE					
DATE OF COLLECTION					
CLIMATOLOGIC CONDITIONS					
FIELD OBSERVATION				SHEET	OF



PROBLEM IDENTIFICATION REPORT

WEATHER CONDITIONS:

Ambient Air Temp. - A.M.:

Ambient Air Temp. - P.M.:

Wind Direction:

Wind Speed:

Precipitation:

Signed: _____

CQA Representative



DAILY LOG	DATE			
	REPORT NO.			
	PAGE	OF		

Date: _____

Project: _____

Job No: _____

Location: _____

CQA Monitor(s): _____

Client: _____

Contractor: _____

Contractor's Supervisor: _____

CORRECTIVE MEASURES REPORT

WEATHER CONDITIONS:

Ambient Air Temp. - A.M.: _____

Ambient Air Temp. - P.M.: _____

Wind Direction: _____

Wind Speed: _____

Precipitation: _____

Corrective Measures Undertaken (reference Problem Identification Report No.)

Retesting Location:

Suggested Method of Minimizing Re-Occurrence:

Approvals (initial):

CQA Engineer: _____

Project Manager: _____

Signed:

CQA Representative

Remedial Investigation Work Plan
Haverstraw Chair Factory Site, Haverstraw, New York

APPENDIX D

Health and Safety Plan (HASP) including CAMP

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1. Introduction

1.1 General

In accordance with OSHA requirements contained in 29 CFR 1910.120, this Health and Safety Plan (HASP) describes the specific health and safety practices and procedures to be employed by Roux Environmental Engineering and Geology, D.P.C. employees (referred to hereafter as “Roux”) during Remedial Investigation (RI) activities at Haverstraw Chair Factory Site (Site) located in Haverstraw, Rockland County, New York. This HASP presents procedures for Roux employees who will be involved with RI field activities; it does not cover the activities of other contractors, subcontractors, or other individuals on the Site. These firms will be required to develop and enforce their own HASPs as discussed in **Section 2.0**. Roux accepts no responsibility for the health and safety of contractor, subcontractor, or other personnel.

This HASP presents information on known Site health and safety hazards using available historical information, and identifies the equipment, materials, and procedures that will be used to eliminate or control these hazards. Environmental monitoring will be performed during field activities to provide real-time data for on-going assessment of potential hazards.

1.2 Background

The BCP Site consists of two portions of legal parcels totaling approximately 4.53-acres, including a 3.68-acre parcel addressed at 30 Liberty Street and a 0.85-acre parcel addressed at 87 Main Street, Haverstraw, New York. The BCP Site is currently undeveloped with building debris staged in the associated parking lots.

As part of this project Roux completed a historical record research, including reviews of Sanborn Fire Insurance Maps, and municipal records for additional information relative to the Site. From at least 1892 through 1902, the eastern portion of the Property was covered by the Hudson River. By 1921, this portion of the Site was developed with a manufacturing structure indicating fill material was utilized to build up the land. The Site was utilized for manufacturing operations including brick manufacturing, chair manufacturing and a refinery from at least 1921 through 1994. By 2006 all manufacturing buildings were demolished. Demolition debris from the former manufacturing and refinery buildings was observed in large piles throughout the undeveloped portions of the Property. The unknown origin and contents of the fill material used to build up the land, the long history of manufacturing and the associated demolition debris represent a Recognized Environmental Condition (REC) for the Site.

Previous environmental investigations completed at the Site have identified elevated levels of polycyclic aromatic hydrocarbons (PAHs), residual petroleum, and metals exceeding Parts 375 Restricted-Residential Soil Cleanup Objectives (RRSCOs).

1.3 Known and Suspected Environmental Conditions

The Site, currently vacant/underutilized land (see **Figure 2**), is located in a suburban portion of Rockland County, comprised of approximately 4.53 acres along the Hudson River off of the Allison Avenue, Liberty Street, Front Street, and Main Street area in the planned development district of the Village of Haverstraw in Rockland County, New York. The Site sits within a highly developed residential, commercial, and recreational area of the Village of Haverstraw. To the north, the Site is bordered by parts of the Hudson River and Bowline Point Park; to the south of the Site sits Emerline Park; east of the Site is the Hudson River; on the west, the Site is bordered by residential homes, a church, library, and a post office. A summary of the previous environmental investigation findings completed for the Site are provided below.

March 2023 – Phase I Environmental Site Assessment

A Phase I Environmental Site Assessment (ESA) completed by Hillman Consulting dated March of 2023 identified recognized environmental concerns (RECs) at the Site.

From at least 1892 through 1902, the eastern portion of the Property was covered by the Hudson River. By 1921, this portion of the Site was developed with a manufacturing structure indicating fill material was utilized to build up the land. The Site was utilized for manufacturing operations including brick manufacturing, chair manufacturing and a refinery from at least 1921 through 1994. By 2006 all manufacturing buildings were demolished. Demolition debris from the former manufacturing and refinery buildings was observed in large piles throughout the undeveloped portions of the Property. The unknown origin and contents of the fill material used to build up the land, the long history of manufacturing and the associated demolition debris represent a Recognized Environmental Condition (REC) for the Site.

October 2024 – Phase II Investigation

Roux Environmental Engineering and Geology, D.P.C. (Roux) completed test pit investigation on the Site in May 2024, which was summarized in the October 2024 Phase II Investigation report. Fifteen soil borings (designated as TP-1 through TP-15) were advanced at the Site on May 30, 2024.

Twelve samples (TP-2 (0-2 ft), TP-3 (0-2 ft), TP-4 (0-2 ft), TP-5 (4-5 ft), TP-6 (2-4 ft), TP-7 (5-7 ft), TP-8 (0-2 ft), TP-11 (2.5-5 ft), TP-12 (4-6 ft), TP-13 (5-7 ft), TP-14 (0-1.5 ft), and TP-15 (3-5 ft)) were submitted for chemical analysis of PAHs and Resource and Recovery Act (RCRA) metals. Select samples were also submitted for volatile organic compounds (VOCs). Results of the investigation are summarized below:

- Urban fill materials were identified across the Site to depths ranging from 0.25 fbg to greater than 10 fbg.

- Seven different PAHs were identified at various concentrations exceeding USCOs, RRSCOs, CSCOs, and ISCOs at TP-2 (0-2 ft), TP-11 (2.5-5 ft), and TP-14 (0-1.5 ft).
- Metals, including arsenic, barium, chromium, lead, mercury, and selenium, were identified exceeding USCOs, RRSCOs, CSCOs, and ISCOs at TP-5 (4-5 ft), TP-6 (2-4 ft), TP-7 (5-7 ft), TP-8 (0-2 ft), TP-11 (2.5-5 ft), TP-13 (5-7 ft), TP-14 (0-1.5 ft), and TP-15 (3-5 ft).
 - Arsenic was detected exceeding its ISCO (16 mg/kg) at TP-7 (28.8 mg/kg); barium was detected exceeding its CSCO (400 mg/kg) at TP-7 (1,040 mg/kg); chromium was detected exceeding its USCO (31 mg/kg) at TP-7 (47.3 mg/kg); lead was detected exceeding its USCO (64 mg/kg) at TP-5 (71.2 mg/kg), TP-8 (73.5 mg/kg), TP-11 (134 mg/kg), TP-13 (78 mg/kg), TP-14 (262 mg/kg), TP-15 (83.9 mg/kg), exceeding its RRSCO (400 mg/kg) at TP-6 (402 mg/kg), and exceeding its CSCO (1,000 mg/kg) at TP-7 (1,510 mg/kg); mercury was detected exceeding its USCO (0.18 mg/kg) at TP-11 (0.21 mg/kg), TP-14 (0.55 mg/kg), exceeding its RRSCO (0.81 mg/kg) at TP-6 (0.9 mg/kg), and exceeding its ISCO (5.7 mg/kg) at TP-7 (10.4 mg/kg); and selenium was detected exceeding its USCO (31 mg/kg) at TP-7 (47.3 mg/kg).
- VOCs were not detected at concentrations above laboratory detection limits for any of the twelve test pits.

1.4 Parameters of Interest

Based on the previous investigations, constituents of potential concern (COPCs) in soil and, potentially groundwater, at the Site include but are not limited to:

- **Polycyclic Aromatic Hydrocarbons (PAHs)** – PAHs present at elevated concentration may include benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, fluoranthene, and indeno(1,2,3-cd)pyrene.
- **Inorganic Compound/Metals** – The inorganic COPCs potentially present at elevated concentrations are arsenic, barium, cadmium, lead, mercury, and selenium.

1.5 Overview of RI Activities

Roux personnel will be on-site to observe and perform RI activities. The field activities to be completed as part of the RI are described below.

Remedial Investigation Activities

1. **Subsurface Soil Sampling:** Roux will advance test pits and soil borings to collect subsurface soil samples for the purpose of determining the nature and extent of potential COPC impacts in the subsurface soil/fill.

- |
2. **Monitoring Well Installation/Development and Sampling:** Roux will be present to observe the installation of ~~six~~eight groundwater monitoring wells, develop the wells, and collect groundwater samples for the purpose of determining the nature and extent of potential COPC impacts.

2. Organizational Structure

This section of the HASP describes the lines of authority, responsibility, and communication as they pertain to health and safety functions at the Site. The purpose of this section is to identify the personnel who impact the development and implementation of the HASP and to describe their roles and responsibilities. This section also identifies other contractors and subcontractors involved in work operations and establishes the lines of communication among them for health and safety matters. The organizational structure described in this section is consistent with the requirements of 29 CFR 1910.120(b)(2). This section will be reviewed by the Project Manager and updated as necessary to reflect the current organizational structure at this Site.

2.1 Roles and Responsibilities

All Roux personnel on the Site must comply with the minimum requirements of this HASP. The specific responsibilities and authority of management, safety and health, and other personnel on this Site are detailed in the following paragraphs.

2.1.1 Corporate Health and Safety Director

The Roux Corporate Health and Safety Director is **Mr. Michael Lesakowski**. The Corporate Health and Safety Director responsible for developing and implementing the Health and Safety program and policies for Roux, and consulting with corporate management to ensure adequate resources are available to properly implement these programs and policies. The Corporate Health and Safety Director coordinates Roux's Health and Safety training and medical monitoring programs and assists project management and field staff in developing site-specific health and safety plans.

2.1.2 Project Manager

The Project Manager for this Site is **Mr. Michael Lesakowski**. The Project Manager has the responsibility and authority to direct all Roux work operations at the Site. The Project Manager coordinates safety and health functions with the Site Safety and Health Officer and bears ultimate responsibility for proper implementation of this HASP. They may delegate authority to expedite and facilitate any application of the program, including modifications to the overall project approach as necessary to circumvent unsafe work conditions. Specific duties of the Project Manager include:

- Preparing and coordinating the Site work plan.
- Providing Roux workers with work assignments and overseeing their performance.
- Coordinating health and safety efforts with the Site Safety and Health Officer (SSHO).
- Reviewing the emergency response coordination plan to assure its effectiveness.

- Serving as the primary liaison with Site contractors and the property owner.

2.1.3 Site Safety and Health Officer

The SSHO for this Site is **Mr. Paul Werthman, P.G.**. The SSHO reports to the Project Manager. The SSHO is on-site or readily accessible to the Site during all work operations and has the authority to halt Site work if unsafe conditions are detected. The specific responsibilities of the SSHO are:

- Managing the safety and health functions for Roux personnel on the Site.
- Serving as the point of contact for safety and health matters.
- Ensuring that Roux field personnel working on the Site have received proper training (per 29 CFR Part 1910.120(e)), that they have obtained medical clearance to wear respiratory protection (per 29 CFR Part 1910.134), and that they are properly trained in the selection, use and maintenance of personal protective equipment, including qualitative respirator fit testing.
- Performing or overseeing Site monitoring as required by the HASP.
- Assisting in the preparation and review of the HASP.
- Maintaining site-specific safety and health records as described in this HASP.
- Coordinating with the Project Manager, Site Workers, and Contractor's SSHO as necessary for safety and health efforts.

2.1.4 Site Workers

Site workers are responsible for: complying with this HASP or a more stringent HASP, if appropriate (i.e., Contractor and Subcontractor's HASP); using proper PPE; reporting unsafe acts and conditions to the SSHO; and following the safety and health instructions of the Project Manager and SSHO.

2.1.5 Other Site Personnel

Other Site personnel who will have health and safety responsibilities will include the Drilling Contractor, who will be responsible for developing, implementing, and enforcing a Health and Safety Plan equally stringent or more stringent than Roux's HASP. Roux assumes no responsibility for the health and safety of anyone outside its direct employment. Each Contractor's HASP shall cover all non-Roux Site personnel. Each Contractor shall assign a SSHO who will coordinate with Roux's SSHO as necessary to ensure effective lines of communication and consistency between contingency plans.

In addition to Roux and Contractor personnel, other individuals who may have responsibilities in the work zone include subcontractors and governmental agencies performing Site inspection work (i.e., the New York State Department of Environmental Conservation). The Contractor shall

be responsible for ensuring that these individuals have received OSHA-required training (29 CFR 1910.120(e)), including initial, refresher and site-specific training, and shall be responsible for the safety and health of these individuals while they are on-site.

3. Hazard Evaluation

Due to the presence of certain contaminants at the Site, the possibility exists that workers will be exposed to hazardous substances during field activities. The principal points of exposure would be through direct contact with and incidental ingestion of soil, and through the inhalation of contaminated particles or vapors. Other points of exposure may include direct contact with groundwater. In addition, the use of drilling and/or medium to large-sized construction equipment (e.g., excavator) will also present conditions for potential physical injury to workers. Further, since work will be performed outdoors, the potential exists for heat/cold stress to impact workers, especially those wearing protective equipment and clothing. Adherence to the medical evaluations, worker training relative to chemical hazards, safe work practices, proper personal protection, environmental monitoring, establishment work zones and Site control, appropriate decontamination procedures and contingency planning outlined herein will reduce the potential for chemical exposures and physical injuries.

3.1 Chemical Hazards

As discussed in Section 1.3, VOC and inorganic impacts have been identified at the Site. Table 1 lists exposure limits for airborne concentrations of the COPCs identified in Section 1.4 of this HASP. Brief descriptions of the toxicology of the prevalent COPCs and related health and safety guidance and criteria are provided below.

- **Polycyclic Aromatic Hydrocarbons (PAHs)** are formed as a result of the pyrolysis and incomplete combustion of organic matter such as fossil fuel. PAH aerosols formed during the combustion process disperse throughout the atmosphere, resulting in the deposition of PAH condensate in soil, water and on vegetation. In addition, several products formed from petroleum processing operations (e.g., roofing materials and asphalt) also contain elevated levels of PAHs. Hence, these compounds are widely dispersed in the environment. PAHs are characterized by a molecular structure containing three or more fused, unsaturated carbon rings. Seven of the PAHs are classified by USEPA as probable human carcinogens (USEPA Class B2). These are: benzo(a)pyrene; benzo(a)anthracene; benzo(b)fluoranthene; benzo(k)fluoranthene; chrysene; dibenzo(a,h)anthracene; and indeno(1,2,3-cd)pyrene. The primary route of exposure to PAHs is through incidental ingestion and inhalation of contaminated particulates. PAHs are characterized by an organic odor and exist as oily liquids in pure form. Acute exposure symptoms may include acne-type blemishes in areas of the skin exposed to sunlight.
- **Arsenic (CAS #7440-38-2)** is a naturally occurring element and is usually found combined with one or more elements, such as oxygen or sulfur. Inhalation is a more important exposure route than ingestion. First phase exposure symptoms include nausea, vomiting, diarrhea and pain in the stomach. Prolonged contact is corrosive to the skin and mucus membranes. Arsenic is considered a Group A human carcinogen

by the USEPA. Exposure via inhalation is associated with an increased risk of lung cancer. Exposure via the oral route is associated with an increased risk of skin cancer.

- **Barium (CAS #7440-39-3)** is a silvery-white metal that can be found in the environment, where it exists naturally. It occurs combined with other chemicals, such as sulfur, carbon or oxygen. Barium oxidizes in air, reacts vigorously with water to form hydroxide, liberating hydrogen. Barium reacts with almost all the non-metals, forming often poisoning compounds. Flammable solid, dangerous when wet, highly toxic by ingestion. Keep away from all ignition sources. Contact with water produces flammable gas. Target organs include the central nervous system and kidneys. This material is considered hazardous by the OSHA Hazard Communication Standard (29CFR 1910.1200).
- **Cadmium (CAS #7440-43-9)** is a soft, malleable, bluish white metal found in zinc ores. Cadmium and its compounds are highly toxic and exposure to this metal is known to cause cancer and targets the body's cardiovascular, renal, gastrointestinal, neurological, reproductive, and respiratory systems.
- **Lead (CAS #7439-92-1)** is a heavy bluish-gray metal that is lustrous when freshly cut. It is rarely found as a pure metal but rather is complexed with other elements to form lead compounds. It is easily malleable, smelted, and can be added to other metals to form alloys. Resistant to air and water corrosion, it does not mix easily with many solvents but will react with hot acids such as nitric and sulfuric. Burning with a bluish-white flame, powdered lead displays pyrophoricity and releases toxic fumes when burned.
- **Mercury (CAS #7439-97-6)** is the only metal that is a liquid metal at room temperature. Occurring naturally as mercuric sulfide (in cinnabar ore) because of its low boiling point can be isolated readily from the ore and condensing the resulting vapor to form a metal that is 99.9% pure. Solid mercury is ductile and very malleable and is soft enough to cut with a knife. A poor conductor of heat, mercury can conduct electricity but behaves much like a noble gas. It does not react with most acids but can react with very strong acids and dissolves readily to form amalgams with many metals, including gold, zinc, and aluminum.
- **Selenium (CAS #7782-49-2)** is a naturally occurring mineral element that is distributed widely in nature in most rocks and soils. In its pure form, it exists as metallic gray to black hexagonal crystals, but in nature it is usually combined with sulfide or with silver, copper, lead, and nickel minerals. Most processed selenium is used in the electronics industry, but it is also used: as a nutritional supplement; in the glass industry; as a component of pigments in plastics, paints, enamels, inks, and rubber; in the preparation of pharmaceuticals; as a nutritional feed additive for poultry and livestock; in pesticide formulations; in rubber production; as an ingredient in antidandruff shampoos; and as a constituent of fungicides. Radioactive selenium is used in diagnostic medicine.

With respect to the anticipated RI activities discussed in Section 1.5, possible routes of exposure to the above-mentioned contaminants are presented in Table 2. The use of proper respiratory equipment, as outlined in Section 7.0 of this HASP, will minimize the potential for exposure to airborne contamination, if deemed necessary. Exposure to contaminants through dermal and other routes will also be minimized through the use of safe work practices (Section 6.0), protective clothing (Section 7.0), and proper decontamination procedures (Section 12.0).

3.2 Physical Hazards

RI field activities at Haverstraw Chair Factory Site may present the following physical hazards:

- The potential for physical injury during heavy construction equipment use, such as backhoes, excavators, and drilling equipment.
- The potential for heat/cold stress to employees during the summer/winter months (see Section 10.0).
- The potential for slip and fall injuries due to rough, uneven terrain and/or open excavations.

These hazards represent only some of the possible means of injury that may be present during RI operations and sampling activities at the Site. Since it is impossible to list all potential sources of injury, it shall be the responsibility of each individual to exercise proper care and caution during all phases of the work.

4. Training

4.1 Site Workers

All personnel performing RI activities at the Site (such as, but not limited to, equipment operators, general laborers, and drillers) and who may be exposed to hazardous substances, health hazards, or safety hazards and their supervisors/managers responsible for the Site shall receive training in accordance with 29 CFR 1910.120(e) before they are permitted to engage in operations in the exclusion zone or contaminant reduction zone. This training includes an initial 40-hour Hazardous Waste Site Worker Protection Course, an 8-hour Annual Refresher Course subsequent to the initial 40-hour training, and 3 days of actual field experience under the direct supervision of a trained, experienced supervisor. Additional site-specific training shall also be provided by the SSHO prior to the start of field activities. A description of topics to be covered by this training is provided below.

4.1.1 Initial and Refresher Training

Initial and refresher training is conducted by a qualified instructor as specified under OSHA 29 CFR 1910.120(e)(5) and is specifically designed to meet the requirements of OSHA 29 CFR 1910.120(e)(3) and 1910.120(e)(8). The training covers, as a minimum, the following topics:

- OSHA HAZWOPER regulations.
- Site safety and hazard recognition, including chemical and physical hazards.
- Medical monitoring requirements.
- Air monitoring, permissible exposure limits, and respiratory protection level classifications.
- Appropriate use of personal protective equipment (PPE), including chemical compatibility and respiratory equipment selection and use.
- Work practices to minimize risk.
- Work zones and Site control.
- Safe use of engineering controls and equipment.
- Decontamination procedures.
- Emergency response and escape.
- Confined space entry procedures.
- Heat and cold stress monitoring.
- Elements of a Health and Safety Plan.
- Spill containment.

Initial training also incorporates workshops for PPE and respiratory equipment use (Levels A, B and C), and respirator fit testing. Records and certification received from the course instructor documenting each employee's successful completion of the training identified above are maintained on file at Roux's Buffalo, NY office. Contractors and Subcontractors are required to provide similar documentation of training for all their personnel who will be involved in on-site work activities.

Any employee who has not been certified as having received health and safety training in conformance with 29 CFR 1910.120(e) is prohibited from working in the exclusion and contamination reduction zones, or to engage in any on-site work activities that may involve exposure to hazardous substances or wastes.

4.1.2 Site Training

Site workers are given a copy of the HASP and provided with a site-specific briefing prior to the commencement of work to ensure that employees are familiar with the HASP and the information and requirements it contains. The Site briefing shall be provided by the SSHO prior to initiating field activities and shall include:

- Names of personnel and alternates responsible for Site safety and health.
- Safety, health, and other hazards present on the Site.
- The site layout including work zones and places of refuge.
- The emergency communications system and emergency evacuation procedures.
- Use of PPE.
- Work practices by which the employee can minimize risks from hazards.
- Safe use of engineering controls and equipment on the site.
- Medical surveillance, including recognition of symptoms and signs of over-exposure as described in Chapter 5 of this HASP.
- Decontamination procedures as detailed in Chapter 12 of this HASP.
- The emergency response plan is detailed in Chapter 15 of this HASP.
- Confined space entry procedures, if required, as detailed in Chapter 13 of this HASP.
- The spill containment program as detailed in Chapter 9 of this HASP.
- Site control as detailed in Chapter 11 of this HASP.

Supplemental health and safety briefings will also be conducted by the SSHO on an as-needed basis during the course of the work. Supplemental briefings are provided as necessary to notify employees of any changes to this HASP as a result of information gathered during ongoing Site characterization and analysis. Conditions for which the SSHO may schedule additional briefings

include but are not limited to: a change in Site conditions (e.g., based on monitoring results); changes in the work schedule/plan; newly discovered hazards; and safety incidents occurring during Site work.

4.2 Supervisor Training

On-site safety and health personnel who are directly responsible for or who supervise the safety and health of workers engaged in hazardous waste operations (i.e., SSHO) shall receive, in addition to the appropriate level of worker training described in Section 4.1, above, eight additional hours of specialized supervisory training, in compliance with 29 CFR 1910.120(e)(4).

4.3 Emergency Response Training

Emergency response training is addressed in Attachment A of this HASP, Emergency Response Plan.

4.4 Site Visitors

Each Contractor's SSHO will provide a site-specific briefing to all Site visitors and other non-Roux personnel who enter the Site beyond the Site entry point. The site-specific briefing will provide information about Site hazards, the Site layout including work zones and places of refuge, the emergency communications system and emergency evacuation procedures, and other pertinent safety and health requirements as appropriate.

Site visitors will not be permitted to enter the exclusion zone or contaminant reduction zones unless they have received the level of training required for Site workers as described in Section 4.1.

5. Medical Monitoring

Medical monitoring examinations are provided to Roux employees as stipulated under 29 CFR Part 1910.120(f). These exams include initial employment, annual and employment termination physicals for all Roux employees involved in hazardous waste site field operations. Post-exposure examinations are also provided for employees who may have been injured, received a health impairment, or developed signs or symptoms of over-exposure to hazardous substances or were accidentally exposed to substances at concentrations above the permissible exposure limits without necessary personal protective equipment. Such exams are performed as soon as possible following development of symptoms or the known exposure event.

Medical evaluations are performed by Health Works, an occupational health care provider under contract with Roux. Health Works is in Seneca Square Plaza, 1900 Ridge Road, West Seneca, New York 14224. The facility can be reached at (716) 823-5050 to schedule routine appointments or post-exposure examinations.

Medical evaluations are conducted according to the Roux Medical Monitoring Program and include an evaluation of the workers' ability to use respiratory protective equipment. The examinations include:

- Occupational/medical history review.
- Physical exam, including vital sign measurement.
- Spirometry testing.
- Eyesight testing.
- Audio testing (minimum baseline and exit, annual for employees routinely exposed to greater than 85db).
- EKG (for employees >40 yrs age or as medical conditions dictate).
- Chest X-ray (baseline and exit, and every 5 years).
- Blood biochemistry (including blood count, white cell differential count, serum multiplastic screening).
- Medical certification of physical requirements (i.e., sight, musculoskeletal, cardiovascular) for safe job performance and to wear respiratory protection equipment.

The purpose of the medical evaluation is to determine an employee's fitness for duty on hazardous waste sites; and to establish baseline medical data. In conformance with OSHA regulations, Roux will maintain and preserve medical records for a period of 30 years following termination of employment. Employees are provided with a copy of the physician's post-exam

report and have access to their medical records and analyses.

6. Safe Work Practices

All Roux employees shall conform to the following safe work practices during all on-site work activities conducted within the exclusion and contamination reduction zones:

- Eating, drinking, chewing gum or tobacco, smoking, or any practice that increases the probability of hand-to-mouth contact is strictly prohibited.
- The hands and face must be thoroughly washed upon leaving the work area and prior to engaging in any activity indicated above.
- Respiratory protective equipment and clothing must be worn by all personnel entering the Site as required by the HASP or as modified by the Site safety officer. Excessive facial hair (i.e., beards, long mustaches, or sideburns) that interferes with the satisfactory respirator-to-face seal is prohibited.
- Contact with surfaces/materials either suspected or known to be contaminated will be avoided to minimize the potential for transfer to personnel, cross contamination and need for decontamination.
- Medicine and alcohol can synergize the effects of exposure to toxic chemicals. Due to possible contraindications, use of prescribed drugs should be reviewed with the Roux occupational physician. Alcoholic beverages and illegal drug intake are strictly forbidden during the workday.
- All personnel shall be familiar with standard operating safety procedures and additional instructions contained in this Health and Safety Plan.
- On-site personnel shall use the “buddy” system. No one may work alone (i.e., out of earshot or visual contact with other workers) in the exclusion zone.
- Personnel and equipment in the contaminated area shall be minimized, consistent with effective Site operations.
- All employees have the obligation to immediately report and if possible, correct unsafe work conditions.
- Use of contact lenses on-site will not be permitted. Spectacle kits for insertion into full-face respirators will be provided for Roux employees, as requested, and required.

The recommended specific safety practices for working around the contractor’s equipment (e.g., backhoes, bulldozers, excavators, drill rigs etc.) are as follows:

- Although the Contractor and subcontractors are responsible for their equipment and safe operation of the Site, Roux personnel are also responsible for their own safety.
- Subsurface work will not be initiated without first clearing underground utility services.
- Heavy equipment should not be operated within 20 feet of overhead wires. This

distance may be increased if windy conditions are anticipated or if lines carry high voltage. The Site should also be sufficiently clear to ensure the project staff can move around the heavy machinery safely.

- Care should be taken to avoid overhead wires when moving heavy equipment from location to location.
- Hard hats, safety boots and safety glasses should be always worn in the vicinity of heavy equipment. Hearing protection is also recommended.
- The work Site should be kept neat. This will prevent personnel from tripping and will allow for fast emergency exit from the Site.
- Proper lighting must be provided when working at night.
- Construction activities should be discontinued during an electrical storm or severe weather conditions.
- The presence of combustible gases should be checked before igniting any open flame.
- Personnel shall stand upwind of any construction operation when not immediately involved in sampling/logging/observing activities.
- Personnel will not approach the edge of an unsecured trench/excavation closer than two feet.

7. Personal Protective Equipment

7.1 Equipment Selection

PPE will be donned when work activities may result in exposure to physical or chemical hazards beyond acceptable limits, and when such exposure can be mitigated through appropriate PPE. The selection of PPE will be based on an evaluation of the performance characteristics of the PPE relative to the requirements and limitations of the Site, the task-specific conditions and duration, and the hazards and potential hazards identified at the Site.

Equipment designed to protect the body against contact with known or suspected chemical hazards are grouped into four categories according to the degree of protection afforded. These categories designated A through D consistent with United States Environmental Protection Agency (USEPA) Level of Protection designation, are:

- Level A: Should be selected when the highest level of respiratory, skin and eye protection is needed.
- Level B: Should be selected when the highest level of respiratory protection is needed, but a lesser level of skin protection is required. Level B protection is the minimum level recommended on initial Site entries until the hazards have been further defined by on-site studies. Level B (or Level A) is also necessary for oxygen-deficient atmospheres.
- Level C: Should be selected when the types of airborne substances are known, the concentrations have been measured and the criteria for using air-purifying respirators are met. In atmospheres where no airborne contaminants are present, Level C provides dermal protection only.
- Level D: Should not be worn on any Site with elevated respiratory or skin hazards. This is generally a work uniform providing minimal protection.

OSHA requires the use of certain PPE under conditions where an immediate danger to life and health (IDLH) may be present. Specifically, OSHA 29 CFR 1910.120(g)(3)(iii) requires use of a positive pressure self-contained breathing apparatus, or positive pressure air-line respirator equipped with an escape air supply when chemical exposure levels present a substantial possibility of immediate serious injury, illness, or death, or impair the ability to escape. Similarly, OSHA 29 CFR 1910.120(g)(3)(iv) requires donning totally encapsulating chemical protective suits (with a protection level equivalent to Level A protection) in conditions where skin absorption of a hazardous substance may result in a substantial possibility of immediate serious illness, injury, or death, or impair the ability to escape.

In situations where the types of chemicals, concentrations, and possibilities of contact are unknown, the appropriate level of protection must be selected based on professional experience and judgment until the hazards can be further characterized. The individual components of clothing and equipment must be assembled into a full protective ensemble to protect the worker from site-specific hazards, while at the same time minimizing hazards and drawbacks of the

personal protective gear itself. Ensemble components are detailed below for levels A/B, C, and D protection.

7.2 Protection Ensembles

7.2.1 Level A/B Protection Ensemble

Level A/B ensembles include similar respiratory protection; however, Level A provides a higher degree of dermal protection than Level B. Use of Level A over Level B is determined by comparing the concentrations of identified substances in the air with skin toxicity data and assessing the effect of the substance (by its measured air concentrations or splash potential) on the small area of the head and neck unprotected by Level B clothing.

The recommended PPE for level A/B is:

- Pressure-demand, full-face piece self-contained breathing apparatus (MSHA/-NIOSH approved) or pressure-demand supplied-air respirator with escape self-contained breathing apparatus (SCBA);
- Chemical-resistant clothing. For Level A, clothing consists of totally encapsulating chemical resistant suit. Level B incorporates hooded one-or two-piece chemical splash suit;
- Inner and outer chemical resistant gloves;
- Chemical-resistant safety boots/shoes; and
- Hardhat.

7.2.2 Level C Protection Ensemble

Level C protection is distinguished from Level B by the equipment used to protect the respiratory system, assuming the same type of chemical-resistant clothing is used. The main selection criterion for Level C is that conditions permit wearing an air-purifying device. The device (when required) must be an air-purifying respirator (MSHA/NIOSH approved) equipped with filter cartridges. Cartridges must be able to remove the substances encountered. Respiratory protection will be used only with proper fitting, training, and the approval of a qualified individual. In addition, an air-purifying respirator can be used only if: oxygen content of the atmosphere is at least 19.5% in volume; substances are identified and concentrations measured; substances have adequate warning properties; the individual passes a qualitative fit-test for the mask; and an appropriate cartridge/canister is used, and its service limit concentration is not exceeded.

Recommended PPE for Level C conditions includes:

- Full-face piece, air-purifying respirator equipped with MSHA and NIOSH approved organic vapor/acid gas/dust/mist combination cartridges or as designated by the SSHO;
- Chemical-resistant clothing (hooded, one or two-piece chemical splash suit or disposable chemical-resistant one-piece suit);

- Inner and outer chemical-resistant gloves;
- Chemical-resistant safety boots/shoes; and
- Hardhat.

An air-monitoring program is part of all response operations when atmospheric contamination is known or suspected. It is particularly important that the air be monitored thoroughly when personnel are wearing air-purifying respirators. Continual surveillance using direct-reading instruments is needed to detect any changes in air quality necessitating a higher level of respiratory protection.

7.2.3 Level D Protection Ensemble

As indicated above, Level D protection is primarily a work uniform. It can be worn in areas where only boots can be contaminated, where there are no inhalable toxic substances and where the atmosphere contains at least 19.5% oxygen.

Recommended PPE for Level D includes:

- Coveralls;
- Safety boots/shoes;
- Safety glasses or chemical splash goggles;
- Hardhat; and
- Optional gloves, escape mask; face shield.

7.2.4 Recommended Level of Protection for Site Tasks

Based upon current information regarding both the contaminants suspected to be present at the Site and the various tasks that are included in the remedial activities, the minimum required levels of protection for these tasks shall be as identified in Table 3.

8. Exposure Monitoring

8.1 General

Based on the results of historic sample analysis and the nature of the proposed work activities at the Site, the possibility exists that organic vapors and/or particulates may be released to the air during intrusive construction activities. Ambient breathing zone concentrations may at times exceed the permissible exposure limits (PELs) established by OSHA for the individual compounds (see Table 1), in which case respiratory protection will be required. Respiratory and dermal protection may be modified (upgraded or downgraded) by the SSHO based upon real-time field monitoring data.

8.1.1 On-Site Work Zone Monitoring

Roux personnel will conduct routine, real-time air monitoring during all intrusive construction phases such as excavation, backfilling, drilling, etc. The work area will be monitored at regular intervals using a PID, combustible gas meter and a particulate meter. Observed values will be recorded and maintained as part of the permanent field record.

Additional air monitoring measurements may be made by Roux personnel to verify field conditions during subcontractor oversight activities. Monitoring instruments will be protected from surface contamination during use. Additional monitoring instruments may be added if the situations or conditions change. Monitoring instruments will be calibrated in accordance with manufacturer's instructions before use.

8.1.2 Off-Site Community Air Monitoring

In addition to on-site monitoring within the work zone(s), monitoring at the downwind portion of the Site perimeter will be conducted. This will provide a real-time method for determination of vapor and/or particulate releases to the surrounding community as a result of ground intrusive investigation work.

Ground intrusive activities are defined in the Generic Community Air Monitoring Plan and ~~attached-included~~ as ~~Attachment Appendix C~~ of the Remedial Investigation Work Plan (RIWP). Ground intrusive activities include soil/waste excavation and handling, test pitting or trenching, and the installation of soil borings or monitoring wells. Non-intrusive activities include the collection of soil and sediment samples or the collection of groundwater samples from existing wells. Continuous monitoring is required for ground intrusive activities and periodic monitoring is required for non-intrusive activities. Periodic monitoring consists of taking a reading upon arrival at a sample location, monitoring while opening a well cap or overturning soil, monitoring while bailing a well, and taking a reading prior to leaving a sampling location. This may be

upgraded to continuous if the sampling location is in close proximity to individuals not involved in the Site activity (i.e., on a curb of a busy street). The action levels below will be used during periodic monitoring.

8.2 Monitoring Action Levels

8.2.1 On-Site Work Zone Action Levels

The PID, or other appropriate instrument(s), will be used by Roux personnel to monitor organic vapor concentrations as specified in this HASP. Combustible gas will be monitored with the “combustible gas” option on the combustible gas meter or other appropriate instrument(s). In addition, fugitive dust/particulate concentrations will be monitored during major soil intrusion (viz., well/boring installation) using a real-time particulate monitor as specified in this plan. In the absence of such monitoring, appropriate respiratory protection for particulates shall be donned. Sustained readings obtained in the breathing zone may be interpreted (with regard to other Site conditions) as follows for Roux personnel:

- Total atmospheric concentrations of unidentified vapors or gases ranging from 0 to 1 ppm above background on the PID) - Continue operations under Level D (see Appendix A).
- Total atmospheric concentrations of unidentified vapors or gases yielding sustained readings from >1 ppm to 5 ppm above background on the PID (vapors not suspected of containing high levels of chemicals toxic to the skin) - Continue operations under Level C (see Appendix A).
- Total atmospheric concentrations of unidentified vapors or gases yielding sustained readings of >5 ppm to 50 ppm above background on the PID - Continue operations under Level B (see Appendix A), re-evaluate and alter (if possible) construction methods to achieve lower vapor concentrations.
- Total atmospheric concentrations of unidentified vapors or gases above 50 ppm on the PID - Discontinue operations and exit the work zone immediately.

The particulate monitor will be used to monitor respirable dust concentrations during all intrusive activities and during handling of Site soil/fill. Action levels based on the instrument readings shall be as follows:

- Less than 50 mg/m³ - Continue field operations.
- 50-150 mg/m³ - Don dust/particulate mask or equivalent
- Greater than 150 mg/m³ - Don dust/particulate mask or equivalent. Initiate engineering controls to reduce respirable dust concentration (viz., wetting of excavated soils or tools at discretion of Site Health and Safety Officer).

Readings from the field equipment will be recorded and documented on the appropriate Project Field Forms. All instruments will be calibrated before use daily and the procedure will be documented on the appropriate Project Field Forms.

8.2.2 Community Air Monitoring Action Levels

In addition to the action levels prescribed in Section 8.2.1 for Roux personnel on-site, the following criteria shall also be adhered to for the protection of downwind receptors consistent with NYSDOH requirements (~~Attachment C~~Appendix F):

- ORGANIC VAPOR PERIMETER MONITORING:
 1. If the sustained ambient air concentration of organic vapors at the downwind perimeter of the exclusion zone exceeds 5 ppm above background for the 15-minute average, work activities will be temporarily halted and monitoring continued. If the sustained organic vapor decreases below 5 ppm over background, work activities can resume with continued monitoring.
 2. If the sustained ambient air concentration of organic vapors at the downwind perimeter of the exclusion zone are greater than 5 ppm over background but less than 25 ppm for the 15-minute average, activities can resume provided that: the organic vapor level 200 feet downwind of the working site or half the distance to the nearest off-site residential or commercial structure, whichever is less, but in no case less than 20 feet, is below 5 ppm over background; and more frequent intervals of monitoring, as directed by the Site Health and Safety Officer, are conducted.
 3. If the sustained organic vapor level is above 25 ppm at the perimeter of the exclusion zone for the 15-minute average, the Site Health and Safety Officer must be notified, and work activities shut down. The Site Health and Safety Officer will determine when re-entry of the exclusion zone is possible and will implement downwind air monitoring to ensure vapor emissions do not impact the nearest off-site residential or commercial structure at levels exceeding those specified in the Organic Vapor Contingency Monitoring Plan below. All readings will be recorded and will be available for New York State Department of Environmental Conservation (DEC) and Department of Health (DOH) personnel to review.
- ORGANIC VAPOR CONTINGENCY MONITORING PLAN:
 1. If the sustained organic vapor level is greater than 5 ppm over background 200 feet downwind from the work area or half the distance to the nearest off-site residential or commercial property, whichever is less, all work activities must be halted.
 2. If, following the cessation of the work activities or as the result of an emergency, sustained organic levels persist above 5 ppm above background 200 feet downwind or half the distance to the nearest off-site residential or commercial property from the work area, then the air quality must be monitored within 20 feet of the perimeter of the nearest off-site residential or commercial structure (20-foot zone).

3. If efforts to abate the emission source are unsuccessful and if sustained organic vapor levels approach or exceed 5 ppm above background within the 20-foot zone for more than 30 minutes or are sustained at levels greater than 10 ppm above background for longer than one minute, then the Major Vapor Emission Response Plan (see below) will automatically be placed into effect.
- **MAJOR VAPOR EMISSION RESPONSE PLAN:**
Upon activation, the following activities will be undertaken:
 1. All Emergency Response Contacts listed in this Health and Safety Plan and the Emergency Response Plan (Attachment A) will be advised.
 2. The local police authorities will immediately be contacted by the Site Health and Safety Officer and advised of the situation.
 3. Frequent air monitoring will be conducted at 30-minute intervals within the 20-foot zone. If two sustained successive readings below action levels are measured, air monitoring may be halted or modified by the Site Health and Safety Officer.

The following personnel are to be notified in the listed sequence if a Major Vapor Emission Plan is activated:

Responsible Person	Contact	Phone Number
SSHO	Police	911
SSHO	State Emergency Response Hotline	(800) 457-7362

Additional emergency numbers are listed in the Emergency Response Plan included as Attachment A.

- **EXPLOSIVE VAPORS:**
 1. Sustained atmospheric concentrations of greater than 10% LEL in the work area - Initiate combustible gas monitoring at the downwind portion of the Site perimeter.
 2. Sustained atmospheric concentrations of greater than 10% LEL at the downwind Site perimeter – Halt work and contact local Fire Department.
- **AIRBORNE PARTICULATE COMMUNITY AIR MONITORING**
Respirable (PM-10) particulate monitoring will be performed on a continuous basis at the upwind and downwind perimeter of the exclusion zone. The monitoring will be performed using real-time monitoring equipment capable of measuring PM-10 and integrating over a period of 15-minutes for comparison to the airborne particulate action levels. The equipment will be equipped with an audible alarm to indicate exceedance of the action level. In addition, fugitive dust migration will be visually assessed during all work activities. All readings will be recorded and will be available for NYSDEC and NYSDOH review. Readings will be interpreted as follows:

1. If the downwind PM-10 particulate level is 100 micrograms per cubic meter (ug/m3) greater than the background (upwind perimeter) reading 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 provided that the downwind PM-10 particulate levels do not exceed 150 ug/m3 above the upwind level and that visible dust is not migrating from the work area.
2. If, after implementation of dust suppression techniques downwind PM-10 levels are greater than 150 ug/m3 above the upwind level, work activities must be stopped and dust suppression controls re-evaluated. Work can resume provided that supplemental dust suppression measures and/or other controls are successful in reducing the downwind PM-10 particulate concentration to within 150 ug/m3 of the upwind level and in preventing visible dust migration.

Pertinent emergency response information including the telephone number of the Fire Department is included in the Emergency Response Plan (Attachment A).

9. Spill Release/Response

This chapter of the HASP describes the potential for, and procedures related to spills or releases of known or suspected petroleum and/or hazardous substances on the Site. The purpose of this Section of the HASP is to plan appropriate response, control, countermeasures, and reporting, consistent with OSHA requirements in 29 CFR 1910.120(b)(4)(ii)(J) and (j)(1)(viii). The spill containment program addresses the following elements:

- Potential hazardous material spills and available controls.
- Initial notification and evaluation.
- Spill response.
- Post-spill evaluation.

9.1 Potential Spills and Available Controls

An evaluation was conducted to determine the potential for hazardous material and oil/petroleum spills at this Site. For this evaluation, hazardous materials posing a significant spill potential are:

- CERCLA Hazardous Substances as identified in 40 CFR Part 302, where such materials pose the potential for release in excess of their corresponding Reportable Quantity (RQ).
- Extremely Hazardous Substances as identified in 40 CFR Part 355, Appendix A, where such materials pose the potential for release in excess of their corresponding Reportable Quantity (RQ).
- Hazardous Chemicals as defined under Section 311(e) of the Emergency Planning and Community Right-To-Know Act of 1986, where such chemicals are present or will be stored in excess of 10,000 lbs.
- Toxic Chemicals as defined in 40 CFR Part 372, where such chemicals are present or will be stored in excess of 10,000 lbs.
- Chemicals regulated under 6NYCRR Part 597, where such materials pose the potential for release in excess of their corresponding Reportable Quantity (RQ).
- Oil/petroleum products are considered to pose a significant spill potential whenever the following situations occur:
 - The potential for a “harmful quantity” of oil (including petroleum and non-petroleum-based fuels and lubricants) to reach navigable waters of the U.S. exists (40 CFR Part 112.4). Harmful quantities are considered by USEPA to be volumes that could form a visible sheen on the water or violate applicable water quality standards.
 - The potential for any amount of petroleum to reach any waters of NY State, including groundwater, exists. Petroleum, as defined by NY State in 6NYCRR Part 612, is a petroleum-based heat source, energy source, or engine lubricant/maintenance fluid.

- The potential for any release, to soil or water, of petroleum from a bulk storage facility regulated under 6NYCRR Part 612. A regulated petroleum storage facility is defined by NY State as a site having stationary tank(s) and intra-facility piping, fixtures, and related equipment with an aggregate storage volume of 1,100 gallons or greater.

The evaluation indicates that, based on Site history and decommissioning records, a hazardous material spill and/or a petroleum product spill is not likely to occur during RI efforts.

9.2 Initial Spill Notification and Evaluation

Any worker who discovers a hazardous substance or oil/petroleum spill will immediately notify the Project Manager and SSHO. The worker will, to the best of his/her ability, report the material involved, the location of the spill, the estimated quantity of material spilled, the direction/flow of the spill material, related fire/explosion incidents, if any, and any associated injuries. The Emergency Response Plan presented in Appendix A of this HASP will immediately be implemented if an emergency release has occurred.

Following the initial report of a spill, the Project Manager will make an evaluation as to whether the release exceeds RQ levels. If an RQ level is exceeded, the Project Manager will notify the Site owner and NYSDEC at 1-800-457-7362 within 2 hours of spill discovery. The Project Manager will also determine what additional agencies (e.g., USEPA) are to be contacted regarding the release, and will follow up with written reports as required by the applicable regulations.

9.3 Spill Response

For all spill situations, the following general response guidelines will apply:

- Only those personnel involved in overseeing or performing containment operations will be allowed within the spill area. If necessary, the area will be roped, ribboned, or otherwise blocked off to prevent unauthorized access.
- Appropriate PPE, as specified by the SSHO, will be donned before entering the spill area.
- Ignition points will be extinguished/removed if fire or explosion hazards exist.
- Surrounding reactive materials will be removed.
- Drains or drainage in the spill area will be blocked to prevent inflow of spilled materials or applied materials.

For minor spills, the Contractor will maintain a Spill Control and Containment Kit in the Field Office or other readily accessible storage location. The kit will consist of, at a minimum, a 50 lb. bag of “speedy dry” granular absorbent material, absorbent pads, shovels, empty 5-gallon pails and an empty open-top 55-gallon drum. Spilled materials will be absorbed and shoveled into a 55-gallon drum for proper disposal (NYSDEC approval will be secured for on-site treatment of the impacted soils/absorbent materials, if applicable). Impacted soils will be hand-excavated to the point that no visible signs of contamination remains and will be drummed with the absorbent.

In the event of a major release or a release that threatens surface water, a spill response contractor will be called to the Site. The response contractor may use heavy equipment (e.g., excavator, backhoe, etc.) to berm the soils surrounding the spill Site or create diversion trenching to mitigate overland migration or release to navigable waters. Where feasible, pumps will be used to transfer free liquid to storage containers. Spill control/cleanup contractors in the Western New York area that may be contacted for assistance include:

- The Environmental Service Group of NY, Inc.: (716) 695-6720
- Environmental Products and Services, Inc.: (716) 447-4700
- Op-Tech: (716) 873-7680

9.4 Post-Spill Evaluation

If a reportable quantity of hazardous material or oil/petroleum is spilled as determined by the Project Manager, a written report will be prepared as indicated in Section 9.2. The report will identify the root cause of the spill, type and amount of material released, date/time of release, response actions, agencies notified and/or involved in cleanup, and procedures to be implemented to avoid repeat incidents. In addition, all re-useable spill cleanup and containment materials will be decontaminated, and spill kit supplies/disposable items will be replenished.

10. Heat/Cold Stress Monitoring

Since some of the work activities at the Site will be scheduled for both the summer and winter months, measures will be taken to minimize heat/cold stress to Roux employees. The Site Safety and Health Officer and/or his or her designee will be responsible for monitoring Roux field personnel for symptoms of heat/cold stress.

10.1 Heat Stress Monitoring

Personal protective equipment may place an employee at risk of developing heat stress, a common and potentially serious illness often encountered at construction, landfill, waste disposal, industrial or other unsheltered sites. The potential for heat stress is dependent on several factors, including environmental conditions, clothing, workload, physical condition, and age. Personal protective equipment may severely reduce the body's normal ability to maintain temperature equilibrium (via evaporation and convection) and require increased energy expenditure due to its bulk and weight.

Proper training and preventive measures will mitigate the potential for serious illness. Heat stress prevention is particularly important because once a person suffers from heat stroke or heat exhaustion, that person may be predisposed to additional heat related illness. To avoid heat stress, the following steps should be taken:

- Adjust work schedules.
- Modify work/rest schedules according to monitoring requirements.
- Mandate work slowdowns as needed.
- Perform work during cooler hours of the day if possible or at night if adequate lighting can be provided.
- Provide shelter (air-conditioned, if possible) or shaded areas to protect personnel during rest periods.
- Maintain worker's body fluids at normal levels. This is necessary to ensure that the cardiovascular system functions adequately. Daily fluid intake must approximately equal the amount of water lost in sweat (i.e., eight fluid ounces must be ingested for approximately every 1 lb of weight lost). The normal thirst mechanism is not sensitive enough to ensure that enough water will be consumed to replace lost perspiration. When heavy sweating occurs, workers should be encouraged to drink more.
- Train workers to recognize the symptoms of heat related illness.

Heat-Related Illness - Symptoms:

- Heat rash may result from continuous exposure to heat or humid air.
- Heat cramps are caused by heavy sweating with inadequate electrolyte replacement. Signs and symptoms include muscle spasms, pain in the hands, feet, and abdomen.

- Heat exhaustion occurs from increased stress on various body organs including inadequate blood circulation due to cardiovascular insufficiency or dehydration. Signs and symptoms include pale, cool, moist skin; heavy sweating; dizziness; nausea; fainting.
- Heat stroke is the most serious form of heat stress. Temperature regulation fails and the body temperature rises to critical levels. Immediate action must be taken to cool the body before serious injury and death occur. Competent medical help must be obtained. Signs and symptoms are red, hot, usually dry skin; lack of or reduced perspiration; nausea; dizziness and confusion; strong, rapid pulse; coma.

The monitoring of personnel wearing protective clothing should commence when the ambient temperature is 70 degrees Fahrenheit or above. For monitoring the body's recuperative ability to excess heat, one or more of the following techniques should be used as a screening mechanism.

- Heart rate may be measured by the radial pulse for 30 seconds as early as possible in the resting period. The rate at the beginning of the rest period should not exceed 100 beats per minute. If the rate is higher, the next work period should be shortened by 10 minutes (or 33%), while the length of the rest periods stay the same. If the pulse rate is 100 beats per minute at the beginning of the next rest period, the following work cycle should be further shortened by 33%.
- Body temperature may be measured orally with a clinical thermometer as early as possible in the resting period. Oral temperature at the beginning of the rest period should not exceed 99.6 degrees Fahrenheit. If it does, the next work period should be shortened by 10 minutes (or 33%), while the length of the rest period remains the same. However, if the oral temperature exceeds 99.6 degrees Fahrenheit at the beginning of the next period, the work cycle may be further shortened by 33%. Oral temperature should be measured at the end of the rest period to make sure that it has dropped below 99.6 degrees Fahrenheit. No Roux employee will be permitted to continue wearing semi-permeable or impermeable garments when his/her oral temperature exceeds 100.6 degrees Fahrenheit.

10.2 Cold Stress Monitoring

Exposure to cold conditions may result in frostbite or hypothermia, each of which progresses in stages as shown below.

- Frostbite occurs when body tissue (usually on the extremities) begins to freeze. The three states of frostbite are:
 1. Frost nip - This is the first stage of the freezing process. It is characterized by a whitened area of skin, along with a slight burning or painful sensation. Treatment consists of removing the victim from the cold conditions, removal of boots and gloves, soaking the injured part in warm water (102 to 108 degrees Fahrenheit) and drinking a warm beverage. Do not rub skin to generate friction/ heat.
 2. Superficial Frostbite - This is the second stage of the freezing process. It is characterized by a whitish gray area of tissue, which will be firm to the touch but will yield little pain. The treatment is identical for Frost nip.

3. Deep Frostbite - In this final stage of the freezing process the affected tissue will be cold, numb, and hard and will yield little to no pain. Treatment is identical to that for Frost nip.
- Hypothermia is a serious cold stress condition occurring when the body loses heat at a rate faster than it is produced. If untreated, hypothermia may be fatal. The stages of hypothermia may not be clearly defined or visible at first, but generally include:
 1. Shivering
 2. Apathy (i.e., a change to an indifferent or uncaring mood)
 3. Unconsciousness
 4. Bodily freezing

Employees exhibiting signs of hypothermia should be treated by medical professionals. Steps that can be taken while awaiting help include:

1. Remove the victim from the cold environment and remove wet or frozen clothing. (Do this carefully as frostbite may have started.)
2. Perform active re-warming with hot liquids for drinking (Note: do not give the victim any liquid containing alcohol or caffeine) and a warm water bath (102 to 108 degrees Fahrenheit).
3. Perform passive re-warming with a blanket or jacket wrapped around the victim.

In any potential cold stress situation, it is the responsibility of the Site Health and Safety Officer to encourage the following:

- Education of workers to recognize the symptoms of frostbite and hypothermia.
- Workers should dress warmly, with more layers of thin clothing as opposed to one thick layer.
- Personnel should remain active and keep moving.
- Personnel should be allowed to take shelter in a heated area, as necessary.
- Personnel should drink warm liquids (no caffeine or alcohol if hypothermia has set in).
- For monitoring the body's recuperation from excess cold, oral temperature recordings should occur:
 1. At the Site Safety Technicians discretion when suspicion is based on changes in a worker's performance or mental status.
 2. At a worker's request.
 3. As a screening measure, two times per shift, under unusually hazardous conditions (e.g., wind chill less than 20 degrees Fahrenheit or wind chill less than 30 degrees Fahrenheit with precipitation).

4. As a screening measure, whenever anyone worker on-site develops hypothermia.

Any person developing moderate hypothermia (a core body temperature of 92 degrees Fahrenheit) will not be allowed to return to work for 48 hours without the recommendation of a qualified medical doctor.

11. Work Zones and Site Control

Work zones around the areas designated for construction activities will be established daily and communicated to all employees and other Site users by the SSHO. It shall be each Contractor's Site Safety and Health Officer's responsibility to ensure that all Site workers are aware of the work zone boundaries and to enforce proper procedures in each area. The zones will include:

- Exclusion Zone ("Hot Zone") - The area where contaminated materials may be exposed, excavated, or handled and all areas where contaminated equipment or personnel may travel. Flagging tape will delineate the zone. All personnel entering the Exclusion Zone must wear the prescribed level of personal protective equipment identified in Section 7.
- Contamination Reduction Zone - The zone where decontamination of personnel and equipment takes place. Any potentially contaminated clothing, equipment and samples must remain in the Contamination Reduction Zone until decontaminated.
- Support Zone - The part of the site that is considered non-contaminated or "clean." Support equipment will be in this zone, and personnel may wear normal work clothes within this zone.

In the absence of other task-specific work zone boundaries established by the SSHO, the following boundaries will apply to all investigation and construction activities involving disruption or handling of Site soils or groundwater:

- Exclusion Zone: 50-foot radius from the outer limit of the sampling/construction activity.
- Contaminant Reduction Zone: 100-foot radius from the outer limit of the sampling/construction activity.
- Support Zone: Areas outside the Contaminant Reduction Zone.

Access of non-essential personnel to the Exclusion and Contamination Reduction Zones will be strictly controlled by the SSHO. Only personnel who are essential to the completion of the task will be allowed access to these areas and only if they are wearing the prescribed level of protection. Entrance of all personnel must be approved by the SSHO.

The SSHO will maintain a Health and Safety Logbook containing the names of Roux workers and their level of protection. The zone boundaries may be changed by the SSHO as environmental conditions warrant, and to respond to the necessary changes in work locations on-site.

12. Decontamination

12.1 Decontamination for Roux Employees

The degree of decontamination required is a function of a particular task and the environment within which it occurs. The following decontamination procedure will remain flexible, thereby allowing the decontamination crew to respond appropriately to the changing environmental conditions that may arise at the Site. All Roux personnel on-site shall follow the procedure below, or the Contractor's procedure (if applicable), whichever is more stringent.

Station 1 - Equipment Drop: Deposit visibly contaminated (if any) re-useable equipment used in the contamination reduction and exclusion zones (tools, containers, monitoring instruments, radios, clipboards, etc.) on plastic sheeting.

Station 2 - Boots and Gloves Wash and Rinse: Scrub outer boots and outer gloves. Deposit tape and gloves in waste disposal container.

Station 3 - Tape, Outer Boot and Glove Removal: Remove tape, outer boots, and gloves. Deposit tape and gloves in waste disposal container.

Station 4 - Canister or Mask Change: If a worker leaves exclusion zones to change canister (or mask), this is the last step in the decontamination procedure. Worker's canister is exchanged, new outer gloves and boot cover donned, and worker returns to duty.

Station 5 - Outer Garment/Face Piece Removal: Protective suit removed and deposited in separate container provided by Contractor. Face piece or goggles are removed if used. Avoid touching face with fingers. Face piece and/or goggles deposited on plastic sheet. Hard hat removed and placed on plastic sheet.

Station 6 - Inner Glove Removal: Inner gloves are the last personal protective equipment to be removed. Avoid touching the outside of the gloves with bare fingers. Dispose of these gloves in waste disposal container.

Following PPE removal, personnel shall wash hands, face, and forearms with absorbent wipes. If field activities proceed for duration of six consecutive months or longer, shower facilities will be provided for worker use in accordance with OSHA 29 CFR 1910.120(n).

12.2 Decontamination for Medical Emergencies

In the event of a minor, non-life-threatening injury, personnel should follow the decontamination procedures as defined, and then administer first-aid.

In the event of a major injury or other serious medical concern (e.g., heat stroke), immediate first aid is to be administered and the victim transported to the hospital in lieu of further decontamination efforts unless exposure to a Site contaminant would be considered "Immediately Dangerous to Life or Health."

12.3 Decontamination of Field Equipment

The Contractor, in accordance with his approved Health and Safety Plan in the Contamination Reduction Zone will conduct decontamination of heavy equipment. As a minimum, this will include manually removing heavy soil contamination, followed by steam cleaning on an impermeable pad.

Roux personnel will conduct decontamination of all tools used for sample collection purposes. It is expected that all tools will be constructed of nonporous, nonabsorbent materials (i.e., metal), which will aid in the decontamination effort. Any tool or part of a tool made of porous, absorbent material (i.e., wood) will be placed into suitable containers and prepared for disposal.

Decontamination of bailers, split-spoons, spatula knives, and other tools used for environmental sampling and examination shall be as follows:

- Disassemble the equipment.
- Water wash to remove all visible foreign matter.
- Wash with detergent.
- Rinse all parts with distilled-deionized water.
- Allow to air dry.
- Wrap all parts in aluminum foil or polyethylene.

13. Confined Space Entry

OSHA 29 CFR 1910.146 identifies a confined space as a space that is large enough and so configured that an employee can physically enter and do assigned work, has limited or restricted means for entry and exit, and is not intended for continuous employee occupancy. Confined spaces include, but are not limited to, trenches, storage tanks, process vessels, pits, sewers, tunnels, underground utility vaults, pipelines, sumps, wells, and excavations.

Confined space entry by Roux employees is not anticipated to be necessary to complete the RI activities identified in Section 2.0. In the event that the scope of work changes or confined space entry appears necessary, the Project Manager will be consulted to determine if feasible engineering alternatives to confined space entry can be implemented. If confined space entry by Roux employees cannot be avoided through reasonable engineering measures, task-specific confined space entry procedures will be developed, and a confined-space entry permit will be issued through Roux's corporate Health and Safety Director. Roux employees shall not enter a confined space without these procedures and permits in place.

14. Fire Prevention and Protection

14.1 General Approach

Recommended practices and standards of the National Fire Protection Association (NFPA) and other applicable regulations will be followed in the development and application of Project Fire Protection Programs. When required by regulatory authorities, the project management will prepare and submit a Fire Protection Plan for the approval of the contracting officers, authorized representative, or other designated official. Essential considerations for the Fire Protection Plan will include:

- Proper Site preparation and safe storage of combustible and flammable materials.
- Availability of coordination with private and public fire authorities.
- Adequate job-site fire protection and inspections for fire prevention.
- Adequate indoctrination and training of employees.

14.2 Equipment and Requirements

Fire extinguishers will be provided by each Contractor and are required on all heavy equipment and in each field trailer. Fire extinguishers will be inspected, serviced, and maintained in accordance with the manufacturer's instructions. As a minimum, all extinguishers shall be checked monthly and weighed semi-annually, and recharged if necessary. Recharge or replacement shall be mandatory immediately after each use.

14.3 Flammable and Combustible Substances

All storage, handling or use of flammable and combustible substances will be under the supervision of qualified persons. All tanks, containers, and pumping equipment, whether portable or stationary, used for the storage and handling of flammable and combustible liquids, will meet the recommendations of the National Fire Protection Association.

14.4 Hot Work

If the scope of work necessitates welding or blowtorch operation, the hot work permit presented in Attachment B will be completed by the SSHO and reviewed/issued by the Project Manager.

15. Emergency Information

In accordance with OSHA 29 CFR Part 1910, an Emergency Response Plan is attached to this HASP as Appendix A. The hospital route map is presented within Appendix A as Figure 1.

16. Field Team Review

Each person performing work at or visiting this site shall sign this section after site-specific training is completed and before being permitted to access the CRZ or Exclusion Zone.

I have read and understand this Site-Specific Health and Safety Plan. I will comply with the provision contained therein.

Site/Project: Haverstraw Chair Factory Site, Buffalo, New York

Name & Company	Signature	Date

17. Approvals

By their signature, the undersigned certify that this HASP is approved and will be utilized at the Haverstraw Chair Factory Site.

_____ Paul Werthman, P.G. – Site Safety and Health Officer	_____ Date
_____ Tom Forbes, P.E. - Office Health and Safety Manager	_____ Date
_____ Mike Lesakowski – Project Manager	_____ Date
_____	_____

18. References

New York State Department of Environmental Conservation. DER-10; Technical Guidance for Site Investigation and Remediation. May 2010.

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Remedial Investigation Work Plan
Haverstraw Chair Factory Site, Haverstraw, New York

APPENDIX E

Field Operating Procedures (FOPs)



FIELD OPERATING PROCEDURES

ROUX ENVIRONMENTAL ENGINEERING AND GEOLOGY, D.P.C.

FOP Number	Description
001.1	Abandonment of Borehole Procedures
002.0	Abandonment of Monitoring Wells Procedure
004.6	Soil Vapor Sample Collection Procedure
007.0	Calibration and Maintenance of Portable Dissolved Oxygen Meter
008.0	Calibration and Maintenance of Portable Field pH/Eh Meter
009.0	Calibration and Maintenance of Portable Field Turbidity Meter
011.1	Calibration and Maintenance of Portable Photoionization Detector
012.0	Calibration and Maintenance of Portable Specific Conductance Meter
013.0	Composite Sample Collection Procedure for Non-Volatile Organic Analysis
015.0	Documentation Requirements for Drilling and Well Installation
017.0	Drill Site Selection Procedure
018.0	Drilling and Excavation Equipment Decontamination Procedures
021.0	Establishing Horizontal and Vertical Control
022.0	Groundwater Level Measurement
023.1	Groundwater Purging Procedures Prior to Sample Collection
024.1	Groundwater Sample Collection Procedures
024.3	Groundwater Sample Collection Procedures for PFAS
025.0	Hand Augering Procedure
026.1	Hollow Stem Auger (HSA) Drilling Procedures
031.2	Low Flow (Minimal Drawdown) Groundwater Purging & Sampling Procedure
032.1	Management of Investigation-Derived Waste (IDW)
033.0	Monitoring Well Construction for Hollow Stem Auger Boreholes
036.0	Monitoring Well Development Procedures
039.1	NAPL Detection and Sample Collection Procedure
040.1	Non-Disposable and Non-Dedicated Sampling Equipment Decontamination
041.0	Overburden Casing Installation Procedure
046.0	Sample Labeling, Storage and Shipment Procedures
047.0	Screening of Soil Samples for Organic Vapors During Drilling Activities
048.0	Screening of Soil Samples for Organic Vapors During UST Removal Activities
054.2	Soil Description Procedures Using The Visual-Manual Method
057.0	Soil Sample Collection for VOC Analysis - EnCore Sampling
058.0	Split-Spoon Sampling Procedures
063.2	Surface and Subsurface Soil Sampling Procedures
065.1	Test Pit Excavation and Logging Procedures
070.0	Well/Piezometer Construction Materials and Design
073.2	Real-Time Air Monitoring During Intrusive Activities
074.0	Underground Storage Tank Excavation & Removal Procedures
076.0	"Before Going Into the Field" Procedure
078.0	Geoprobe Drilling Procedures
079.0	Stockpile Sampling Procedures for Chemical Analysis
080.0	Stockpile-Borrow Source Sampling Procedures for Physical Analysis
082.0	Waste Sampling Procedures
084.0	Calibration and Maintenance of Portable Particulate Meter
085.0	Field Quality Control Procedures
088.0	Underground Piping Decommissioning Procedures
090.0	Outdoor Ambient Air VOC Sample Collection Procedure

Notes:

1. FOPs are identified by the sequential FOP number and revision number. For example, FOP number 097.3 indicates FOP 97, revision 3.



FIELD OPERATING PROCEDURES

Abandonment of Borehole Procedures

ABANDONMENT OF BOREHOLE PROCEDURE

PURPOSE

Soil borings that are not completed as monitoring wells will be plugged by filling the holes with a cement/bentonite grout. Field staff will calculate the borehole volume and compare it to the final installed volume of grout to evaluate whether bridging or loss to the formation has occurred. These calculations and the actual volume placed will be noted on the Boring Log.

PROCEDURE

1. Determine most suitable seal materials. Grout specifications generally have mixture ratios as follows:

Grout Slurry Composition (% Weight)

1.5 to 3.0%	-	Bentonite (Quick Gel)
40 to 60 %	-	Cement (Portland Type I)
40 to 60 %	-	Potable Water

2. Calculate the volume of the borehole base on the bit or auger head diameter plus 10% and determine the volume of grout to be emplaced. Generally, the total mixed volume is the borehole volume plus 20%.
3. Identify the equipment to be used for the preparation and mixing of the grout. Ensure the volume of the tanks to be used for mixing has been measured adequately. Document these volumes on the Well Abandonment/Decommissioning Log (sample attached).
4. Identify the source of the water to be used for the grout and determine its suitability for use. In particular, water with high sulfate, or chloride levels or heated water should not be used. These types of waters can cause operational difficulties or modify the set-up for the grout.

ABANDONMENT OF BOREHOLE PROCEDURE

5. Identify the equipment to be used for emplacing the grout. Ensure that the pump to be used has adequate pressure to enable complete return to surface.
6. Identify the volumes to be pumped at each stage or in total if only one stage is to be used.
7. Prepare the borehole abandonment plan and discuss the plan and activities with the drilling contractor prior to beginning any mixing activities.
8. Begin mixing the grout to be emplaced.
9. Record the type and amount of materials used during the mixing operation. Ensure the ratios are within specifications tolerance.
10. Begin pumping the grout through the return line bypass system to confirm all pump and surface fittings are secure.
11. Initiate downhole pumping from the bottom of the borehole. Record the times and volumes emplaced on the Well Abandonment/Decommissioning Log (sample attached).
12. Document the return circulation of grout. This may be facilitated by using a colored dye or other tagging method if a mudded borehole condition exists prior to grout injection.
13. Identify what procedures will be used for grouting in the upper 3 feet. When casing exists in the borehole, decisions are required as to the timing for removal and final disposition of the casing. Generally, it will not be removed prior to grouting because of the potential for difficult access and loss of circulation in the upper soil or rock layers. Accordingly, when cement return is achieved at surface, the casing is commonly removed and the borehole is topped off with grout or soils. If casing removal is not possible or not desired, the casing left in place should be cut off at a depth of 5 feet or greater below ground surface. If casing is not present during grouting, the grout level in the borehole is topped off after the rods or tremie pipe is removed.

FOP 001.1

ABANDONMENT OF BOREHOLE PROCEDURE

14. Clear and clean the surface near the borehole.
15. The uppermost five feet of the borehole at the land surface should be filled with material physically similar to the natural soils. The surface of the borehole should be restored to the condition of the area surrounding the borehole. For example, concrete or asphalt will be patched with concrete or asphalt of the same type and thickness, grassed areas will be seeded, and topsoil will be used in other areas. All solid waste materials generated during the decommissioning process must be disposed of properly.
16. A follow-up check at each site should be made within one week to 10 days of completion. It should be noted that on occasion, the grout and/or surface material may settle over several days. If settling occurs, additional material physically similar to surrounding materials (i.e., asphalt, concrete, or soil) must be used to match the existing grade.
17. Document borehole and/or well/piezometer decommissioning activities on a Well Abandonment/Decommissioning Log (sample attached).

ATTACHMENTS

Well Abandonment/Decommissioning Log (sample)

REFERENCES

ASTM D 5299: *Guide for Decommissioning of Ground Water Wells, Vadose Zone Monitoring Devices, Boreholes, and Other Devices for Environmental Activities.*

NYSDEC, July 1988, *Drilling and Monitoring Well Installation Guidance Manual.*

NYSDEC, November 2009, *CP-43: Groundwater Monitoring Well Decommissioning Policy.*

Driscoll, F.G., 1987, *Groundwater and Wells*, Johnson Division, St. Paul, Minnesota, 1089 p.



ABANDONMENT OF BOREHOLE PROCEDURE

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DATE:



The logo for Roux, featuring the word "ROUX" in white, bold, sans-serif capital letters inside a blue rectangular box with a slight drop shadow.

ROUX

The title "FIELD OPERATING PROCEDURES" written in a blue, outlined, sans-serif font, oriented vertically along the left side of the page.

FIELD OPERATING PROCEDURES

Abandonment of Monitoring Wells Procedure

ABANDONMENT OF MONITORING WELLS PROCEDURE

PURPOSE

This guideline presents a method for the abandonment and decommissioning of wells that are no longer reliable as competent monitors of formation groundwater. Well abandonment and decommissioning is required in order to remove a potential pathway for the vertical migration of impacted groundwater and/or surface water.

PROCEDURE

1. Examine the existing well to be abandoned/decommissioned and review well construction detail information (if applicable) to determine well depth,, screened interval, diameter, material of composition and other construction details. Establish appropriate equipment requirements for removal of the well.
2. Determine the most suitable seal materials as discussed in the next section.
3. Attempt to remove the well using a drilling rig, by using the following procedures:
 - Attaching the winch line to the well to see if it can be removed by pulling;
 - Using the rig's hydraulics to advance casing incrementally;
 - If a cable tool rig is available, bump back the casing using the cathead and drive block.
3. Upon removal of the well, ream the borehole by advancing the augers approximately one foot beyond the total depth of the well. Rotate the augers at a speed sufficient to remove the construction materials (i.e., filter pack, bentonite seal, etc.) from the borehole annulus (if possible). Backfill the resulting borehole with cement/bentonite grout, by tremie method, to approximately one foot below ground surface. Fill the remaining borehole to match the existing grade elevation and material of construction (i.e., clean native soil, concrete or asphalt, as necessary). Go to Step 10.

ABANDONMENT OF MONITORING WELLS PROCEDURE

4. If the well cannot be removed from the borehole over-drill the borehole and well to approximately two (2) feet below the well depth. Upon reaching the desired depth, remove the well from within the augers and go back to Step 3.
5. If the borehole cannot be reamed out using conventional drilling techniques (i.e., over-drilled), remove or puncture the base plate of the well screen using the drill rig and associated equipment by pounding with the drill rods. Upon filling the well with grout by tremie method, slowly pull the well from the ground surface to allow the grout to evacuate through the bottom of the well to fill the void space created by removal of the well casing. Continue adding grout mix to the well casing, as necessary, to fill the void space to approximately one foot below ground surface. Fill the remaining borehole to match the existing grade elevation and material of construction (i.e., clean native soil, concrete or asphalt, as necessary). Go to Step 10.

If the driller is unsuccessful at removing or puncturing the base plate of the well due, in part, to well construction materials (i.e., stainless steel or black iron), go to Step 6.

6. Insert a tremie pipe down the well to the bottom and pump a cement/bentonite grout mixture to a depth one to two feet above the top of the screen.
7. Perform a hydraulic pressure test on the portion of the well casing above the grouted screen section. Allow the grout to set up for a period not less than 72 hours before pressure testing of the grouted interval. Place a pneumatic packer a maximum of 4.5 feet above the top of the slotted screen section of the well. The infiltration pressure applied to the packer shall not exceed the pressure rating of the well casing material. If the interval between the top of the grout and the bottom of the packer is not saturated, potable water will be used to fill the interval. A gauge pressure of 5 psig at the well head shall be applied to the interval for a period of 5 minutes to allow for temperature stabilization. After 5 minutes, the pressure will be maintained at 5 psig for 30 minutes. The grout seal shall be considered acceptable if the total loss of water to the seal does not exceed 0.5 gallons over a 30-minute period.

ABANDONMENT OF MONITORING WELLS PROCEDURE

8. If the grout seal is determined to be unacceptable, tremie grout an additional 5 feet of well riser above the failing interval and retest as specified above (see Step 7).
9. If the grout seal is determined to be acceptable, tremie grout the remainder of the well until grout displaces all formation water and a grout return is visible in the well at the surface. Cut off well casing at a depth of five feet or greater below ground surface and backfill the remaining borehole to match the existing grade elevation and material of construction (i.e., clean native soil, concrete or asphalt, as necessary).
10. Record all well construction details and abandonment procedures on the **Well Abandonment/Decommissioning Log** (sample attached).

CEMENT/BENTONITE GROUT MIXTURE

The cement/bentonite grout mixture identified below is generally considered the most suitable seal material for monitoring well advancement and abandonment. Grout specifications generally have mixture ratios as follows:

Grout Slurry Composition (% Weight)

1.5 to 3.0%	-	Bentonite (Quick Gel)
40 to 60%	-	Cement (Portland Type I)
40 to 60%	-	Potable Water

MISCELLANEOUS

All removed well materials (PVC, stainless steel, steel pipe) should be decontaminated (if necessary) as per the project specific **Drilling and Excavation Equipment Decontamination FOP** and removed from the site. The project manager will determine the destination of final disposal for all well materials. All drill cuttings (depending on site protocol) should be placed in DOT-approved 55-gallon drums, labeled and sampled in



FOP 002.0

ABANDONMENT OF MONITORING WELLS PROCEDURE

accordance with Roux's field operating procedure **Management of Investigation-Derived Waste** in order to determine proper removal and disposal procedures. The drilling subcontractor will provide any potable water utilized during this field activity from a known and reliable source (see Notes section).

ATTACHMENTS

Well Abandonment/Decommissioning Log (sample)

REFERENCES

New York State Department of Environmental Conservation, July 1988, *Drilling and Monitoring Well Installation Guidance Manual*.

Driscoll, F.G., 1987, *Groundwater and Wells*, Johnson Division, St. Paul, Minnesota, p. 1089.

Roux's FOPs

- 018 *Drilling/Excavation Equipment Decontamination Protocols*
- 032 *Management of Investigation-Derived Waste*

NOTES

Tap water may be used from any municipal water treatment system. The use of an untreated potable water supply is not an acceptable substitute.



FOP 002.0

ABANDONMENT OF MONITORING WELLS PROCEDURE

WELL ABANDONMENT/
DECOMMISSIONING LOG

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FIELD OPERATING PROCEDURES

Soil Vapor Sample Collection Procedures

**SOIL VAPOR SAMPLE
COLLECTION PROCEDURE**

BACKGROUND

In October 2006, the New York State Department of Health (NYSDOH) finalized their vapor intrusion guidance document entitled “Guidance for Evaluating Soil Vapor Intrusion in the State of New York.” (www.health.state.ny.us/nysdoh/gas/svi_guidance/), which has been guiding NYSDOH and New York State Department of Environmental Conservation (NYSDEC) decisions concerning the need for subslab vapor mitigation at sites undergoing investigation, cleanup and monitoring under formal NY State remedial programs (e.g., Brownfield Cleanup Program sites, Inactive Hazardous Waste Site Remediation Program sites, etc.). Per the most recent update, May 2017, guidance presents three (3) soil vapor/indoor air matrices to assist in interpreting the comparison of subslab and ambient air data. As of May 2017, eight compounds have been assigned to these three (3) current matrices (i.e., “Matrix A”, “Matrix B”, and “Matrix C”) as follows:

Soil Vapor / Indoor Air Matrix	Volatile Chemical
Matrix A	Carbon tetrachloride
	1,1-Dichloroethene
	cis-1,2-Dichloroethene
	Trichloroethene
Matrix B	Methylene Chloride
	Tetrachlorethene
	1,1,1-Trichloroethane
Matrix C	Vinyl chloride

The matrices are attached as Figures 1, 2, and 3.

**SOIL VAPOR SAMPLE
COLLECTION PROCEDURE**

PURPOSE

The procedures presented herein delineate the scope of additional investigation at a building on the project site to determine if volatile organic compounds (VOCs) detected in groundwater and/or soil near the building are intruding into the building airspace or have the potential, in sufficient concentrations, to adversely impact indoor air quality. The soil vapor, subslab vapor, and ambient air monitoring procedures follow the NYSDOH Guidance for Evaluating Soil Vapor Intrusion in the State of New York (October 2006) as well as USEPA Methods TO-14 and TO-15, for volatile organic compounds (VOCs) using Summa passive canisters.

SURVEYS AND PRE-SAMPLING BUILDING PREPARATION (IF REQUIRED)

If required, a pre-sampling inspection should be performed prior to each sampling event to identify and minimize conditions that may interfere with the proposed testing. The inspection should evaluate the type of structure, floor layout, airflows, and physical conditions of the building(s) being studied. This information, along with information on sources of potential indoor air contamination, should be identified on a building inventory form. An example of the building inventory form is attached. Items to be included in the building inventory include the following:

- Construction characteristics, including foundation cracks and utility penetrations or other openings that may serve as preferential pathways for vapor intrusion;
- Presence of an attached garage;
- Recent renovations or maintenance to the building (e.g., fresh paint, new carpet or furniture);
- Mechanical equipment that can affect pressure gradients (e.g., heating systems, clothes dryers or exhaust fans);

**SOIL VAPOR SAMPLE
COLLECTION PROCEDURE**

- Use or storage of petroleum products (e.g., fuel containers, gasoline operated equipment and unvented kerosene heaters); and
- Recent use of petroleum-based finishes or products containing volatile chemicals.

Each room on the floor of the building being tested and on lower floors, if possible, should be inspected. This is important because even products stored in another area of a building can affect the air of the room being tested.

The presence and description of odors (e.g., solvent, moldy) and portable vapor monitoring equipment readings (e.g., PIDs, ppb RAE, Jerome Mercury Vapor Analyzer, etc.) should be noted and used to help evaluate potential sources. This includes taking readings near products stored or used in the building.

Potential interference from products or activities releasing volatile chemicals may need to be controlled. Removing the source from the indoor environment prior to testing is the most effective means of reducing interference. Ensuring that containers are tightly sealed may be acceptable. When testing for volatile organic compounds, containers should be tested with portable vapor monitoring equipment to determine whether compounds are leaking. The inability to eliminate potential interference may be justification for not testing, especially when testing for similar compounds at low levels. The investigator should consider the possibility that chemicals may adsorb onto porous materials and may take time to dissipate.

In some cases, the goal of the testing is to evaluate the impact from products used or stored in the building (e.g., pesticide misapplications, school renovation projects). If the goal of the testing is to determine whether products are an indoor volatile chemical contaminant source, the removing these sources does not apply.

**SOIL VAPOR SAMPLE
COLLECTION PROCEDURE**

Once interfering conditions are corrected (if applicable), ventilation may be needed prior to sampling to eliminate residual contamination in the indoor air. If ventilation is appropriate, it should be completed 24 hours or more prior to the scheduled sampling time. Where applicable, ventilation can be accomplished by operating the building's HVAC system to maximize outside air intake. Opening windows and doors, and operating exhaust fans may also help or may be needed if the building has no HVAC system.

Air samples are sometimes designed to represent typical exposure in a mechanically ventilated building and the operation of HVAC systems during sampling should be noted on the building inventory form (see attached sample). In general, the building's HVAC system should be operating under normal conditions. Unnecessary building ventilation should be avoided within 24 hours prior to and during sampling. During colder months, heating systems should be operating to maintain normal indoor air temperatures (i.e., 65 – 75 °F) for at least 24 hours prior to and during the scheduled sampling time.

Depending upon the goal of the indoor air sampling, some situations may warrant deviation from the above protocol regarding building ventilation. In such cases, building conditions and sampling efforts should be understood and noted within the framework and scope of the investigation.

To avoid potential interferences and dilution effects, every effort should be made to avoid the following for 24 hours prior to sampling:

- Opening any windows, fireplace dampers, openings or vents;
- Operating ventilation fans unless special arrangements are made;
- Smoking in the building;
- Painting;
- Using a wood stove, fireplace or other auxiliary heating equipment (e.g., kerosene heater);
- Operating or storing automobile in an attached garage;

**SOIL VAPOR SAMPLE
COLLECTION PROCEDURE**

- Allowing containers of gasoline or oil to remain within the house or garage area, except for fuel oil tanks;
- Cleaning, waxing or polishing furniture, floors or other woodwork with petroleum- or oil-based products;
- Using air fresheners, scented candles or odor eliminators;
- Engaging in any hobbies that use materials containing volatile chemicals;
- Using cosmetics including hairspray, nail polish, nail polish removers, perfume/cologne, etc.;
- Lawn mowing, paving with asphalt, or snow blowing;
- Applying pesticides; and
- Using building repair or maintenance products, such as caulk or roofing tar.

PRODUCT INVENTORY (IF REQUIRED)

If required, the primary objective of the product inventory is 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. This information is used to help formulate an indoor environment profile.

An inventory should be provided for 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.

The presence and description of odors (e.g., solvent, moldy) and portable vapor monitoring equipment readings (e.g., PIDs, ppb RAE, Jerome Mercury Vapor Analyzer, etc.) should be noted and used to help evaluate potential sources. This includes taking readings near products stored or used in the building. Products in buildings should be inventoried every

**SOIL VAPOR SAMPLE
COLLECTION PROCEDURE**

time air is tested to provide an accurate assessment of the potential contribution of volatile chemicals. If available, chemical ingredients of interest (e.g., analyte list) should be recorded for each product. If the ingredients are not listed on the label, record the product's exact and full name, and the manufacturer's name, address and telephone number, if available. In some cases, Material Safety Data Sheets (MSDS) may be useful for identifying confounding sources of volatile chemicals in air. Adequately documented photographs of the products and their labeled ingredients can supplement the inventory and facilitate recording the information.

SAMPLE LOCATIONS

The following are types of samples that are collected to investigate the soil vapor intrusion pathway:

- Subsurface vapor samples:
 - *Soil vapor* samples (i.e., soil vapor samples not beneath the foundation or slab of a building) and
 - *Sub-slab vapor* samples (i.e., soil vapor samples immediately beneath the foundation or slab of a building);
- Indoor air samples; and
- Outdoor air samples.

The types of samples that should be collected depend upon the specific objective(s) of the sampling, as described below.

- Soil vapor
Soil vapor samples are collected to determine whether this environmental medium is contaminated, characterize the nature and extent of contamination, and identify possible sources of the contamination. Soil vapor sampling results are used when evaluating the following:
 - The potential for *current* human exposures;
 - The potential for *future* human exposures (e.g., should a building be constructed); and

**SOIL VAPOR SAMPLE
COLLECTION PROCEDURE**

- The effectiveness of measures implemented to remediate contaminated subsurface vapors.

- Sub-slab vapor

Sub-slab vapor samples are collected to characterize the nature and extent of soil vapor contamination immediately beneath a building with a basement foundation and/or a slab-on-grade. Sub-slab vapor sampling results are used when evaluating the following:

- *Current* human exposures;
- The potential for *future* human exposures (e.g., if the structural integrity of the building changes or the use of the building changes); and
- Site-specific attenuation factors (i.e., the ratio of indoor air to sub-slab vapor concentrations).

Sub-slab vapor samples are collected after soil vapor characterization and/or other environmental sampling (e.g., soil and groundwater characterization) indicate a need. Subslab samples are typically collected concurrently with indoor and outdoor air samples. However, outside of the heating season, sub-slab vapor samples may be collected independently depending on the sampling objective (e.g., characterize the extent of subsurface vapor contamination outside of the heating season to develop a more comprehensive, focused investigation plan for the heating season).

- Indoor air

Indoor air samples are collected to characterize exposures to air within a building, including those with earthen floors and crawlspaces. Indoor air sampling results are used when evaluating the following:

- *Current* human exposures;
- The potential for *future* exposures (e.g., if a currently vacant building should become occupied); and
- Site-specific attenuation factors (e.g., the ratio of indoor air to sub-slab vapor concentrations).

Indoor air samples are collected after subsurface vapor characterization and other environmental sampling (e.g., soil and groundwater characterization) indicate a need. When indoor air samples are collected, concurrent sub-slab vapor and

**SOIL VAPOR SAMPLE
COLLECTION PROCEDURE**

outdoor air samples are collected to evaluate the indoor air results appropriately. However, indoor air and outdoor air samples, without sub-slab vapor samples, may be collected when confirming the effectiveness of a mitigation system.

In addition, site-specific situations may warrant collecting indoor air samples prior to characterizing subsurface vapors and/or without concurrent sub-slab sampling due to a need to examine immediate inhalation hazards. Examples of such situations may include, but are not limited to, the following:

- In response to a spill event when there is a need to qualitatively and/or quantitatively characterize the contamination;
- If high readings are obtained in a building when screening with field equipment (e.g., a photoionization detector (PID), an organic vapor analyzer, or an explosimeter) and the source is unknown;
- If significant odors are present and the source needs to be characterized; or
- If groundwater beneath the building is contaminated, the building is prone to groundwater intrusion or flooding (e.g., sump pit overflows), and subsurface vapor sampling is not feasible.

■ Outdoor air

Outdoor air samples are collected to characterize site-specific background outdoor air conditions. These samples must be collected simultaneously with indoor air samples. They may also be collected concurrently with soil vapor samples. Outdoor air sampling results are primarily used when evaluating the extent to which outdoor sources may be influencing indoor air quality. They may also be used in the evaluation of soil vapor results (i.e., to identify potential outdoor air interferences associated with the infiltration of outdoor air into the sampling apparatus while the soil vapor sample was collected).

**SOIL VAPOR SAMPLE
COLLECTION PROCEDURE**

SOIL VAPOR SAMPLE COLLECTION PROCEDURES

Soil vapor probe installations (see Figure 4 attached) may be permanent, semi-permanent, or temporary. In general, permanent installations are preferred for data consistency reasons. Soil implants or probes should be constructed in the same manner at all sampling locations to minimize possible discrepancies. The following procedures should be included in any construction protocol:

- Soil vapor probes should be installed using direct push technology or, if necessary to attain the desired depth, using an auger;
- Porous backfill material (e.g., glass beads or coarse sand) should be used to create a sampling zone 1 to 2 feet in length;
- Soil vapor probes should be fitted with inert tubing (e.g., polyethylene, stainless steel, or Teflon®) of the appropriate size (typically 1/8 inch to 1/4 inch diameter) and of laboratory or food grade quality to the surface;
- Soil vapor probes should be sealed above the sampling zone with a bentonite slurry for a minimum distance of 3 feet to prevent outdoor air infiltration and the remainder of the borehole backfilled with clean material;
- For multiple probe depths, the borehole should be grouted with bentonite between probes to create discrete sampling zones; and
- For permanent installations, a protective casing should be set around the top of the probe tubing and grouted in place to the top of bentonite to minimize infiltration of water or outdoor air, as well as to prevent accidental damage.

Soil vapor samples should be collected in the same manner at all locations to minimize possible discrepancies. The following procedures should be included in any sampling protocol:

- At least 24 hours after the installation of permanent probes and shortly after the installation of temporary probes, one to three implant volumes (i.e., the volume of

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the sample probe and tube) must be purged prior to collecting the samples to ensure samples collected are representative;

- Flow rates for both purging and collecting must not exceed 0.2 liters per minute to minimize outdoor air infiltration during sampling;
- The target final field vacuum after 24 hours will be approximately -5 inches of mercury. Samples with a final field vacuum of greater than -10 inches of mercury, or equal to zero, will be flagged (usability of data will depend on sample volume and reporting limits that can be achieved).
- Samples must be collected, using conventional sampling methods, in an appropriate container — one which meets the objectives of the sampling (e.g., investigation of areas where low or high concentrations of volatile chemicals are expected; to minimize losses of volatile chemicals that are susceptible to photodegradation), meets the requirements of the sampling and analytical methods (e.g., low flow rate; Summa® canisters if analyzing by using EPA Method TO-15), and is certified clean by the laboratory;
- Sample size depends upon the volume of sample required to achieve minimum reporting limit requirements; and
- A tracer gas (e.g., helium, butane, or sulfur hexafluoride) must be used when collecting soil vapor samples to verify that adequate sampling techniques are being implemented (i.e., to verify infiltration of outdoor air is not occurring) (discussed later in this procedure). Once verified, continued use of the tracer gas may be reconsidered.

When soil vapor samples are collected, the following actions should be taken to document local conditions during sampling that may influence interpretation of the results:

- If sampling near a commercial or industrial building, uses of volatile chemicals during normal operations of the facility should be identified;

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- Outdoor plot sketches should be drawn that include the site, area streets, neighboring commercial or industrial facilities (with estimated distance to the site), outdoor ambient air sample locations (if applicable), and compass orientation (north);
- Weather conditions (e.g., precipitation, outdoor temperature, barometric pressure, wind speed and direction) should be noted for the past 24 to 48 hours; and
- Any pertinent observations should be recorded, such as odors and readings from field instrumentation.

The field sampling team must maintain a sample log sheet summarizing the following:

- Sample identification,
- Date and time of sample collection,
- Sampling depth,
- Identity of samplers,
- Sampling methods and devices,
- Purge volumes,
- Volume of soil vapor extracted,
- If canisters used, the vacuum before and after samples collected,
- Apparent moisture content (dry, moist, saturated, etc.) of the sampling zone, and
- Chain of custody protocols and records used to track samples from sampling point to analysis.

SUB-SLAB VAPOR SAMPLE COLLECTION PROCEDURES

During colder months, heating systems should be operating to maintain normal indoor air temperatures (i.e., 65 – 75 °F) for at least 24 hours prior to and during the scheduled sampling time. Prior to installation of the sub-slab vapor probe, the building floor should be inspected and any penetrations (cracks, floor drains, utility perforations, sumps, etc.) should be noted and recorded. Probes should be installed at locations where the potential for ambient air infiltration via floor penetrations is minimal.

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Sub-slab vapor probe installations (see Figure 5 attached) may be permanent, semi-permanent, or temporary. Sub-slab implants or probes should be constructed in the same manner at all sampling locations to minimize possible discrepancies. The following procedures should be included in any construction protocol:

- Permanent recessed probes must be constructed with brass or stainless steel tubing and fittings;
- Temporary probes must be constructed with polyethylene or Teflon® tubing of laboratory or food grade quality;
- Tubing should not extend further than 2 inches into the sub-slab material;
- Coarse sand or glass beads should be added to cover about 1 inch of the probe tip for permanent installations; and
- The soil vapor probe should be sealed to the surface with permagum grout, melted beeswax, putty or other non-VOC-containing and non-shrinking products for temporary installations or cement for permanent installations.

Sub-slab vapor samples should be collected in the following manner:

- After installation of the probes, one to three volumes (i.e., the volume of the sample probe and tube) must be purged prior to collecting the samples to ensure samples collected are representative;
- Flow rates for both purging and collecting must not exceed 0.2 liters per minute to minimize outdoor air infiltration during sampling;
- The target final field vacuum after 24 hours will be approximately -5 inches of mercury. Samples with a final field vacuum of greater than -10 inches of mercury, or equal to zero, will be flagged (usability of data will depend on sample volume and reporting limits that can be achieved).
- Samples must be collected, using conventional sampling methods, in an appropriate container — one which meets the objectives of the sampling (e.g., investigation of areas where low or high concentrations of volatile chemicals are expected; to minimize losses of volatile chemicals that are susceptible to photodegradation), meets the requirements of the sampling and analytical methods (e.g., low flow rate; Summa® canisters if analyzing by using EPA Method TO-15), and is certified clean by the laboratory;

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- Sample size depends upon the volume of sample required to achieve minimum reporting limit requirements [Section 2.9 of the Guidance], the flow rate, and the sampling duration; and
- Ideally, samples should be collected over the same period of time as concurrent indoor and outdoor air samples.

When sub-slab vapor samples are collected, the following actions should be taken to document conditions during sampling and ultimately to aid in the interpretation of the sampling results:

- If sampling within a commercial or industrial building, uses of volatile chemicals in commercial or industrial processes and/or during building maintenance, should be identified;
- The use of heating or air conditioning systems during sampling should be noted;
- Floor plan sketches should be drawn that include the floor layout with sample locations, chemical storage areas, garages, doorways, stairways, location of basement sumps or subsurface drains and utility perforations through building foundations, HVAC system air supply and return registers, compass orientation (north), and any other pertinent information should be completed;
- If possible, photographs should accompany floor plan sketches;
- Outdoor plot sketches should be drawn that include the building site, area streets, outdoor air sample locations (if applicable), compass orientation (north), footings that create separate foundation sections, and paved areas;
- Weather conditions (e.g., precipitation, indoor and outdoor temperature, and barometric pressure) and ventilation conditions (e.g., heating system active and windows closed) should be reported;
- Smoke tubes or other devices should be used to confirm pressure relationships and air flow patterns, especially between floor levels and between suspected contaminant sources and other areas; and
- Any pertinent observations, such as spills, floor stains, smoke tube results, odors and readings from field instrumentation (e.g., vapors via PID, ppb RAE, Jerome Mercury Vapor Analyzer, etc.), should be recorded.

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The field sampling team must maintain a sample log sheet summarizing the following:

- Sample identification,
- Date and time of sample collection,
- Sampling depth,
- Identity of samplers,
- Sampling methods and devices,
- Soil vapor purge volumes,
- Volume of soil vapor extracted,
- If canisters used, the vacuum before and after samples collected,
- Apparent moisture content (dry, moist, saturated, etc.) of the sampling zone, and
- Chain of custody protocols and records used to track samples from sampling point to analysis.

The following describes the subslab air sampling procedure:

1. Canisters will be supplied by the laboratory that will be conducting the analysis.
2. Sampling will take place in accordance with the project work plan sufficiently spaced to allow locations to be modified, if necessary.
3. The number of Summa canisters required as well as the flow rate of the constant differential low volume flow controllers will be supplied by the laboratory in accordance with the project work plan.
4. The sampling program will consist of concurrently collecting and analyzing one sub-slab vapor sample and one indoor ambient air sample (discussed in the next section). Sample locations should be selected based on the likelihood for potential continuous human occupancy during the workday (i.e., due to the size of the areas and available infrastructure), and to account for the possibility of varying foundation depths in different areas of the building. In addition, sample locations typically are based upon the results of a subsurface investigation (i.e., soil gas survey or boring advancement) conducted prior to air sample collection activities. Canisters are typically placed in areas where the highest concentrations of soil gas were observed. Indoor air sample locations

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preferably should be selected near the middle of the sampled room, well away from the edges where dilution is more likely to occur.

5. Collect at least one outdoor ambient air sample from a location on the building roof or designated background area of the site positioned away from building ventilation system equipment on the highest portion of the building roof or site. See the Outdoor Ambient Air Sampling Procedure section in this procedure.
6. Field personnel should assure conservative sampling conditions prior to and throughout the sampling event. The building should be closed (windows and doors shut) and existing building ventilation systems should be turned off 12 to 24 hours before the air sampling is scheduled to begin as well as during sample collection. Any air-handling units that may induce large pressure gradients (i.e., exhaust fans, HVAC units etc.) should also be turned off.
7. Any activity being conducted by current building tenants involving volatile organic compounds, such as the use of lacquer thinner and cleaning solvents, prior to and/or during air sampling activities should be noted in the Project Field Book. These activities have the potential to bias the analytical results.
8. At each location, drill an approximately $\frac{3}{4}$ -inch diameter hole through the concrete slab (typically 6-8 inches thick) using a hand-held hammer drill.
9. Measure and record the concrete thickness in the Project Field Book.
10. Insert polyethylene or Teflon® tubing of laboratory or food grade quality into the drilled hole and no further than 2 inches into the subslab material.
11. Seal the tubing with an appropriately sized volatile organic compound-free stopper (i.e., permagum grout, melted beeswax, putty, or other non-VOC-containing and non-shrinking product) into the concrete core hole and secure in-place making sure the fit is very snug. Supplement any visible gaps between the stopper and concrete slab with a VOC-free sealant, such as beeswax or bentonite slurry.

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12. Run the tubing assembly through a shroud (plastic pail, cardboard box, or garbage bag) creating a tight seal with the surface making sure not to disturb the seal around the tubing penetration.
13. Enrich the atmosphere of the shroud with helium. Measure and record the helium concentration within the shroud.
14. Purge approximately 1 to 3 tubing volumes (i.e., the volume of the sample probe and tube) using a hand pump (or similar approved device) to ensure the collection of a representative sample.
15. Flow rates for both purging and sample collection must not exceed 0.2 liters per minute to minimize outdoor air infiltration during sampling.
16. Use a portable monitoring device to analyze a sample of soil vapor for the tracer **prior to and after** sampling for the compounds of concern. Note that the tracer gas samples can be collected via syringe, Tedlar bag etc. They need not be collected in Summa® canisters or minicans.
17. If concentrations greater than 10% of tracer gas are observed either prior to and/or after sampling, the probe seal should be enhanced to reduce the infiltration of outdoor air. Following enhancement of the seal, repeat steps 14 through 17 above until purged concentrations are less than 10% of the tracer gas within the shroud.
18. Following tubing purge and adequate seal integrity testing via helium tracer gas, immediately attach a 6-liter Summa Canister fitted with a 24-hour regulator (or approved other duration) to the opposite end of the tubing. Concurrent with each subslab sample location, prepare an indoor ambient air sample by staging a second Summa Canister on a ladder (approximately 2 to 5-feet above the floor) adjacent to the sub-slab sample location.
19. All Summa Canister valves should remain closed until all subslab borings are complete and all of the canisters in their respective positions.

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20. Open the valves to all of the canisters for the required collection period (i.e., 24-hours). Record initial canister pressure on the Air Canister Field Record form.
21. Following sample collection and prior to closing canister valve, record final canister pressure on the Air Canister Field Record form. Close canister valve.
22. Collect all Summa Canisters and ship, under chain-of-custody command to an approved analytical laboratory for VOC analysis in accordance with USEPA Method TO-14 or TO-15.
23. Repair all concrete openings with a cement patch.
24. Analytical results submitted by the laboratory should be reported as concentrations of each VOC at each location, typically in parts per billion by volume (ppbv).

INDOOR AIR SAMPLE COLLECTION PROCEDURES

During colder months, heating systems should be operating to maintain normal indoor air temperatures (i.e., 65 – 75 °F) for at least 24 hours prior to and during the scheduled sampling time. If possible, prior to collecting indoor samples, a pre-sampling inspection, discussed earlier in this procedure, should be performed to evaluate the physical layout and conditions of the building being investigated, to identify conditions that may affect or interfere with the proposed sampling, and to prepare the building for sampling.

In general, indoor air samples should be collected in the following manner:

- Sampling duration should reflect the exposure scenario being evaluated without compromising the detection limit or sample collection flow rate (e.g., an 8 hour sample from a workplace with a single shift versus a 24 hour sample from a workplace with multiple shifts). To ensure that air is representative of the locations sampled and to avoid undue influence from sampling personnel, samples should be collected for at least 1 hour. If the goal of the sampling is to

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represent average concentrations over longer periods, then longer duration sampling periods may be appropriate. Typically, 24 hour samples are collected from residential settings;

- Personnel should avoid lingering in the immediate area of the sampling device while samples are being collected;
- Sample flow rates must conform to the specifications in the sample collection method and, if possible, should be consistent with the flow rates for concurrent outdoor air and sub-slab samples;
- The target final field vacuum after 24 hours will be approximately -5 inches of mercury. Samples with a final field vacuum of greater than -10 inches of mercury, or equal to zero, will be flagged (usability of data will depend on sample volume and reporting limits that can be achieved); and
- Samples must be collected, using conventional sampling methods, in an appropriate container — one which meets the objectives of the sampling (e.g., investigation of areas where low or high concentrations of volatile chemicals are expected; to minimize losses of volatile chemicals that are susceptible to photodegradation), meets the requirements of the sampling and analytical methods (e.g., low flow rate; Summa® canisters if analyzing by using EPA Method TO-15), and is certified clean by the laboratory.

At sites with tetrachloroethene contamination, passive air monitors that are specifically analyzed for tetrachloroethene (i.e., "perc badges") are commonly used to collect indoor and outdoor air samples. If site characterization activities indicate that degradation products of tetrachloroethene also represent a vapor intrusion concern, perc badges may be used to indicate the likelihood of vapor intrusion (i.e., by using tetrachloroethene as a surrogate) followed, as needed, by more comprehensive sampling and laboratory analyses to quantify both tetrachloroethene and its degradation products. Perc badge samples ideally should be collected over a twenty-four hour period, but for no less than eight hours.

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The following actions should be taken to document conditions during indoor air sampling and ultimately to aid in the interpretation of the sampling results:

- A product inventory survey must be completed (discussed earlier);
- The use of heating or air conditioning systems during sampling should be noted;
- Floor plan sketches should be drawn that include the floor layout with sample locations, chemical storage areas, garages, doorways, stairways, location of basement sumps or subsurface drains and utility perforations through building foundations, HVAC system supply and return registers, compass orientation (north), and any other pertinent information should be completed;
- If possible, photographs should accompany floor plan sketches;
- Outdoor plot sketches should be drawn that include the building site, area streets, outdoor air sample locations (if applicable), compass orientation (north), footings that create separate foundation sections, and paved areas;
- Weather conditions (e.g., precipitation, indoor and outdoor temperature, and barometric pressure) and ventilation conditions (e.g., heating system active and windows closed) should be reported;
- Smoke tubes or other devices should be used to confirm pressure relationships and air flow patterns, especially between floor levels and between suspected contaminant sources and other areas; and
- Any pertinent observations, such as spills, floor stains, smoke tube results, odors and readings from field instrumentation (e.g., vapors via PID, ppb RAE, Jerome Mercury Vapor Analyzer, etc.), should be recorded.

The field sampling team must maintain a sample log sheet summarizing the following:

- Sample identification,
- Date and time of sample collection,
- Sampling height,

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- Identity of samplers,
- Sampling methods and devices,
- Depending upon the method, volume of air sampled,
- If canisters used, the vacuum before and after samples collected,
- Chain of custody protocols and records used to track samples from sampling point to analysis.

The following describes the indoor air sampling procedure:

1. Canisters will be supplied by the laboratory that will be conducting the analysis.
2. Sampling will take place in accordance with the project work plan sufficiently spaced to allow locations to be modified, if necessary.
3. The number of Summa canisters required as well as the flow rate of the constant differential low volume flow controllers will be supplied by the laboratory in accordance with the project work plan. Indoor air sampling typically requires the continuous collection of samples over a 24-hour period.
4. The sampling program will consist of concurrently collecting and analyzing one sub-slab vapor sample and one indoor ambient air sample. Sample locations should be selected based on the likelihood for potential continuous human occupancy during the workday (i.e., due to the size of the areas and available infrastructure), and to account for the possibility of varying foundation depths in different areas of the building. In addition, sample locations typically are based upon the results of a subsurface investigation (i.e., soil gas survey or boring advancement) conducted prior to air sample collection activities. Canisters are typically placed in areas where the highest concentrations of soil gas were observed. Indoor air sample locations preferably should be selected near the middle of the sampled room, well away from the edges where dilution is more likely to occur.
5. Collect at least one outdoor ambient air sample from a location on the building roof or designated background area of the site positioned away from building ventilation system equipment on the highest portion of the building

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roof or site. See the Outdoor Ambient Air Sampling Procedure presented in this procedure.

6. Field personnel should assure conservative sampling conditions prior to and throughout the sampling event. The building should be closed (windows and doors shut) and existing building ventilation systems should be turned off 12 to 24 hours before the air sampling is scheduled to begin as well as during sample collection. Any air-handling units that may induce large pressure gradients (i.e., exhaust fans, HVAC units etc.) should also be turned off.
7. Any activity being conducted by current building tenants involving volatile organic compounds, such as the use of lacquer thinner and cleaning solvents, prior to and/or during air sampling activities should be noted in the Project Field Book. These activities have the potential to bias the analytical results.
8. Concurrent with each subslab sample location, prepare an indoor ambient air sample by staging a second Summa Canister on a ladder (approximately 2 to 5-feet above the floor) adjacent to the sub-slab sample location.
9. All Summa Canister valves should remain closed until all subslab borings are complete and all of the canisters in their respective positions.
10. Open the valves to all of the canisters for the required collection period (i.e., 24-hours). Record initial canister pressure on the Air Canister Field Record form.
11. Following sample collection and prior to closing canister valve, record final canister pressure on the Air Canister Field Record form. Close canister valve.
12. Collect all Summa Canisters and ship, under chain-of-custody command to an approved analytical laboratory for VOC analysis in accordance with USEPA Method TO-14 or TO-15.
13. Analytical results submitted by the laboratory should be reported as concentrations of each VOC at each location, typically in parts per billion by volume (ppbv).

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OUTDOOR AIR SAMPLE COLLECTION PROCEDURES

Outdoor air samples must be collected simultaneously with indoor air samples and may be collected concurrently with subsurface vapor samples. Outdoor air samples must be collected in the same manner as indoor samples.

The following actions should be taken to document conditions during outdoor air sampling and ultimately to aid in the interpretation of the sampling results:

- Outdoor plot sketches should be drawn that include the building site, area streets, outdoor air sample locations (if applicable), the location of potential interferences (e.g., gasoline stations, factories, lawn movers, etc.), compass orientation (north), footings that create separate foundation sections, and paved areas;
- Weather conditions (e.g., precipitation, indoor and outdoor temperature, and barometric pressure) and ventilation conditions (e.g., heating system active and windows closed) should be reported; and
- 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) should be recorded.

The following describes the outdoor air sampling procedure:

1. Canisters will be supplied by the laboratory that will be conducting the analysis.
2. Sampling will take place in accordance with the project work plan sufficiently spaced to allow locations to be modified, if necessary.
3. The number of Summa canisters required as well as the flow rate of the constant differential low volume flow controllers will be supplied by the laboratory in accordance with the project work plan.
4. Sample locations typically are collected upwind of the facility.

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5. Collect at least one outdoor ambient air sample from a location on the building roof or designated background area of the site positioned away from building ventilation system equipment on the highest portion of the building roof or site. Place canisters on the ground or step ladder, with a clear plastic sheet beneath to prevent contamination. Locate the sampling inlet approximately 18-inches above the ground surface.
6. Sample collection should take place on warm, dry days. If rain or high humidity conditions develop during sampling, the sampling event should be suspended. Temperature, barometric pressure, and wind speed should be monitored during the sampling event, for use in analysis of the results.
7. The combination of sampling location, height, and meteorological conditions will assure that sampling will measure VOCs at their highest concentrations.
8. All Summa Canister valves should remain closed until all subslab borings are complete and all of the indoor and outdoor canisters in their respective positions.
9. Open the valves to all of the canisters for the required collection period (i.e., 24-hours). Record initial canister pressure on the Air Canister Field Record form.
10. Following sample collection and prior to closing canister valve, record final canister pressure on the Air Canister Field Record form. Close canister valve.
11. Collect all Summa Canisters and ship, under chain-of-custody command to an approved analytical laboratory for VOC analysis in accordance with USEPA Method TO-14 or TO-15.
12. Air samples will be analyzed by Gas Chromatography/Mass Spectroscopy (GC/MS) in accordance with EPA Method TO-14 or TO-15.

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13. Analytical results will be reported as concentrations of each VOC at each location during each sampling event, typically in parts per billion by volume (ppbv).

TRACER GAS

When collecting soil vapor samples as part of a vapor intrusion evaluation, a tracer gas serves as a quality assurance/quality control device to verify the integrity of the soil vapor probe seal. Without the use of a tracer, there is no way to verify that a soil vapor sample has not been diluted by surface air.

Depending on the nature of the contaminants of concern, a number of different compounds can be used as a tracer. Typically, sulfur hexafluoride (SF₆) or helium are used as tracers because they are readily available, have low toxicity, and can be monitored with portable measurement devices. Butane and propane (or other gases) could also be used as a tracer in some situations. The protocol for using a tracer gas is straightforward: simply enrich the atmosphere in the immediate vicinity of the area where the probe intersects the ground surface with the tracer gas, and measure a vapor sample from the probe for the presence of high concentrations (> 10%) of the tracer. A cardboard box, a plastic pail, or even a garbage bag can serve to keep the tracer gas in contact with the probe during the testing.

There are two basic approaches to testing for the tracer gas:

- Include the tracer gas in the list of target analytes reported by the laboratory; or
- Use a portable monitoring device to analyze a sample of soil vapor for the tracer prior to and after sampling for the compounds of concern. (Note that the tracer gas samples can be collected via syringe, Tedlar bag etc. They need not be collected in Summa® canisters or minicans.)

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The advantage of the second approach is that the real time tracer sampling results can be used to confirm the integrity of the probe seals prior to formal sample collection. Figure 6 (attached) depicts common methods for using tracer gas. In each of the examples, a, b and c, the tracer gas is released in the enclosure prior to initially purging the sample point. Care should be taken to avoid excessive purging prior to sample collection. Care should also be taken to prevent pressure build-up in the enclosure during introduction of the tracer gas. Inspection of the installed sample probe, specifically noting the integrity of the surface seal and the porosity of the soil in which the probe is installed, will help to determine the tracer gas setup. Figure 6(a) may be most effective at preventing tracer gas infiltration; however, it may not be required in some situations depending on site-specific conditions. Figures 6(b) and 6(c) may be sufficient for probes installed in tight soils with well-constructed surface seals. In all cases, the same tracer gas application should be used for all probes at any given site.

Because minor leakage around the probe seal should not materially affect the usability of the soil vapor sampling results, the mere presence of the tracer gas in the sample should not be a cause for alarm. Consequently, portable field monitoring devices with detection limits in the low ppm range are more than adequate for screening samples for the tracer. If high concentrations ($> 10\%$) of tracer gas are observed in a sample, the probe seal should be enhanced to reduce the infiltration of ambient air.

During the initial stages of a soil vapor sampling program, tracer gas samples should be collected at each of the sampling probes. If the results of the initial samples indicate that the probe seals are adequate, the project manager can consider reducing the number of locations at which tracer gas samples are employed. At a minimum, at least 10% of the subsequent samples should be supported with tracer gas analyses. When using permanent soil vapor probes as part of a long-term monitoring program, annual testing of the probe integrity is recommended.

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QUALITY ASSURANCE / QUALITY CONTROL (QA/QC)

Extreme care should be taken during all aspects of sample collection to ensure that sampling error is minimized and high quality data are obtained. The sampling team members should avoid actions (e.g., fueling vehicles, using permanent marking pens, and wearing freshly dry-cleaned clothing or personal fragrances), which can cause sample interference in the field. Appropriate QA/QC protocols must be followed for sample collection and laboratory analysis, such as use of certified clean sample devices, meeting sample holding times and temperatures, sample accession, chain of custody, etc. Samples should be delivered to the analytical laboratory as soon as possible after collection. In addition, laboratory accession procedures must be followed including field documentation (sample collection information and locations), chain of custody, field blanks, field sample duplicates, and laboratory duplicates, as appropriate.

Some methods require collecting samples in duplicate (e.g., indoor air sampling using passive sampling devices for tetrachloroethene) to assess errors. Duplicate and/or split samples should be collected in accordance with the requirements of the sampling and analytical methods being implemented.

For certain regulatory programs, a Data Usability Summary Report (DUSR) may be required to determine whether or not the data, as presented, meets the site or project specific criteria for data quality and data use. This requirement may dictate the level of QC and the category of data deliverable to request from the laboratory. Guidance on preparing a DUSR is available by contacting the NYSDEC's Division of Environmental Remediation.

New York State Public Health Law requires laboratories analyzing environmental samples collected from within New York State to have current Environmental Laboratory Approval Program (ELAP) certification for the appropriate analyte and environmental matrix

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combinations. If ELAP certification is not currently required for an analyte (e.g., trichloroethene), the analysis should be performed by a laboratory that has ELAP certification for similar compounds in air and uses analytical methods with detection limits similar to background (e.g., tetrachloroethene via EPA Method TO-15).

The work plan must state that all samples that will be used to make decisions on appropriate actions to address exposures and environmental contamination will be analyzed by an ELAP-certified laboratory. If known, the name of the laboratory should also be provided. Similarly, the name of the laboratory that was used must be included in the report of the sampling results. For samples collected and tested in the field for screening purposes by using field testing technology, the qualifications of the field technician must be documented in the work plan.

The target final field vacuum of any sample canister after 24 hours will be approximately -5 inches of mercury. Samples with a final field vacuum of greater than -10 inches of mercury, or equal to zero, will be flagged (usability of data will depend on sample volume and reporting limits that can be achieved).

DECISION MATRICES (FIGURES 1, 2, AND 3)

The considerations in assigning a chemical to a matrix include the following:

- Human health risks, including such factors as a chemical's ability to cause cancer, reproductive, developmental, liver, kidney, nervous system, immune system or other effects, in animals and humans and the doses that may cause those effects;
- The data gaps in its toxicological database;
- Background concentrations of volatile chemicals in indoor air [Section 3.2.4]; and
- Analytical capabilities currently available.

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To use the matrices accurately as a tool in the decision-making process, the following must be noted:

- The matrices are generic. As such, it may be necessary to modify recommended actions to accommodate building-specific conditions (e.g., dirt floor in basement, crawl spaces, etc.) and/or site-specific conditions (e.g., proximity of building to identified subsurface contamination) for the protection of public health. Additionally, actions more conservative than those specified within the matrix may be implemented at any time. For example, the decision to implement more conservative actions may be based on a comparison of the costs associated with resampling or monitoring to the costs associated with installation and monitoring of a mitigation system.
- Indoor air concentrations detected in samples collected from the building's basement or, if the building has a slab-on-grade foundation, from the building's lowest occupied living space should be used.
- Actions provided in the matrix are specific to addressing human exposures. Implementation of these actions does not preclude the need to investigate possible sources of vapor contamination, nor does it preclude the need to remediate contaminated soil vapors or the source of soil vapor contamination.
- When current exposures are attributed to sources other than vapor intrusion, the agencies must be provided documentation (e.g., applicable environmental data, completed indoor air sampling questionnaire, digital photographs, etc.) to support a proposed action other than that provided in the matrix and to support assessment and follow-up by the agencies.

RECOMMENDED ACTIONS

Actions recommended in the matrix are based on the relationship between sub-slab vapor concentrations and corresponding indoor air concentrations. They are intended to address both potential and current human exposures and include the following:



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- *No further action*

When the volatile chemical is not detected in the indoor air sample and the concentration detected in the corresponding sub-slab vapor sample is not expected to substantially affect indoor air quality.

- *Identify source(s) and resample or mitigate*

Reasonable and practical actions are recommended to identify the source(s) affecting indoor air quality and that actions be implemented to reduce indoor air concentrations to within background ranges. The concentration detected in the indoor air sample is likely due to indoor and/or outdoor sources rather than soil vapor intrusion given the concentration detected in the sub-slab vapor sample. Resampling may be required in the event indoor and/or outdoor sources are not readily identified or confirmed to demonstrate SVI mitigation actions are not needed. Steps should be taken to identify potential source(s) and to reduce exposures accordingly (e.g., by keeping containers tightly capped or by storing volatile chemical-containing products in places where people do not spend much time, such as a garage or shed). Mitigation may be required if soil vapor intrusion cannot be ruled out.

- *Monitor*

Monitoring, including sub-slab vapor, basement air, lowest occupied living space air, and outdoor air sampling, is needed to determine whether concentrations in the indoor air or sub-slab vapor have changed. Monitoring may also be needed to determine whether existing building conditions (e.g., positive pressure HVAC systems) are maintaining the desired mitigation endpoint and to determine whether changes are needed. The type and frequency of monitoring is determined on a site-specific and building specific basis, taking into account applicable environmental data and building operating conditions.

- *Mitigate*

Mitigation is needed to minimize current or potential exposures associated with soil vapor intrusion. Methods to mitigate exposures related to soil vapor intrusion are described in Section 4 of the Guidance.

**SOIL VAPOR SAMPLE
COLLECTION PROCEDURE**

TIME OF YEAR

Sub-slab vapor samples and, unless there is an immediate need for sampling, indoor air samples are typically collected during the heating season because soil vapor intrusion is more likely to occur when a building's heating system is in operation and air is being drawn into the building. In general, heating systems are expected to be operating routinely from November 15th to March 31st throughout the state. However, this timeframe may vary depending on factors, such as the location of the site (e.g., upstate versus downstate) and the weather conditions for a particular year.

A vapor intrusion investigation may also be conducted outside of the heating season. However, the results may not be used to rule out exposures. For example, results indicating "no further action" or "monitoring required" must be verified during the heating season to ensure these actions are protective during the heating season as well.

SAMPLING ROUNDS

Investigating a soil vapor intrusion pathway usually requires more than one round of subsurface vapor, indoor air, and/or outdoor air sampling, for reasons such as the following:

- To characterize the nature and extent of subsurface vapor contamination (similar to the delineation of groundwater contamination) and to address corresponding exposure concerns;
- To evaluate fluctuations in concentrations due to
 - Different weather conditions (e.g., seasonal effects),
 - Changes in building conditions (e.g., various operating conditions of a building's HVAC system),
 - Changes in source strength, or
 - Vapor migration or contaminant biodegradation processes (particularly when degradation products may be more toxic than the parent compounds); or

**SOIL VAPOR SAMPLE
COLLECTION PROCEDURE**

- To confirm sampling results or the effectiveness of mitigation or remedial systems.

Overall, successive rounds of sampling are conducted until the following questions can be answered:

- Are subsurface vapors contaminated? If so, what are the nature and extent of contamination? What is/are the source(s) of the contamination?
- What are the current and potential exposures to contaminated subsurface vapors?
- What actions, if any, are needed to prevent or mitigate exposures and to remediate subsurface vapor contamination?

Toward this end, multiple rounds of sampling may be required to characterize the nature and extent of subsurface vapor contamination such that

- Both potential and current exposures are adequately addressed;
- Measures can be designed to remediate subsurface vapor contamination, either directly (e.g., SVE system) or indirectly (e.g., soil excavation or groundwater remediation), given that monitoring and mitigation are considered temporary measures implemented to address exposures related to vapor intrusion until contaminated environmental media are remediated; and
- The effectiveness of remedial measures can be monitored and confirmed (e.g., endpoint sampling).

ATTACHMENTS

- Figure 1** *Soil Vapor/Indoor Air Matrix A*
Figure 2 *Soil Vapor/Indoor Air Matrix B*
Figure 3 *Soil Vapor/Indoor Air Matrix C*
Figure 4 *Schematics of a permanent soil vapor probe and permanent nested soil vapor probes*
Figure 5 *Schematic of a sub-slab vapor probe*
Figure 6 *Schematics of tracer gas applications*

Air Canister Field Record

Indoor Air Quality Questionnaire and Building Inventory



**SOIL VAPOR SAMPLE
COLLECTION PROCEDURE**

REFERENCES

New York State Department of Health, *Guidance for Evaluating Soil Vapor Intrusion in the State of New York*, October 2006.

New York State Department of Health, *Indoor Air Sampling & Analysis Guidance*. (February 1, 2005).

Office of Solid Waste and Emergency Response (OSWER). *Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance)*. November 2002.

United States Environmental Protection Agency. *EPA Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air*. 1988

- Method TO-15, Determination of Volatile Organic Compounds (VOCs) in Air Collected in Specially Prepared Canisters and Analyzed by Gas Chromatography/Mass Spectrometry (GC/MS). Pp. 15-1 through 15-62.
- Method TO-17, Determination of Volatile Organic Compounds in Ambient Air using Active Sampling on Sorbent Tubes. Pp. 17-1 through 17-49.
- Compendium of Methods for the Determination of Air Pollutants in Indoor Air, EPA/600/4-90-010.

SOIL VAPOR SAMPLE COLLECTION PROCEDURE

FIGURE 1

Soil Vapor/Indoor Air Matrix A

May 2017

Analytes Assigned:

Trichloroethene (TCE), *cis*-1,2-Dichloroethene (c12-DCE), 1,1-Dichloroethene (11-DCE), Carbon Tetrachloride

SUB-SLAB VAPOR CONCENTRATION of COMPOUND (mcg/m ³)	INDOOR AIR CONCENTRATION of COMPOUND (mcg/m ³)		
	< 0.2	0.2 to < 1	1 and above
< 6	1. No further action	2. No Further Action	3. IDENTIFY SOURCE(S) and RESAMPLE or MITIGATE
6 to < 60	4. No further action	5. MONITOR	6. MITIGATE
60 and above	7. MITIGATE	8. MITIGATE	9. MITIGATE

No further action: No additional actions are recommended to address human exposures.

Identify Source(s) and Resample or Mitigate: We recommend that reasonable and practical actions be taken to identify the source(s) affecting the indoor air quality and that actions be implemented to reduce indoor air concentrations to within background ranges. For example, if an indoor or outdoor air source is identified, we recommend the appropriate party implement actions to reduce the levels. In the event that indoor or outdoor sources are not readily identified or confirmed, resampling (which might include additional sub-slab vapor and indoor air sampling locations) is recommended to demonstrate that SVI mitigation actions are not needed. Based on the information available, mitigation might also be recommended when soil vapor intrusion cannot be ruled out.

Monitor: We recommend monitoring (sampling on a recurring basis), including but not necessarily limited to sub-slab vapor, basement air and outdoor air sampling, to determine whether concentrations in the indoor air or sub-slab vapor have changed and/or to evaluate temporal influences. Monitoring might also be recommended to determine whether existing building conditions (e.g., positive pressure heating, ventilation and air-conditioning systems) are maintaining the desired mitigation endpoint and to determine whether changes are needed. The type and frequency of monitoring is determined based on site-, building- and analyte-specific information, taking into account applicable environmental data and building operating conditions. Monitoring is an interim measure required to evaluate exposures related to soil vapor intrusion until contaminated environmental media are remediated.

Mitigate: We recommend mitigation to minimize current or potential exposures associated with soil vapor intrusion. The most common mitigation methods are sealing preferential pathways in conjunction with installing a sub-slab depressurization system and changing the pressurization of the building in conjunction with monitoring. The type, or combination of types, of mitigation is determined on a building-specific basis, taking into account building construction and operating conditions. Mitigation is considered a temporary measure implemented to address exposures related to soil vapor intrusion until contaminated environmental media are remediated.

These general recommendations are made with consideration being given to the additional notes on page 2.

MATRIX A Page 1 of 2

SOIL VAPOR SAMPLE
COLLECTION PROCEDURE

ADDITIONAL NOTES FOR MATRIX A

This matrix summarizes actions recommended to address current and potential exposures related to soil vapor intrusion. To use the matrix appropriately as a tool in the decision-making process, the following should be noted:

- [1] The matrix is generic. As such, it may be appropriate to modify a recommended action to accommodate analyte-specific, building-specific conditions (e.g., dirt floor in basement, crawl spaces, thick slabs, current occupancy, etc.), and/or factors provided in Section 3.2 of the guidance (e.g., current land use, environmental conditions, etc.). For example, collection of additional samples may be recommended when the matrix indicates "no further action" for a particular building, but the results of adjacent buildings (especially sub-slab vapor results) indicate a need to take actions to address exposures related to soil vapor intrusion. Mitigation might be recommended when the results of multiple contaminants indicate monitoring is recommended. Proactive actions may be proposed at any time. For example, the party implementing the actions may decide to install sub-slab depressurization systems on buildings where the matrix indicates "no further action" or "monitoring." Such an action might be undertaken for reasons other than public health (e.g., seeking community acceptance, reducing costs, etc.). However, actions implemented *in lieu* of sampling will typically be expected to be captured in the final engineering report and site management plan, and might not rule out the need for post-implementation sampling (e.g., to document effectiveness or to support terminating the action).
- [2] Actions provided in the matrix are specific to addressing human exposures. Implementation of these actions does not preclude investigating possible sources of soil vapor contamination, nor does it preclude remediating contaminated soil vapor or the source of soil vapor contamination.
- [3] Appropriate care should be taken during all aspects of sample collection to ensure that high quality data are obtained. Since the data are being used in the decision-making process, the laboratory analyzing the environmental samples must have current Environmental Laboratory Approval Program (ELAP) certification for the appropriate analyte and environmental matrix combinations. Furthermore, samples should be analyzed by methods that can achieve a minimum reporting limit of 0.20 microgram per cubic meter for indoor and outdoor air samples. For sub-slab vapor samples and dirt floor soil vapor samples, a minimum reporting limit of 1 microgram per cubic meter is recommended.
- [4] Sub-slab vapor and indoor air samples are typically collected when the likelihood of soil vapor intrusion is considered to be the greatest (i.e., worst-case conditions). If samples are collected at other times (typically, samples collected outside of the heating season), then resampling during worst-case conditions might be appropriate to verify that actions taken to address exposures related to soil vapor intrusion are protective of human health.
- [5] When current exposures are attributed to sources other than soil vapor intrusion, the agencies should be given documentation (e.g., applicable environmental data, completed indoor air sampling questionnaire, digital photographs, etc.) to support a proposed action other than that provided in the matrix box and to support agency assessment and follow-up.
- [6] The party responsible for implementing the recommended actions will differ depending upon several factors, including but not limited to the following: the identified source of the volatile chemicals, the environmental remediation program, and analyte-specific, site-specific and building-specific factors.

SOIL VAPOR SAMPLE COLLECTION PROCEDURE

FIGURE 2

Soil Vapor/Indoor Air Matrix B

May 2017

Analytes Assigned:

Tetrachloroethene (PCE), 1,1,1-Trichloroethane (111-TCA), Methylene Chloride

SUB-SLAB VAPOR CONCENTRATION of COMPOUND (mcg/m ³)	INDOOR AIR CONCENTRATION of COMPOUND (mcg/m ³)		
	< 3	3 to < 10	10 and above
< 100	1. No further action	2. No Further Action	3. IDENTIFY SOURCE(S) and RESAMPLE or MITIGATE
100 to < 1,000	4. No further action	5. MONITOR	6. MITIGATE
1,000 and above	7. MITIGATE	8. MITIGATE	9. MITIGATE

No further action: No additional actions are recommended to address human exposures.

Identify Source(s) and Resample or Mitigate: We recommend that reasonable and practical actions be taken to identify the source(s) affecting the indoor air quality and that actions be implemented to reduce indoor air concentrations to within background ranges. For example, if an indoor or outdoor air source is identified, we recommend the appropriate party implement actions to reduce the levels. In the event that indoor or outdoor sources are not readily identified or confirmed, resampling (which might include additional sub-slab vapor and indoor air sampling locations) is recommended to demonstrate that SVI mitigation actions are not needed. Based on the information available, mitigation might also be recommended when soil vapor intrusion cannot be ruled out.

Monitor: We recommend monitoring (sampling on a recurring basis), including but not necessarily limited to sub-slab vapor, basement air and outdoor air sampling, to determine whether concentrations in the indoor air or sub-slab vapor have changed and/or to evaluate temporal influences. Monitoring might also be recommended to determine whether existing building conditions (e.g., positive pressure heating, ventilation and air-conditioning systems) are maintaining the desired mitigation endpoint and to determine whether changes are needed. The type and frequency of monitoring is determined based on site-, building- and analyte-specific information, taking into account applicable environmental data and building operating conditions. Monitoring is an interim measure required to evaluate exposures related to soil vapor intrusion until contaminated environmental media are remediated.

Mitigate: We recommend mitigation to minimize current or potential exposures associated with soil vapor intrusion. The most common mitigation methods are sealing preferential pathways in conjunction with installing a sub-slab depressurization system and changing the pressurization of the building in conjunction with monitoring. The type, or combination of types, of mitigation is determined on a building-specific basis, taking into account building construction and operating conditions. Mitigation is considered a temporary measure implemented to address exposures related to soil vapor intrusion until contaminated environmental media are remediated.

These general recommendations are made with consideration being given to the additional notes on page 2.

MATRIX B Page 1 of 2



SOIL VAPOR SAMPLE
COLLECTION PROCEDURE

ADDITIONAL NOTES FOR MATRIX B

This matrix summarizes actions recommended to address current and potential exposures related to soil vapor intrusion. To use the matrix appropriately as a tool in the decision-making process, the following should be noted:

- [1] The matrix is generic. As such, it may be appropriate to modify a recommended action to accommodate analyte-specific, building-specific conditions (e.g., dirt floor in basement, crawl spaces, thick slabs, current occupancy, etc.), and/or factors provided in Section 3.2 of the guidance (e.g., current land use, environmental conditions, etc.). For example, collection of additional samples may be recommended when the matrix indicates "no further action" for a particular building, but the results of adjacent buildings (especially sub-slab vapor results) indicate a need to take actions to address exposures related to soil vapor intrusion. Mitigation might be recommended when the results of multiple contaminants indicate monitoring is recommended. Proactive actions may be proposed at any time. For example, the party implementing the actions may decide to install sub-slab depressurization systems on buildings where the matrix indicates "no further action" or "monitoring." Such an action might be undertaken for reasons other than public health (e.g., seeking community acceptance, reducing costs, etc.). However, actions implemented *in lieu* of sampling will typically be expected to be captured in the final engineering report and site management plan, and might not rule out the need for post-implementation sampling (e.g., to document effectiveness or to support terminating the action).
- [2] Actions provided in the matrix are specific to addressing human exposures. Implementation of these actions does not preclude investigating possible sources of soil vapor contamination, nor does it preclude remediating contaminated soil vapor or the source of soil vapor contamination.
- [3] Appropriate care should be taken during all aspects of sample collection to ensure that high quality data are obtained. Since the data are being used in the decision-making process, the laboratory analyzing the environmental samples must have current Environmental Laboratory Approval Program (ELAP) certification for the appropriate analyte and environmental matrix combinations. Furthermore, samples should be analyzed by methods that can achieve a minimum reporting limit of 1 microgram per cubic meter for indoor and outdoor air samples. For sub-slab vapor samples and dirt floor soil vapor samples, a minimum reporting limit of 1 microgram per cubic meter is recommended.
- [4] Sub-slab vapor and indoor air samples are typically collected when the likelihood of soil vapor intrusion is considered to be the greatest (i.e., worst-case conditions). If samples are collected at other times (typically, samples collected outside of the heating season), then resampling during worst-case conditions might be appropriate to verify that actions taken to address exposures related to soil vapor intrusion are protective of human health.
- [5] When current exposures are attributed to sources other than soil vapor intrusion, the agencies should be given documentation (e.g., applicable environmental data, completed indoor air sampling questionnaire, digital photographs, etc.) to support a proposed action other than that provided in the matrix box and to support agency assessment and follow-up.
- [6] The party responsible for implementing the recommended actions will differ depending upon several factors, including but not limited to the following: the identified source of the volatile chemicals, the environmental remediation program, and analyte-specific, site-specific and building-specific factors.

SOIL VAPOR SAMPLE COLLECTION PROCEDURE

FIGURE 3

Soil Vapor/Indoor Air Matrix C

May 2017

Analytes Assigned:
Vinyl Chloride

SUB-SLAB VAPOR CONCENTRATION of COMPOUND (mcg/m ³)	INDOOR AIR CONCENTRATION of COMPOUND (mcg/m ³)	
	< 0.2	0.2 and above
< 6	1. No further action	2. IDENTIFY SOURCE(S) and RESAMPLE or MITIGATE
6 to < 60	3. MONITOR	4. MITIGATE
60 and above	5. MITIGATE	6. MITIGATE

No further action: No additional actions are recommended to address human exposures.

Identify Source(s) and Resample or Mitigate: We recommend that reasonable and practical actions be taken to identify the source(s) affecting the indoor air quality and that actions be implemented to reduce indoor air concentrations to within background ranges. For example, if an indoor or outdoor air source is identified, we recommend the appropriate party implement actions to reduce the levels. In the event that indoor or outdoor sources are not readily identified or confirmed, resampling (which might include additional sub-slab vapor and indoor air sampling locations) is recommended to demonstrate that SVI mitigation actions are not needed. Based on the information available, mitigation might also be recommended when soil vapor intrusion cannot be ruled out.

Monitor: We recommend monitoring (sampling on a recurring basis), including but not necessarily limited to sub-slab vapor, basement air and outdoor air sampling, to determine whether concentrations in the indoor air or sub-slab vapor have changed and/or to evaluate temporal influences. Monitoring might also be recommended to determine whether existing building conditions (e.g., positive pressure heating, ventilation and air-conditioning systems) are maintaining the desired mitigation endpoint and to determine whether changes are needed. The type and frequency of monitoring is determined based on site-, building- and analyte-specific information, taking into account applicable environmental data and building operating conditions. Monitoring is an interim measure required to evaluate exposures related to soil vapor intrusion until contaminated environmental media are remediated.

Mitigate: We recommend mitigation to minimize current or potential exposures associated with soil vapor intrusion. The most common mitigation methods are sealing preferential pathways in conjunction with installing a sub-slab depressurization system and changing the pressurization of the building in conjunction with monitoring. The type, or combination of types, of mitigation is determined on a building-specific basis, taking into account building construction and operating conditions. Mitigation is considered a temporary measure implemented to address exposures related to soil vapor intrusion until contaminated environmental media are remediated.

These general recommendations are made with consideration being given to the additional notes on page 2.

MATRIX C Page 1 of 2

SOIL VAPOR SAMPLE
COLLECTION PROCEDURE

ADDITIONAL NOTES FOR MATRIX C

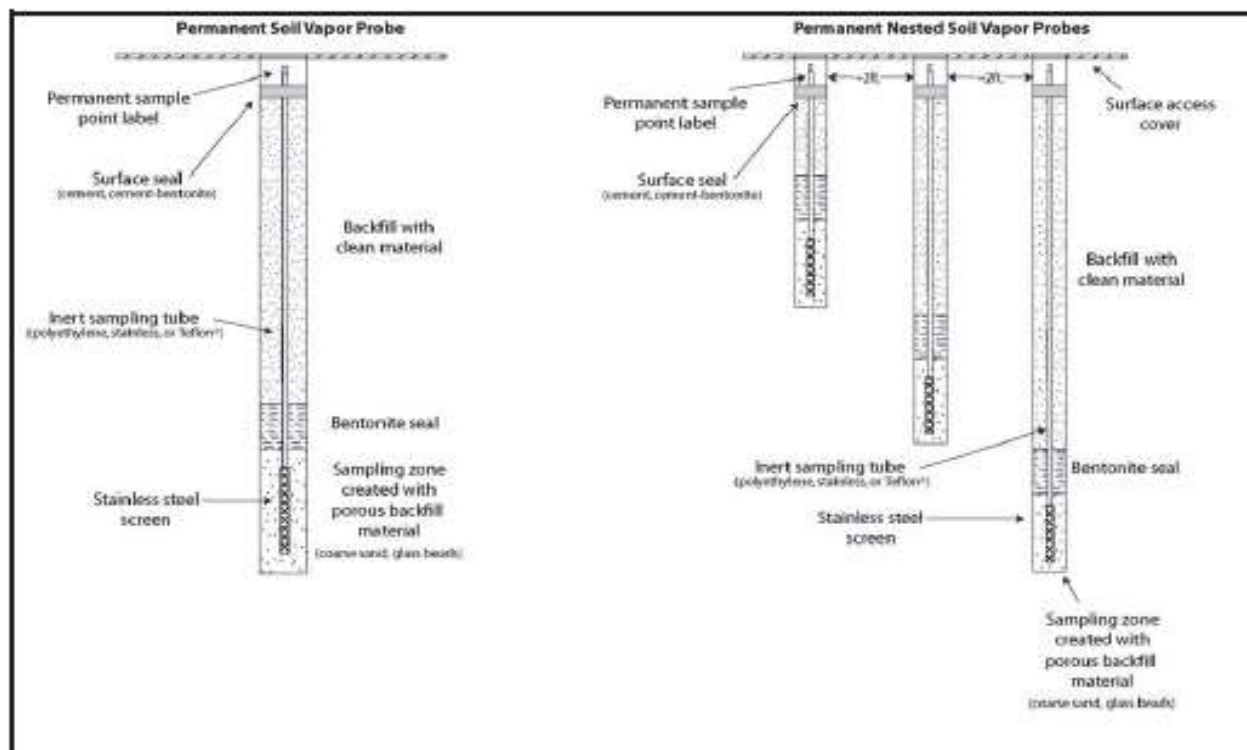
This matrix summarizes actions recommended to address current and potential exposures related to soil vapor intrusion. To use the matrix appropriately as a tool in the decision-making process, the following should be noted:

- [1] The matrix is generic. As such, it may be appropriate to modify a recommended action to accommodate analyte-specific, building-specific conditions (e.g., dirt floor in basement, crawl spaces, thick slabs, current occupancy, etc.), and/or factors provided in Section 3.2 of the guidance (e.g., current land use, environmental conditions, etc.). For example, collection of additional samples may be recommended when the matrix indicates "no further action" for a particular building, but the results of adjacent buildings (especially sub-slab vapor results) indicate a need to take actions to address exposures related to soil vapor intrusion. Mitigation might be recommended when the results of multiple contaminants indicate monitoring is recommended. Proactive actions may be proposed at any time. For example, the party implementing the actions may decide to install sub-slab depressurization systems on buildings where the matrix indicates "no further action" or "monitoring." Such an action might be undertaken for reasons other than public health (e.g., seeking community acceptance, reducing costs, etc.). However, actions implemented *in lieu* of sampling will typically be expected to be captured in the final engineering report and site management plan, and might not rule out the need for post-implementation sampling (e.g., to document effectiveness or to support terminating the action).
- [2] Actions provided in the matrix are specific to addressing human exposures. Implementation of these actions does not preclude investigating possible sources of soil vapor contamination, nor does it preclude remediating contaminated soil vapor or the source of soil vapor contamination.
- [3] Appropriate care should be taken during all aspects of sample collection to ensure that high quality data are obtained. Since the data are being used in the decision-making process, the laboratory analyzing the environmental samples must have current Environmental Laboratory Approval Program (ELAP) certification for the appropriate analyte and environmental matrix combinations. Furthermore, samples should be analyzed by methods that can achieve a minimum reporting limit of 0.20 microgram per cubic meter for indoor and outdoor air samples. For sub-slab vapor samples and dirt floor soil vapor samples, a minimum reporting limit of 1 microgram per cubic meter is recommended.
- [4] Sub-slab vapor and indoor air samples are typically collected when the likelihood of soil vapor intrusion is considered to be the greatest (i.e., worst-case conditions). If samples are collected at other times (typically, samples collected outside of the heating season), then resampling during worst-case conditions might be appropriate to verify that actions taken to address exposures related to soil vapor intrusion are protective of human health.
- [5] When current exposures are attributed to sources other than soil vapor intrusion, the agencies should be given documentation (e.g., applicable environmental data, completed indoor air sampling questionnaire, digital photographs, etc.) to support a proposed action other than that provided in the matrix box and to support agency assessment and follow-up.
- [6] The party responsible for implementing the recommended actions will differ depending upon several factors, including but not limited to the following: the identified source of the volatile chemicals, the environmental remediation program, and analyte-specific, site-specific and building-specific factors.

SOIL VAPOR SAMPLE COLLECTION PROCEDURE

FIGURE 4

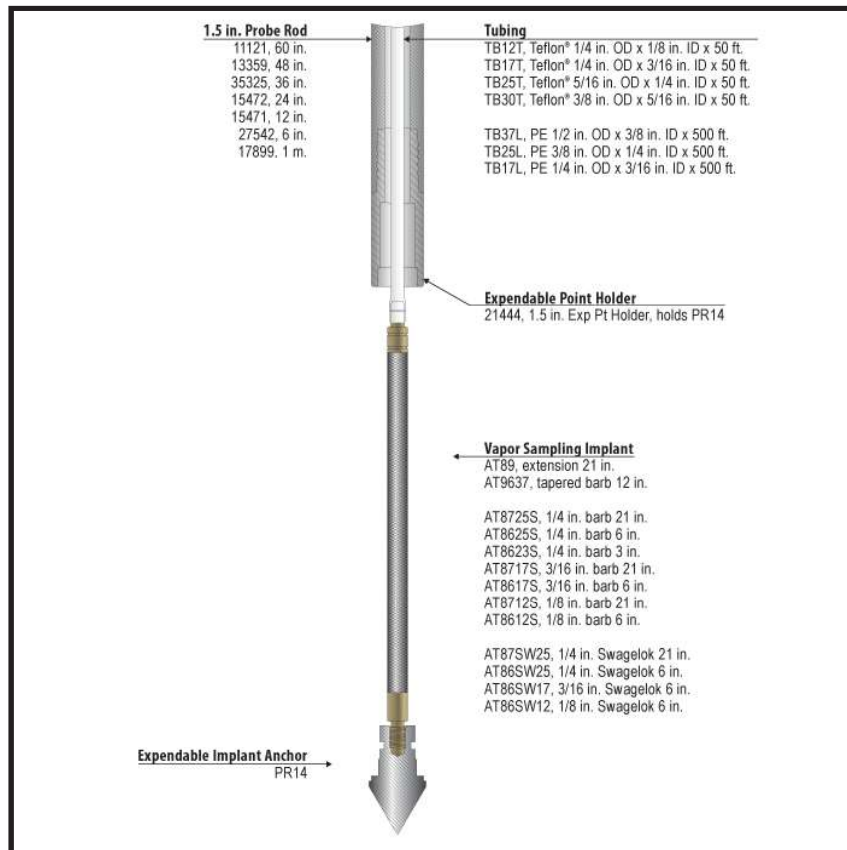
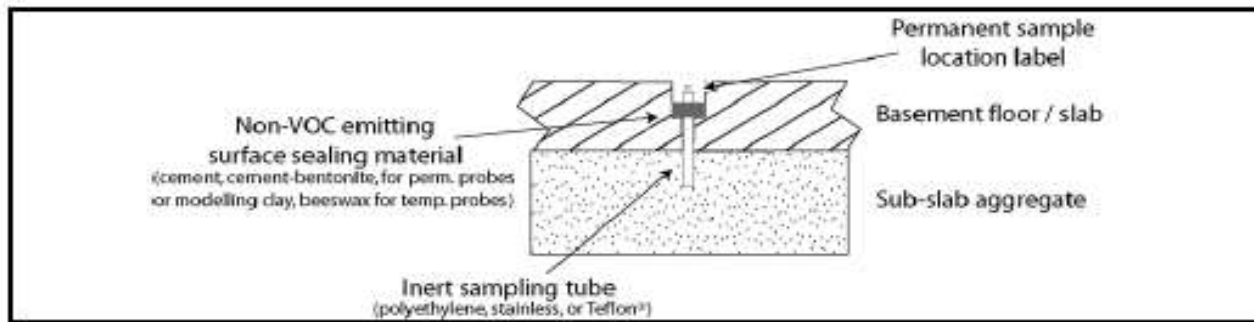
Schematics of a permanent soil vapor probe and permanent nested soil vapor probes



SOIL VAPOR SAMPLE COLLECTION PROCEDURE

FIGURE 5

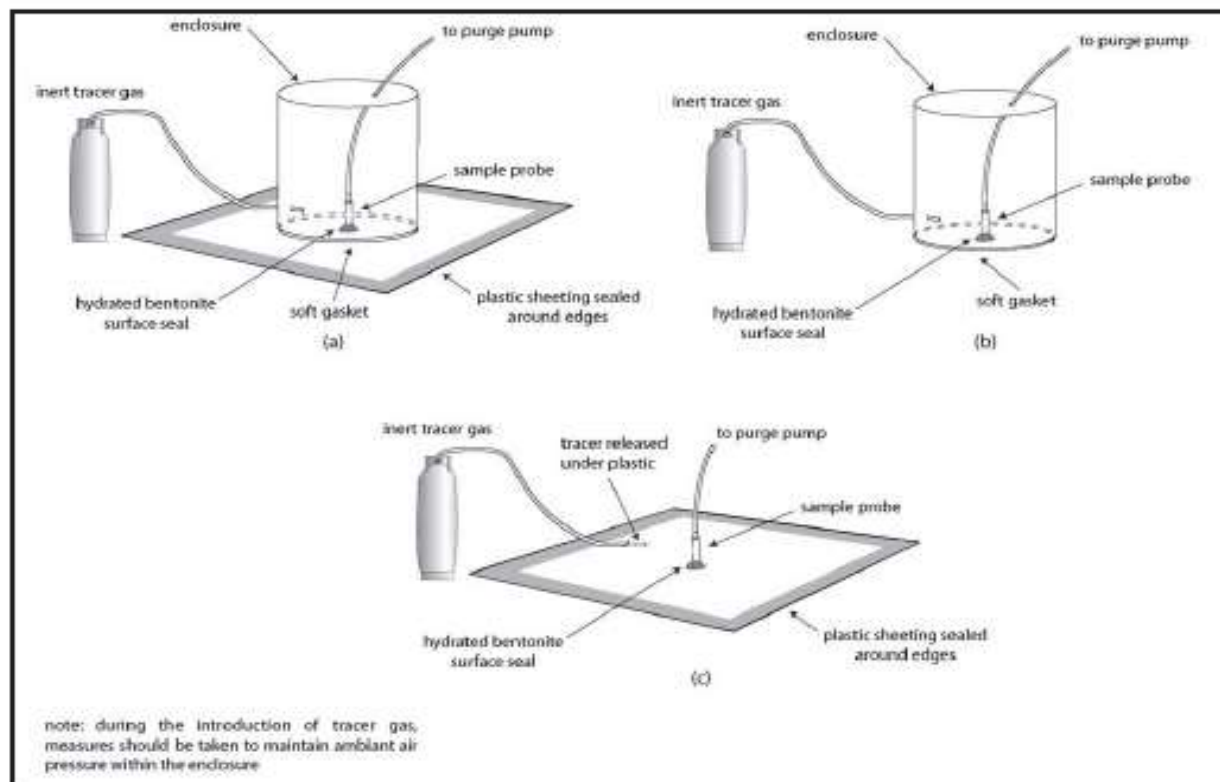
Schematic of a sub-slab vapor probe



SOIL VAPOR SAMPLE COLLECTION PROCEDURE

FIGURE 6

Schematics of tracer gas applications



SOIL VAPOR SAMPLE COLLECTION PROCEDURE

AIR CANISTER FIELD RECORD

PROJECT INFORMATION:

Project:

Job No:

Location:

Field Staff:

Client:

SAMPLE I.D.:**WEATHER CONDITIONS:**

Ambient Air Temp. - A.M.:

Ambient Air Temp. - P.M.:

Wind Direction:

Wind Speed:

Precipitation:

Size of Canister:

Canister Serial No.:

Flow Controller No.:

Sample Date(s):

Shipping Date:

Sample Type: ☐ Indoor Air ☐ Outdoor Air☐ Subslab, complete section below ☐ Soil Gas

Soil Gas Probe Depth:

FIELD SAMPLING INFORMATION:

READING	TIME	VACUUM (inches Hg) or PRESSURE (psig)	DATE	INITIALS
Lab Vacuum (on tag)				
Field Vacuum Check ¹				
Initial Field Vacuum ²				
Final Field Vacuum ³				
Duration of Sample Collection				

LABORATORY CANISTER PRESSURIZATION:

Initial Vacuum (inches Hg and psia)	
Final Pressure (psia)	
Pressurization Gas	

SUBSLAB SHROUD:

Shroud Helium Concentration:

Calculated tubing volume: $\times 3 =$

Purged Tubing Volume Concentration:

Is the purged volume concentration less than or equal to 10% in shroud?

☐ YES, continue sampling☐ NO, improve surface seal and retest**NOTES:**¹ Vacuum measured using portable vacuum gauge (provided by Lab)² Vacuum measured by canister gauge upon opening valve³ Vacuum measured by canister gauge prior to closing valve

COMPOSITE TIME (hours)	FLOW RATE RANGE (ml/min)
15 Min.	316 - 333
0.5 Hours	158 - 166.7
1	79.2 - 83.3
2	39.6 - 41.7
4	19.8 - 20.8
6	13.2 - 13.9
8	9.9 - 10.4
10	7.92 - 8.3
12	6.6 - 6.9
24	3.5 - 4.0

Signed: _____



SOIL VAPOR SAMPLE COLLECTION PROCEDURE

BENCHMARK ENVIRONMENTAL ENGINEERING & SCIENCE, PLLC

INDOOR AIR QUALITY QUESTIONNAIRE & BUILDING INVENTORY

Project Name: _____ Project No.: _____
 Project Location: _____ Client: _____
 Preparer's Name: _____ Date/Time: _____
 Preparer's Affiliation: _____ Phone No.: _____
 Purpose of Investigation: _____

1. OCCUPANT:
 Interviewed: ☐ yes ☐ no
 Last Name: _____ First Name: _____
 Address: _____
 County: _____
 Home Phone: _____ Office Phone: _____
 Number of Occupants/persons at this location: _____ Age of Occupant(s): _____

2. OWNER OR LANDLORD: (check if same as occupant)
 Interviewed: ☐ yes ☐ no
 Last Name: _____ First Name: _____
 Address: _____
 County: _____
 Home Phone: _____ Office Phone: _____

3. BUILDING CHARACTERISTICS:
 Type of Building: (check appropriate box) ☐ Residential ☐ Commercial/Multi-use
☐ Industrial ☐ Other: _____
 If the property is residential, type (check appropriate response):
☐ Single Family ☐ 3 Family
☐ Attached Rowhouse ☐ Split Level ☐ Colonial
☐ Cape Cod ☐ Contemporary ☐ Mobile Home
☐ Duplex ☐ Apartment House ☐ Townhouse/Condo
☐ 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)? ☐ yes ☐ no If yes, how many? _____

Other Characteristics:
 Number of floors: _____ Building age: _____
 Is the building insulated? ☐ yes ☐ no How air tight? ☐ tight ☐ average ☐ not tight

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BENCHMARK ENVIRONMENTAL ENGINEERING & SCIENCE, PLLC

INDOOR AIR QUALITY QUESTIONNAIRE & BUILDING INVENTORY

4. AIR FLOW
 Use air current tubes or tracer smoke to evaluate air flow patterns and qualitatively describe:

Airflow between floors: _____

 Airflow near source: _____

 Outdoor air infiltration: _____

 Infiltration into air ducts: _____

5. BASEMENT AND CONSTRUCTION DETAILS (check all that apply):
 a. Above grade foundation ☐ none ☐ stone
 b. Basement ☐ none ☐ crawlspace ☐ slab
 c. Basement floor ☐ concrete ☐ dirt ☐ none
 d. Basement walls ☐ concrete ☐ masonry ☐ masonry with
 e. Concrete floor ☐ finished ☐ sealed ☐ sealed with
 f. Foundation walls ☐ poured ☐ block ☐ stone
 g. Foundation walls ☐ finished ☐ sealed ☐ sealed with
 h. The basement is: ☐ wet ☐ damp ☐ dry
 i. The basement is: ☐ finished ☐ unfinished ☐ partially finished
 j. Sump present? ☐ yes ☐ no
 k. Water in Sump? ☐ yes ☐ no ☐ not applicable

Basement/Lowest level depth below grade: _____
 Identify potential soil vapor entry points and approximate size (e.g., cracks, utility ports, drains):

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BENCHMARK ENVIRONMENTAL ENGINEERING & SCIENCE, PLLC

INDOOR AIR QUALITY QUESTIONNAIRE & BUILDING INVENTORY

6. HEATING, VENTING, AND AIR CONDITIONING (check all that apply):
 Type of heating system(s) used in this building: (check all that apply - note primary)
☐ Hot air circulation ☐ Hot pump ☐ Hot water baseboard
☐ Space Heater ☐ Warm radiation ☐ Radiant floor
☐ Electric baseboard ☐ Wood stove ☐ Outdoor wood boiler
☐ Other: _____

The primary type of fuel used is:
☐ Natural Gas ☐ Fuel oil ☐ Propane
☐ Electric ☐ Propane ☐ Coal
☐ Wood ☐ Coal ☐ Other: _____

Domestic hot water tank fueled by: _____
 Boiler/furnace located in:
☐ Basement ☐ Outdoor ☐ Attic ☐ Other: _____
 Air Conditioning:
☐ Central Air ☐ Window units ☐ Packaged units ☐ None

Are there air distribution ducts present? ☐ yes ☐ no

Describe the supply and return air registers and their location where visible, including whether there is a cold air return and whether the return is located in the basement. Indicate the locations on the floor plan diagram.

7. OCCUPANCY
 Is basement/lowest level occupied? ☐ Full time ☐ Occasionally ☐ Seldom ☐ Almost Never
 General Use of Each Floor (e.g., family room, bedrooms, laundry, workshop, storage):
 Basement: _____
 First Floor: _____
 Second Floor: _____
 Third Floor: _____
 Fourth Floor: _____

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BENCHMARK ENVIRONMENTAL ENGINEERING & SCIENCE, PLLC

INDOOR AIR QUALITY QUESTIONNAIRE & BUILDING INVENTORY

8. FACTORS THAT MAY INFLUENCE INDOOR AIR QUALITY

a. Is there an attached garage? ☐ yes ☐ no
 b. Does the garage have a separate heating unit? ☐ yes ☐ no ☐ NA
 c. Are petroleum-powered machines or vehicles stored in the garage? ☐ yes ☐ no ☐ NA
 (e.g., lawnmower, etc., oil) If yes, please specify: _____
 d. Has the building ever had a fire? ☐ yes ☐ no
 If yes, when? _____
 e. Is a kerosene or tented gas space heater present? ☐ yes ☐ no
 If yes, when? _____
 f. Is there a workshop or hobby/craft area? ☐ yes ☐ no
 If yes, when? _____
 g. Is there smoking in the building? ☐ yes ☐ no
 If yes, when? _____
 h. Have cleaning products been used in the building? ☐ yes ☐ no
 If yes, when? _____
 i. Have chemicals been used in the building? ☐ yes ☐ no
 If yes, when? _____
 j. Has painting been done in the last 6 months? ☐ yes ☐ no
 If yes, when? _____
 k. Is there new carpet in the building? ☐ yes ☐ no
 If yes, when? _____
 l. Have air fresheners been used recently? ☐ yes ☐ no
 If yes, when? _____
 m. Is there a kitchen exhaust fan? ☐ yes ☐ no
 If yes, when? _____
 n. Is there a bathroom exhaust fan? ☐ yes ☐ no
 If yes, when? _____

Page 4 of 8



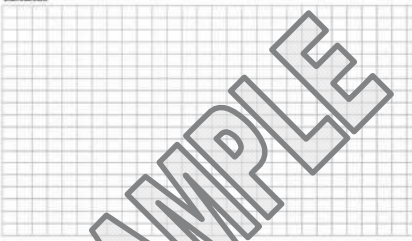
U.S. ENVIRONMENTAL PROTECTION AGENCY
INDOOR AIR QUALITY CRITERIA
SCIENTIFIC PLAN

INDOOR AIR QUALITY QUESTIONNAIRE & BUILDING INVENTORY

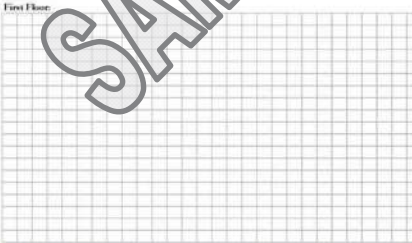
II. FLOOR PLANS

Draw a plan view sketch of the basement and first floor of the building. Indicate air sampling locations, possible indoor air pollution sources and IED meter readings. If the building does not have a basement, plan, omit.

Basement:



First Floor:



Section A-10 Quality Control and Building Inventory

Page 6 of 8

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FIELD OPERATING PROCEDURES

Calibration and Maintenance of Portable Dissolved Oxygen Meter

**CALIBRATION AND MAINTENANCE OF PORTABLE
DISSOLVED OXYGEN METER**

PURPOSE

This guideline describes a method for calibration of a portable dissolved oxygen meter. This meter measures the concentration of dissolved oxygen within a water sample. This parameter is of interest both as a general indicator of water quality, and because of its pertinence to fate and transport of organics and inorganics. This guideline presents a method for calibration of this meter, which is performed to verify instrument accuracy and function. All field instruments will be calibrated, verified and recalibrated at frequencies required by their respective operating manuals or manufacturer's specifications, but not less than once each day that the instrument is in use. Field personnel should have access to all operating manuals for the instruments used for the field measurements. This procedure also documents critical maintenance activities for this meter.

ACCURACY

The calibrated accuracy of the dissolved oxygen meter will be within $\pm 1\%$ of full-scale over the temperature range of 23° to 113° F (-5° to +45° C).

PROCEDURE

1. Calibrate the dissolved oxygen meter to ambient air based on probe temperature and true local atmospheric pressure conditions (or feet above sea level). Because procedures vary with different brands and models of meters, refer to the manufacturer's recommended calibration procedures.
2. In the event of a failure to adequately calibrate, follow the corrective action directed by the manufacturer.
3. If calibration cannot be achieved or maintained, obtain a replacement instrument (rental instruments) and/or order necessary repairs/adjustment.

**CALIBRATION AND MAINTENANCE OF PORTABLE
DISSOLVED OXYGEN METER**

4. Document the calibration results and related information in the Project Field Book and on an **Equipment Calibration Log** (see attached sample). Information will include, at a minimum:
- Time, date, and initials of the field team member performing the calibration
 - The unique identifier for the meter, including manufacturer, model, and serial number
 - The brand and expiration dates of calibration solutions
 - The calibration readings
 - The instrument settings (if applicable)
 - The approximate response time
 - The overall adequacy of calibration including the Pass or fail designation in accordance with the accuracy specifications presented above
 - Corrective action taken (see Step 5 above) in the event of failure to adequately calibrate

MAINTENANCE

- When not in use or between measurements, the dissolved oxygen probe will be kept immersed in or moist with deionized water.
- The meter batteries will be checked prior to each meter's use and will be replaced when the meter cannot be redline adjusted.
- The meter response time and stability will be tracked to determine the need for instrument maintenance. When response time becomes greater than two minutes, probe service is indicated.

ATTACHMENTS

Equipment Calibration Log (sample)



FOP 007.0

CALIBRATION AND MAINTENANCE OF PORTABLE DISSOLVED OXYGEN METER

EQUIPMENT CALIBRATION

PROJECT INFORMATION:

Project Name: _____

Date: _____

Project No.: _____

Client: _____

Instrument Source: ☐ BM ☐ Rental

METER TYPE	UNITS	TIME	MAKE/MODEL	SERIAL NUMBER	CAL. BY	STANDARD	READING	SETTLE
☐ pH meter	units		Myron L. Company Ultra Meter 6P	606987		4.00		
						7.00		
						10.01		
						< 0.4		
☐ Turbidity meter	NTU		Hach 2100P Turbidimeter	970600014560		20		
						100		
						800		
☐ Sp. conductance meter	uS/mS		Myron L. Company Ultra Meter 6P	606987		uS @ 25 °C		
☐ PID	ppm		Photovac 2020 PID			open air zero		MIBK re
						ppm Iso. Gas		factor :
☐ Particulate meter	mg/m ³					zero air		
☐ Oxygen	%					open air		
☐ Hydrogen sulfide	ppm					open air		
☐ Carbon monoxide	ppm					open air		
☐ LEL	%					open air		
☐ Radiation Meter	uR/h					background area		
☐								

ADDITIONAL REMARKS:

PREPARED BY: _____

DATE: _____



The logo for Roux, featuring the word "ROUX" in white, bold, sans-serif capital letters inside a blue rectangular box with a slight drop shadow.

ROUX

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FIELD OPERATING PROCEDURES

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Calibration and
Maintenance of
Portable Field pH/Eh
Meter

**CALIBRATION AND MAINTENANCE OF PORTABLE
FIELD pH/Eh METER**

PURPOSE

This guideline describes a method for calibration of a portable pH/Eh meter. The pH/Eh meter measures the hydrogen ion concentration or acidity of a water sample (pH function), and the oxidation/reduction potential of a water sample (Eh function). Calibration is performed to verify instrument accuracy and function. All field instruments will be calibrated, verified and recalibrated at frequencies required by their respective operating manuals or manufacturer's specifications, but not less than once each day that the instrument is in use. Field personnel should have access to all operating manuals for the instruments used for the field measurements. This procedure also documents critical maintenance activities for this meter.

ACCURACY

The calibrated accuracy of the pH/Eh meter will be:

pH ± 0.2 pH unit, over the temperature range of ± 0.2 C.

Eh ± 0.2 millivolts (mV) over the range of ± 399.9 mV, otherwise ± 2 mV.

PROCEDURE

Note: Meters produced by different manufacturers may have different calibration procedures. These instructions will take precedence over the procedure provided herein. This procedure is intended to be used as a general guideline, or in the absence of available manufacturer's instructions.

1. Obtain and active the meter to be used. As stated above, initial calibrations will be performed at the beginning of each sampling day.

**CALIBRATION AND MAINTENANCE OF PORTABLE
FIELD pH/Eh METER**

2. Immerse the sensing probe in a container of certified pH 7.0 buffer solution traceable to the National Bureau of Standards.
3. Measure the temperature of the buffer solution, and adjust the temperature setting accordingly.
4. Compare the meter reading to the known value of the buffer solution while stirring. If the reading obtained by the meter does not agree with the known value of the buffer solution, recalibrate the meter according to the manufacturer's instructions until the desired reading is obtained. This typically involves accessing and turning a dial or adjustment screw while measuring the pH of the buffer solution. The meter is adjusted until the output agrees with the known solution pH.
5. Repeat Steps 2 through 5 with a pH 4.0 and 10.0 buffer solution to provide a three-point calibration. Standards used to calibrate the pH meter will be of concentrations that bracket the expected values of the samples to be analyzed, especially for two-point calibrations (see note below).

Note: Some pH meters only allow two-point calibrations. Two-point calibrations should be within the suspected range of the groundwater to be analyzed. For example, if the groundwater pH is expected to be approximately 8, the two-point calibration should bracket that value. Buffer solutions of 7 and 10 should then be used for the two-point calibration.

6. Document the calibration results and related information in the Project Field Book and on an **Equipment Calibration Log** (see attached sample). Information will include, at a minimum:
 - Time, date, and initials of the field team member performing the calibration
 - The unique identifier for the meter, including manufacturer, model, and serial number
 - The brand and expiration dates of buffer solutions
 - The instrument readings
 - The instrument settings (if applicable)

FOP 008.0

CALIBRATION AND MAINTENANCE OF PORTABLE FIELD pH/Eh METER

- Pass or fail designation in accordance with the accuracy specifications presented above
- Corrective action taken (see Maintenance below) in the event of failure to adequately calibrate

MAINTENANCE

- When not in use, or between measurements, keep the pH/Eh probe immersed in or moist with buffer solutions.
- Check the meter batteries at the end of each day and recharge or replace as needed.
- Replace the pH/Eh probe any time that the meter response time becomes greater than two minutes or the meter consistently fails to retain its calibrated accuracy for a minimum of ten sample measurements.
- If a replacement of the pH/Eh probe fails to resolve instrument response time and stability problems, obtain a replacement instrument (rental instruments) and/or order necessary repairs/adjustment.

ATTACHMENTS

Equipment Calibration Log (sample)



FOP 008.0

CALIBRATION AND MAINTENANCE OF PORTABLE FIELD pH/Eh METER

EQUIPMENT CALIBRATION

PROJECT INFORMATION:

Project Name: _____

Date: _____

Project No.: _____

Client: _____

Instrument Source: ☐ BM ☐ Rental

METER TYPE	UNITS	TIME	MAKE/MODEL	SERIAL NUMBER	CAL. BY	STANDARD	READING	SETTLE
☐ pH meter	units		Myron L. Company Ultra Meter 6P	606987		4.00		
						7.00		
						10.01		
						< 0.4		
☐ Turbidity meter	NTU		Hach 2100P Turbidimeter	970600014560		20		
						100		
						800		
☐ Sp. conductance meter	uS/mS		Myron L. Company Ultra Meter 6P	606987		uS @ 25 °C		
☐ PID	ppm		Photovac 2020 PID			open air zero		MIBK re
						ppm Iso. Gas		factor :
☐ Particulate meter	mg/m ³					zero air		
☐ Oxygen	%					open air		
☐ Hydrogen sulfide	ppm					open air		
☐ Carbon monoxide	ppm					open air		
☐ LEL	%					open air		
☐ Radiation Meter	uR/h					background area		
☐								

ADDITIONAL REMARKS:

PREPARED BY: _____

DATE: _____





FIELD OPERATING PROCEDURES

Calibration and Maintenance of Portable Field Turbidity Meter

**CALIBRATION AND MAINTENANCE OF PORTABLE
FIELD TURBIDITY METER**

PURPOSE

This guideline describes the method for calibration of the HACH 2100P portable field turbidity meter. Turbidity is one water quality parameter measured during purging and development of wells. Turbidity is measured as a function of the samples ability to transmit light, expressed as Nephelometric Turbidity Units (NTUs). The turbidity meter is factory calibrated and must be checked daily prior to using the meter in the field. Calibration is performed to verify instrument accuracy and function. This procedure also documents critical maintenance activities for this meter.

ACCURACY

Accuracy shall be $\pm 2\%$ of reading below 499 NTU or $\pm 3\%$ of reading above 500 NTU with resolution to 0.01 NTU in the lowest range. The range key provides for automatic or manual range selection for ranges of 0.00 to 9.99, 0.0 to 99.9 and 0 to 1000 NTU. Another key provides for selecting automatic signal averaging. Pressing the key shall toggle signal averaging on or off.

PROCEDURE

Calibration of the 2100P Turbidimeter is based on formazin, the primary standard for turbidity. The instrument's electronic and optical design provides long-term stability and minimizes the need for frequent calibration. The two-detector ratioing system compensates for most fluctuations in lamp output. **A formazin recalibration should be performed at least once every three months**, more often if experience indicates the need. During calibration, use a primary standard such as StablCal™ Stabilized Standards or formazin standards.



**CALIBRATION AND MAINTENANCE OF PORTABLE
FIELD TURBIDITY METER**

Note: Meters produced by different manufacturers may have different calibration check procedures. These manufacturers' instructions will take precedence over the procedure provided here. This procedure is intended to be used as a general guideline, or in the absence of available manufacturer's instructions.

Note: Because the turbidity meter measures light transmission, it is critical that the meter and standards be cared for as precision optical instruments. Scratches, dirt, dust, etc. can all temporarily or permanently affect the accuracy of meter readings.

Preparing StablCal Stabilized Standards in Sealed Vials

Sealed vials that have been sitting undisturbed for longer than a month must be shaken to break the condensed suspension into its original particle size. Start at *step 1* for these standards. If the standards are used on at least a weekly interval, start at *step 3*.

Note: These instructions do not apply to < 0.1 NTU StablCal Standards; < 0.1 NTU StablCal Standards should not be shaken or inverted.

1. Shake the standard vigorously for 2-3 minutes to re-suspend any particles.
2. Allow the standard to stand undisturbed for 5 minutes.
3. Gently invert the vial of StablCal 5 to 7 times.
4. Prepare the vial for measurement using traditional preparation techniques. This usually consists of oiling the vial (see *Section 2.3.2 on page 11 of the manual*)



**CALIBRATION AND MAINTENANCE OF PORTABLE
FIELD TURBIDITY METER**

and marking the vial to maintain the same orientation in the sample cell compartment (see *Section 2.3.3 on page 12 of the manual*). This step will eliminate any optical variations in the sample vial.

5. Let the vial stand for one minute. The standard is now ready for use in the calibration procedure.

Calibration Procedure

1. Turn the meter on.
2. Shake pre-mixed formazin primary standards in accordance with the above procedure.
3. Wipe the outside of the < 0.1 NTU standard and insert the sample cell in the cell compartment by aligning the orientation mark on the cell with the mark on the front of the cell compartment.
4. Close the lid and press **I/O**.
5. Press the **CAL** button. The **CAL** and **S0** icons will be displayed and the 0 will flash. The four-digit display will show the value of the **S0** standard for the previous calibration. If the blank value was forced to 0.0, the display will be blank. Press the right arrow key ($\rightarrow$) to get a numerical display.
6. Press **READ**. The instrument will count from 60 to 0, read the blank and use it to calculate a correction factor for the 20 NTU standard measurement. If the dilution water is ≥ 0.5 NTU, E 1 will appear when the calibration is calculated (see *Section 3.6.2.3 on page 31 of the manual*). The display will automatically increment to the next standard. Remove the sample cell from the cell compartment

**CALIBRATION AND MAINTENANCE OF PORTABLE
FIELD TURBIDITY METER**

Note: The turbidity of the dilution water can be “forced” to zero by pressing → rather than reading the dilution water. The display will show “S0 NTU” and the ↑ key must be pressed to continue with the next standard.

7. Repeat steps 1 through 7 for the 20, 100 and 800 standards.
8. Following the 800 NTU standard calibration, the display will increment back to the **S0** display. Remove the sample cell from the cell compartment.
9. Press **CAL** to accept the calibration. The instrument will return to measurement mode automatically.
10. Document the calibration results and related information in the Project Field Book and on an **Equipment Calibration Log** (see attached sample). Information will include, at a minimum:
 - Time, date, and initials of the field team member performing the calibration
 - The unique identifier for the meter, including manufacturer, model, and serial number
 - The brand of calibration standards
 - The instrument readings
 - The instrument settings (if applicable)
 - Pass or fail designation in accordance with the accuracy specifications presented above
 - Corrective action taken (see Maintenance below) in the event of failure to adequately calibrate.

Note: Pressing **CAL** completes the calculation of the calibration coefficients. If calibration errors occurred during calibration, error messages will appear after **CAL** is pressed. If **E 1** or **E 2** appear, check the standard preparation and review the calibration; repeat the calibration if necessary. If “**CAL?**” appears, an error may have

**CALIBRATION AND MAINTENANCE OF PORTABLE
FIELD TURBIDITY METER**

occurred during calibration. If “CAL?” is flashing, the instrument is using the default calibration.

NOTES

- If the **I/O** key is pressed during calibration, the new calibration data is lost and the old calibration will be used for measurements. Once in calibration mode, only the **READ**, **I/O**, **↑**, and **→** keys function. Signal averaging and range mode must be selected before entering the calibration mode.
- If **E 1** or **E 2** are displayed, an error occurred during calibration. Check the standard preparation and review the calibration; repeat the calibration if necessary. Press **DIAG** to cancel the error message (**E 1** or **E 2**). To continue without repeating the calibration, press **I/O** twice to restore the previous calibration. If “CAL?” is displayed, an error may have occurred during calibration. The previous calibration may not be restored. Either recalibrate or use the calibration as is.
- To review a calibration, press **CAL** and then **↑** to view the calibration standard values. As long as **READ** is never pressed and **CAL** is not flashing, the calibration will not be updated. Press **CAL** again to return to the measurement mode.

MAINTENANCE

- **Cleaning:** Keep the turbidimeter and accessories as clean as possible and store the instrument in the carrying case when not in use. Avoid prolonged exposure to sunlight and ultraviolet light. Wipe spills up promptly. Wash sample cells with non-abrasive laboratory detergent, rinse with distilled or demineralized water, and air dry. Avoid scratching the cells and wipe all moisture and fingerprints off the cells before inserting them into the instrument. Failure to do so can give inaccurate readings. See *Section 2.3.1 on page 11 of the manual* for more information about sample cell care.
- **Battery Replacement:** AA alkaline cells typically last for about 300 tests with the signal-averaging mode off, about 180 tests if signal averaging is used. The “battery” icon flashes when battery replacement is needed. Refer to *Section 1.4.2 on page 5 of the manual* for battery installation instructions. If the batteries are changed within 30

**CALIBRATION AND MAINTENANCE OF PORTABLE
FIELD TURBIDITY METER**

seconds, the instrument retains the latest range and signal average selections. If it takes more than 30 seconds, the instrument uses the default settings. If, after changing batteries, the instrument will not turn off or on and the batteries are good, remove the batteries and reinstall them. If the instrument still won't function, contact Hach Service or the nearest authorized dealer.

- **Lamp Replacement:** The procedure in *Section 4.0 on page 49 of the manual* explains lamp installation and electrical connections. Use a small screwdriver to remove and install the lamp leads in the terminal block. The instrument requires calibration after lamp replacement.

ATTACHMENTS

Equipment Calibration Log (sample)

FOP 009.0

**CALIBRATION AND MAINTENANCE OF PORTABLE
FIELD TURBIDITY METER**

EQUIPMENT CALIBRATION

PROJECT INFORMATION:

Project Name: _____

Date: _____

Project No.: _____

Client: _____

Instrument Source: ☐ BM ☐ Rental

METER TYPE	UNITS	TIME	MAKE/MODEL	SERIAL NUMBER	CAL. BY	STANDARD	READING	SETTLE
☐ pH meter	units		Myron L. Company Ultra Meter 6P	606987		4.00		
						7.00		
						10.01		
						< 0.4		
☐ Turbidity meter	NTU		Hach 2100P Turbidimeter	970600014560		20		
						100		
						800		
☐ Sp. conductance meter	uS/mS		Myron L. Company Ultra Meter 6P	606987		uS @ 25 °C		
☐ PID	ppm		Photovac 2020 PID			open air zero		MIBK re
						ppm Iso. Gas		factor :
☐ Particulate meter	mg/m ³					zero air		
☐ Oxygen	%					open air		
☐ Hydrogen sulfide	ppm					open air		
☐ Carbon monoxide	ppm					open air		
☐ LEL	%					open air		
☐ Radiation Meter	uR/h					background area		
☐								

ADDITIONAL REMARKS: _____

PREPARED BY: _____

DATE: _____



The logo for Roux, featuring the word "ROUX" in white, bold, sans-serif capital letters inside a blue rectangular box with a slight drop shadow.

ROUX

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FIELD OPERATING PROCEDURES

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Calibration and
Maintenance of
Portable
Photoionization
Detector (PID)

**CALIBRATION AND MAINTENANCE OF PORTABLE
PHOTOIONIZATION DETECTOR**

PURPOSE

This procedure describes a general method for the calibration and maintenance of a portable photoionization detector (PID). The PID detects and initially quantifies a reading of the volatile organic compound (VOC) concentration in air. The PID is used as a field-screening tool for initial evaluation of soil samples and for ambient air monitoring of compounds with ionization potentials (IP) less than the PID lamp electron voltage (eV) rating. The IP is the amount of energy required to move an electron to an infinite distance from the nucleus thus creating a positive ion plus an electron. It should be noted that all of the major components of air (i.e., carbon dioxide, methane, nitrogen, oxygen etc.) have IP's above 12 eV. As a result, they will not be ionized by the 9.8, 10.6, or 11.7 eV lamps typically utilized in field PIDs. The response of the PID will then be the sum of the organic and inorganic compounds in air that are ionized by the appropriate lamp (i.e., 9.8, 10.6 or 11.7 eV). Attached to this FOP is a table summarizing common organic compounds and their respective IPs.

Calibration is performed to verify instrument accuracy and function. All field instruments will be calibrated, verified and recalibrated at frequencies required by their respective operating manuals or manufacturer's specifications, but not less than once each day that the instrument is in use. Compound-specific calibration methods should be selected on a project-by-project basis to increase the accuracy of the instrument. The best way to calibrate a PID to different compounds is to use a standard of the gas of interest. However, correction factors have been determined that enable the user to quantify a large number of chemicals using only a single calibration gas, typically isobutylene. Field personnel should have access to all operating manuals for the instruments used for the field measurements. This procedure also documents critical maintenance activities for this meter.

FOP 011.1

CALIBRATION AND MAINTENANCE OF PORTABLE PHOTOIONIZATION DETECTOR

Note: The information included below is equipment manufacturer- and model-specific, however, accuracy, calibration, and maintenance procedures for this type of portable equipment are typically similar. The information below pertains to the MiniRAE 2000 Portable VOC Monitor equipped with a 10.6 eV lamp. The actual equipment to be used in the field will be equivalent or similar. The following information is provided for general reference; the equipment-specific manufacturer's manual should be followed with precedence over this FOP.

Note: The PID indicates total VOC concentration readings that are normalized to a calibration standard, so actual quantification of individual compounds is not provided. In addition, the PID response to compounds is highly variable, dependent on ionization potential of the compound, and the presence or absence of other compounds.

ACCURACY

The MiniRAE 2000 is accurate to ± 2 ppm or 10% of the reading for concentrations ranging from 0-2,000 ppm and $\pm 20\%$ of the reading at concentrations greater than 2,000 ppm. Response time is less than two seconds to 90 percent of full-scale. The operating temperature range is 0 to 45° C and the operating humidity range is 0 to 95 % relative humidity (non-condensing).

CALIBRATION PROCEDURE

The calibration method and correction factor, if applicable, will be selected on a project-by-project basis and confirmed with the Project Manager prior to the start of field work.

1. Calibrate all field test equipment at the beginning of each sampling day. Check and recalibrate the PID according to the manufacture's specifications.



**CALIBRATION AND MAINTENANCE OF PORTABLE
PHOTOIONIZATION DETECTOR**

2. Calibrate the PID using a compressed gas cylinder or equivalent containing the calibration standard, a flow regulator, and a tubing assembly. In addition, a compressed gas cylinder containing zero air (“clean” air) may be required if ambient air conditions do not permit calibration to “clean air”.
3. Fill two Tedlar® bags equipped with a one-way valve with zero-air (if applicable) and the calibration standard gas.
4. Assemble the calibration equipment and actuate the PID in its calibration mode.
5. Select the appropriate calibration method. Calibration may be completed with two methods: 1) where the calibration standard gas is the same as the measurement gas (no correction factor is applied) or 2) where the calibration standard gas is not the same as the measurement gas and a correction factor will be applied. An isobutylene standard gas must be used as the calibration standard gas for the use of correction factors with the MiniRAE 2000. See below for additional instructions for calibration specific to use with or without correction factors.

Calibrating Without a Correction Factor

Navigate within the menu to select the “cal memory” for the specific calibration standard gas prior to calibration. The default gas selections for the MiniRAE 2000 are as follows:

Cal Memory #0	Isobutylene
Cal Memory #1	Hexane
Cal Memory #2	Xylene
Cal Memory #3	Benzene
Cal Memory #4	Styrene
Cal Memory #5	Toluene
Cal Memory #6	Vinyl Chloride
Cal Memory #7	Custom

FOP 011.1

CALIBRATION AND MAINTENANCE OF PORTABLE PHOTOIONIZATION DETECTOR

The calibration standard gas for Cal Memory #1-7 may be toggled for selection of any of the approximately 100 preprogrammed calibration standard gases for use without an applied correction factor (i.e., the calibration gas must be the same as the measurement gas).

Calibrating With a Correction Factor

Navigate within the menu to select the “Cal Memory”.

Select “Cal Memory #0” and toggle for selection of any of the approximately 100 preprogrammed chemicals. During calibration, the unit requests isobutylene gas and displays the isobutylene concentration immediately following calibration, but when the unit is returned to the normal reading mode, it displays the selected chemical and applies the correction factor.

If the pre-programmed list does not include the desired chemical or a user-defined measurement gas and correction factor is desired, toggle Cal Memory #0 to “user defined custom gas”. A list of approximately 300 correction factors is attached in Technical Note 106 generated by MiniRAE.

6. Once the PID settings have been verified, connect the PID probe to the zero air calibration bag (or calibrate to ambient air if conditions permit) and wait for a stable indication.
7. Connect the PID probe to the calibration standard bag. Measure an initial reading of the standard and wait for a stable indication.
8. Keep the PID probe connected to the calibration standard bag, calibrate to applicable concentration (typically 100 ppm with isobutylene) with the standard and wait for a stable indication.
9. Document the calibration results and related information in the Project Field Book and on an **Equipment Calibration Log** (see attached sample), indicating the meter readings before and after the instrument has been adjusted. This is important, not only for data validation, but also to establish



FOP 011.1

CALIBRATION AND MAINTENANCE OF PORTABLE PHOTOIONIZATION DETECTOR

maintenance schedules and component replacement. Information will include, at a minimum:

- Time, date and initials of the field team member performing the calibration
- The unique identifier for the meter, including manufacturer, model, and serial number
- The calibration standard and concentration
- Correction factors used, if any
- The brand and expiration date of the calibration standard gas
- The instrument readings: before and after calibration
- The instrument settings (if applicable)
- Pass or fail designation in accordance with the accuracy specifications presented above
- Corrective action taken (see Maintenance below) in the event of failure to adequately calibrate.

MAINTENANCE

- The probe and dust filter of the PID should be checked before and after every use for cleanliness. Should instrument response become unstable, recalibration should be performed. If this does not resolve the problem, access the photoionization bulb and clean with the manufacturer-supplied abrasive compound, then recalibrate.
- The PID battery must be recharged after each use. Store the PID in its carrying case when not in use. Additional maintenance details related to individual components of the PID are provided in the equipment manufacturer's instruction manual. If calibration or instrument performance is not in accordance with specifications, send the instrument to the equipment manufacturer for repair.
- Maintain a log for each monitoring instrument. Record all maintenance performed on the instrument on this log with date and name of the organization performing the maintenance.



FOP 011.1

CALIBRATION AND MAINTENANCE OF PORTABLE PHOTOIONIZATION DETECTOR

ATTACHMENTS

Table 1; Summary of Ionization Potentials
Equipment Calibration Log (sample)
Technical Note TN-106



CALIBRATION AND MAINTENANCE OF PORTABLE PHOTOIONIZATION DETECTOR

TABLE 1

SUMMARY OF IONIZATION POTENTIALS

Chemical Name	Ionization Potential (eV)	Cannot be Read by 10.6 eV PID
A		
2-Amino pyridine	8	
Acetaldehyde	10.21	
Acetamide	9.77	
Acetic acid	10.69	X
Acetic anhydride	10	
Acetone	9.69	
Acetonitrile	12.2	X
Acetophenone	9.27	
Acetyl bromide	10.55	
Acetyl chloride	11.02	X
Acetylene	11.41	X
Acrolein	10.1	
Acrylamide	9.5	
Acrylonitrile	10.91	X
Allyl alcohol	9.67	
Allyl chloride	9.9	
Ammonia	10.2	
Aniline	7.7	
Anisidine	7.44	
Anisole	8.22	
Arsine	9.89	
B		
1,3-Butadiene (butadiene)	9.07	
1-Bromo-2-chloroethane	10.63	X
1-Bromo-2-methylpropane	10.09	
1-Bromo-4-fluorobenzene	8.99	
1-Bromobutane	10.13	
1-Bromopentane	10.1	
1-Bromopropane	10.18	
1-Bromopropene	9.3	
1-Butanethiol	9.14	
1-Butene	9.58	
1-Butyne	10.18	
2,3-Butadione	9.23	
2-Bromo-2-methylpropane	9.89	
2-Bromobutane	9.98	
2-Bromopropane	10.08	

CALIBRATION AND MAINTENANCE OF PORTABLE PHOTOIONIZATION DETECTOR

TABLE 1

SUMMARY OF IONIZATION POTENTIALS

Chemical Name	Ionization Potential (eV)	Cannot be Read by 10.6 eV PID
2-Bromothiophene	8.63	
2-Butanone (MEK)	9.54	
3-Bromopropene	9.7	
3-Butene nitrile	10.39	
Benzaldehyde	9.53	
Benzene	9.25	
Benzenethiol	8.33	
Benzonitrile	9.71	
Benzotrifluoride	9.68	
Biphenyl	8.27	
Boron oxide	13.5	X
Boron trifluoride	15.56	X
Bromine	10.54	
Bromobenzene	8.98	
Bromochloromethane	10.77	X
Bromoform	10.48	
Butane	10.63	X
Butyl mercaptan	9.15	
cis-2-Butene	9.13	
m-Bromotoluene	8.81	
n-Butyl acetate	10.01	
n-Butyl alcohol	10.04	
n-Butyl amine	8.71	
n-Butyl benzene	8.69	
n-Butyl formate	10.5	
n-Butyraldehyde	9.86	
n-Butyric acid	10.16	
n-Butyronitrile	11.67	X
o-Bromotoluene	8.79	
p-Bromotoluene	8.67	
p-tert-Butyltoluene	8.28	
s-Butyl amine	8.7	
s-Butyl benzene	8.68	
sec-Butyl acetate	9.91	
t-Butyl amine	8.64	
t-Butyl benzene	8.68	
trans-2-Butene	9.13	
C		

CALIBRATION AND MAINTENANCE OF PORTABLE PHOTOIONIZATION DETECTOR

TABLE 1

SUMMARY OF IONIZATION POTENTIALS

Chemical Name	Ionization Potential (eV)	Cannot be Read by 10.6 eV PID
1-Chloro-2-methylpropane	10.66	X
1-Chloro-3-fluorobenzene	9.21	
1-Chlorobutane	10.67	X
1-Chloropropane	10.82	X
2-Chloro-2-methylpropane	10.61	X
2-Chlorobutane	10.65	X
2-Chloropropane	10.78	X
2-Chlorothiophene	8.68	
3-Chloropropene	10.04	
Camphor	8.76	
Carbon dioxide	13.79	X
Carbon disulfide	10.07	
Carbon monoxide	14.01	X
Carbon tetrachloride	11.47	X
Chlorine	11.48	X
Chlorine dioxide	10.36	
Chlorine trifluoride	12.65	X
Chloroacetaldehyde	10.61	X
α -Chloroacetophenone	9.44	
Chlorobenzene	9.07	
Chlorobromomethane	10.77	X
Chlorofluoromethane (Freon 22)	12.45	X
Chloroform	11.37	X
Chlorotrifluoromethane (Freon 13)	12.91	X
Chrysene	7.59	
Cresol	8.14	
Crotonaldehyde	9.73	
Cumene (isopropyl benzene)	8.75	
Cyanogen	13.8	X
Cyclohexane	9.8	
Cyclohexanol	9.75	
Cyclohexanone	9.14	
Cyclohexene	8.95	
Cyclo-octatetraene	7.99	
Cyclopentadiene	8.56	
Cyclopentane	10.53	
Cyclopentanone	9.26	
Cyclopentene	9.01	

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CALIBRATION AND MAINTENANCE OF PORTABLE
PHOTOIONIZATION DETECTOR

TABLE 1

SUMMARY OF IONIZATION POTENTIALS

Chemical Name	Ionization Potential (eV)	Cannot be Read by 10.6 eV PID
Cyclopropane	10.06	
m-Chlorotoluene	8.83	
o-Chlorotoluene	8.83	
p-Chlorotoluene	8.7	
D		
1,1-Dibromoethane	10.19	
1,1-Dichloroethane	11.12	X
1,1-Dimethoxyethane	9.65	
1,1-Dimethylhydrazine	7.28	
1,2-Dibromoethane	9.45	
1,2-Dichloro-1,1,2,2-tetrafluoroethane (Freon 114)	12.2	X
1,2-Dichloroethane	11.12	X
1,2-Dichloropropane	10.87	X
1,3-Dibromopropane	10.07	
1,3-Dichloropropane	10.85	X
2,2-Dimethyl butane	10.06	
2,2-Dimethyl propane	10.35	
2,3-Dichloropropene	9.82	
2,3-Dimethyl butane	10.02	
3,3-Dimethyl butanone	9.17	
cis-Dichloroethene	9.65	
Decaborane	9.88	
Diazomethane	9	
Diborane	12	X
Dibromochloromethane	10.59	
Dibromodifluoromethane	11.07	X
Dibromomethane	10.49	
Dibutylamine	7.69	
Dichlorodifluoromethane (Freon 12)	12.31	X
Dichlorofluoromethane	12.39	X
Dichloromethane	11.35	X
Diethoxymethane	9.7	
Diethyl amine	8.01	
Diethyl ether	9.53	
Diethyl ketone	9.32	
Diethyl sulfide	8.43	
Diethyl sulfite	9.68	
Difluorodibromomethane	11.07	X

CALIBRATION AND MAINTENANCE OF PORTABLE PHOTOIONIZATION DETECTOR

TABLE 1

SUMMARY OF IONIZATION POTENTIALS

Chemical Name	Ionization Potential (eV)	Cannot be Read by 10.6 eV PID
Dihydropyran	8.34	
Diiodomethane	9.34	
Diisopropylamine	7.73	
Dimethoxymethane (methylal)	10	
Dimethyl amine	8.24	
Dimethyl ether	10	
Dimethyl sulfide	8.69	
Dimethylaniline	7.13	
Dimethylformamide	9.18	
Dimethylphthalate	9.64	
Dinitrobenzene	10.71	X
Dioxane	9.19	
Diphenyl	7.95	
Dipropyl amine	7.84	
Dipropyl sulfide	8.3	
Durene	8.03	
m-Dichlorobenzene	9.12	
N,N-Diethyl acetamide	8.6	
N,N-Diethyl formamide	8.89	
N,N-Dimethyl acetamide	8.81	
N,N-Dimethyl formamide	9.12	
o-Dichlorobenzene	9.06	
p-Dichlorobenzene	8.95	
p-Dioxane	9.13	
trans-Dichloroethene	9.66	
E		
Epichlorohydrin	10.2	
Ethane	11.65	X
Ethanethiol (ethyl mercaptan)	9.29	
Ethanolamine	8.96	
Ethene	10.52	
Ethyl acetate	10.11	
Ethyl alcohol	10.48	
Ethyl amine	8.86	
Ethyl benzene	8.76	
Ethyl bromide	10.29	
Ethyl chloride (chloroethane)	10.98	X
Ethyl disulfide	8.27	

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CALIBRATION AND MAINTENANCE OF PORTABLE
PHOTOIONIZATION DETECTOR

TABLE 1

SUMMARY OF IONIZATION POTENTIALS

Chemical Name	Ionization Potential (eV)	Cannot be Read by 10.6 eV PID
Ethyl ether	9.51	
Ethyl formate	10.61	X
Ethyl iodide	9.33	
Ethyl isothiocyanate	9.14	
Ethyl mercaptan	9.29	
Ethyl methyl sulfide	8.55	
Ethyl nitrate	11.22	X
Ethyl propionate	10	
Ethyl thiocyanate	9.89	
Ethylene chlorohydrin	10.52	
Ethylene diamine	8.6	
Ethylene dibromide	10.37	
Ethylene dichloride	11.05	X
Ethylene oxide	10.57	
Ethylenimine	9.2	
Ethynylbenzene	8.82	
F		
2-Furaldehyde	9.21	
Fluorine	15.7	X
Fluorobenzene	9.2	
Formaldehyde	10.87	X
Formamide	10.25	
Formic acid	11.05	X
Freon 11 (trichlorofluoromethane)	11.77	X
Freon 112 (1,1,2,2-tetrachloro-1,2-difluoroethane)	11.3	X
Freon 113 (1,1,2-trichloro-1,2,2-trifluoroethane)	11.78	X
Freon 114 (1,2-dichloro-1,1,2,2-tetrafluoroethane)	12.2	X
Freon 12 (dichlorodifluoromethane)	12.31	X
Freon 13 (chlorotrifluoromethane)	12.91	X
Freon 22 (chlorofluoromethane)	12.45	X
Furan	8.89	
Furfural	9.21	
m-Fluorotoluene	8.92	
o-Fluorophenol	8.66	
o-Fluorotoluene	8.92	
p-Fluorotoluene	8.79	
H		
1-Hexene	9.46	

CALIBRATION AND MAINTENANCE OF PORTABLE PHOTOIONIZATION DETECTOR

TABLE 1

SUMMARY OF IONIZATION POTENTIALS

Chemical Name	Ionization Potential (eV)	Cannot be Read by 10.6 eV PID
2-Heptanone	9.33	
2-Hexanone	9.35	
Heptane	10.08	
Hexachloroethane	11.1	X
Hexane	10.18	
Hydrazine	8.1	
Hydrogen	15.43	X
Hydrogen bromide	11.62	X
Hydrogen chloride	12.74	X
Hydrogen cyanide	13.91	X
Hydrogen fluoride	15.77	X
Hydrogen iodide	10.38	
Hydrogen selenide	9.88	
Hydrogen sulfide	10.46	
Hydrogen telluride	9.14	
Hydroquinone	7.95	
I		
1-Iodo-2-methylpropane	9.18	
1-Iodobutane	9.21	
1-Iodopentane	9.19	
1-Iodopropane	9.26	
2-Iodobutane	9.09	
2-Iodopropane	9.17	
Iodine	9.28	
Iodobenzene	8.73	
Isobutane	10.57	
Isobutyl acetate	9.97	
Isobutyl alcohol	10.12	
Isobutyl amine	8.7	
Isobutyl formate	10.46	
Isobutyraldehyde	9.74	
Isobutyric acid	10.02	
Isopentane	10.32	
Isophorone	9.07	
Isoprene	8.85	
Isopropyl acetate	9.99	
Isopropyl alcohol	10.16	
Isopropyl amine	8.72	

CALIBRATION AND MAINTENANCE OF PORTABLE PHOTOIONIZATION DETECTOR

TABLE 1

SUMMARY OF IONIZATION POTENTIALS

Chemical Name	Ionization Potential (eV)	Cannot be Read by 10.6 eV PID
Isopropyl benzene	8.69	
Isopropyl ether	9.2	
Isovaleraldehyde	9.71	
m-Iodotoluene	8.61	
o-Iodotoluene	8.62	
p-Iodotoluene	8.5	
K		
Ketene	9.61	
L		
2,3-Lutidine	8.85	
2,4-Lutidine	8.85	
2,6-Lutidine	8.85	
M		
2-Methyl furan	8.39	
2-Methyl naphthalene	7.96	
1-Methyl naphthalene	7.96	
2-Methyl propene	9.23	
2-Methyl-1-butene	9.12	
2-Methylpentane	10.12	
3-Methyl-1-butene	9.51	
3-Methyl-2-butene	8.67	
3-Methylpentane	10.08	
4-Methylcyclohexene	8.91	
Maleic anhydride	10.8	X
Mesityl oxide	9.08	
Mesitylene	8.4	
Methane	12.98	X
Methanethiol (methyl mercaptan)	9.44	
Methyl acetate	10.27	
Methyl acetylene	10.37	
Methyl acrylate	9.9	
Methyl alcohol	10.85	X
Methyl amine	8.97	
Methyl bromide	10.54	
Methyl butyl ketone	9.34	
Methyl butyrate	10.07	
Methyl cellosolve	9.6	
Methyl chloride	11.28	X

CALIBRATION AND MAINTENANCE OF PORTABLE PHOTOIONIZATION DETECTOR

TABLE 1

SUMMARY OF IONIZATION POTENTIALS

Chemical Name	Ionization Potential (eV)	Cannot be Read by 10.6 eV PID
Methyl chloroform (1,1,1-trichloroethane)	11	X
Methyl disulfide	8.46	
Methyl ethyl ketone	9.53	
Methyl formate	10.82	X
Methyl iodide	9.54	
Methyl isobutyl ketone	9.3	
Methyl isobutyrate	9.98	
Methyl isocyanate	10.67	X
Methyl isopropyl ketone	9.32	
Methyl isothiocyanate	9.25	
Methyl mercaptan	9.44	
Methyl methacrylate	9.7	
Methyl propionate	10.15	
Methyl propyl ketone	9.39	
α -Methyl styrene	8.35	
Methyl thiocyanate	10.07	
Methylal (dimethoxymethane)	10	
Methylcyclohexane	9.85	
Methylene chloride	11.32	X
Methyl-n-amyl ketone	9.3	
Monomethyl aniline	7.32	
Monomethyl hydrazine	7.67	
Morpholine	8.2	
n-Methyl acetamide	8.9	
N		
1-Nitropropane	10.88	X
2-Nitropropane	10.71	X
Naphthalene	8.12	
Nickel carbonyl	8.27	
Nitric oxide, (NO)	9.25	
Nitrobenzene	9.92	
Nitroethane	10.88	X
Nitrogen	15.58	X
Nitrogen dioxide	9.78	
Nitrogen trifluoride	12.97	X
Nitromethane	11.08	X
Nitrotoluene	9.45	
p-Nitrochloro benzene	9.96	

CALIBRATION AND MAINTENANCE OF PORTABLE PHOTOIONIZATION DETECTOR

TABLE 1

SUMMARY OF IONIZATION POTENTIALS

Chemical Name	Ionization Potential (eV)	Cannot be Read by 10.6 eV PID
O		
Octane	9.82	
Oxygen	12.08	X
Ozone	12.08	X
P		
1-Pentene	9.5	
1-Propanethiol	9.2	
2,4-Pentanedione	8.87	
2-Pentanone	9.38	
2-Picoline	9.02	
3-Picoline	9.02	
4-Picoline	9.04	
n-Propyl nitrate	11.07	X
Pentaborane	10.4	
Pentane	10.35	
Perchloroethylene	9.32	
Pheneloic	8.18	
Phenol	8.5	
Phenyl ether (diphenyl oxide)	8.82	
Phenyl hydrazine	7.64	
Phenyl isocyanate	8.77	
Phenyl isothiocyanate	8.52	
Phenylene diamine	6.89	
Phosgene	11.77	X
Phosphine	9.87	
Phosphorus trichloride	9.91	
Phthalic anhydride	10	
Propane	11.07	X
Propargyl alcohol	10.51	
Propiolactone	9.7	
Propionaldehyde	9.98	
Propionic acid	10.24	
Propionitrile	11.84	X
Propyl acetate	10.04	
Propyl alcohol	10.2	
Propyl amine	8.78	
Propyl benzene	8.72	
Propyl ether	9.27	

CALIBRATION AND MAINTENANCE OF PORTABLE PHOTOIONIZATION DETECTOR

TABLE 1

SUMMARY OF IONIZATION POTENTIALS

Chemical Name	Ionization Potential (eV)	Cannot be Read by 10.6 eV PID
Propyl formate	10.54	
Propylene	9.73	
Propylene dichloride	10.87	X
Propylene imine	9	
Propylene oxide	10.22	
Propyne	10.36	
Pyridine	9.32	
Pyrrole	8.2	
Q		
Quinone	10.04	
S		
Stibine	9.51	
Styrene	8.47	
Sulfur dioxide	12.3	X
Sulfur hexafluoride	15.33	X
Sulfur monochloride	9.66	
Sulfuryl fluoride	13	X
T		
o-Terphenyls	7.78	
1,1,2,2-Tetrachloro-1,2-difluoroethane (Freon 112)	11.3	X
1,1,1-Trichloroethane	11	X
1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)	11.78	X
2,2,4-Trimethyl pentane	9.86	
o-Toluidine	7.44	
Tetrachloroethane	11.62	X
Tetrachloroethene	9.32	
Tetrachloromethane	11.47	X
Tetrahydrofuran	9.54	
Tetrahydropyran	9.25	
Thiolacetic acid	10	
Thiophene	8.86	
Toluene	8.82	
Tribromoethene	9.27	
Tribromofluoromethane	10.67	X
Tribromomethane	10.51	
Trichloroethene	9.45	
Trichloroethylene	9.47	
Trichlorofluoromethane (Freon 11)	11.77	X

CALIBRATION AND MAINTENANCE OF PORTABLE PHOTOIONIZATION DETECTOR

TABLE 1

SUMMARY OF IONIZATION POTENTIALS

Chemical Name	Ionization Potential (eV)	Cannot be Read by 10.6 eV PID
Trichloromethane	11.42	X
Triethylamine	7.5	
Trifluoromonobromo-methane	11.4	X
Trimethyl amine	7.82	
Tripropyl amine	7.23	
V		
o-Vinyl toluene	8.2	
Valeraldehyde	9.82	
Valeric acid	10.12	
Vinyl acetate	9.19	
Vinyl bromide	9.8	
Vinyl chloride	10	
Vinyl methyl ether	8.93	
W		
Water	12.59	X
X		
2,4-Xylidine	7.65	
m-Xylene	8.56	
o-Xylene	8.56	
p-Xylene	8.45	

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CALIBRATION AND MAINTENANCE OF PORTABLE PHOTOIONIZATION DETECTOR

EQUIPMENT CALIBRATION LOG

PROJECT INFORMATION:

Project Name: _____
 Project No.: _____
 Client: _____

Date: _____

Instrument Source: ☐ BM ☐ Rental

METER TYPE	UNITS	TIME	MAKE/MODEL	SERIAL NUMBER	CAL. BY	STANDARD	POST CAL. READING	SETTINGS
☐ pH meter	units		Myron L Company Ultra Meter 6P	606987		4.00 7.00 10.01		
☐ Turbidity meter	NTU		Hach 2100P Turbidimeter	9706000145		0.4 100 800		
☐ Sp. Cond. meter	uS mS		Myron L Company Ultra Meter 6P			_____ mS @ 25 °C		
☐ PID	ppm		MinRAE 20			open air zero _____ ppm Iso. Gas		MIBK response factor = 1.0
☐ Dissolved Oxygen	ppm		YSI Model 5					
☐ Particulate meter	mg/m ³					zero air		
☐ Oxygen	%					open air		
☐ Hydrogen sulfide	ppm					open air		
☐ Carbon monoxide	ppm					open air		
☐ LEL	%					open air		
☐ Radiation Meter	uR/H					background area		
☐								

ADDITIONAL REMARKS:

PREPARED BY: _____ DATE: _____





Correction Factors, Ionization Energies*, And Calibration Characteristics

Correction Factors and Ionization Energies

RAE Systems PIDs can be used for the detection of a wide variety of gases that exhibit different responses. In general, any compound with ionization energy (IE) lower than that of the lamp photons can be measured.* The best way to calibrate a PID to different compounds is to use a standard of the gas of interest. However, correction factors have been determined that enable the user to quantify a large number of chemicals using only a single calibration gas, typically isobutylene. In our PIDs, correction factors can be used in one of three ways:

- 1) Calibrate the monitor with isobutylene in the usual fashion to read in isobutylene equivalents. Manually multiply the reading by the correction factor (CF) to obtain the concentration of the gas being measured.
- 2) Calibrate the unit with isobutylene in the usual fashion to read in isobutylene equivalents. Call up the correction factor from the instrument memory or download it from a personal computer and then call it up. The monitor will then read directly in units of the gas of interest.
- 3) Calibrate the unit with isobutylene, but input an equivalent, "corrected" span gas concentration when prompted for this value. The unit will then read directly in units of the gas of interest.

** The term "ionization energy" is more scientifically correct and replaces the old term "ionization potential." High-boiling ("heavy") compounds may not vaporize enough to give a response even when their ionization energies are below the lamp photon energy. Some inorganic compounds like H₂O₂ and NO₂ give weak response even when their ionization energies are well below the lamp photon energy.*

Example 1:

With the unit calibrated to read isobutylene equivalents, the reading is 10 ppm with a 10.6 eV lamp. The gas being measured is butyl acetate, which has a correction factor of 2.6. Multiplying 10 by 2.6 gives an adjusted butyl acetate value of 26 ppm. Similarly, if the gas being measured were trichloroethylene (CF = 0.54), the adjusted value with a 10 ppm reading would be 5.4 ppm.

Example 2:

With the unit calibrated to read isobutylene equivalents, the reading is 100 ppm with a 10.6 eV lamp. The gas measured is m-xylene (CF = 0.43). After downloading this factor, the unit should read about 43 ppm when exposed to the same gas, and thus read directly in m-xylene values.

Example 3:

The desired gas to measure is ethylene dichloride (EDC). The CF is 0.6 with an 11.7 eV lamp. During calibration with 100 ppm isobutylene, insert 0.6 times 100, or 60 at the prompt for the calibration gas concentration. The unit then reads directly in EDC values.

Conversion to mg/m³

To convert from ppm to mg/m³, use the following formula:

$$\text{Conc. (mg/m}^3\text{)} = \frac{[\text{Conc. (ppmv)} \times \text{mol. wt. (g/mole)}]}{\text{molar gas volume (L)}}$$

For air at 25 °C (77 °F), the molar gas volume is 24.4 L/mole and the formula reduces to:

$$\text{Conc. (mg/m}^3\text{)} = \text{Conc. (ppmv)} \times \text{mol. wt. (g/mole)} \times 0.041$$

For example, if the instrument is calibrated with a gas standard in ppmv, such as 100 ppm isobutylene, and the user wants the display to read in mg/m³ of hexane, whose m.w. is 86 and CF is 4.3, the overall correction factor would be 4.3 x 86 x 0.041 equals 15.2.

Correction Factors for Mixtures

The correction factor for a mixture is calculated from the sum of the mole fractions X_i of each component divided by their respective correction factors CF_i:

$$\text{CF}_{\text{mix}} = 1 / (X_1/\text{CF}_1 + X_2/\text{CF}_2 + X_3/\text{CF}_3 + \dots X_i/\text{CF}_i)$$

Thus, for example, a vapor phase mixture of 5% benzene and 95% n-hexane would have a CF_{mix} of $\text{CF}_{\text{mix}} = 1 / (0.05/0.53 + 0.95/4.3) = 3.2$. A reading of 100 would then correspond to 320 ppm of the total mixture, comprised of 16 ppm benzene and 304 ppm hexane.



For a spreadsheet to compute the correction factor and TLV of a mixture see the appendix at the end of the CF table.

TLVs and Alarm Limits for Mixtures

The correction factor for mixtures can be used to set alarm limits for mixtures. To do this one first needs to calculate the exposure limit for the mixture. The Threshold Limit Value (TLV) often defines exposure limits. The TLV for the mixture is calculated in a manner similar to the CF calculation:

$$TLV_{mix} = 1 / (X_1/TLV_1 + X_2/TLV_2 + X_3/TLV_3 + \dots X_i/TLV_i)$$

In the above example, the 8-h TLV for benzene is 0.5 ppm and for n-hexane 50 ppm. Therefore the TLV of the mixture is $TLV_{mix} = 1 / (0.05/0.5 + 0.95/50) = 8.4$ ppm, corresponding to 8.0 ppm hexane and 0.4 ppm benzene. For an instrument calibrated on isobutylene, the reading corresponding to the TLV is:

$$Alarm\ Reading = TLV_{mix} / CF_{mix} = 8.4 / 3.2 = 2.6\ ppm$$

A common practice is to set the lower alarm limit to half the TLV, and the higher limit to the TLV. Thus, one would set the alarms to 1.3 and 2.6 ppm, respectively.

Calibration Characteristics

a) Flow Configuration. PID response is essentially independent of gas flow rate as long as it is sufficient to satisfy the pump demand. Four main flow configurations are used for calibrating a PID:

- 1) Pressurized gas cylinder (Fixed-flow regulator):** The flow rate of the regulator should match the flow demand of the instrument pump or be slightly higher.
- 2) Pressurized gas cylinder (Demand-flow regulator):** A demand-flow regulator better matches pump speed differences, but results in a slight vacuum during calibration and thus slightly high readings.
- 3) Collapsible gas bag:** The instrument will draw the calibration gas from the bag at its normal flow rate, as long as the bag valve is large enough. The bag should be filled with enough gas to allow at least one minute of flow (~0.6 L for a MiniRAE, ~0.3 L for MultiRAE).

4) T (or open tube) method: The T method uses a T-junction with gas flow higher than the pump draw. The gas supply is connected to one end of the T, the instrument inlet is connected to a second end of the T, and excess gas flow escapes through the third, open end of the T. To prevent ambient air mixing, a long tube should be connected to the open end, or a high excess rate should be used. Alternatively, the instrument probe can be inserted into an open tube slightly wider than the probe. Excess gas flows out around the probe.

The first two cylinder methods are the most efficient in terms of gas usage, while the bag and T methods give slightly more accurate results because they match the pump flow better.

b) Pressure. Pressures deviating from atmospheric pressure affect the readings by altering gas concentration and pump characteristics. It is best to calibrate with the instrument and calibration gas at the same pressure as each other and the sample gas. (Note that the cylinder pressure is not relevant because the regulator reduces the pressure to ambient.) If the instrument is calibrated at atmospheric pressure in one of the flow configurations described above, then 1) pressures slightly above ambient are acceptable but high pressures can damage the pump and 2) samples under vacuum may give low readings if air leaks into the sample train.

c) Temperature. Because temperature effects gas density and concentration, the temperature of the calibration gas and instrument should be as close as possible to the ambient temperature where the unit will be used. We recommend that the temperature of the calibration gas be within the instrument's temperature specification (typically 14° to 113° F or -10° to 45° C). Also, during actual measurements, the instrument should be kept at the same or higher temperature than the sample temperature to avoid condensation in the unit.

d) Matrix. The matrix gas of the calibration compound and VOC sample is significant. Some common matrix components, such as methane and water vapor can affect the VOC signal. PIDs are



most commonly used for monitoring VOCs in air, in which case the preferred calibration gas matrix is air. For a MiniRAE, methane, methanol, and water vapor reduce the response by about 20% when their concentration is 15,000 ppm and by about 40% at 30,000 ppm. Despite earlier reports of oxygen effects, RAE PID responses with 10.6 eV lamps are independent of oxygen concentration, and calibration gases in a pure nitrogen matrix can be used. H₂ and CO₂ up to 5 volume % also have no effect.

- e) Concentration.** Although RAE Systems PIDs have electronically linearized output, it is best to calibrate in a concentration range close to the actual measurement range. For example, 100 ppm standard gas for anticipated vapors of 0 to 250 ppm, and 500 ppm standard for expected concentrations of 250 to 1000 ppm. The correction factors in this table were typically measured at 50 to 100 ppm and apply from the ppb range up to about 1000 ppm. Above 1000 ppm the CF may vary and it is best to calibrate with the gas of interest near the concentration of interest.
- f) Filters.** Filters affect flow and pressure conditions and therefore all filters to be used during sampling should also be in place during calibration. Using a water trap (hydrophobic filter) greatly reduces the chances of drawing water aerosols or dirt particles into the instrument. Regular filter replacements are recommended because dirty filters can adsorb VOCs and cause slower response time and shifts in calibration.
- g) Instrument Design.** High-boiling (“heavy”) or very reactive compounds can be lost by reaction or adsorption onto materials in the gas sample train, such as filters, pumps and other sensors. Multi-gas meters, including EntryRAE, MultiRAE and AreaRAE have the pump and other sensors upstream of the PID and are prone to these losses. Compounds possibly affected by such losses are shown in green in the table, and may give slow response, or in extreme cases, no response at all. In many cases the multi-gas meters can still give a rough indication of the relative concentration, without giving an accurate,

quantitative reading. The ppbRAE and MiniRAE series instruments have inert sample trains and therefore do not exhibit significant loss; nevertheless, response may be slow for the very heavy compounds and additional sampling time up to a minute or more should be allowed to get a stable reading.

Table Abbreviations:

- CF** = Correction Factor (multiply by reading to get corrected value for the compound when calibrated to isobutylene)
- NR** = No Response
- IE** = Ionization Energy (values in parentheses are not well established)
- C** = Confirmed Value indicated by “+” in this column; all others are preliminary or estimated values and are subject to change
- ne** = Not Established ACGIH 8-hr. TWA
- C##** = Ceiling value, given where 8-hr.TWA is not available

Disclaimer:

Actual readings may vary with age and cleanliness of lamp, relative humidity, and other factors. For accurate work, the instrument should be calibrated regularly under the operating conditions used. The factors in this table were measured in dry air at room temperature, typically at 50-100 ppm. CF values may vary above about 1000 ppm.

Updates:

The values in this table are subject to change as more or better data become available. Watch for updates of this table on the Internet at

<http://www.raesystems.com>

IE data are taken from the CRC Handbook of Chemistry and Physics, 73rd Edition, D.R. Lide (Ed.), CRC Press (1993) and NIST Standard Ref. Database 19A, NIST Positive Ion Energetics, Vers. 2.0, Lias, et.al., U.S. Dept. Commerce (1993). Exposure limits (8-h TWA and Ceiling Values) are from the 2005 ACGIH Guide to Occupational Exposure Values, ACGIH, Cincinnati, OH 2005. Equations for exposure limits for mixtures of chemicals were taken from the 1997 TLVs and BEIs handbook published by the ACGIH (1997).



Compound Name	Synonym/Abbreviation	CAS No.	Formula	9.8	C	10.6	C	11.7	C	IE (eV)	TWA
Acetaldehyde		75-07-0	C ₂ H ₄ O	NR	+	6	+	3.3	+	10.23	C25
Acetic acid	Ethanoic Acid	64-19-7	C ₂ H ₄ O ₂	NR	+	22	+	2.6	+	10.66	10
Acetic anhydride	Ethanoic Acid Anhydride	108-24-7	C ₄ H ₆ O ₃	NR	+	6.1	+	2.0	+	10.14	5
Acetone	2-Propanone	67-64-1	C ₃ H ₆ O	1.2	+	1.1	+	1.4	+	9.71	500
Acetone cyanohydrin	2-Hydroxyisobutyronitrile	75-86-5	C ₄ H ₇ NO					4	+	11.1	C5
Acetonitrile	Methyl cyanide, Cyanomethane	75-05-8	C ₂ H ₃ N					100		12.19	40
Acetylene	Ethyne	74-86-2	C ₂ H ₂					2.1	+	11.40	ne
Acrolein	Propenal	107-02-8	C ₃ H ₄ O	42	+	3.9	+	1.4	+	10.10	0.1
Acrylic acid	Propenoic Acid	79-10-7	C ₃ H ₄ O ₂			12	+	2.0	+	10.60	2
Acrylonitrile	Propenenitrile	107-13-1	C ₃ H ₃ N			NR	+	1.2	+	10.91	2
Allyl alcohol		107-18-6	C ₃ H ₆ O	4.5	+	2.4	+	1.6	+	9.67	2
Allyl chloride	3-Chloropropene	107-05-1	C ₃ H ₅ Cl			4.3		0.7		9.9	1
Ammonia		7664-41-7	H ₃ N	NR	+	9.7	+	5.7	+	10.16	25
Amyl acetate	mix of n-Pentyl acetate & 2-Methylbutyl acetate	628-63-7	C ₇ H ₁₄ O ₂	11	+	2.3	+	0.95	+	<9.9	100
Amyl alcohol	1-Pentanol	75-85-4	C ₅ H ₁₂ O			5		1.6		10.00	ne
Aniline	Aminobenzene	62-53-3	C ₇ H ₇ N	0.50	+	0.48	+	0.47	+	7.72	2
Anisole	Methoxybenzene	100-66-3	C ₇ H ₈ O	0.89	+	0.58	+	0.56	+	8.21	ne
Arsine	Arsenic trihydride	7784-42-1	AsH ₃			1.9	+			9.89	0.05
Benzaldehyde		100-52-7	C ₇ H ₆ O					1		9.49	ne
Benzenamine, N-methyl-	N-Methylphenylamine	100-61-8	C ₇ H ₉ N			0.7				7.53	
Benzene		71-43-2	C ₆ H ₆	0.55	+	0.53	+	0.6	+	9.25	0.5
Benzonitrile	Cyanobenzene	100-47-0	C ₇ H ₅ N			1.6				9.62	ne
Benzyl alcohol	α-Hydroxytoluene, Hydroxymethylbenzene, Benzenemethanol	100-51-6	C ₇ H ₈ O	1.4	+	1.1	+	0.9	+	8.26	ne
Benzyl chloride	α-Chlorotoluene, Chloromethylbenzene	100-44-7	C ₇ H ₇ Cl	0.7	+	0.6	+	0.5	+	9.14	1
Benzyl formate	Formic acid benzyl ester	104-57-4	C ₈ H ₈ O ₂	0.9	+	0.73	+	0.66	+		ne
Boron trifluoride		7637-07-2	BF ₃	NR		NR		NR		15.5	C1
Bromine		7726-95-6	Br ₂	NR	+	1.30	+	0.74	+	10.51	0.1
Bromobenzene		108-86-1	C ₆ H ₅ Br			0.6		0.5		8.98	ne
2-Bromoethyl methyl ether		6482-24-2	C ₃ H ₇ OBBr			0.84	+			~10	ne
Bromoform	Tribromomethane	75-25-2	CHBr ₃	NR	+	2.5	+	0.5	+	10.48	0.5
Bromopropane, 1-	n-Propyl bromide	106-94-5	C ₃ H ₇ Br	150	+	1.5	+	0.6	+	10.18	ne
Butadiene	1,3-Butadiene, Vinyl ethylene	106-99-0	C ₄ H ₆	0.8		0.85	+	1.1		9.07	2
Butadiene diepoxide, 1,3-	1,2,3,4-Diepoxybutane	298-18-0	C ₄ H ₆ O ₂	25	+	3.5	+	1.2		~10	ne
Butanal	1-Butanal	123-72-8	C ₄ H ₈ O			1.8				9.84	
Butane		106-97-8	C ₄ H ₁₀			67	+	1.2		10.53	800
Butanol, 1-	Butyl alcohol, n-Butanol	71-36-3	C ₄ H ₁₀ O	70	+	4.7	+	1.4	+	9.99	20
Butanol, t-	tert-Butanol, t-Butyl alcohol	75-65-0	C ₄ H ₁₀ O	6.9	+	2.9	+			9.90	100
Butene, 1-	1-Butylene	106-98-9	C ₄ H ₈			0.9				9.58	ne
Butoxyethanol, 2-	Butyl Cellosolve, Ethylene glycol monobutyl ether	111-76-2	C ₆ H ₁₄ O ₂	1.8	+	1.2	+	0.6	+	<10	25
Butoxyethanol acetate	Ethanol, 2-(2-butoxyethoxy)-, acetate	124-17-4	C ₁₀ H ₂₀ O ₄			5.6				≤10.6	
Butoxyethoxyethanol	2-(2-Butoxyethoxy)ethanol	112-34-5	C ₈ H ₁₈ O ₃			4.6				≤10.6	
Butyl acetate, n-		123-86-4	C ₆ H ₁₂ O ₂			2.6	+			10	150
Butyl acrylate, n-	Butyl 2-propenoate, Acrylic acid butyl ester	141-32-2	C ₇ H ₁₂ O ₂			1.6	+	0.6	+		10
Butylamine, n-		109-73-9	C ₄ H ₁₁ N	1.1	+	1.1	+	0.7	+	8.71	C5
Butyl cellosolve	see 2-Butoxyethanol	111-76-2									
Butyl hydroperoxide, t-		75-91-2	C ₄ H ₁₀ O ₂	2.0	+	1.6	+			<10	1
Butyl mercaptan	1-Butanethiol	109-79-5	C ₄ H ₁₀ S	0.55	+	0.52	+			9.14	0.5
Carbon disulfide		75-15-0	CS ₂	4	+	1.2	+	0.44		10.07	10
Carbon tetrachloride	Tetrachloromethane	56-23-5	CCl ₄	NR	+	NR	+	1.7	+	11.47	5
Carbonyl sulfide	Carbon oxysulfide	463-58-1	COS							11.18	
Cellosolve	see 2-Ethoxyethanol										
CFC-14	see Tetrafluoromethane										
CFC-113	see 1,1,2-Trichloro-1,2,2-trifluoroethane										



Compound Name	Synonym/Abbreviation	CAS No.	Formula	9.8	C	10.6	C	11.7	C	IE (eV)	TWA
Chlorine		7782-50-5	Cl ₂					1.0	+	11.48	0.5
Chlorine dioxide		10049-04-4	ClO ₂	NR	+	NR	+	NR	+	10.57	0.1
Chlorobenzene	Monochlorobenzene	108-90-7	C ₆ H ₅ Cl	0.44	+	0.40	+	0.39	+	9.06	10
Chlorobenzotrifluoride, 4-	PCBTf, OXSOL 100	98-56-6	C ₇ H ₄ ClF ₃	0.74	+	0.63	+	0.55	+	<9.6	25
	p-Chlorobenzotrifluoride										
Chloro-1,3-butadiene, 2-	Chloroprene	126-99-8	C ₄ H ₅ Cl			3					10
Chloro-1,1-difluoroethane, 1-	HCFC-142B, R-142B	75-68-3	C ₂ H ₃ ClF ₂	NR		NR		NR		12.0	ne
Chlorodifluoromethane	HCFC-22, R-22	75-45-6	CHClF ₂	NR		NR		NR		12.2	1000
Chloroethane	Ethyl chloride	75-00-3	C ₂ H ₅ Cl	NR	+	NR	+	1.1	+	10.97	100
Chloroethanol	Ethylene chlorhydrin	107-07-3	C ₂ H ₅ ClO					2.9		10.52	C1
Chloroethyl ether, 2-	bis(2-chloroethyl) ether	111-44-4	C ₄ H ₈ Cl ₂ O	8.6	+	3.0	+				5
Chloroethyl methyl ether, 2-	Methyl 2-chloroethyl ether	627-42-9	C ₃ H ₇ ClO			3					ne
Chloroform	Trichloromethane	67-66-3	CHCl ₃	NR	+	NR	+	3.5	+	11.37	10
Chloro-2-methylpropene, 3-	Methallyl chloride, Isobutenyl chloride	563-47-3	C ₄ H ₇ Cl	1.4	+	1.2	+	0.63	+	9.76	ne
Chloropicrin		76-06-2	CCl ₃ NO ₂	NR	+	~400	+	7	+	?	0.1
Chlorotoluene, o-	o-Chloromethylbenzene	95-49-8	C ₇ H ₇ Cl			0.5		0.6		8.83	50
Chlorotoluene, p-	p-Chloromethylbenzene	106-43-4	C ₇ H ₇ Cl					0.6		8.69	ne
Chlorotrifluoroethene	CTFE, Chlorotrifluoroethylene	79-38-9	C ₂ ClF ₃	6.7	+	3.9	+	1.2	+	9.76	5
	Genetron 1113										
Chlorotrimethylsilane		75-77-4	C ₃ H ₉ ClSi	NR		NR		0.82	+	10.83	ne
Cresol, m-	m-Hydroxytoluene	108-39-4	C ₇ H ₈ O	0.57	+	0.50	+	0.57	+	8.29	5
Cresol, o-	o-Hydroxytoluene	95-48-7	C ₇ H ₈ O			1.0				8.50	
Cresol, p-	p-Hydroxytoluene	106-44-5	C ₇ H ₈ O			1.4				8.35	
Crotonaldehyde	trans-2-Butenal	123-73-9	C ₄ H ₆ O	1.5	+	1.1	+	1.0	+	9.73	2
		4170-30-3									
Cumene	Isopropylbenzene	98-82-8	C ₉ H ₁₂	0.58	+	0.54	+	0.4	+	8.73	50
Cyanogen bromide		506-68-3	CNBr	NR		NR		NR		11.84	ne
Cyanogen chloride		506-77-4	CNCl	NR		NR		NR		12.34	C0.3
Cyclohexane		110-82-7	C ₆ H ₁₂	3.3	+	1.4	+	0.64	+	9.86	300
Cyclohexanol	Cyclohexyl alcohol	108-93-0	C ₆ H ₁₂ O	1.5	+	0.9	+	1.1	+	9.75	50
Cyclohexanone		108-94-1	C ₆ H ₁₀ O	1.0	+	0.9	+	0.7	+	9.14	25
Cyclohexene		110-83-8	C ₆ H ₁₀			0.8	+			8.95	300
Cyclohexylamine		108-91-8	C ₆ H ₁₃ N			1.2				8.62	10
Cyclopentane 85%		287-92-3	C ₅ H ₁₀	NR	+	15	+	1.1		10.33	600
2,2-dimethylbutane 15%											
Cyclopropylamine	Aminocyclopropane	765-30-0	C ₃ H ₇ N	1.1	+	0.9	+	0.9	+		ne
Decamethylcyclopentasiloxane		541-02-6	C ₁₀ H ₃₀ O ₅ Si ₅	0.16	+	0.13	+	0.12	+		ne
Decamethyltetrasiloxane		141-62-8	C ₁₀ H ₃₀ O ₃ Si ₄	0.17	+	0.13	+	0.12	+	<10.2	ne
Decane		124-18-5	C ₁₀ H ₂₂	4.0	+	1.4	+	0.35	+	9.65	ne
Diacetone alcohol	4-Methyl-4-hydroxy-2-pentanone	123-42-2	C ₆ H ₁₂ O ₂			0.7					50
Dibromochloromethane	Chlorodibromomethane	124-48-1	CHBr ₂ Cl	NR	+	5.3	+	0.7	+	10.59	ne
Dibromo-3-chloropropane, 1,2-	DBCP	96-12-8	C ₃ H ₅ Br ₂ Cl	NR	+	1.7	+	0.43	+		0.001
Dibromoethane, 1,2-	EDB, Ethylene dibromide, Ethylene bromide	106-93-4	C ₂ H ₄ Br ₂	NR	+	1.7	+	0.6	+	10.37	ne
Dichlorobenzene, o-	1,2-Dichlorobenzene	95-50-1	C ₆ H ₄ Cl ₂	0.54	+	0.47	+	0.38	+	9.08	25
Dichlorodifluoromethane	CFC-12	75-71-8	CCl ₂ F ₂			NR	+	NR	+	11.75	1000
Dichlorodimethylsilane		75-78-5	C ₂ H ₆ Cl ₂ Si	NR		NR		1.1	+	>10.7	ne
Dichloroethane, 1,2-	EDC, 1,2-DCA, Ethylene dichloride	107-06-2	C ₂ H ₄ Cl ₂			NR	+	0.6	+	11.04	10
Dichloroethene, 1,1-	1,1-DCE, Vinylidene chloride	75-35-4	C ₂ H ₂ Cl ₂			0.82	+	0.8	+	9.79	5
Dichloroethene, c-1,2-	c-1,2-DCE, cis-Dichloroethylene	156-59-2	C ₂ H ₂ Cl ₂			0.8				9.66	200
Dichloroethene, t-1,2-	t-1,2-DCE, trans-Dichloroethylene	156-60-5	C ₂ H ₂ Cl ₂			0.45	+	0.34	+	9.65	200
Dichloro-1-fluoroethane, 1,1-	R-141B	1717-00-6	C ₂ H ₃ Cl ₂ F	NR	+	NR	+	2.0	+		ne
Dichloromethane	see Methylene chloride										



Compound Name	Synonym/Abbreviation	CAS No.	Formula	9.8	C	10.6	C	11.7	C IE (eV)	TWA
Dichloropentafluoropropane	AK-225, mix of ~45% 3,3-dichloro-1,1,1,2,2-pentafluoropropane (HCFC-225ca) & ~55% 1,3-Dichloro-1,1,2,2,3-pentafluoropropane (HCFC-225cb)	442-56-0 507-55-1	C ₃ HCl ₂ F ₅	NR	+	NR	+	25	+	ne
Dichloropropane, 1,2-		78-87-5	C ₃ H ₆ Cl ₂					0.7	10.87	75
Dichloro-1-propene, 1,3-		542-75-6	C ₃ H ₄ Cl ₂	1.3	+	0.96	+		<10	1
Dichloro-1-propene, 2,3-		78-88-6	C ₃ H ₄ Cl ₂	1.9	+	1.3	+	0.7	<10	ne
Dichloro-1,1,1-trifluoroethane, 2,2-	R-123	306-83-2	C ₂ HCl ₂ F ₃	NR	+	NR	+	10.1	+	11.5
Dichloro-2,4,6-trifluoropyridine, 3,5-	DCTFP	1737-93-5	C ₅ Cl ₂ F ₃ N	1.1	+	0.9	+	0.8	+	ne
Dichlorvos *	Vapona; O,O-dimethyl O-dichlorovinyl phosphate	62-73-7	C ₄ H ₇ Cl ₂ O ₄ P			0.9	+		<9.4	0.1
Dicyclopentadiene	DCPD, Cyclopentadiene dimer	77-73-6	C ₁₀ H ₁₂	0.57	+	0.48	+	0.43	+	8.8
Diesel Fuel		68334-30-5	m.w. 226			0.9	+			11
Diesel Fuel #2 (Automotive)		68334-30-5	m.w. 216	1.3		0.7	+	0.4	+	11
Diethylamine		109-89-7	C ₄ H ₁₁ N			1	+		8.01	5
Diethylaminopropylamine, 3-		104-78-9	C ₇ H ₁₈ N ₂			1.3				ne
Diethylbenzene	See Dowtherm J									
Diethylmaleate		141-05-9	C ₈ H ₁₂ O ₄			4				ne
Diethyl sulfide	see Ethyl sulfide									
Diglyme	See Methoxyethyl ether	111-96-6	C ₆ H ₁₄ O ₃							
Diisobutyl ketone	DIBK, 2,2-dimethyl-4-heptanone	108-83-8	C ₉ H ₁₈ O	0.71	+	0.61	+	0.35	+	9.04
Diisopropylamine		108-18-9	C ₆ H ₁₅ N	0.84	+	0.74	+	0.5	+	7.73
Diketene	Ketene dimer	674-82-8	C ₄ H ₄ O ₂	2.6	+	2.0	+	1.4	+	9.6
Dimethylacetamide, N,N-	DMA	127-19-5	C ₄ H ₉ NO	0.87	+	0.8	+	0.8	+	8.81
Dimethylamine		124-40-3	C ₂ H ₇ N			1.5			8.23	5
Dimethyl carbonate	Carbonic acid dimethyl ester	616-38-6	C ₃ H ₆ O ₃	NR	+	~70	+	1.7	+	~10.5
Dimethyl disulfide	DMDS	624-92-0	C ₂ H ₆ S ₂	0.2	+	0.20	+	0.21	+	7.4
Dimethyl ether	see Methyl ether									
Dimethylethylamine	DMEA	598-56-1	C ₄ H ₁₁ N	1.1	+	1.0	+	0.9	+	7.74
Dimethylformamide, N,N-	DMF	68-12-2	C ₃ H ₇ NO	0.7	+	0.7	+	0.8	+	9.13
Dimethylhydrazine, 1,1-	UDMH	57-14-7	C ₂ H ₈ N ₂			0.8	+	0.8	+	7.28
Dimethyl methylphosphonate	DMMP, methyl phosphonic acid dimethyl ester	756-79-6	C ₃ H ₉ O ₃ P	NR	+	4.3	+	0.74	+	10.0
Dimethyl sulfate		77-78-1	C ₂ H ₆ O ₄ S	~23		~20	+	2.3	+	0.1
Dimethyl sulfide	see Methyl sulfide									
Dimethyl sulfoxide	DMSO, Methyl sulfoxide	67-68-5	C ₂ H ₆ OS			1.4	+		9.10	ne
Dioxane, 1,4-		123-91-1	C ₄ H ₈ O ₂			1.3			9.19	25
Dioxolane, 1,3-	Ethylene glycol formal	646-06-0	C ₃ H ₆ O ₂	4.0	+	2.3	+	1.6	+	9.9
Dowtherm A see Therminol® *										
Dowtherm J (97% Diethylbenzene) *		25340-17-4	C ₁₀ H ₁₄			0.5				
DS-108F Wipe Solvent	Ethyl lactate/Isopar H/Propoxypropanol ~7:2:1	97-64-3 64742-48-9 1569-01-3	m.w. 118	3.3	+	1.6	+	0.7	+	ne
Epichlorohydrin	ECH Chloromethyloxirane, 1-chloro2,3-epoxypropane	106-89-8	C ₂ H ₅ ClO	~200	+	8.5	+	1.4	+	10.2
Ethane		74-84-0	C ₂ H ₆			NR	+	15	+	11.52
Ethanol	Ethyl alcohol	64-17-5	C ₂ H ₆ O			10	+	3.1	+	10.47
Ethanolamine *	MEA, Monoethanolamine	141-43-5	C ₂ H ₇ NO	5.6	+	1.6	+		8.96	3
Ethene	Ethylene	74-85-1	C ₂ H ₄			9	+	4.5	+	10.51
Ethoxyethanol, 2-	Ethyl cellosolve	110-80-5	C ₄ H ₁₀ O ₂			1.3			9.6	5
Ethyl acetate		141-78-6	C ₄ H ₈ O ₂			4.6	+	3.5	10.01	400
Ethyl acetoacetate		141-97-9	C ₆ H ₁₀ O ₃	1.4	+	1.2	+	1.0	<10	ne
Ethyl acrylate		140-88-5	C ₅ H ₈ O ₂			2.4	+	1.0	<10.3	5
Ethylamine		75-04-7	C ₂ H ₇ N			0.8			8.86	5



Compound Name	Synonym/Abbreviation	CAS No.	Formula	9.8	C	10.6	C	11.7	C	IE (Ev)	TWA
Ethylbenzene		100-41-4	C ₈ H ₁₀	0.52	+	0.52	+	0.51	+	8.77	100
Ethyl caprylate	Ethyl octanoate	106-32-1	C ₁₀ H ₂₀ O ₂		+	0.52	+	0.51	+		
Ethylenediamine	1,2-Ethanediamine; 1,2-Diaminoethane	107-15-3	C ₂ H ₈ N ₂	0.9	+	0.8	+	1.0	+	8.6	10
Ethylene glycol *	1,2-Ethandiol	107-21-1	C ₂ H ₆ O ₂			16	+	6	+	10.16	C100
Ethylene glycol, Acrylate	2-hydroxyethyl Acrylate	818-61-1	C ₅ H ₈ O ₃			8.2				≤10.6	
Ethylene glycol dimethyl ether	1,2-Dimethoxyethane, Monoglyme	110-71-4	C ₄ H ₁₀ O ₂	1.1		0.86		0.7		9.2	ne
Ethylene glycol monobutyl ether acetate	2-Butoxyethyl acetate	112-07-2	C ₈ H ₁₆ O ₃			1.3				≤10.6	
Ethylene glycol, monothio	mercapto-2-ethanol	60-24-2	C ₂ H ₆ OS			1.5				9.65	
Ethylene oxide	Oxirane, Epoxyethane	75-21-8	C ₂ H ₄ O			13	+	3.5	+	10.57	1
Ethyl ether	Diethyl ether	60-29-7	C ₄ H ₁₀ O			1.1	+	1.7		9.51	400
Ethyl 3-ethoxypropionate	EEP	763-69-9	C ₇ H ₁₄ O ₃	1.2	+	0.75	+				ne
Ethyl formate		109-94-4	C ₃ H ₆ O ₂					1.9		10.61	100
Ethylhexyl □acrylate, 2-	Acrylic acid 2-ethylhexyl ester	103-11-7	C ₁₁ H ₂₀ O ₂			1.1	+	0.5	+		ne
Ethylhexanol	2-Ethyl-1-hexanol	104-76-7	C ₈ H ₁₈ O			1.9				≤10.6	
Ethylidenenorbornene	5-Ethylidene bicyclo(2,2,1)hept-2-ene	16219-75-3	C ₉ H ₁₂	0.4	+	0.39	+	0.34	+	≤8.8	ne
Ethyl (S)-(-)-lactate see also DS-108F	Ethyl lactate, Ethyl (S)-(-)-hydroxypropionate	687-47-8 97-64-3	C ₅ H ₁₀ O ₃	13	+	3.2	+	1.6	+	~10	ne
Ethyl mercaptan	Ethanethiol	75-08-1	C ₂ H ₆ S	0.60	+	0.56	+			9.29	0.5
Ethyl sulfide	Diethyl sulfide	352-93-2	C ₄ H ₁₀ S			0.5	+			8.43	ne
Formaldehyde	Formalin	50-00-0	CH ₂ O	NR	+	NR	+	1.6	+	10.87	C0.3
Formamide		75-12-7	CH ₃ NO			6.9	+	4		10.16	10
Formic acid		64-18-6	CH ₂ O ₂	NR	+	NR	+	9	+	11.33	5
Furfural	2-Furaldehyde	98-01-1	C ₅ H ₄ O ₂			0.92	+	0.8	+	9.21	2
Furfuryl alcohol		98-00-0	C ₅ H ₆ O ₂			0.80	+			<9.5	10
Gasoline #1		8006-61-9	m.w. 72			0.9	+				300
Gasoline #2, 92 octane		8006-61-9	m.w. 93	1.3	+	1.0	+	0.5	+		300
Glutaraldehyde	1,5-Pentanedial, Glutaric dialdehyde	111-30-8	C ₅ H ₈ O ₂	1.1	+	0.8	+	0.6	+		C0.05
Glycidyl methacrylate	2,3-Epoxypropyl methacrylate	106-91-2	C ₇ H ₁₀ O ₃	2.6	+	1.2	+	0.9	+		0.5
Halothane	2-Bromo-2-chloro-1,1,1-trifluoroethane	151-67-7	C ₂ HBrClF ₃					0.6		11.0	50
HCFC-22 see Chlorodifluoromethane HCFC-123 see 2,2-Dichloro-1,1,1-trifluoroethane HCFC-141B see 1,1-Dichloro-1-fluoroethane HCFC-142B see 1-Chloro-1,1-difluoroethane HCFC-134A see 1,1,1,2-Tetrafluoroethane HCFC-225 see Dichloropentafluoropropane											
Heptane, n-		142-82-5	C ₇ H ₁₆	45	+	2.8	+	0.60	+	9.92	400
Heptanol, 4-	Dipropylcarbinol	589-55-9	C ₇ H ₁₆ O	1.8	+	1.3	+	0.5	+	9.61	ne
Hexamethyldisilazane, 1,1,1,3,3,3- *	HMDS	999-97-3	C ₆ H ₁₉ NSi ₂			0.2	+	0.2	+	~8.6	ne
Hexamethyldisiloxane	HMDSx	107-46-0	C ₆ H ₁₈ OSi ₂	0.33	+	0.27	+	0.25	+	9.64	ne
Hexane, n-		110-54-3	C ₆ H ₁₄	350	+	4.3	+	0.54	+	10.13	50
Hexanol, 1-	Hexyl alcohol	111-27-3	C ₆ H ₁₄ O	9	+	2.5	+	0.55	+	9.89	ne
Hexene, 1-		592-41-6	C ₆ H ₁₂			0.8				9.44	30
HFE-7100	see Methyl nonafluorobutyl ether										
Histoclear (Histo-Clear)	Limonene/corn oil reagent		m.w. ~136	0.5	+	0.4	+	0.3	+		ne
Hydrazine *		302-01-2	H ₄ N ₂	>8	+	2.6	+	2.1	+	8.1	0.01
Hydrazoic acid	Hydrogen azide		HN ₃							10.7	
Hydrogen	Synthesis gas	1333-74-0	H ₂	NR	+	NR	+	NR	+	15.43	ne
Hydrogen cyanide	Hydrocyanic acid	74-90-8	HCN	NR	+	NR	+	NR	+	13.6	C4.7
Hydrogen iodide *	Hydriodic acid	10034-85-2	HI			~0.6*				10.39	
Hydrogen peroxide		7722-84-1	H ₂ O ₂	NR	+	NR	+	NR	+	10.54	1
Hydrogen sulfide		7783-06-4	H ₂ S	NR	+	3.3	+	1.5	+	10.45	10
Hydroxypropyl methacrylate		27813-02-1 923-26-2	C ₇ H ₁₂ O ₃	9.9	+	2.3	+	1.1	+		ne
Iodine *		7553-56-2	I ₂	0.1	+	0.1	+	0.1	+	9.40	C0.1



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Compound Name	Synonym/Abbreviation	CAS No.	Formula	9.8	C	10.6	C	11.7	C	IE (eV)	TWA
Iodomethane	Methyl iodide	74-88-4	CH ₃ I	0.21	+	0.22	+	0.26	+	9.54	2
Isoamyl acetate	Isopentyl acetate	123-92-2	C ₇ H ₁₄ O ₂	10.1		2.1		1.0		<10	100
Isobutane	2-Methylpropane	75-28-5	C ₄ H ₁₀			100	+	1.2	+	10.57	ne
Isobutanol	2-Methyl-1-propanol	78-83-1	C ₄ H ₁₀ O	19	+	3.8	+	1.5		10.02	50
Isobutene	Isobutylene, Methyl butene	115-11-7	C ₄ H ₈	1.00	+	1.00	+	1.00	+	9.24	Ne
Isobutyl acrylate	Isobutyl 2-propenoate	106-63-8	C ₇ H ₁₂ O ₂			1.5	+	0.60	+		Ne
Isoflurane	1-Chloro-2,2,2-trifluoroethyl difluoromethyl ether, forane	26675-46-7	C ₃ H ₂ ClF ₅ O	NR	+	NR	+	48	+	~11.7	Ne
Isooctane	2,2,4-Trimethylpentane	540-84-1	C ₈ H ₁₈			1.2				9.86	ne
Isopar E Solvent	Isoparaffinic hydrocarbons	64741-66-8	m.w. 121	1.7	+	0.8	+				Ne
Isopar G Solvent	Photocopier diluent	64742-48-9	m.w. 148			0.8	+				Ne
Isopar K Solvent	Isoparaffinic hydrocarbons	64742-48-9	m.w. 156	0.9	+	0.5	+	0.27	+		Ne
Isopar L Solvent	Isoparaffinic hydrocarbons	64742-48-9	m.w. 163	0.9	+	0.5	+	0.28	+		Ne
Isopar M Solvent	Isoparaffinic hydrocarbons	64742-47-8	m.w. 191			0.7	+	0.4	+		Ne
Isopentane	2-Methylbutane	78-78-4	C ₅ H ₁₂			8.2					Ne
Isophorone		78-59-1	C ₉ H ₁₄ O					3		9.07	C5
Isoprene	2-Methyl-1,3-butadiene	78-79-5	C ₅ H ₈	0.69	+	0.63	+	0.60	+	8.85	Ne
Isopropanol	Isopropyl alcohol, 2-propanol, IPA	67-63-0	C ₃ H ₈ O	500	+	6.0	+	2.7		10.12	200
Isopropyl acetate		108-21-4	C ₅ H ₁₀ O ₂			2.6				9.99	100
Isopropyl ether	Diisopropyl ether	108-20-3	C ₆ H ₁₄ O			0.8				9.20	250
Jet fuel JP-4	Jet B, Turbo B, F-40	8008-20-6 +	m.w. 115			1.0	+	0.4	+		Ne
	Wide cut type aviation fuel	64741-42-0									
Jet fuel JP-5	Jet 5, F-44, Kerosene type aviation fuel	8008-20-6 +	m.w. 167			0.6	+	0.5	+		29
		64747-77-1									
Jet fuel JP-8	Jet A-1, F-34, Kerosene type aviation fuel	8008-20-6 +	m.w. 165			0.6	+	0.3	+		30
		64741-77-1									
Jet fuel A-1 (JP-8)	F-34, Kerosene type aviation fuel	8008-20-6 +	m.w. 145			0.67					34
		64741-77-1									
Jet Fuel TS	Thermally Stable Jet Fuel, Hydrotreated kerosene fuel	8008-20-6 +	m.w. 165	0.9	+	0.6	+	0.3	+		30
		64742-47-8									
Limonene, D-	(R)-(+)-Limonene	5989-27-5	C ₁₀ H ₁₆			0.33	+			~8.2	Ne
Kerosene C10-C16 petro.distillate – see Jet Fuels		8008-20-6									
MDI – see 4,4'-Methylenebis(phenylisocyanate)											
Maleic anhydride	2,5-Furandione	108-31-6	C ₄ H ₂ O ₃							~10.8	0.1
Mesitylene	1,3,5-Trimethylbenzene	108-67-8	C ₉ H ₁₂	0.36	+	0.35	+	0.3	+	8.41	25
Methallyl chloride – see 3-Chloro-2-methylpropene											
Methane	Natural gas	74-82-8	CH ₄	NR	+	NR	+	NR	+	12.61	Ne
Methanol	Methyl alcohol, carbinol	67-56-1	CH ₄ O	NR	+	NR	+	2.5	+	10.85	200
Methoxyethanol, 2-	Methyl cellosolve, Ethylene glycol monomethyl ether	109-86-4	C ₃ H ₈ O ₂	4.8	+	2.4	+	1.4	+	10.1	5
Methoxyethoxyethanol, 2-	2-(2-Methoxyethoxy)ethanol	111-77-3	C ₇ H ₁₆ O	2.3	+	1.2	+	0.9	+	<10	Ne
	Diethylene glycol monomethyl ether										
Methoxyethyl ether, 2-	bis(2-Methoxyethyl) ether, Diethylene glycol dimethyl ether, Diglyme	111-96-6	C ₆ H ₁₄ O ₃	0.64	+	0.54	+	0.44	+	<9.8	Ne
Methyl acetate		79-20-9	C ₃ H ₆ O ₂	NR	+	6.6	+	1.4	+	10.27	200
Methyl acrylate	Methyl 2-propenoate, Acrylic acid methyl ester	96-33-3	C ₄ H ₆ O ₂			3.7	+	1.2	+	(9.9)	2
Methylamine	Aminomethane	74-89-5	CH ₅ N			1.2				8.97	5
Methyl amyl ketone	MAK, 2-Heptanone, Methyl pentyl ketone	110-43-0	C ₇ H ₁₄ O	0.9	+	0.85	+	0.5	+	9.30	50
Methyl bromide	Bromomethane	74-83-9	CH ₃ Br	110	+	1.7	+	1.3	+	10.54	1
Methyl t-butyl ether	MTBE, <i>tert</i> -Butyl methyl ether	1634-04-4	C ₅ H ₁₂ O			0.9	+			9.24	40
Methyl cellosolve	see 2-Methoxyethanol										
Methyl chloride	Chloromethane	74-87-3	CH ₃ Cl	NR	+	NR	+	0.74	+	11.22	50
Methylcyclohexane		107-87-2	C ₇ H ₁₄	1.6	+	0.97	+	0.53	+	9.64	400
Methylene bis(phenylisocyanate), 4,4'- *	MDI, Mondur M		C ₁₅ H ₁₀ N ₂ O ₂	Very slow ppb level response							0.005





Compound Name	Synonym/Abbreviation	CAS No.	Formula	9.8	C	10.6	C	11.7	C	IE (eV)	TWA
Methylene chloride	Dichloromethane	75-09-2	CH ₂ Cl ₂	NR	+	NR	+	0.89	+	11.32	25
Methyl ether	Dimethyl ether	115-10-6	C ₂ H ₆ O	4.8	+	3.1	+	2.5	+	10.03	Ne
Methyl ethyl ketone	MEK, 2-Butanone	78-93-3	C ₄ H ₈ O	0.86	+	0.9	+	1.1	+	9.51	200
Methylhydrazine	Monomethylhydrazine, Hydrazomethane	60-34-4	C ₂ H ₆ N ₂	1.4	+	1.2	+	1.3	+	7.7	0.01
Methyl isoamyl ketone	MIAC, 5-Methyl-2-hexanone	110-12-3	C ₇ H ₁₄ O	0.8	+	0.76	+	0.5	+	9.28	50
Methyl isobutyl ketone	MIBK, 4-Methyl-2-pentanone	108-10-1	C ₆ H ₁₂ O	0.9	+	0.8	+	0.6	+	9.30	50
Methyl isocyanate	CH ₃ NCO	624-83-9	C ₂ H ₃ NO	NR	+	4.6	+	1.5		10.67	0.02
Methyl isothiocyanate	CH ₃ NCS	551-61-6	C ₂ H ₃ NS	0.5	+	0.45	+	0.4	+	9.25	ne
Methyl mercaptan	Methanethiol	74-93-1	CH ₄ S	0.65		0.54		0.66		9.44	0.5
Methyl methacrylate		80-62-6	C ₅ H ₈ O ₂	2.7	+	1.5	+	1.2	+	9.7	100
Methyl nonafluorobutyl ether	HFE-7100DL	163702-08-7, 163702-07-6	C ₅ H ₃ F ₉ O			NR	+	~35	+		ne
Methyl-1,5-pentanediamine, 2-(coats lamp) *	Dytek-A amine, 2-Methyl pentamethylenediamine	15520-10-2	C ₆ H ₁₆ N ₂			~0.6	+			<9.0	ne
Methyl propyl ketone	MPK, 2-Pentanone	107-87-9	C ₅ H ₁₂ O			0.93	+	0.79	+	9.38	200
Methyl-2-pyrrolidinone, N-	NMP, N-Methylpyrrolidone, 1-Methyl-2-pyrrolidinone, 1-Methyl-2-pyrrolidone	872-50-4	C ₅ H ₉ NO	1.0	+	0.8	+	0.9	+	9.17	ne
Methyl salicylate	Methyl 2-hydroxybenzoate	119-36-8	C ₈ H ₈ O ₃	1.3	+	0.9	+	0.9	+	~9	ne
Methylstyrene, α-	2-Propenylbenzene	98-83-9	C ₉ H ₁₀			0.5				8.18	50
Methyl sulfide	DMS, Dimethyl sulfide	75-18-3	C ₂ H ₆ S	0.49	+	0.44	+	0.46	+	8.69	ne
Mineral spirits	Stoddard Solvent, Varsol 1, White Spirits	8020-83-5, 8052-41-3, 68551-17-7	m.w. 144	1.0		0.69	+	0.38	+		100
Mineral Spirits - Viscor 120B Calibration Fluid, b.p. 156-207°C		8052-41-3	m.w. 142	1.0	+	0.7	+	0.3	+		100
Monoethanolamine - see Ethanolamine											
Mustard *	HD, Bis(2-chloroethyl) sulfide	505-60-2, 39472-40-7, 68157-62-0	C ₄ H ₈ Cl ₂ S			0.6					0.0005
Naphtha - see VM & P Naptha											
Naphthalene	Mothballs	91-20-3	C ₁₀ H ₈	0.45	+	0.42	+	0.40	+	8.13	10
Nickel carbonyl (in CO)	Nickel tetracarbonyl	13463-39-3	C ₄ NiO ₄			0.18				<8.8	0.001
Nicotine		54-11-5	C ₁₀ H ₁₄ N ₂			2.0				≤10.6	
Nitric oxide		10102-43-9	NO	~6		5.2	+	2.8	+	9.26	25
Nitrobenzene		98-95-3	C ₆ H ₅ NO ₂	2.6	+	1.9	+	1.6	+	9.81	1
Nitroethane		79-24-3	C ₂ H ₅ NO ₂					3		10.88	100
Nitrogen dioxide		10102-44-0	NO ₂	23	+	16	+	6	+	9.75	3
Nitrogen trifluoride		7783-54-2	NF ₃	NR		NR		NR		13.0	10
Nitromethane		75-52-5	CH ₃ NO ₂					4		11.02	20
Nitropropane, 2-		79-46-9	C ₃ H ₇ NO ₂					2.6		10.71	10
Nonane		111-84-2	C ₉ H ₂₀			1.4				9.72	200
Norpar 12	n-Paraffins, mostly C ₁₀ -C ₁₃	64771-72-8	m.w. 161	3.2	+	1.1	+	0.28	+		ne
Norpar 13	n-Paraffins, mostly C ₁₃ -C ₁₄	64771-72-8	m.w. 189	2.7	+	1.0	+	0.3	+		ne
Octamethylcyclotetrasiloxane		556-67-2	C ₈ H ₂₄ O ₄ Si ₄	0.21	+	0.17	+	0.14	+		ne
Octamethyltrisiloxane		107-51-7	C ₈ H ₂₄ O ₂ Si ₃	0.23	+	0.18	+	0.17	+	<10.0	ne
Octane, n-		111-65-9	C ₈ H ₁₈	13	+	1.8	+			9.82	300
Octene, 1-		111-66-0	C ₈ H ₁₆	0.9	+	0.75	+	0.4	+	9.43	75
Pentane		109-66-0	C ₅ H ₁₂	80	+	8.4	+	0.7	+	10.35	600
Peracetic acid *	Peroxyacetic acid, Acetyl hydroperoxide	79-21-0	C ₂ H ₄ O ₃	NR	+	NR	+	2.3	+		ne
Peracetic/Acetic acid mix *	Peroxyacetic acid, Acetyl hydroperoxide	79-21-0	C ₂ H ₄ O ₃			50	+	2.5	+		ne
Perchloroethene	PCE, Perchloroethylene, Tetrachloroethylene	127-18-4	C ₂ Cl ₄	0.69	+	0.57	+	0.31	+	9.32	25
PGME	Propylene glycol methyl ether, 1-Methoxy-2-propanol	107-98-2	C ₆ H ₁₂ O ₃	2.4	+	1.5	+	1.1	+		100



Compound Name	Synonym/Abbreviation	CAS No.	Formula	9.8	C	10.6	C	11.7	C	IE (eV)	TWA
PGMEA	Propylene glycol methyl ether acetate, 1-Methoxy-2-acetoxyp propane, 1-Methoxy-2-propanol acetate	108-65-6	C ₆ H ₁₂ O ₃	1.65	+	1.0	+	0.8	+		ne
Phenol	Hydroxybenzene	108-95-2	C ₆ H ₆ O	1.0	+	1.0	+	0.9	+	8.51	5
Phosgene	Dichlorocarbonyl	75-44-5	CCl ₂ O	NR	+	NR	+	8.5	+	11.2	0.1
Phosgene in Nitrogen	Dichlorocarbonyl	75-44-5	CCl ₂ O	NR	+	NR	+	6.8	+	11.2	0.1
Phosphine (coats lamp)		7803-51-2	PH ₃	28		3.9	+	1.1	+	9.87	0.3
Photocopier Toner	Isoparaffin mix					0.5	+	0.3	+		ne
Picoline, 3-	3-Methylpyridine	108-99-6	C ₆ H ₇ N			0.9				9.04	ne
Pinene, α-		2437-95-8	C ₁₀ H ₁₆			0.31	+	0.47		8.07	ne
Pinene, β-		18172-67-3	C ₁₀ H ₁₆	0.38	+	0.37	+	0.37	+	~8	100
Piperylene, isomer mix	1,3-Pentadiene	504-60-9	C ₅ H ₈	0.76	+	0.69	+	0.64	+	8.6	100
Propane		74-98-6	C ₃ H ₈			NR	+	1.8	+	10.95	2500
Propanol, n-	Propyl alcohol	71-23-8	C ₃ H ₈ O			5		1.7		10.22	200
Propene	Propylene	115-07-1	C ₃ H ₆	1.5	+	1.4	+	1.6	+	9.73	ne
Propionaldehyde	Propanal	123-38-6	C ₃ H ₆ O			1.9				9.95	ne
Propyl acetate, n-		109-60-4	C ₅ H ₁₀ O ₂			3.5		2.3		10.04	200
Propylamine, n-	1-Propylamine, 1-Aminopropane	107-10-8	C ₃ H ₉ N	1.1	+	1.1	+	0.9	+	8.78	ne
Propylene carbonate *		108-32-7	C ₄ H ₆ O ₃			62	+	1	+	10.5	ne
Propylene glycol	1,2-Propanediol	57-55-6	C ₃ H ₈ O ₂	18		5.5	+	1.6	+	<10.2	ne
Propylene glycol propyl ether	1-Propoxy-2-propanol	1569-01-3	C ₆ H ₁₄ O ₂	1.3	+	1.0	+	1.6	+		ne
Propylene oxide	Methyloxirane	75-56-9	C ₃ H ₆ O	~240		6.6	+	2.9	+	10.22	20
		16088-62-3									
		15448-47-2									
Propyleneimine	2-Methylaziridine	75-55-8	C ₃ H ₇ N	1.5	+	1.3	+	1.0	+	9.0	2
Propyl mercaptan, 2-	2-Propanethiol, Isopropyl mercaptan	75-33-2	C ₃ H ₈ S	0.64	+	0.66	+			9.15	ne
Pyridine		110-86-1	C ₅ H ₅ N	0.78	+	0.7	+	0.7	+	9.25	5
Pyrrolidine (coats lamp)	Azacyclohexane	123-75-1	C ₄ H ₉ N	2.1	+	1.3	+	1.6	+	~8.0	ne
RR7300 (PGME/PGMEA)	70:30 PGME:PGMEA (1-Methoxy-2-propanol:1-Methoxy-2-acetoxyp propane)	107-98-2	C ₄ H ₁₀ O ₂ / C ₆ H ₁₂ O ₃			1.4	+	1.0	+		ne
Sarin	GB, Isopropyl methylphosphonofluoridate	107-44-8	C ₄ H ₁₀ FO ₂ P			~3					
		50642-23-4									
Stoddard Solvent - see Mineral Spirits		8020-83-5									
Styrene		100-42-5	C ₈ H ₈	0.45	+	0.40	+	0.4	+	8.43	20
Sulfur dioxide		7446-09-5	SO ₂	NR		NR	+	NR	+	12.32	2
Sulfur hexafluoride		2551-62-4	SF ₆	NR		NR		NR		15.3	1000
Sulfuryl fluoride	Vikane	2699-79-8	SO ₂ F ₂	NR		NR		NR		13.0	5
Tabun *	Ethyl N, N-dimethylphosphoramidocyanidate	77-81-6	C ₅ H ₁₁ N ₂ O ₂ P			0.8					15ppt
Tetrachloroethane, 1,1,1,2-		630-20-6	C ₂ H ₂ Cl ₄					1.3		~11.1	ne
Tetrachloroethane, 1,1,1,2-		79-34-5	C ₂ H ₂ Cl ₄	NR	+	NR	+	0.60	+	~11.1	1
Tetrachlorosilane		10023-04-7	SiCl ₄	NR		NR		15	+	11.79	ne
Tetraethyl lead	TEL	78-00-2	C ₈ H ₂₀ Pb	0.4		0.3		0.2		~11.1	0.008
Tetraethyl orthosilicate	Ethyl silicate, TEOS	78-10-4	C ₈ H ₂₀ O ₄ Si			0.7	+	0.2	+	~9.8	10
Tetrafluoroethane, 1,1,1,2-	HFC-134A	811-97-2	C ₂ H ₂ F ₄			NR		NR			ne
Tetrafluoroethene	TFE, Tetrafluoroethylene, Perfluoroethylene	116-14-3	C ₂ F ₄			~15				10.12	ne
Tetrafluoromethane	CFC-14, Carbon tetrafluoride	75-73-0	CF ₄			NR	+	NR	+	>15.3	ne
Tetrahydrofuran	THF	109-99-9	C ₄ H ₈ O	1.9	+	1.7	+	1.0	+	9.41	200
Tetramethyl orthosilicate	Methyl silicate, TMOS	681-84-5	C ₄ H ₁₂ O ₄ Si	10	+	1.9	+			~10	1
Therminol® D-12 *	Hydrotreated heavy naphtha	64742-48-9	m.w. 160	0.8	+	0.51	+	0.33	+		ne
Therminol® VP-1 *	Dowtherm A, 3:1 Diphenyl oxide: Biphenyl	101-84-8	C ₁₂ H ₁₀ O			0.4	+				1
		92-52-4	C ₁₂ H ₁₀								
Toluene	Methylbenzene	108-88-3	C ₇ H ₈	0.54	+	0.50	+	0.51	+	8.82	50



Compound Name	Synonym/Abbreviation	CAS No.	Formula	9.8	C	10.6	C	11.7	C	IE (eV)	TWA
Tolylene-2,4-diisocyanate	TDI, 4-Methyl-1,3-phenylene-2,4-diisocyanate	584-84-9	C ₉ H ₆ N ₂ O ₂	1.4	+	1.4	+	2.0	+		0.002
Trichlorobenzene, 1,2,4-	1,2,4-TCB	120-82-1	C ₆ H ₃ Cl ₃	0.7	+	0.46	+			9.04	C5
Trichloroethane, 1,1,1-	1,1,1-TCA, Methyl chloroform	71-55-6	C ₂ H ₃ Cl ₃			NR	+	1	+	11	350
Trichloroethane, 1,1,2-	1,1,2-TCA	79-00-5	C ₂ H ₃ Cl ₃	NR	+	NR	+	0.9	+	11.0	10
Trichloroethene	TCE, Trichloroethylene	79-01-6	C ₂ HCl ₃	0.62	+	0.54	+	0.43	+	9.47	50
Trichloromethylsilane	Methyltrichlorosilane	75-79-6	CH ₃ Cl ₃ Si	NR		NR		1.8	+	11.36	ne
Trichlorotrifluoroethane, 1,1,2-	CFC-113	76-13-1	C ₂ Cl ₃ F ₃			NR		NR		11.99	1000
Triethylamine	TEA	121-44-8	C ₆ H ₁₅ N	0.95	+	0.9	+	0.65	+	7.3	1
Triethyl borate	TEB; Boric acid triethyl ester	150-46-9	C ₆ H ₁₅ O ₃ B			2.2	+	1.1	+	~10	ne
Triethyl phosphate	Ethyl phosphate	78-40-0	C ₆ H ₁₅ O ₄ P	~50	+	3.1	+	0.60	+	9.79	ne
Trifluoroethane, 1,1,2-		430-66-0	C ₂ H ₃ F ₃					34		12.9	ne
Trimethylamine		75-50-3	C ₃ H ₉ N			0.9				7.82	5
Trimethylbenzene, 1,3,5- - see Mesitylene		108-67-8									25
Trimethyl borate	TMB; Boric acid trimethyl ester, Boron methoxide	121-43-7	C ₃ H ₉ O ₃ B			5.1	+	1.2	+	10.1	ne
Trimethyl phosphate	Methyl phosphate	512-56-1	C ₃ H ₉ O ₄ P			8.0	+	1.3	+	9.99	ne
Trimethyl phosphite	Methyl phosphite	121-45-9	C ₃ H ₉ O ₃ P			1.1	+		+	8.5	2
Turpentine	Pinenes (85%) + other diisoprenes	8006-64-2	C ₁₀ H ₁₆	0.37	+	0.30	+	0.29	+	~8	20
Undecane		1120-21-4	C ₁₁ H ₂₄			2				9.56	ne
Varsol – see Mineral Spirits											
Vinyl acetate		108-05-4	C ₄ H ₆ O ₂	1.5	+	1.2	+	1.0	+	9.19	10
Vinyl bromide	Bromoethylene	593-60-2	C ₂ H ₃ Br			0.4				9.80	5
Vinyl chloride	Chloroethylene, VCM	75-01-4	C ₂ H ₃ Cl			2.0	+	0.6	+	9.99	5
Vinyl-1-cyclohexene, 4-	Butadiene dimer, 4-Ethenylcyclohexene	100-40-3	C ₈ H ₁₂	0.6	+	0.56	+			9.83	0.1
Vinylidene chloride - see 1,1-Dichloroethene											
Vinyl-2-pyrrolidinone, 1-	NVP, N-vinylpyrrolidone, 1-ethenyl-2-pyrrolidinone	88-12-0	C ₆ H ₉ NO	1.0	+	0.8	+	0.9	+		ne
Viscor 120B - see Mineral Spirits - Viscor 120B Calibration Fluid											
V. M. & P. Naphtha	Ligroin; Solvent naphtha; Varnish maker's & painter's naphtha	64742-89-8	m.w. 111 (C ₈ -C ₉)	1.7	+	0.97	+				300
Xylene, m-	1,3-Dimethylbenzene	108-38-3	C ₈ H ₁₀	0.50	+	0.44	+	0.40	+	8.56	100
Xylene, o-	1,2-Dimethylbenzene	95-47-6	C ₈ H ₁₀	0.56	+	0.46	+	0.43		8.56	100
Xylene, p-	1,4-Dimethylbenzene	106-42-3	C ₈ H ₁₀	0.48	+	0.39	+	0.38	+	8.44	100
None				1		1		1			
Undetectable				1E+6		1E+6		1E+6			

* Compounds indicated in green can be detected using a MiniRAE 2000 or ppbRAE/+ with slow response, but may be lost by adsorption on a MultiRAE or EntryRAE. Response on multi-gas meters can give an indication of relative concentrations, but may not be quantitative and for some chemicals no response is observed.

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**Appendix I:****Example of Automatic Calculation of Correction Factors, TLVs and Alarm Limits for Mixtures**

(Calculations performed using Excel version of this database, available on request)

Compound	CF 9.8 eV	CF 10.6 eV	CF 11.7eV	Mol. Frac	Conc ppm	TLV ppm	STEL Ppm
Benzene	0.55	0.53	0.6	0.01	1	0.5	2.5
Toluene	0.54	0.5	0.51	0.06	10	50	150
Hexane, n-	300	4.3	0.54	0.06	10	50	150
Heptane, n-	45	2.8	0.6	0.28	50	400	500
Styrene	0.45	0.4	0.42	0.06	10	20	40
Acetone	1.2	1.1	1.4	0.28	50	750	1000
Isopropanol	500	6	2.7	0.28	50	400	500
None	1	1	1	0.00	0	1	
Mixture Value:	2.1	1.5	0.89	1.00	181	56	172
TLV Alarm Setpoint when Calibrated to Isobutylene:	26 ppm	37 ppm	62 ppm		ppm	ppm	ppm
STEL Alarm Setpoint, same Calibration	86 ppm	115 ppm	193 ppm				

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FIELD OPERATING PROCEDURES

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Calibration and
Maintenance of
Portable Specific
Conductance Meter

FOP 012.0

CALIBRATION AND MAINTENANCE OF PORTABLE SPECIFIC CONDUCTANCE METER

PURPOSE

This guideline describes a method for calibration of a portable specific conductance meter. This meter measures the ability of a water sample to conduct electricity, which is largely a function of the dissolved solids within the water. The instrument has been calibrated by the manufacturer according to factory specifications. This guideline presents a method for checking the factory calibration of a portable specific conductance meter. A calibration check is performed to verify instrument accuracy and function. All field test equipment will be checked at the beginning of each sampling day. This procedure also documents critical maintenance activities for this meter.

ACCURACY

The calibrated accuracy of the specific conductance meter will be within ± 1 percent of full-scale, with repeatability of ± 1 percent. The built-in cell will be automatically temperature compensated from at least 32° to 160° F (0° to 71°C).

PROCEDURE

Note: The information included below is equipment manufacturer- and model-specific, however, accuracy, calibration, and maintenance procedures for this type of portable equipment are typically similar. The information below pertains to the Myron L Company Ultrameter Model 6P. The actual equipment to be used in the field will be equivalent or similar.



**CALIBRATION AND MAINTENANCE OF PORTABLE
SPECIFIC CONDUCTANCE METER**

1. Calibrate all field test equipment at the beginning of each sampling day. Check and recalibrate the specific conductance meter according to the manufacture's specifications.
2. Use a calibration solution of known specific conductivity and salinity. For maximum accuracy, use a Standard Solution Value closest to the samples to be tested.
3. Rinse conductivity cell three times with proper standard.
4. Re-fill conductivity cell with same standard.
5. Press **COND** or **TDS**, then press **CAL/MCLR**. The "CAL" icon will appear on the display.
6. Press the **↑/MS** or **MR/↓** key to step the displayed value toward the standard's value or hold a key down to cause rapid scrolling of the reading.
7. Press **CAL/MCLR** once to confirm new value and end the calibration sequence for this particular solution type.
8. Repeat steps 1 through 7 with additional new solutions, as necessary.
9. Document the calibration results and related information in the Project Field Book and on an **Equipment Calibration Log** (see attached sample), indicating the meter readings before and after the instrument has been adjusted. This is important, not only for data validation, but also to establish maintenance schedules and component replacement. Information will include, at a minimum:
 - Time, date and initials of the field team member performing the calibration
 - The unique identifier for the meter, including manufacturer, model, and serial number
 - The brand and expiration date of the calibration standards
 - The instrument readings: before and after calibration

FOP 012.0

CALIBRATION AND MAINTENANCE OF PORTABLE SPECIFIC CONDUCTANCE METER

- The instrument settings (if applicable)
- The overall adequacy of calibration including the Pass or fail designation in accordance with the accuracy specifications presented above.
- Corrective action taken (see Maintenance below) in the event of failure to adequately calibrate.

MAINTENANCE

NOTE: Ultrameters should be rinsed with clean water after use. Solvents should be avoided. Shock damage from a fall may cause instrument failure.

Temperature Extremes

Solutions in excess of 160°F/71°C should not be placed in the cell cup area; this may cause damage. Care should be exercised not to exceed rated operating temperature. Leaving the Ultrameter in a vehicle or storage shed on a hot day can easily subject the instrument to over 150°F voiding the warranty.

Battery Replacement

Dry Instrument THOROUGHLY. Remove the four bottom screws. Open instrument carefully; it may be necessary to rock the bottom slightly side to side to release it from the RS-232 connector. Carefully detach battery from circuit board. Replace with 9-volt alkaline battery. Replace bottom, ensuring the sealing gasket is installed in the groove of the top half of case. Re-install screws, tighten evenly and securely.



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CALIBRATION AND MAINTENANCE OF PORTABLE SPECIFIC CONDUCTANCE METER

NOTE: Because of nonvolatile EEPROM circuitry, all data stored in memory and all calibration settings are protected even during power loss or battery replacement.

Cleaning Sensors

The conductivity cell cup should be kept as clean as possible. Flushing with clean water following use will prevent buildup on electrodes. However, if very dirty samples — particularly scaling types — are allowed to dry in the cell cup, a film will form. This film reduces accuracy. When there are visible films of oil, dirt, or scale in the cell cup or on the electrodes, use a foaming non-abrasive household cleaner. Rinse out the cleaner and your Ultrameter is ready for accurate measurements.

NOTE: Maintain a log for each monitoring instrument. Record all maintenance performed on the instrument on this log with date and name of the organization performing the maintenance.

ATTACHMENTS

Equipment Calibration Log (sample)



FOP 012.0

CALIBRATION AND MAINTENANCE OF PORTABLE SPECIFIC CONDUCTANCE METER

EQUIPMENT CALIBRATION

PROJECT INFORMATION:

Project Name: _____

Date: _____

Project No.: _____

Client: _____

Instrument Source: ☐ BM ☐ Rental

METER TYPE	UNITS	TIME	MAKE/MODEL	SERIAL NUMBER	CAL. BY	STANDARD	READING	SETTLE
☐ pH meter	units		Myron L. Company Ultra Meter 6P	606987		4.00		
						7.00		
						10.01		
						< 0.4		
☐ Turbidity meter	NTU		Hach 2100P Turbidimeter	970600014560		20		
						100		
						800		
☐ Sp. conductance meter	uS/mS		Myron L. Company Ultra Meter 6P	606987		uS @ 25 °C		
☐ PID	ppm		Photovac 2020 PID			open air zero		MIBK re
						ppm Iso. Gas		factor :
☐ Particulate meter	mg/m ³					zero air		
☐ Oxygen	%					open air		
☐ Hydrogen sulfide	ppm					open air		
☐ Carbon monoxide	ppm					open air		
☐ LEL	%					open air		
☐ Radiation Meter	uR/h					background area		
☐								

ADDITIONAL REMARKS: _____

PREPARED BY: _____

DATE: _____



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FIELD OPERATING PROCEDURES

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Composite Sample
Collection Procedure
for Non-VOC Analysis

FOP 013.0

COMPOSITE SAMPLE COLLECTION PROCEDURE FOR NON-VOLATILE ORGANIC ANALYSIS

PURPOSE

This guideline addresses the procedure to be used when soil samples are to be composited in the field.

PROCEDURE

1. Transfer equal weighted aliquots of soil from individual split-spoon samples, excavator bucket, hand auger or surface soil sample location to a large precleaned stainless steel (or Pyrex glass) mixing bowl.
2. Thoroughly mix (homogenize) and break up the soil using a stainless steel scoop or trowel.
3. Spread the composite sample evenly on a stainless steel tray and quarter the sample.
4. Discard alternate (i.e., diagonal) quarters and, using a small stainless steel scoop or spatula, collect equal portions of subsample from the remaining two quarters until the amount required for the composite sample is acquired. Transfer these subsamples to a precleaned stainless steel (or Pyrex glass) mixing bowl and re-mix.
5. Transfer the composite sample to the laboratory provided, precleaned sample jars. Store any excess sample from the stainless steel tray in a separate, precleaned, wide-mouth sample jar and refrigerate for future use, if applicable.
6. Decontaminate all stainless steel (or Pyrex glass) equipment in accordance with **Roux's** Non-disposable and Non-dedicated Sampling Equipment Decontamination procedures.
7. Prepare samples in accordance with Benchmark's Sample Labeling, Storage and Shipment FOP.



FOP 013.0

COMPOSITE SAMPLE COLLECTION PROCEDURE FOR NON-VOLATILE ORGANIC ANALYSIS

8. Record all sampling details in the Project Field Book and on the Soil/Sediment Sample Collection Summary Log (sample attached).

ATTACHMENTS

Soil/Sediment Sample Collection Summary Log (sample)

REFERENCES

Roux's FOPs:

- 040 *Non-disposable and Non-dedicated Sampling Equipment Decontamination*
- 046 *Sample Labeling, Storage and Shipment*



COMPOSITE SAMPLE COLLECTION PROCEDURE FOR NON-VOLATILE ORGANIC ANALYSIS

[illegible]

MS/MSD/MSB - Collect at a frequency of 1 per 20 samples of each matrix for all those parameters analyzed for the samples collected the same day.

Field Blank - Pour clean deionized water (used as final decon rinse water) into sample containers while at the sampling site. Collect field blanks at a frequency of 1 per lot of deionized water. Note water lot number and dates in use for decon in 'Comments' section.

Investigation Derived Waste (IDW) Characterization samples - One composited sample from all drums of decon fluids and soil. Please note number of drums and labels on collection log.

Notes:

1. See QAPP for sampling frequency and actual number of QC samples.
2. CWM - clear, wide-mouth glass jar with Teflon-lined cap.
3. HDPE - high density polyethylene bottle.
4. MS/MSD/MSB - Matrix Spike, Matrix Spike Duplicate, Matrix Spike Blank.
5. BD - Blind Duplicate - indicate location of duplicate.

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Documentation
Requirements for
Drilling and Well
Installation

**DOCUMENTATION REQUIREMENTS FOR DRILLING AND WELL
INSTALLATION**

PURPOSE

The purpose of these documentation requirements is to document the procedures used for drilling and installing wells in order to ensure the quality of the data obtained from these operations. Roux field technical personnel will be responsible for developing and maintaining documentation for quality control of field operations. At least one field professional will monitor each major operation (e.g. one person per drilling rig) to document and record field procedures for quality control. These procedures provide a description of the format and information for this documentation.

PROCEDURE

Project Field Book

Personnel assigned by the Roux Field Team Leader or Project Manager will maintain a Project Field Book for all site activities. These Field Books will be started upon initiation of any site activities to document the field investigation process. The Field Books will meet the following criteria:

- Permanently bound, with nominal 8.5-inch by 11-inch gridded pages.
- Water resistant paper.
- Pages must be pre-numbered or numbered in the field, front and back.

Notations in the field book will be in black or blue ink that will not smudge when wet. Information that may be recorded in the Field Book includes:

- Time and date of all entries.



FOP 015.0

DOCUMENTATION REQUIREMENTS FOR DRILLING AND WELL INSTALLATION

- Name and location of project site and project job number.
- Listing of key project, client and agency personnel and telephone numbers.
- Date and time of daily arrivals and departures, name of person keeping the log, names and affiliation of persons on site, purpose of visit (if applicable), weather conditions, outline of project activities to be completed.
- Details of any variations to the procedures/protocols (i.e., as presented in the Work Plan or Field Operating Procedures) and the basis for the change.
- Field-generated data relating to implementation of the field program, including sample locations, sample descriptions, field measurements, instrument calibration, etc.
- Record of all photographs taken in the field, including date, time, photographer, site location and orientation, sequential number of photograph, and roll number.

Upon completion of the site activities, all Field Books will be photocopied and both the original and photocopied versions placed in the project files. In addition, all field notes except those presented on specific field forms will be neatly transcribed into Field Activity Daily Log (FADL) forms (sample attached).

Field Borehole/Monitoring Well Installation Log Form

Examples of the Field Borehole Log and Field Borehole/Monitoring Well Installation Log forms are attached to this Field Operating Procedure. One form will be completed for every boring by the **Roux** field person overseeing the drilling. At a minimum, these forms will include:

- Project name, location, and number.
- Boring number.



FOP 015.0

DOCUMENTATION REQUIREMENTS FOR DRILLING AND WELL INSTALLATION

- Rig type and drilling method.
- Drilling dates.
- Sampling method.
- Sample descriptions, to meet the requirements of the Unified Soil Classification System (USCS) for soils and the Unified Rock Classification System (URCS) for rock.
- Results of photoionization evaluations (scan and/or headspace determinations).
- Blow counts for sampler penetration (Standard Penetration Test, N-Value).
- Drilling rate, rig chatter, and other drilling-related information, as necessary.

All depths recorded on Boring/Monitoring Well Installation Log forms will be expressed in increments tenths of feet, and not in inches.

Well Completion Detail Form

An example of this form is attached to this Field Operating Procedure. One form will be completed for every boring by the **Roux** field person overseeing the well installation. At a minimum, these forms will include:

- Project name, location, and number.
- Well number.
- Installation dates.
- Dimensions and depths of the various well components illustrated in the Well Completion Detail (attached). These include the screened interval, bottom caps or plugs, centralizers, and the tops and bottoms of the various annular materials.



**DOCUMENTATION REQUIREMENTS FOR DRILLING AND WELL
INSTALLATION**

- Drilling rate, rig chatter, and other drilling related information.

All depths recorded on Field Borehole/Monitoring Well Installation Logs will be expressed in tenths of feet, and not in inches.

Daily Drilling Report Form

An example of this form is attached to this Field Operating Procedure. This form should be used to summarize all drilling activities. One form should be completed for each rig for each day. These forms will include summaries of:

- Footage drilled, broken down by diameter (e.g. 200 feet of 6-inch diameter hole, 50 feet of 10-inch diameter hole).
- Footage of well and screen installed, broken down by diameter.
- Quantities of materials used, including sand, cement, bentonite, centralizers, protective casings, traffic covers, etc. recorded by well or boring location.
- Active time (hours), and activity (drilling, decontamination, development, well installation, surface completions, etc.)
- Down-time (hours) and reason.
- Mobilizations and other events.
- Other quantities that will be the basis for drilling invoices.

The form should be signed daily by both the **Roux** field supervisor and the driller's representative, and provided to the **Roux** Field Team Leader.



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DOCUMENTATION REQUIREMENTS FOR DRILLING AND WELL INSTALLATION

Other Project Field Forms

Well purging/well development forms, test pit logs, environmental sampling field data sheets, water level monitoring forms, and well testing (slug test or pumping test) forms. Refer to specific guidelines for form descriptions.

ATTACHMENTS

- Field Activity Daily Log (FADL) (sample)
- Field Borehole Log (sample)
- Field Borehole/Monitoring Well Installation Log (sample)
- Stick-up Well/Piezometer Completion Detail (sample)
- Flush-mount Well/Piezometer Completion Detail (sample)
- Daily Drilling Report (sample)



DOCUMENTATION REQUIREMENTS FOR DRILLING AND WELL INSTALLATION

FIELD ACTIVITY DAILY LOG

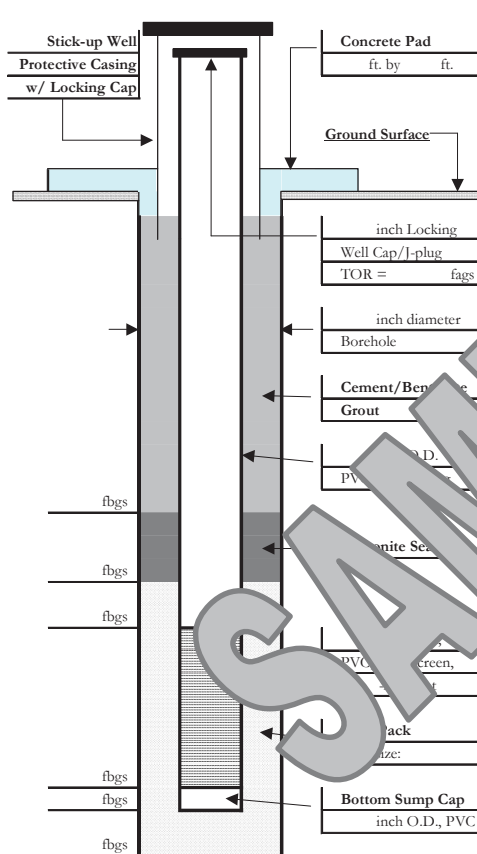
(CONTINUED)

FOP 015.0

DOCUMENTATION REQUIREMENTS FOR DRILLING AND WELL INSTALLATION

STICK-UP WELL/PIEZOMETER COMPLETION DETAIL

Project Name: _____ WELL NUMBER: _____
 Client: _____ Date Installed: _____
 Boring Location: _____ Project Number: _____



The diagram illustrates a cross-section of a stick-up well or piezometer. Key components labeled include:

- Stick-up Well Protective Casing w/ Locking Cap**: The top section of the well casing.
- Concrete Pad**: The base of the well, with dimensions in feet by feet.
- Ground Surface**: The level of the ground above the well.
- inch Locking**: A locking mechanism for the casing.
- Well Cap/1-plug**: The cap at the top of the well casing.
- TOR = fags**: The Total Open Return (TOR) in feet above ground surface.
- inch diameter Borehole**: The diameter of the hole drilled into the ground.
- Cement/Bentonite Grout**: The material used to seal the annulus around the casing.
- PVC Screen**: The screen at the bottom of the well casing.
- Bottom Sump Cap**: The cap at the bottom of the well, made of 1/2 inch O.D. PVC.

Additional labels include "fbgs" (feet below ground surface) at various depths and "PVC" for the casing material.

Driller Information	
Company:	
Driller:	
Helper:	
Permit Number:	
Drill Rig Type:	

Well Information	
Land Surface Location:	fmsl (approximate)
Drilling Method:	
Soil Sample Collection Method:	
Filtering Fluid:	
Filtering During Drilling:	gallons (approximate)

Construction	
Casing:	
Screen:	
Grout:	
Seal:	

Development	
Purpose:	
Technique(s):	
Date Completed:	
BM/TK Personnel:	
Total Volume Purge:	gallons
Static Water Level:	fbTOR
Pump Depth:	
Purge Duration:	minutes
Yield:	gpm
Specific Capacity:	gpm/ft

Comments: _____

PREPARED BY: _____ DATE: _____



FOP 015.0

DOCUMENTATION REQUIREMENTS FOR DRILLING AND WELL INSTALLATION

FLUSHMOUNT WELL/PIEZOMETER COMPLETION DETAIL

Project Name:	WELL NUMBER:
Client:	Date Installed:
Boring Location:	Project Number:

SAMPLE

Driller Information	
Company:	
Driller:	
Helper:	
Permit Number:	
Drill Rig Type:	

Well Information	
Land Surface Elevation:	fmsl (approximate)
Drilling Method:	
Soil Sample Collection Method:	
Fluid:	
Fluid During Drilling:	gallons (approximate)

Well Completion	
Casing:	
Pack:	
Seal:	

Well Development	
Well Purpose:	
Technique(s):	
Date Completed:	
BM/TK Personnel:	
Total Volume Purge:	gallons
Static Water Level:	ftTOR
Pump Depth:	
Purge Duration:	minutes
Yield:	gpm
Specific Capacity:	gpm/ft

Comments:

PREPARED BY: _____ DATE: _____



FOP 015.0

DOCUMENTATION REQUIREMENTS FOR DRILLING AND WELL INSTALLATION

DAILY DRILLING REPORT

CONTRACTOR:		DATE:	
DRILLING EQUIPMENT:		PROJECT:	
CREW MEMBERS:		JOB NUMBER:	
SITE NAME:		BM PERSONNEL:	

CATEGORY	Total Hours	a.m.												p.m.												a.m.											
		6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6											
MOB / DEMOB																																					
DRILLING																																					
WELL INSTALLATION																																					
DEVELOPMENT / TESTING																																					
GROUTING																																					
STEAM / DECON																																					
DOWN TIME (explain below)																																					
STANDBY (explain below)																																					
CLEANUP																																					
PREP FOR DRILLING																																					
LUNCH																																					
OTHER:																																					

REMARKS:

DRILLING & WELL MATERIALS: Describe nature, quantities, etc.

ITEM OR SERVICE	LOCATION	TOTALS
Starting depth (fbgs)		--
Ending depth (fbgs)		--
Total footage drilled (feet)		--
Drilling Method (HSA, air, cable etc.)		--
Auger/Bit size		--
CSSS starting depth (fbgs)		--
CSSS ending depth (fbgs)		--
Total CSSS footage		--
-inch Schedule 40 PVC screen, slot size =		
-inch Schedule 40 PVC riser		
-inch Schedule 40 PVC screen, slot size =		
-inch Schedule 40 PVC riser		
-inch Schedule 40 PVC screen, slot size =		
-inch Schedule 40 PVC riser		
Sand pack, size =		
Bentonite pellets/chips, size =		
Cement/bentonite grout		
☐ Protective casing ☐ Flushmount road box		
Lockable J-plug		
Lock		

PERSONNEL TIME LOG:

POSITION	NAME	HOURS
Observer		
Drillers		

DRILLER (optional):

BM REP.



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ROUX

FIELD OPERATING PROCEDURES

Drill Site Selection Procedure

DRILL SITE SELECTION PROCEDURE

PURPOSE

This procedure presents a method for selecting a site location for drilling. Drill site selection should be based on the project objectives, ease of site access, freedom from obstructions and buried metallic objects (drums) and site safety (appropriate set backs from overhead and buried services).

PROCEDURE

The following procedure outlines procedures prior to drilling activities:

1. Review project objectives and tentatively select drilling locations that provide necessary information for achieving objectives (i.e., Work Plan).
2. Clear locations with property owner/operator to ensure that drilling activities will not interfere with site operations and select appropriate access routes.
3. Stake locations in the field, measure distance from locations to recognizable landmarks, such as building or fence lines and plot locations on site plan. Ensure location is relatively flat, free of overhead wires and readily accessible. Survey location if property ownership is in doubt.
4. Obtain clearances from appropriate utilities and if buried waste/metallic objects are suspected, screen location with appropriate geophysical method.
5. Establish a secure central staging area for storage of drilling supplies and for equipment decontamination. Locate a secure storage area for drilling samples, as necessary.

ATTACHMENTS

none



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ROUX

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FIELD OPERATING PROCEDURES

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Drilling and Excavation
Equipment
Decontamination
Procedures

**DRILLING AND EXCAVATION EQUIPMENT
DECONTAMINATION PROCEDURES**

PURPOSE

This procedure is to be used for the decontamination of drilling and excavation equipment (i.e., drill rigs, backhoes, augers, drill bits, drill rods, buckets, and associated equipment) used during a subsurface investigation. The purpose of this procedure is to remove chemical constituents associated with a particular drilling or excavation location from this equipment. This prevents these constituents from being transferred between drilling or excavation locations, or being transported out of controlled areas.

PROCEDURE

The following procedure will be utilized prior to the use of drilling or excavation equipment at each location, and prior to the demobilization of such equipment from the site:

1. Remove all loose soil and other particulate materials from the equipment at the survey site.
2. Wrap augers, tools, plywood, and other reusable items with a plastic cover prior to transport from the site of use to the decontamination facility.
3. Transport equipment to the decontamination facility. All equipment must be decontaminated at an established decontamination facility. This facility will be placed within a controlled area, and will be equipped with necessary features to contain and collect wash water and entrained materials.
4. Wash equipment thoroughly with pressurized low-volume water or steam, supplied by a pressure washer or steam cleaner.
5. If necessary, use a brush or scraper to remove visible soils adhering to the equipment, and a non-phosphate detergent to remove any oils, grease, and/or hydraulic fluids adhering to the equipment. Continue pressure washing until all visible contaminants are removed.

FOP 018.0

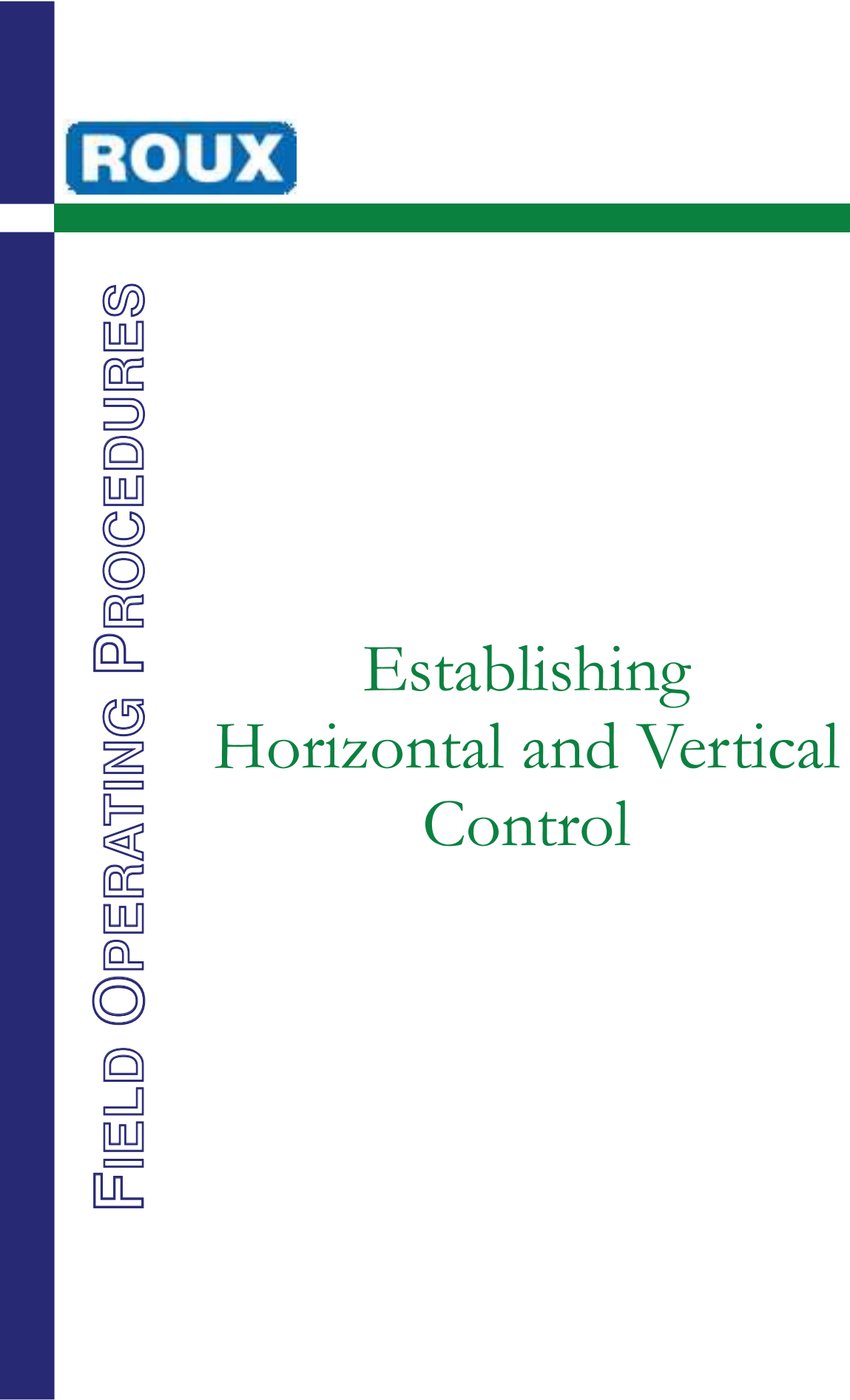
DRILLING AND EXCAVATION EQUIPMENT DECONTAMINATION PROCEDURES

6. Allow equipment to air dry.
7. Store equipment in a clean area or wrap the equipment in new plastic sheeting as necessary to ensure cleanliness until ready for use.
8. Manage all wash waters and entrained solids as described in the **Roux** Field Operating Procedure for Management of Investigation-Derived Waste.

ATTACHMENTS

none





ROUX

FIELD OPERATING PROCEDURES

Establishing Horizontal and Vertical Control

ESTABLISHING HORIZONTAL AND VERTICAL CONTROL

PURPOSE

This guideline presents a method for establishing horizontal and vertical controls at a project site. It is imperative that this procedure be performed accurately, as all topographic and site maps, monitoring well locations and test pit locations will be based on these controls.

PROCEDURE

A. Establishing Horizontal Primary and Project Control

1. Research the State Plan Coordinate, USGS or project site applicable horizontal control monuments.
2. At the project site, recover the above-mentioned monuments, two markers minimum being recovered.
3. Establish control points on the project site by bringing in the primary control points recovered in the field.
4. All control points will be tied into a closed traverse to assure the error of closure.
5. Compute closures for obtaining degree of accuracy to adjust traverse points.

B. Establishing Vertical Primary and Project Control

1. Research project or USGS datum for recovering monument(s) for vertical control if different than those previously found.
2. Recover the monuments in the field, two markers minimum being found.
3. Set the projects benchmarks.
4. Run a level line from the monuments to the set project benchmarks and back, setting turning points on all benchmarks set on site.

FOP 021.0

ESTABLISHING HORIZONTAL AND VERTICAL CONTROL

5. Reduce field notes and compute error of closure to adjust benchmarks set on site.
6. Prepare the recovery sketches and tabulate a list for horizontal and vertical control throughout project site.



ROUX



FIELD OPERATING PROCEDURES

Groundwater Level Measurement

GROUNDWATER LEVEL MEASUREMENT

PURPOSE

This procedure describes the methods used to obtain accurate and consistent water level measurements in monitoring wells, piezometers and well points. Water levels will be measured at monitoring wells and, if practicable, in supply wells to estimate purge volumes associated with sampling, and to develop a potentiometric surface of the groundwater in order to estimate the direction and velocity of flow in the aquifer. Water levels in monitoring wells will be measured using an electronic water level indicator (e-line) that has been checked for operation prior to mobilization.

PROCEDURE

1. Decontaminate the e-line probe and a lower portion of cable following the procedures referenced in the **Roux** Field Operating Procedure for Non-Disposable and Non-Dedicated Sampling Equipment Decontamination. Store the e-line in a protected area until use. This may include wrapping the e-line in clean plastic until the time of use.
2. Unlock and remove the well protective cap or cover and place on clean plastic.
3. Lower the probe slowly into the monitoring well until the audible alarm sounds. This indicates the depth to water has been reached.
4. Move the cable up and down slowly to identify the depth at which the alarm just begins to sound. Measure this depth against the mark on the lip of the well riser used as a surveyed reference point (typically the north side of the riser).
5. Read depth from the graduated cable to the nearest 0.01 foot. Do not use inches. If the e-line is not graduated, use a rule or tape measure graduated in 0.01-foot increments to measure from the nearest reference mark on the e-line cable.

FOP 022.0

GROUNDWATER LEVEL MEASUREMENT

6. Record the water level on a Water Level Monitoring Record (sample attached).
7. Remove the probe from the well slowly, drying the cable and probe with a clean paper wipe. Be sure to repeat decontamination before use in another well.
8. Replace well plug and protective cap or cover. Lock in place as appropriate.

ATTACHMENTS

Water Level Monitoring Record (sample)

REFERENCES

Roux FOPs:

040 *Non-Disposable and Non-Dedicated Sampling Equipment Decontamination*



GROUNDWATER LEVEL MEASUREMENT

Project Name:	Client:
Project No.:	Location:
Field Personnel:	Date:
Weather:	

[illegible]

DATE:



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ROUX

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FIELD OPERATING PROCEDURES

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Groundwater Purging
Procedures Prior to
Sample Collection

**GROUNDWATER PURGING PROCEDURES PRIOR
TO SAMPLE COLLECTION**

PURPOSE

This procedure describes the methods for monitoring well/piezometer purging prior to groundwater sample collection in order to collect representative groundwater samples. The goal of purging is to remove stagnant, non-representative groundwater from the well and/or prevent stagnant water from entering collected samples. Purging involves the removal of at least three to five volumes of water in wells with moderate yields and at least one well volume from wells with low yields (slow water level recovery).

Purge and sample wells in order of least-to-most contaminated (this is not necessary if dedicated or disposable equipment is used). If you do not know this order, sample the upgradient wells first, then the furthest down-gradient or side-gradient wells, and finally the wells closest to, but down-gradient of the most contaminated area. Sampling should commence immediately following purging or as soon as the well has adequately recharged and not more than 24-hours following end time of evacuation.

PROCEDURE

1. Prepare the electronic water level indicator (e-line) in accordance with the procedures referenced in the **Roux** Field Operating Procedure for Groundwater Level Measurement and decontaminate the e-line probe and a lower portion of cable following the procedures referenced in the **Roux** Field Operating Procedure for Non-disposable and Non-dedicated Sampling Equipment Decontamination. Store the e-line in a protected area until use. This may include wrapping the e-line in clean plastic until the time of use.
2. Inspect the interior and exterior of the well/piezometer for signs of vandalism or damage and record condition on the Groundwater Field Form and/or Groundwater Well Inspection Form (samples attached). Specifically, inspect



FOP 023.1

GROUNDWATER PURGING PROCEDURES PRIOR TO SAMPLE COLLECTION

the integrity of the following: concrete surface seal, lock, protective casing and well cover, well riser and J-plug/cap. Report any irregular findings to the Project Manager.

3. Unlock and remove the well protective cap or cover and place on clean plastic to avoid introducing foreign material into the well.
4. Calibrate the photoionization detector (PID) in accordance with the **Roux** Field Operating Procedure for Calibration and Maintenance of Portable Photoionization Detector.
5. Monitor the well for organic vapors using a PID, as per the Work Plan. If a reading of greater than 5 ppm is recorded, the well should be allowed to vent until levels drop below 5 ppm before proceeding with purging.
6. Lower the e-line probe slowly into the monitoring well and record the initial water level in accordance with the procedures referenced in the **Roux** Field Operating Procedure for Groundwater Level Measurement.
7. Following static water level determinations, slowly lower the e-line to the bottom of the well/piezometer. Record the total depth to the nearest 0.01-foot and compare to the previous total depth measurement. If a significant discrepancy exists, re-measure the total depth. Continue with purging activities observing purge water to determine whether the well/piezometer had become silted due to inactivity or damaged (i.e., well sand within purge water). Upon confirmation of the new total depth and determination of the cause (i.e., siltation or damage), notify the Project Manager following field activities.
8. Calculate the volume of water in the well based on the water level below the top of riser and the total depth of the well using the following equation:

$$V = 0.0408[(B)^2 \times \{(A) - (C)\}]$$

Where,



**GROUNDWATER PURGING PROCEDURES PRIOR
TO SAMPLE COLLECTION**

A = Total Depth of Well (feet below measuring point)

B = Casing diameter (inches)

C = Static Water Level (feet below measuring point)

9. **For wells where the water level is 20 feet or less below the top of riser**, a peristaltic pump may be used to purge the well. Measure the purged volume using a calibrated container (i.e., graduated 5-gallon bucket) and record measurements on the attached Groundwater Well Development and Purge Log. Use new and dedicated tubing for each well. During the evacuation of shallow wells, the intake opening of the pump tubing should be positioned just below the surface of the water. As the water level drops, lower the tubing as needed to maintain flow. For higher yielding wells, the intake level should not be lowered past the top of the screen. Pumping from the top of the water column will ensure proper flushing of the well. Continue pumping until the required volumes are removed (typically three well volumes). For higher yielding wells, adjust the purging rate to maintain the water level above the screen. For lower yielding wells or wells where the screen straddles the water table, maintain purging at a rate that matches the rate of recovery of the well (well yield). If the well purges to dryness and is slow to recharge (greater than 15 minutes), terminate evacuation. **A peristaltic pump and dedicated tubing cannot be used to collect VOC or SVOC project-required samples; only non-organic compounds may be collected using this type of pump.**
10. **For wells where the water level is initially below 20 feet**, or drawn down to this level because of slow recharge rate, conduct purging using one of three devices listed below:
- Bailer – A bottom filling dedicated polyethylene bailer attached to a length of dedicated hollow-braid polypropylene rope. Purging a well utilizing a bailer should be conducted smoothly and slowly as not to agitate the groundwater or damage the well.
 - Well Wizard Purge Pump (or similar) – This pneumatic bladder pump uses compressed air to push water to the surface. Groundwater is not in contact

**GROUNDWATER PURGING PROCEDURES PRIOR
TO SAMPLE COLLECTION**

with the drive air during the pumping process, therefore the pump may be used for sample collection.

- Submersible Pump (12 or 24 volt, or similar) – These submersible pumps are constructed of PVC or stainless steel and are capable of pumping up to 70 feet from ground surface using a 12 volt battery (standard pump) and standard low flow controller. For depths up to 200 feet from ground surface, a high performance power booster controller is used with a 12 volt battery. Unless these pumps are dedicated to the monitoring well location, decontamination between locations is necessary and an equipment blank may be required.
- Waterra™ Pump – This manually operated pump uses dedicated polyethylene tubing and a check valve that can be used as an optional method for purging deeper wells. The pump utilizes positive pressure to evacuate the well, therefore the pump may be used for sample collection, and however over-agitation groundwater should be avoided.

Prior to use in a well, non-dedicated bailers, exterior pump bodies and pump tubing should be cleaned in accordance with the **Roux** Field Operating Procedure for Non-Disposable and Non-Dedicated Sampling Equipment Decontamination. Dedicated and/or disposable equipment should be contained within the sealed original manufacturers packaging and certified pre-cleaned by the manufacturer with a non-phosphate laboratory detergent and rinsed using de-ionized water.

8. Purging will continue until a predetermined volume of water has been removed (typically three well volumes) or to dryness. Measurements for pH, temperature, specific conductance, dissolved oxygen (optional), Eh (optional), and turbidity will be recorded following removal of each well volume. Purge the well to dryness or until the readings for indicator parameters listed above (or well-specific indicator parameters) stabilize within the following limits for each parameter measured:

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GROUNDWATER PURGING PROCEDURES PRIOR TO SAMPLE COLLECTION

Field Parameter	Stabilization Criteria
Dissolved Oxygen	± 0.3 mg/L
Turbidity	± 10 %
Specific Conductance	± 3 %
Eh	± 10 mV
PH	± 0.1 unit

Stabilization criteria presented within the project Work Plan will take precedence.

DOCUMENTATION AND SAMPLE COLLECTION

This section pertains to the documentation of collected field data during and following purging activities and sample collection.

1. Record all data including the final three stable readings for each indicator parameter on the attached Groundwater Well Purge & Sample Log.
2. Record, at a minimum, the “volume purged,” “purging stop-time,” “purged dry (Y/N),” “purged below sand pack (Y/N),” and any problems purging on the attached Groundwater Well Purge & Sample Log.
3. Collect groundwater samples in accordance with the **Roux** Field Operating Procedure for Groundwater Sample Collection. Record “sample flow rate” as an average, “time sample collected,” and any other pertinent information related to the sampling event on the attached Groundwater Well Purge & Sample Log.
4. Restore the well to its capped/covered and locked condition.



FOP 023.1

GROUNDWATER PURGING PROCEDURES PRIOR TO SAMPLE COLLECTION

ALTERNATIVE METHODS

Alternative purging and sampling methods and equipment, other than those described herein are acceptable if they provide representative groundwater samples. The purging and sampling method and equipment must not adversely affect sample integrity, chemistry, temperature, and turbidity. In addition, alternative equipment must have minimal or no effect on groundwater geochemistry, aquifer permeability and well materials. Equipment materials must also minimize sorption and leaching. The field team is responsible for documenting and describing any alternative equipment and procedures used to purge a well and collect samples.

ATTACHMENTS

Groundwater Field Form
Groundwater Well Inspection Form

REFERENCES

Roux FOPs:

- 011 *Calibration and Maintenance of Portable Photoionization Detector*
- 022 *Groundwater Level Measurement*
- 024 *Groundwater Sample Collection Procedures*
- 040 *Non-disposable and Non-dedicated Sampling Equipment Decontamination*



FOP 023.1

GROUNDWATER PURGING PROCEDURES PRIOR TO SAMPLE COLLECTION

GROUNDWATER FIELD FORM

Project Name: _____ Date: _____
Location: _____ Project No.: _____ Field Team: _____

Well No.			Diameter (inches):			Sample Time:			
Product Depth (ftTOR):			Water Column (ft):			DTW when sampled:			
DTW (static) (ftTOR):			Casing Volume:			Purpose: ☐ Development ☐ Sample			
Total Depth (ftTOR):			Purge Volume (gal):			Purge Method:			
Time	Water Level (ftTOR)	Acc. Volume (gallons)	pH (units)	Temp. (deg. C)	SC (uS)	Turbidity (NTU)	DO (mg/L)	ORP (mV)	Appearance & Odor
0	Initial								
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
Sample Information:			Date: (if different from above)						
S1									
S2									

Well No.			Diameter (inches):			Sample Time:			
Product Depth (ftTOR):			Water Column (ft):			DTW when sampled:			
DTW (static) (ftTOR):			Casing Volume:			Purpose: ☐ Development ☐ Sample			
Total Depth (ftTOR):			Purge Volume (gal):			Purge Method:			
Time	Water Level (ftTOR)	Acc. Volume (gallons)	pH (units)	Temp. (deg. C)	SC (uS)	Turbidity (NTU)	DO (mg/L)	ORP (mV)	Appearance & Odor
0	Initial								
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
Sample Information:			Date: (if different from above)						
S1									
S2									

REMARKS:

Note: All water level measurements are in feet, distance from top of riser.

Volume Calculation

Diam.	Vol. (g/ft)
1"	0.041
2"	0.163
4"	0.653
6"	1.469

Stabilization Criteria

Parameter	Criteria
pH	± 0.1 unit
SC	± 3%
Turbidity	± 10%
DO	± 0.3 mg/L
ORP	± 10 mV

PREPARED BY: _____



FOP 023.1

GROUNDWATER PURGING PROCEDURES PRIOR
TO SAMPLE COLLECTION

GROUNDWATER WELL INSPECTION FORM

Project:	WELL I.D.:
Client:	
Job No.:	
Date:	
Time:	
EXTERIOR INSPECTION	
Protective Casing:	
Lock:	
Hinge/Lid:	
Concrete Surface Seal:	
Bollards:	
Label/I.D.:	
Other:	
INTERIOR INSPECTION	
Well Riser:	
Annular Space:	
Well Cap:	
Water Level (fbTOR):	
Total Depth (fbTOR):	
Other:	
Comments/Corrective Actions:	

PREPARED BY: _____

DATE: _____





FIELD OPERATING PROCEDURES

Groundwater Sample Collection Procedures

GROUNDWATER SAMPLE COLLECTION PROCEDURES

PURPOSE

This procedure describes the methods for collecting groundwater samples from monitoring wells and domestic supply wells following purging and sufficient recovery. This procedure also includes the preferred collection order in which water samples are collected based on the volatilization sensitivity or suite of analytical parameters required.

PROCEDURE

Allow approximately 3 to 10 days following well development before performing purge and sample activities at any well location. Conversely, perform sampling as soon as practical after sample purging at any time after the well has recovered sufficiently to sample, or within 24 hours after evacuation, if the well recharges slowly. If the well does not yield sufficient volume for all required laboratory analytical testing (including quality control), a decision should be made to prioritize analyses based on contaminants of concern at the site. If the well takes longer than 24 hours to recharge, the Project Manager should be consulted. The following two procedures outline sample collection activities for monitoring and domestic type wells.

Monitoring Wells

1. Purge the monitoring well in accordance with the **Roux** FOPs for Groundwater Purging Procedures Prior to Sample Collection or Low Flow (Minimal Drawdown) Groundwater Purging & Sampling Procedures. Perform sampling as soon as practical after purging at any time after the well has recovered sufficiently to sample, or within 24 hours after evacuation, if the well recharges slowly. If the well does not yield sufficient volume for all required laboratory analytical testing (including quality control), a decision should be made to prioritize analyses based on contaminants of concern at the site. Analyses will be prioritized in the order of the parameters volatilization sensitivity. After volatile organics have been collected, field parameters

GROUNDWATER SAMPLE COLLECTION PROCEDURES

must be measured from the next sample collected. If a well takes longer than 24 hours to recharge, the Project Manager should be consulted.

2. Sampling equipment that is not disposable or dedicated to the well will be decontaminated in accordance with the **Roux** Field Operating Procedure for Non-Disposable and Non-Dedicated Sampling Equipment Decontamination.
3. Calibrate all field meters (i.e., pH/Eh, turbidity, specific conductance, dissolved oxygen, PID etc.) in accordance with the **Roux** Field Operating Procedure for Calibration and Maintenance of the specific field meter.
4. Prepare the electronic water level indicator (e-line) in accordance with the procedures referenced in the **Roux** Field Operating Procedure for Groundwater Level Measurement and decontaminate the e-line probe and a lower portion of cable following the procedures referenced in the **Roux** Field Operating Procedure for Non-disposable and Non-dedicated Sampling Equipment Decontamination. Store the e-line in a protected area until use. This may include wrapping the e-line in clean plastic until the time of use.
5. Inspect the well/piezometer for signs of vandalism or damage and record condition on the Groundwater Field Form (sample attached). Specifically, inspect the integrity of the following: concrete surface seal, lock, protective casing and well cover, well casing and J-plug/cap. Report any irregular findings to the Project Manager.
6. Unlock and remove the well protective cap or cover and place on clean plastic to avoid introducing foreign material into the well.
7. Calibrate the photoionization detector (PID) in accordance with the **Roux** Field Operating Procedure for Calibration and Maintenance of Portable Photoionization Detector.
8. Monitor the well for organic vapors using a PID, as per the Work Plan. If a reading of greater than 5 ppm is recorded, the well should be allowed to vent until levels drop below 5 ppm before proceeding with purging. Record PID measurements on a well-specific Groundwater Field Form (sample attached).

GROUNDWATER SAMPLE COLLECTION PROCEDURES

9. Lower the e-line probe slowly into the monitoring well and record the measurement on a well-specific Groundwater Field Form (sample attached).
10. Groundwater samples will be collected directly from the sampling valve on the flow through cell (low-flow), discharge port of a standard pump assembly (peristaltic, pneumatic, submersible, or Waterra™ pump) or bailer (stainless steel, PVC or polyethylene) into appropriate laboratory provided containers. In low-yielding wells at which the flow through cell is not used, the samples may be collected using a disposable bailer. **A peristaltic pump and dedicated tubing cannot be used to collect VOC or SVOC project-required samples; only non-organic compounds may be collected using this type of pump.**
11. If disposable polyethylene bailers are used, the bailer should be lowered *slowly* below the surface of the water to minimize agitation and volatilization. For wells that are known to produce turbid samples (values greater than 50 NTU), the bailer should be lowered and retrieved at a rate that limits surging of the well.
12. Sampling data will be recorded on a Groundwater Field Form (sample attached).
13. Pre-label all sample bottles in the field using a waterproof permanent marker in accordance with the **Roux** Sample Labeling, Storage, and Shipment FOP. The following information, at a minimum, should be included on the label:
 - Project Number;
 - Sample identification code (as per project specifications);
 - Date of sample collection (mm, dd, yy);
 - Time of sample collection (military time only) (hh:mm);
 - Specify “grab” or “composite” sample type;
 - Sampler initials;
 - Preservative(s) (if applicable); and
 - Analytes for analysis (if practicable).
14. Collect a separate sample of approximately 200 ml into an appropriate container prior to collecting the first and following the last groundwater sample collected to measure the following field parameters:

GROUNDWATER SAMPLE COLLECTION PROCEDURES

Parameter	Units
Dissolved Oxygen	parts per million (ppm)
Specific Conductance	μ mhos/cm or μ S or mS
pH	pH units
Temperature	°C or °F
Turbidity	NTU
Eh (<i>optional</i>)	mV
PID VOCs (<i>optional</i>)	ppm

Record all field measurements on a Groundwater Field Form (sample attached).

15. Collect samples into pre-cleaned bottles provided by the analytical laboratory with the appropriate preservative(s) added based on the volatilization sensitivity or suite of analytical parameters required, as designated in the **Sample Collection Order** section below.
16. Lower the e-line probe slowly into the monitoring well and record the measurement on a well-specific Groundwater Field Form (sample attached).
17. The samples will be labeled, stored, and shipped in accordance with the **Roux** Field Operating Procedure for Sample Labeling, Storage, and Shipment Procedures.

Domestic Supply Wells

1. Calculate or estimate the volume of water in the well. It is desirable to purge at least one casing volume before sampling. This is controlled, to some extent, by the depth of the well, well yield and the rate of the existing pump. If the volume of water in the well cannot be calculated, the well should be purged continuously for no less than 15 minutes.
2. Connect a sampling tap to an accessible fitting between the well and the pressure tank where practicable. A hose will be connected to the device and the hose discharge located 25 to 50 feet away. The well will be allowed to pump until the lines and one

GROUNDWATER SAMPLE COLLECTION PROCEDURES

well volume is removed. Flow rate will be measured with a container of known volume and a stopwatch.

3. Place a clean piece of polyethylene or Teflon™ tubing on the sampling port and collect the samples in the order designated below and in the sample containers supplied by the laboratory for the specified analytes. **DO NOT** use standard garden hose to collect samples.
4. Sampling results and measurements will be recorded on a Groundwater Field Form (sample attached) as described in the previous section.
5. Collect samples into pre-cleaned bottles provided by the analytical laboratory with the appropriate preservative(s) added based on the volatilization sensitivity or suite of analytical parameters required, as designated in the **Sample Collection Order** section below.
6. The samples will be labeled, stored, and shipped in accordance with the **Roux** Field Operating Procedure for Sample Labeling, Storage, and Shipment Procedures.

SAMPLE COLLECTION ORDER

All groundwater samples, from monitoring wells and domestic supply wells, will be collected in accordance with the following.

1. Samples will be collected preferentially in recognition of volatilization sensitivity. The preferred order of sampling if no free product is present is:
 - Field parameters
 - Volatile Organic Compounds (VOCs)
 - Purgeable organic carbons (POC)
 - Purgeable organic halogens (POH)
 - Total Organic Halogens (TOX)
 - Total Organic Carbon (TOC)
 - Extractable Organic Compounds (i.e., BNAs, SVOCs, etc.)
 - Total petroleum hydrocarbons (TPH) and oil and grease



GROUNDWATER SAMPLE COLLECTION PROCEDURES

- PCBs and pesticides
 - Total metals (Dissolved Metals)
 - Total Phenolic Compounds
 - Cyanide
 - Sulfate and Chloride
 - Turbidity
 - Nitrate (as Nitrogen) and Ammonia
 - Preserved inorganics
 - Radionuclides
 - Unpreserved inorganics
 - Bacteria
 - Field parameters
2. Document the sampling procedures and related information in the Project Field Book and on a Groundwater Field Form (sample attached).
 3. 1,4-dioxane will be analyzed via the 8270 SIM method.

DOCUMENTATION

The three words used to ensure adequate documentation for groundwater sampling are accountability, controllability, and traceability. Accountability is undertaken in the sampling plan and answers the questions who, what, where, when, and why to assure that the sampling effort meets its goals. Controllability refers to checks (including QA/QC) used to ensure that the procedures used are those specified in the sampling plan. Traceability is documentation of what was done, when it was done, how it was done, and by whom it was done, and is found in the field forms, Project Field Book, and chain-of-custody forms. At a minimum, adequate documentation of the sampling conducted in the field consists of an entry in the Project Field Book (with sewn binding), field data sheets for each well, and a chain-of-custody form.

GROUNDWATER SAMPLE COLLECTION PROCEDURES

As a general rule, if one is not sure whether the information is necessary, it should nevertheless be recorded, as it is impossible to over-document one's fieldwork. Years may go by before the documentation comes under close scrutiny, so the documentation must be capable of defending the sampling effort without the assistance or translation of the sampling crew.

The minimum information to be recorded daily with an indelible pen in the Project Field Book and/or field data sheets includes date and time(s), name of the facility, name(s) of the sampling crew, site conditions, the wells sampled, a description of how the sample shipment was handled, and a QA/QC summary. After the last entry for the day in the Project Field Book, the Field Team Leader should sign the bottom of the page under the last entry and then draw a line across the page directly under the signature.

PRECAUTIONS/RECOMMENDATIONS

The following precautions should be adhered to prior to and during sample collection activities:

- Field vehicles should be parked downwind (to avoid potential sample contamination concerns) at a minimum of 15 feet from the well and the engine turned off prior to PID vapor analysis and VOC sample collection.
- Ambient odors, vehicle exhaust, precipitation, or windy/dusty conditions can potentially interfere with obtaining representative samples. These conditions should be minimized and should be recorded in the field notes. Shield sample bottles from strong winds, rain, and dust when being filled.
- The outlet from the sampling device should discharge below the top of the sample's air/water interface, when possible. The sampling plan should specify

GROUNDWATER SAMPLE COLLECTION PROCEDURES

how the samples will be transferred from the sample collection device to the sample container to minimize sample alterations.

- The order of sampling should be from the least contaminated to the most contaminated well to reduce the potential for cross contamination of sampling equipment (see the Sampling Plan or Work Plan).
- Samples should not be transferred from one sampling container to another.
- Sampling equipment must not be placed on the ground, because the ground may be contaminated and soil contains trace metals. Equipment and supplies should be removed from the field vehicle only when needed.
- Smoking and eating should not be allowed until the well is sampled and hands are washed with soap and water, due to safety and possibly sample contamination concerns. These activities should be conducted beyond a 15-foot radius of the well.
- No heat-producing or electrical instruments should be within 15 feet of the well, unless they are intrinsically safe, prior to PID vapor analysis.
- Minimize the amount of time that the sample containers remain open.
- Do not touch the inside of sample bottles or the groundwater sample as it enters the bottle. Disposable gloves may be a source of phthalates, which could be introduced into groundwater samples if the gloves contact the sample.
- Sampling personnel should use a new pair of disposable gloves for each well sampled to reduce the potential for exposure of the sampling personnel to contaminants and to reduce sample cross contamination. In addition, sampling personnel should change disposable gloves between purging and sampling operations at the same well.
- Sampling personnel should not use perfume, insect repellent, hand lotion, etc., when taking groundwater samples. If insect repellent must be used, then sampling personnel should not allow samples or sampling equipment to contact the

FOP 024.1

GROUNDWATER SAMPLE COLLECTION PROCEDURES

repellent, and it should be noted in the documentation that insect repellent was used.

- Complete the documentation of the well. A completed assemblage of paperwork for a sampling event includes the completed field forms, entries in the Project Field Book (with a sewn binding), transportation documentation (if required), and possibly chain-of-custody forms.

ATTACHMENTS

Groundwater Field Form (sample)

REFERENCES

1. Wilson, Neal. *Soil Water and Ground Water Sampling*, 1995

Roux FOPs:

- 007 *Calibration and Maintenance of Portable Dissolved Oxygen Meter*
- 008 *Calibration and Maintenance of Portable Field pH/Eh Meter*
- 009 *Calibration and Maintenance of Portable Field Turbidity Meter*
- 011 *Calibration and Maintenance of Portable Photoionization Detector*
- 012 *Calibration and Maintenance of Portable Specific Conductance Meter*
- 022 *Groundwater Level Measurement*
- 023 *Groundwater Purging Procedures Prior to Sample Collection (optional)*
- 031 *Low Flow (Minimal Drawdown) Groundwater Purging & Sampling Procedures (optional)*
- 040 *Non-Disposable and Non-Dedicated Sampling Equipment Decontamination*
- 046 *Sample Labeling, Storage and Shipment Procedures*



FOP 024.1

GROUNDWATER SAMPLE COLLECTION PROCEDURES

GROUNDWATER FIELD FORM

Project Name: _____ Date: _____
 Location: _____ Project No.: _____ Field Team: _____

Well No.			Diameter (inches):			Sample Time:			
Product Depth (ftTOR):			Water Column (ft):			DTW when sampled:			
DTW (static) (ftTOR):			Casing Volume:			Purpose: ☐ Development ☐ Sample			
Total Depth (ftTOR):			Purge Volume (gal):			Purge Method:			
Time	Water Level (ftTOR)	Acc. Volume (gallons)	pH (units)	Temp. (deg. C)	SC (uS)	Turbidity (NTU)	DO (mg/L)	ORP (mV)	Appearance & Odor
0	Initial								
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
Sample Information:			Date: (if different from above)						
S1									
S2									

Well No.			Diameter (inches):			Sample Time:			
Product Depth (ftTOR):			Water Column (ft):			DTW when sampled:			
DTW (static) (ftTOR):			Casing Volume:			Purpose: ☐ Development ☐ Sample			
Total Depth (ftTOR):			Purge Volume (gal):			Purge Method:			
Time	Water Level (ftTOR)	Acc. Volume (gallons)	pH (units)	Temp. (deg. C)	SC (uS)	Turbidity (NTU)	DO (mg/L)	ORP (mV)	Appearance & Odor
0	Initial								
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
Sample Information:			Date: (if different from above)						
S1									
S2									

REMARKS:

Note: All water level measurements are in feet, distance from top of riser.

Volume Calculation

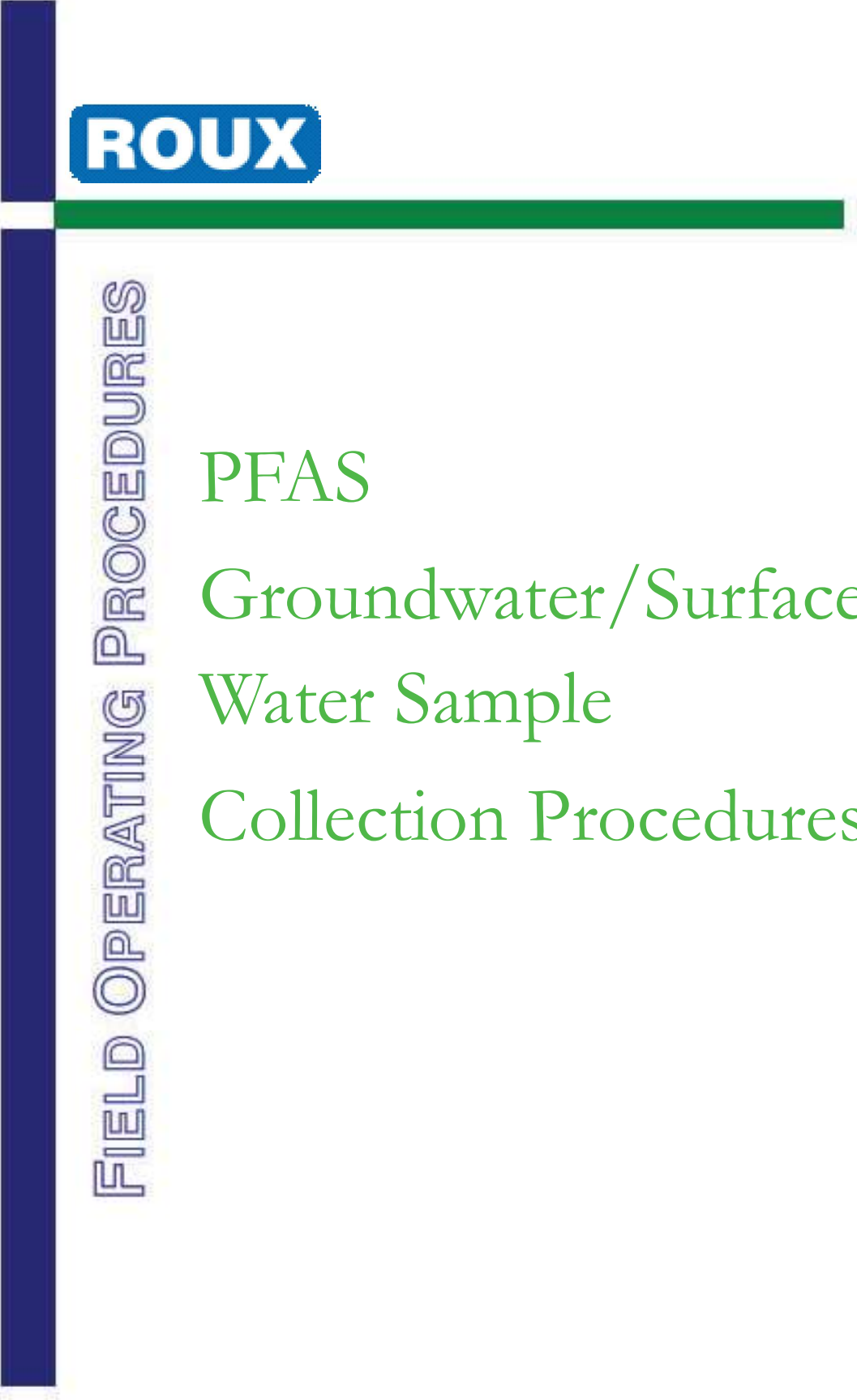
Diam.	Vol. (g/ft)
1"	0.041
2"	0.163
4"	0.653
6"	1.469

Stabilization Criteria

Parameter	Criteria
pH	± 0.1 unit
SC	± 3%
Turbidity	± 10%
DO	± 0.3 mg/L
ORP	± 10 mV

PREPARED BY: _____





ROUX

FIELD OPERATING PROCEDURES

PFAS

Groundwater/Surface
Water Sample
Collection Procedures

FOP 024.3

PFAS GROUNDWATER/ SURFACE WATER SAMPLE COLLECTION PROCEDURES

PURPOSE

This procedure describes the methods for collecting per-and polyfluoroalkyl substances (PFAS) groundwater samples from monitoring wells, following purging and sufficient recovery, and surface water locations. This procedure is specific to sites where PFAS sample analysis is required, and analysis specific collection and handling procedures are needed. PFAS sample analysis will be completed when Site analysis requires sampling of the full TAL/TCL analyte list. This field operating procedure (FOP) describes the personal protective equipment (PPE) and sampling equipment/materials appropriate for PFAS sample collection. PFAS laboratory analysis is performed using extremely low detection limits (parts per trillion). Therefore, cross contamination from potential sources (i.e., field equipment, consumer products) must be minimized to the extent possible.

PROCEDURE

Prior to sampling, discuss with the Site's Project Manager whether the monitoring wells that are to be sampled for the PFAS analytical parameters are new monitoring wells or existing monitoring wells. The specific handing and collection procedures for PFAS sampling are solely based on job preparation and sampling equipment used for the job. The standard practice of a 10 volume surge and purge of a newly installed monitoring well for development as discussed in **Roux's** FOP 036.0 – Monitoring Well Development Procedures and three volume well purge and/or low flow sampling that are discussed in **Roux's** FOP 023.1 – Groundwater Procedures Prior to Sample Collection remain the same. FOP 064.0 – Surface Water Sampling Procedures remains the same with the exceptions made in this FOP for PFAS sampling. The field sampling personnel must be prepared with appropriate clothing, equipment, and sampling containers for PFAS sampling as discussed below.



**PFAS GROUNDWATER/ SURFACE WATER SAMPLE COLLECTION
PROCEDURES**

FIELD CLOTHING

Unacceptable Field Clothing

- No Gore-Tex®, this includes but not limited to boots, gloves, coveralls, hats, and coats.
- No Tyvex®, this includes but not limited to coveralls, boots, hoods and head coverings. Tyvex® is also found in everyday items such as envelopes, receipts, and adhesives.
- No clothes, jackets, boots, or gloves that have been pretreated with Teflon® water proofing. Teflon® can be found in everyday items such as scissors, plumbers' tape, adhesive tapes, Teflon ® paper for crafting and cookware utensils.
- No clothing that has been waterproofed with PFAS materials
- No brand-new unwashed cotton clothing.
- Clothing that has been washed with fabric softeners prior to sampling.

Acceptable Field Clothing

- Well-worn, washed clothes, jackets, hats, and coveralls without fabric softener usage.
- Rain Gear made from PVC, polyurethane, or rubber only (it cannot contain any of the products listed above).
- Disposable powder free nitrile gloves.

FIELD EQUIPMENT

Unacceptable Field Equipment

- Sampling Equipment containing Teflon® or Low-Density Polyethylene (LDPE). Sampling equipment that may contain these materials include submersible pumps, bailers, tubing, braided poly rope or cord, fishing line.



FOP 024.3

PFAS GROUNDWATER/ SURFACE WATER SAMPLE COLLECTION PROCEDURES

- No LDPE or glass lined sampling containers, or Teflon®-lined caps.
- Waterproof field books, binders, plastic clip boards, spiral hard cover notebooks.
- No adhesives or permanent makers can be used (i.e., Post-It® notes and Sharpies).
- No Aluminum foil or sampling tins.
- No blue ice packs
- Avoid using paper towels

Acceptable Field Equipment

- Sampling Equipment made from High Density Polyethylene (HDPE), stainless steel, acetate, silicon, or polypropylene.
- Sampling Containers made from HDPE polypropylene

Acceptable Field Equipment (continued)

- Sampling Equipment (i.e. bailers) made from Poly Vinyl Chloride (PVC)
- Nylon rope/twine
- Ice
- Alconox

ADDITIONAL PROCEDURES

- Keep all bottle ware in a dedicated cooler containing only PFAS sample containers.
- Avoid consumption of food or drink prior to and during the sampling event.
- Do not apply cosmetics or moisturizers prior to sampling.



FOP 024.3

PFAS GROUNDWATER/ SURFACE WATER SAMPLE COLLECTION PROCEDURES

- Do not use standard commercial sunscreen or insect repellents. Use only all natural or organic products.
- Collect PFAS sample from each location prior to collecting other samples for analysis to avoid contact with other sample containers and packing materials.
- New disposable nitrile gloves will be donned at each sampling location.
- Don new disposable nitrile gloves while handling empty sample containers, filling sampling containers, sealing sample containers, and placing containers into sampling coolers.
- Single use (dedicated) or disposable sampling equipment is preferred when multiple locations are sampled.
- Perform a standard two-step decontamination using Alconox detergent and laboratory provided PFAS-free water for all non-dedicated sampling equipment.
- Equipment blanks should be comprised of laboratory provided PFAS-free water. The water should be poured over and/or brought into direct contact with all sampling equipment (bailer, rope, tubing, gloves, water level meter, etc.). The equipment blank will then be sealed and returned to the sample cooler. One equipment blank will be collected each day PFAS samples are collected, or once every 20 samples, whichever is more frequent. Additional equipment blanks may be collected as needed.
- One field duplicate and one matrix spike/matrix spike duplicate (MS/MSD) will be collected for every 20 samples.
- Field blanks should be comprised of laboratory provided PFAS-free water. The field blank should be uncapped and placed near the field crew while purging/sampling preparations take place (i.e. prepare bottle set, calibrate groundwater quality meters, prepare bailers for sampling, etc.). The intent of the uncapped blank is to capture any ambient PFAS compounds that may emanate from the field crew or equipment during typical preparations associated with groundwater/surface water sampling. The field blank will then be capped and returned to the sample cooler.

FOP 024.3

PFAS GROUNDWATER/ SURFACE WATER SAMPLE COLLECTION PROCEDURES

ATTACHMENTS

Groundwater Field Form (sample)

Surface Water Quality Field Collection Log (Sample)

REFERENCES

Roux FOPs:

036.0 Monitoring Well Development Procedures

023.1 Groundwater Purging Procedures Prior to Sample Collection

064.0 Surface Water Sampling Procedures



FOP 024.3

PFAS GROUNDWATER/ SURFACE WATER SAMPLE COLLECTION PROCEDURES

GROUNDWATER FIELD FORM

Project Name: _____ Date: _____
 Location: _____ Project No.: _____ Field Team: _____

Well No.			Diameter (inches):			Sample Time:			
Product Depth (ftTOR):			Water Column (ft):			DTW when sampled:			
DTW (static) (ftTOR):			Casing Volume:			Purpose: ☐ Development ☐ Sample			
Total Depth (ftTOR):			Purge Volume (gal):			Purge Method:			
Time	Water Level (ftTOR)	Acc. Volume (gallons)	pH (units)	Temp. (deg. C)	SC (uS)	Turbidity (NTU)	DO (mg/L)	ORP (mV)	Appearance & Odor
0	Initial								
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
Sample Information:			Date: (if different from above)						
S1									
S2									

Well No.			Diameter (inches):			Sample Time:			
Product Depth (ftTOR):			Water Column (ft):			DTW when sampled:			
DTW (static) (ftTOR):			Casing Volume:			Purpose: ☐ Development ☐ Sample			
Total Depth (ftTOR):			Purge Volume (gal):			Purge Method:			
Time	Water Level (ftTOR)	Acc. Volume (gallons)	pH (units)	Temp. (deg. C)	SC (uS)	Turbidity (NTU)	DO (mg/L)	ORP (mV)	Appearance & Odor
0	Initial								
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
Sample Information:			Date: (if different from above)						
S1									
S2									

REMARKS:

Note: All water level measurements are in feet, distance from top of riser.

Volume Calculation

Diam.	Vol. (g/ft)
1"	0.041
2"	0.163
4"	0.653
6"	1.469

Stabilization Criteria

Parameter	Criteria
pH	± 0.1 unit
SC	± 3%
Turbidity	± 10%
DO	± 0.3 mg/L
ORP	± 10 mV

PREPARED BY: _____



PFAS GROUNDWATER/ SURFACE WATER SAMPLE COLLECTION PROCEDURES

SURFACE WATER QUALITY FIELD COLLECTION LOG

PROJECT INFORMATION

Project Name: _____
 Project No.: _____
 Client: _____

SAMPLE DESCRIPTION

ID.: _____
 Matrix: _____
 Location: _____

SAMPLE INFORMATION

Date Collected: _____
 Time Collected: _____
 Date Shipped to Lab: _____
 Collected By: _____
 Sample Collection Method: _____

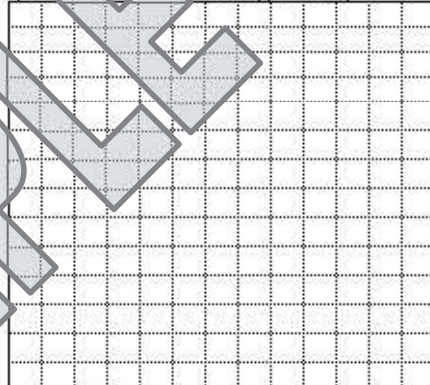
LABORATORY ANALYSIS

SAMPLING INFORMATION

Weather: _____
 Air Temperature: _____
 Depth of Sample: _____

LOCATION SKETCH

(note: scale, dimensions are approximate)



Parameter	First	Last	Units
pH			units
Temp.			°C
Cond.			µmS
Turbidity			NTU
Eh			mV
D.O.			ppm
Odor			olfactory
Appearance			visual

EXACT LOCATION (if applicable)

Northings (ft) _____ Eastings (ft) _____ Surface Elevation (fmsl) _____

ADDITIONAL LABORATORY ANALYSIS:

ADDITIONAL REMARKS:

PREPARED BY: _____

DATE: _____





FIELD OPERATING PROCEDURES

Hand Augering Procedures

HAND AUGERING PROCEDURES

PURPOSE

This guideline presents a method for hand augering, which enables the recovery of representative surface and shallow subsurface samples for classification and sample collection (ASTM D1452).

PROCEDURE

1. Review project objectives and the Project Health and Safety Plan (HASP).
2. Follow **Roux's** FOP: Drill Site Selection Procedure prior to implementing any hand augering activity.
3. Establish a central staging area for storage of augering supplies and for equipment decontamination (include plastic-covered work bench/table as necessary). Locate a secure storage area for augered samples.
4. Assemble auger and decontaminate in accordance with **Roux's** FOP: Non-Disposable and Non-Dedicated Sampling Equipment Decontamination.
5. Cover the area to be sampled with plastic sheeting, as determined by the Project Work Plan.
6. Make the auger boring through the plastic sheeting by rotating and advancing the auger to the desired depth below ground surface.
7. Withdraw the auger from the hole and remove soil for examination, soil classification, on-site testing (if applicable) and laboratory physical/chemical sample collection (if applicable) in accordance with specific **Roux** FOPs (Soil Description Procedures Using the Unified Soil Classification System; Composite Sample Collection Procedure for Non-Volatile Organic Analysis; and/or Soil Sample Handling for VOC Analysis) and as directed by the Project Work Plan.

FOP 025.0

HAND AUGERING PROCEDURES

8. Document all properties and sample locations in the Project Field Book and Hand Auger Borehole Log (sample attached). Specifically, total depth, borehole diameter, depth of sample collection, personnel, etc. should be recorded.
9. Place sample in appropriate container(s), label and store for future reference or ship to laboratory for analysis in accordance with **Roux's** Field Operating Procedure for Sample Labeling, Storage and Shipment.
10. Decontaminate auger in accordance with **Roux's** Field Operating Procedure for Non-Disposable and Non-Dedicated Sampling Equipment Decontamination.
11. Advance auger to next sample interval and repeat steps 7 through 12 as necessary.
12. Backfill auger holes in accordance with approved procedures outlined in the Project Work Plan.

ATTACHMENTS

Hand Auger Borehole Log (sample)

REFERENCES

Roux FOPs:

- 013 *Composite Sample Collection Procedure for Non-Volatile Organic Analysis*
- 017 *Drill Site Selection Procedure*
- 040 *Non-Disposable and Non-Dedicated Sampling Equipment Decontamination*
- 046 *Sample Labeling, Storage and Shipment*
- 054 *Soil Description Procedures Using the Unified Soil Classification System*
- 057 *Soil Sample Handling for Volatile Organic Compound Analysis – Encore Sampling*



FOP 025.0

HAND AUGERING PROCEDURES

HAND AUGER BOREHOLE LOG

Project:		BOREHOLE I.D.:	
Project No.:		Excavation Date:	
Client:		Excavation Method:	
Location:		Logged / Checked By:	

Hand Auger Location: <i>NOT TO SCALE</i> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 50%;">TIME</th> <th style="width: 50%;">BOREHOLE DIMENSIONS</th> </tr> <tr> <td>Start:</td> <td>Diameter: (approx.)</td> </tr> <tr> <td>End:</td> <td>Depth: (approx.)</td> </tr> </table> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th colspan="2">Hand Auger Cross Section:</th> </tr> <tr> <td style="width: 10%;">Grade - 0'</td> <td style="width: 90%;"></td> </tr> <tr><td>2'</td><td></td></tr> <tr><td>4'</td><td></td></tr> <tr><td>6'</td><td></td></tr> <tr><td>8'</td><td></td></tr> <tr><td>10'</td><td></td></tr> </table>		TIME	BOREHOLE DIMENSIONS	Start:	Diameter: (approx.)	End:	Depth: (approx.)	Hand Auger Cross Section:		Grade - 0'		2'		4'		6'		8'		10'		<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 10%;">Depth (fbgs)</th> <th style="width: 50%;">SAMPLE DESCRIPTION USCS Classification: Color, Moisture Condition of Soil, Temperature, Scale (mm) Plasticity, Fabric, Bedding, Weathering / Fracture, Other</th> <th style="width: 10%;">Photos Y / N</th> <th style="width: 30%;">Samples Collected (fbgs)</th> </tr> <tr><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td></tr> </table>	Depth (fbgs)	SAMPLE DESCRIPTION USCS Classification: Color, Moisture Condition of Soil, Temperature, Scale (mm) Plasticity, Fabric, Bedding, Weathering / Fracture, Other	Photos Y / N	Samples Collected (fbgs)																								
TIME	BOREHOLE DIMENSIONS																																																	
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COMMENTS:			
GROUNDWATER ENCOUNTERED:	yes	no	If yes, depth to GW:
VISUAL IMPACTS:	yes	no	Describe:
OLFACTORY OBSERVATIONS:	yes	no	Describe:
NON-NATIVE FILL ENCOUNTERED:	yes	no	
OTHER OBSERVATIONS:	yes	no	Describe:
SAMPLES COLLECTED:	yes	no	Sample I.D.:
			Sample I.D.:
			Sample I.D.:



A thick vertical bar on the left side of the slide, colored dark blue at the top and bottom, and green in the middle.

ROUX

FIELD OPERATING PROCEDURES

Hollow Stem Auger Drilling Procedures

HOLLOW STEM AUGER (HSA) DRILLING PROCEDURES

PURPOSE

This guideline presents a method for drilling a borehole through unconsolidated materials, including soils or overburden, and consolidated materials, including bedrock.

PROCEDURE

The following procedure will be used to drill a borehole for sampling and/or well installation, using hollow-stem auger methods and equipment.

1. Follow **Roux's** Field Operating Procedure for Drill Site Selection Procedure prior to implementing any drilling activity.
2. Perform drill rig safety checks with the driller by completing the Drilling Safety Checklist form (sample attached).
3. Conduct tailgate health and safety meeting with project team and drillers by completing the Tailgate Safety Meeting Form.
4. Calibrate air-monitoring equipment in accordance with the appropriate **Roux's** Field Operating Procedures (i.e., PID, FID, combustible gas meter) or manufacturer's recommendations for calibration of field meters (i.e., DataRAM 4 Particulate Meter).
5. Ensure all drilling equipment (i.e., augers, rods, split-spoons) appear clean and free of soil prior to initiating any subsurface intrusion. Decontamination of drilling equipment should be in accordance with **Roux's** FOP: Drilling and Excavation Equipment Decontamination Procedures.
6. Mobilize the auger rig to the site and position over the borehole.
7. Level and stabilize the rig using the rig jacks, and recheck the rig location against the planned drilling location. If necessary, raise the jacks and adjust the rig position.



FOP 026.1

HOLLOW STEM AUGER (HSA) DRILLING PROCEDURES

8. Place a metal or plywood auger pan over the borehole location to collect the auger cuttings. This auger pan will be equipped with a 12-inch nominal diameter hole for auger passage. As an alternative, a piece of polyethylene tarp may be used as a substitute.
9. Advance augers into the subsurface. For sampling or pilot-hole drilling, nominal 8-inch outside diameter (OD) augers should be used. The boring diameter will be approved by the **Roux** field supervisor.
10. Collect soil samples via split spoon sampler in accordance with **Roux's** Field Operating Procedure for Split Spoon Sampling.
11. Check augers periodically during drilling to ensure the boring is plumb. Adjust rig position as necessary to maintain plumb.
12. Continue drilling until reaching the assigned total depth, or until auger refusal occurs. Auger refusal is when the drilling penetration drops below 0.1 feet per 10 minutes, with the full weight of the rig on the auger bit, and a center bit (not center plug) in place.
13. Plug and abandon boreholes not used for well installation in accordance with **Roux's** Field Operating Procedure for Abandonment of Borehole.

OTHER PROCEDURAL ISSUES

- Slip rings may be used for lifting a sampling or bit string. The string will not be permitted to extend more than 15 feet above the mast crown.
- Borings will not be over drilled (rat holed) without the express permission of the **Roux** field supervisor. All depth measurements should be accurate to the nearest 0.1 foot, to the extent practicable.
- Potable water may be placed in the auger stem if critically necessary for borehole control or to accomplish sampling objectives and must be approved by the **Roux** Project Manager and/or NYSDEC Project Manager. Upon approval,



FOP 026.1

HOLLOW STEM AUGER (HSA) DRILLING PROCEDURES

the potable water source and quantity used will be documented in the Project Field Book and subsequent report submittal.

ATTACHMENTS

Drilling Safety Checklist (sample)
Tailgate Safety Meeting Form (sample)

REFERENCES

Roux FOPs:

- 001 *Abandonment of Borehole Procedures*
- 010 *Calibration and Maintenance of Portable Flame Ionization Detector*
- 011 *Calibration and Maintenance of Portable Photoionization Detector*
- 017 *Drill Site Selection Procedure*
- 018 *Drilling and Excavation Equipment Decontamination Procedures*
- 058 *Split Spoon Sampling Procedures*



FOP 026.1

HOLLOW STEM AUGER (HSA) DRILLING PROCEDURES

DRILLING SAFETY CHECKLIST

Project: **Supplemental Phase II RFI/ICMs**

Date:

Project No.: **0041-009-500**

Drilling Company:

Client: **RealCo., Inc.**

Drill Rig Type:

ITEMS TO CHECK	OK	ACTION NEEDED
"Kill switches" installed by the manufacturer are in operable condition and all workers at the drill site are familiar with their location and how to activate them?		
"Kill switches" are accessible to workers on both sides of the rotating stem? NOTE: Optional based on location and number of switches provided by the manufacturer.		
Cables on drill rig are free of kinks, frayed wires, "bird cages" and worn or missing sections?		
Cables are terminated at the working end with a proper eye splice, either swaged Coupling or using cable clamps?		
Cable clamps are installed with the saddle on the live or load side? Clamps should not be alternated and should be of the correct size and number for the cable size to which it is installed. Clamps are complete with no missing parts?		
Hooks installed on hoist cables are the safety type with a functional latch to prevent accidental separation?		
Safety latches are functional and completely span the entire throat of the hook and have positive action to close the throat except when manually displaced for connecting or disconnecting a load?		
Drive shafts, belts, chain drives and universal joints shall be guarded to prevent accidental insertion of hands and fingers or tools.		
Outriggers shall be extended prior to and whenever the boom is raised off its cradle. Hydraulic outriggers must maintain pressure to continuously support and stabilize the drill rig even while unattended.		
Outriggers shall be properly supported on the ground surface to prevent settling into the soil.		
Controls are properly labeled and have freedom of movement. Controls should not be blocked or locked in an action position.		
Safeties on any device shall not be bypassed or neutralized.		
Controls shall be operated smoothly and cables and lifting devices shall not be jerked or operated erratically to overcome resistance.		
Slings, chokers and lifting devices are inspected before using and are in proper working order? Damaged units are removed from service and are properly tagged?		
Shackles and clevises are in proper working order and pins and screws are fully inserted before placing under a load?		
High-pressure hoses have a safety (chain, cable or strap) at each end of the hose section to prevent whipping in the event of a failure?		
Rotating parts of the drill string shall be free of sharp projections or hooks, which could entrap clothing or foreign objects?		
Wire ropes should not be allowed to bend around sharp edges without cushion material.		
The exclusion zone is centered over the borehole and the radius is equal or greater than the boom height?		

ITEMS TO CHECK	OK	ACTION NEEDED
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FOP 026.1

HOLLOW STEM AUGER (HSA) DRILLING PROCEDURES

DRILLING SAFETY CHECKLIST

Project: **Supplemental Phase II RFI/ICMs** Date: _____
Project No.: **0041-009-500** Drilling Company: _____
Client: **RealCo., Inc.** Drill Rig Type: _____

ITEMS TO CHECK	OK	ACTION NEEDED
The work area around the borehole shall be kept clear of trip hazards and walking surfaces should be free of slippery material.		
Workers shall not proceed higher than the drilling deck without a fall restraining device and must attach the device in a manner to restrict fall to less than 6 feet.		
A fire extinguisher of appropriate size shall be immediately available to the drill crew. The drill crew shall have received annual training on proper use of the fire extinguisher.		
29 CFR 1910.333 © (3) Except where electrical distribution and transmission lines have been de-energized and visibly grounded, drill rigs will be operated proximate to, under, by, or near power lines only in accordance with the following: .333 © (3) (ii) 50 kV or less - minimum clearance is 10 ft. For 50 kV or over - 10ft. Plus ½ in. For each additional kV Roux Policy: Maintain 20 feet clearance		
29 CFR 1910.333 © (3) (iii) While the rig is in transit with the boom in the down position, clearance from energized power lines will be maintained as follows: Less than 50 kV - 4 feet 50 to 365 kV - 10 feet 365 to 720 kV - 16 feet		

Name: _____ (printed)
Signed: _____ Date: _____



FOP 026.1

HOLLOW STEM AUGER (HSA) DRILLING PROCEDURES

TAILGATE SAFETY MEETING FORM

Project Name: _____ Date: _____ Time: _____
Project Number: _____ Client: _____
Work Activities: _____

HOSPITAL INFORMATION:

Name: _____
Address: _____ City: _____ State: _____ Zip: _____
Phone No.: _____ Ambulance Phone No. _____

SAFETY TOPICS PRESENTED:

Chemical Hazards: _____

Physical Hazards: _____ Slips, Trips, Falls

PERSONAL PROTECTIVE EQUIPMENT:

Activity:	PPE Level:	A	B	C	D
Activity:	PPE Level:	A	B	C	D
Activity:	PPE Level:	A	B	C	D
Activity:	PPE Level:	A	B	C	D
Activity:	PPE Level:	A	B	C	D

New Equipment: _____

Other Safety Topic (s): _____ Environmental Hazards (aggressive fauna)
Eating, drinking, use of tobacco products is prohibited in the Exclusion Zone (EZ)

ATTENDEES

Name Printed	Signatures
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

Meeting conducted by: _____



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ROUX

FIELD OPERATING PROCEDURES

Low-Flow (Minimal
Drawdown)
Groundwater Purging
& Sampling Procedure

**LOW FLOW (MINIMAL DRAWDOWN) GROUNDWATER
PURGING & SAMPLING PROCEDURES**

PURPOSE

This procedure describes the methods used for performing low flow (minimal drawdown) purging, also referred to as micro-purging, at a well prior to groundwater sampling to obtain a representative sample from the water-bearing zone. This method of purging is used to minimize the turbidity of the produced water. This may increase the representativeness of the groundwater samples by avoiding the necessity of filtering suspended solids in the field prior to preservation of the sample.

Well purging is typically performed immediately preceding groundwater sampling. The sample should be collected as soon as the parameters measured in the field (i.e., pH, specific conductance, dissolved oxygen, Eh, temperature, and turbidity) have stabilized.

PROCEDURE

Allow approximately 3 to 10 days following well development for groundwater to return to static conditions before performing low-flow purge and sample activities at any well location. Conversely, perform low-flow sampling as soon as purged groundwater has stabilized. If the well does not yield sufficient volume (i.e., cannot maintain a constant water level during purging) for low-flow purge and sampling, then an alternative method must be performed in accordance with **Roux's** Groundwater Purging Procedures Prior to Sample Collection FOP.

1. Water samples should not be taken immediately following well development. Sufficient time should be allowed to stabilize the groundwater flow regime in

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LOW FLOW (MINIMAL DRAWDOWN) GROUNDWATER PURGING & SAMPLING PROCEDURES

the vicinity of the monitoring well. This lag time will depend on site conditions and methods of installation but may exceed one week.

2. Prepare the electronic water level indicator (e-line) in accordance with the procedures referenced in the **Roux's** Groundwater Level Measurement FOP and decontaminate the e-line probe and a lower portion of cable following the procedures referenced in the **Roux's** Non-disposable and Non-dedicated Sampling Equipment Decontamination FOP. Store the e-line in a protected area until use. This may include wrapping the e-line in clean plastic until the time of use.
3. Calibrate all sampling devices and monitoring equipment in accordance with manufacturer's recommendations, the site Quality Assurance Project Plan (QAPP) and/or Field Sampling Plan (FSP). Calibration of field instrumentation should be followed as specified in **Roux's** Calibration and Maintenance FOP for each individual meter.
4. Inspect the well/piezometer for signs of vandalism or damage and record condition on the Groundwater Field Form (sample attached). Specifically, inspect the integrity of the following: concrete surface seal, lock, protective casing and well cover, well casing and J-plug/cap. Report any irregular findings to the Project Manager.
5. Unlock and remove the well protective cap or cover and place on clean plastic to avoid introducing foreign material into the well.
6. Monitor the well for organic vapors using a PID, as per the Work Plan. If a reading of greater than 5 ppm is recorded, the well should be allowed to vent until levels drop below 5 ppm before proceeding with purging.
7. Lower the e-line probe slowly into the monitoring well and record the initial water level in accordance with the procedures referenced in **Roux's** Groundwater Level Measurement FOP. Refer to the construction diagram for the well to identify the screened depth.



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LOW FLOW (MINIMAL DRAWDOWN) GROUNDWATER PURGING & SAMPLING PROCEDURES

8. Decontaminate all non-dedicated pump and tubing equipment following the procedures referenced in the **Roux's** Non-disposable and Non-dedicated Sampling Equipment Decontamination FOP.
9. Lower the purge pump or tubing (i.e., low-flow electrical submersible, peristaltic, etc.) slowly into the well until the pump/tubing intake is approximately in the middle of the screened interval. Rapid insertion of the pump will increase the turbidity of well water, and can increase the required purge time. This step can be eliminated if dedicated tubing is already within the well.

Placement of the pump close to the bottom of the well will cause increased entrainment of solids, which may have settled in the well over time. Low-flow purging has the advantage of minimizing mixing between the overlying stagnant casing water and water within the screened interval. The objective of low-flow purging is to maintain a purging rate, which minimizes stress (drawdown) of the water level in the well. Low-flow refers to the velocity with which water enters the pump intake and that is imparted to the formation pore water in the immediate vicinity of the well screen.

10. Lower the e-line back down the well as water levels will be frequently monitored during purge and sample activities.
11. Begin pumping to purge the well. The pumping rate should be between 100 and 500 milliliters (ml) per minute (0.03 to 0.13 gallons per minute) depending on site hydrogeology. Periodically check the well water level with the e-line adjusting the flow rate as necessary to stabilize drawdown within the well. If possible, a steady flow rate should be maintained that results in a stabilized water level (drawdown of 0.3 feet or less). If the water level exceeds 2 feet below static and declining, slow the purge rate until the water level generally stabilizes. Record each pumping rate and water level during the event. If the water level continues to drop and will not stabilize, the monitoring location is not conducive to low-flow sampling and conventional purge and sample methods should be performed.



**LOW FLOW (MINIMAL DRAWDOWN) GROUNDWATER
PURGING & SAMPLING PROCEDURES**

The low flow rate determined during purging will be maintained during the collection of analytical samples. At some sites where geologic heterogeneities are sufficiently different within the screened interval, high conductivity zones may be preferentially sampled.

12. Measure and record field parameters (pH, specific conductance, Eh, dissolved oxygen (DO), temperature, and turbidity) during purging activities. In lieu of measuring all of the parameters, a minimum subset could be limited to pH, specific conductance, and turbidity or DO. A reduction in the field parameter list must be approved by the Project Manager and/or the NYSDEC Project Manager.

Water quality indicator parameters should be used to determine purging needs prior to sample collection in each well. Stabilization of indicator parameters should be used to determine when formation water is first encountered during purging. In general, the order of stabilization is pH, temperature, and specific conductance, followed by Eh, DO and turbidity. Performance criteria for determination of stabilization should be based on water-level drawdown, pumping rate and equipment specifications for measuring indicator parameters. An in-line flow through cell to continuously measure the above parameters may be used. The in-line device should be disconnected or bypassed during sample collection.

13. Purging will continue until parameters of water quality have stabilized or at least a minimum of three (3) well volumes have been removed. Record measurements for field indicator parameters (including water levels) at regular intervals during purging. The stability of these parameters with time can be used to guide the decision to discontinue purging. Proper adjustments must be made to stabilize the flow rate as soon as possible.
14. Record well purging and sampling data in the Project Field Book or on the Groundwater Field Form (sample attached). Measurements should be taken approximately every three to five minutes, or as merited given the rapidity of change.

**LOW FLOW (MINIMAL DRAWDOWN) GROUNDWATER
PURGING & SAMPLING PROCEDURES**

15. Purging is complete when field indicator parameters stabilize. Stabilization is achieved after all field parameters have stabilized for three successive readings. Three successive readings should be within ± 0.1 units for pH, $\pm 3\%$ for specific conductance, ± 10 mV for Eh, and $\pm 10\%$ for turbidity and dissolved oxygen. These stabilization guidelines are provided for rough estimates only, actual site-specific knowledge may be used to adjust these requirements higher or lower.

An in-line water quality measurement device (e.g., flow-through cell) should be used to establish the stabilization time for several field parameters on a well-specific basis. Data on pumping rate, drawdown, and volume required for parameter stabilization can be used as a guide for conducting subsequent sampling activities.

16. Collect all project-required samples from the discharge tubing at the flow rate established during purging in accordance with **Roux's** Groundwater Sample Collection Procedures FOP. **A peristaltic pump and dedicated tubing cannot be used to collect VOC or SVOC project-required samples; only non-organic compounds may be collected using this type of pump.** Continue to maintain a constant flow rate such that the water level is not drawn down as described above. Fill sample containers with minimal turbulence by allowing the ground water to flow from the tubing along the inside walls of the container.
17. If field filtration is recommended as a result of increased turbidity greater than 50 NTU, an in-line filter equipped with a 0.45-micron filter should be utilized. Collection of a filtered sample must be accompanied by an unfiltered sample.
18. Replace the dedicated tubing down the well taking care to avoid contact with the ground surface.
19. Restore the well to its capped/covered and locked condition.
20. Upon purge and sample collection completion, slowly lower the e-line to the bottom of the well/piezometer. Record the total depth to the nearest 0.01-

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LOW FLOW (MINIMAL DRAWDOWN) GROUNDWATER PURGING & SAMPLING PROCEDURES

foot and compare to the previous total depth measurement. If a significant discrepancy exists, re-measure the total depth. Record observations of purge water to determine whether the well/piezometer had become silted due to inactivity or damaged (i.e., well sand within purge water). Upon confirmation of the new total depth and determination of the cause (i.e., siltation or damage), notify the Project Manager following project field activities.

ATTACHMENTS

Groundwater Field Form (sample)

REFERENCES

United States Environmental Protection Agency, 540/S-95/504, 1995. *Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures*.

Roux FOPs:

- 007 *Calibration and Maintenance of Portable Dissolved Oxygen Meter*
- 008 *Calibration and Maintenance of Portable Field pH/Eh Meter*
- 009 *Calibration and Maintenance of Portable Field Turbidity Meter*
- 011 *Calibration and Maintenance of Portable Photoionization Detector*
- 012 *Calibration and Maintenance of Portable Specific Conductance Meter*
- 022 *Groundwater Level Measurement*
- 024 *Groundwater Sample Collection Procedures*
- 040 *Non-Disposable and Non-Dedicated Sampling Equipment Decontamination*
- 046 *Sample Labeling, Storage and Shipment Procedures*



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LOW FLOW (MINIMAL DRAWDOWN) GROUNDWATER PURGING & SAMPLING PROCEDURES

GROUNDWATER FIELD FORM

Project Name: _____ Date: _____
Location: _____ Project No.: _____ Field Team: _____

Well No.			Diameter (inches):			Sample Time:			
Product Depth (ftTOR):			Water Column (ft):			DTW when sampled:			
DTW (static) (ftTOR):			Casing Volume:			Purpose: ☐ Development ☐ Sample			
Total Depth (ftTOR):			Purge Volume (gal):			Purge Method:			
Time	Water Level (ftTOR)	Acc. Volume (gallons)	pH (units)	Temp. (deg. C)	SC (uS)	Turbidity (NTU)	DO (mg/L)	ORP (mV)	Appearance & Odor
0	Initial								
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
Sample Information:			Date: (if different from above)						
S1									
S2									

Well No.			Diameter (inches):			Sample Time:			
Product Depth (ftTOR):			Water Column (ft):			DTW when sampled:			
DTW (static) (ftTOR):			Casing Volume:			Purpose: ☐ Development ☐ Sample			
Total Depth (ftTOR):			Purge Volume (gal):			Purge Method:			
Time	Water Level (ftTOR)	Acc. Volume (gallons)	pH (units)	Temp. (deg. C)	SC (uS)	Turbidity (NTU)	DO (mg/L)	ORP (mV)	Appearance & Odor
0	Initial								
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
Sample Information:			Date: (if different from above)						
S1									
S2									

REMARKS:

Note: All water level measurements are in feet, distance from top of riser.

Volume Calculation

Diam.	Vol. (g/ft)
1"	0.041
2"	0.163
4"	0.653
6"	1.469

Stabilization Criteria

Parameter	Criteria
pH	± 0.1 unit
SC	± 3%
Turbidity	± 10%
DO	± 0.3 mg/L
ORP	± 10 mV

PREPARED BY: _____



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ROUX

FIELD OPERATING PROCEDURES

Management of Investigative-Derived Waste (IDW)

MANAGEMENT OF INVESTIGATION-DERIVED WASTE (IDW)

PURPOSE

The purpose of these guidelines is to ensure the proper holding, storage, transportation, and disposal of materials generated from field investigation activities that may contain hazardous wastes. Investigation-derived waste (IDW) includes the following:

- Drill cuttings, discarded soil samples, drilling mud solids, and used sample containers.
- Well development and purge waters and discarded groundwater samples.
- Decontamination waters and associated solids.
- Soiled disposable personal protective equipment (PPE).
- Used disposable sampling equipment.
- Used plastic sheeting and aluminum foil.
- Other equipment or materials that either contain or have been in contact with potentially impacted environmental media.

Because these materials may contain regulated chemical constituents, they must be managed as a solid waste. This management may be terminated if characterization analytical results indicate the absence of these constituents.

PROCEDURE

1. Contain all investigation-derived wastes in Department of Transportation (DOT)-approved 55-gallon drums, roll-off boxes, or other containers suitable for the wastes.

MANAGEMENT OF INVESTIGATION-DERIVED WASTE (IDW)

2. Contain wastes from separate borings or wells in separate containers (i.e. do not combine wastes from several borings/wells in a single container, unless it is a container used specifically for transfer purposes, or unless specific permission to do so has been provided by the **Roux** Field Team Leader. Unused samples from surface sample locations within a given area may be combined.
3. To the extent practicable, separate solids from drilling muds, decontamination waters, and similar liquids. Place solids within separate containers.
4. Transfer all waste containers to a staging area. Access to this area will be controlled. Waste containers must be transferred to the staging area as soon as practicable after the generating activity is complete.
5. Pending transfer, all containers will be covered and secured when not immediately attended.
6. Label all containers with regard to contents, origin, date of generation, using **Roux's** IDW container label (sample attached). Use indelible ink for all labeling.
7. Complete the Investigative Derived Waste Container Log (sample attached) as waste containers are labeled in order to track and inventory project waste. Leave a copy of the log with the site manager or fax copy to the owner/operator as necessary.
8. Collect samples for waste characterization purposes, or use boring/well sample analytical data for characterization.
9. For wastes determined to be hazardous in character, **be aware of accumulation time limitations**. Coordinate the disposal of these wastes with the plant manager/owner/operator, if applicable.
10. Upon Property Owner, Project Manager, and/or NYSDEC Project Manager approval, dispose of investigation-derived wastes as follows:

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MANAGEMENT OF INVESTIGATION-DERIVED WASTE (IDW)

- Soil, water, and other environmental media for which analysis does not detect organic constituents, and for which inorganic constituents are at levels that meet the Site's cleanup objectives, may be spread on the Property or otherwise treated as a non-waste material. Disposal quantity and on-site location will be documented on Project Field Books and in the project report submittal.
- Soil, water, and other environmental media in which organic compounds are detected or metals are present above the Site's cleanup objectives will be disposed off-site in accordance with applicable state and federal regulations. Disposal quantity and off-site location will be documented on Project Field Books and in the project report submittal.
- Personal protective equipment, disposable bailers, and similar equipment may be disposed as municipal waste, unless waste characterization results mandate otherwise.

WASTE STORAGE MANAGEMENT

Hazardous materials generated on site should be temporarily stored in a secure location that is under the control of the owner/operator or does not allow for vandalism (i.e., within a locked building structure or within a locked fenced in area). A waste-staging area should be designated on-site by the Project Manager in conjunction with the owner/operator.

ATTACHMENTS

Investigation Derived Waste Container Log (sample)
Investigation Derived Waste Container Label (sample)

REFERENCES

None



FOP 032.1

MANAGEMENT OF INVESTIGATION-DERIVED WASTE (IDW)

INVESTIGATION DERIVED WASTE

[illegible]

Prepared By: _____
Signed: _____

FOP 032.1

MANAGEMENT OF INVESTIGATION-DERIVED WASTE (IDW)

IDW Container Label (sample):

Project Name:	
Project Number:	
Container I.D.:	
Contents/Matrix:	
Estimated Quantity:	
Date of Generation:	
Date of Sample Collection:	
Contact Name:	
Contact Phone Number:	

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ROUX

FIELD OPERATING PROCEDURES

Monitoring Well Construction for Hollow Stem Auger Boreholes

**MONITORING WELL CONSTRUCTION FOR
HOLLOW STEM AUGER BOREHOLES**

PURPOSE

Wells will be installed within selected boreholes for the purpose of evaluating groundwater characteristics. Well installation procedures depend upon the drilling method. This procedure describes well construction and installation for boreholes drilled using the hollow stem auger method. Refer to the **Roux's** Hollow Stem Auger Drilling Procedures FOP. Nominal dimensions and materials for the well are shown in the attached well construction diagram.

PROCEDURE

1. Advance borehole in accordance with the **Roux's** Hollow Stem Auger Drilling Procedure FOP to the required depth. The nominal inside diameter (ID) of the auger stem used should be at least 2 inches larger than the outside diameter (OD) of the riser and screen selected for the well installation. Record the monitoring well construction on the Field Borehole/Monitoring Well Installation Log (sample attached) (see Documentation Requirements for Drilling and Well Installation FOP).
2. Remove the drill rods and center bit/plug from the auger stem and verify borehole depth using weighted measuring tape.
3. In the event of an over drill (i.e. borehole depth is more than one foot greater than desired base of screen depth), use bentonite chips poured through the auger stem to seal the over drilled portion of the borehole. Be sure to note bentonite chip thickness on Field Borehole/Monitoring Well Installation Log.
4. Add a maximum of 6 inches of filter pack material through the auger stem to the base of the borehole. (Note: This step may be avoided if dense non-aqueous phase liquids are suspected to be present and it is desirable to have the screen and/or sump at the base of the borehole.)

**MONITORING WELL CONSTRUCTION FOR
HOLLOW STEM AUGER BOREHOLES**

5. Measure the length of the well string (i.e. riser and screen), and lower the well string into the well assembly to the desired depth. All measurements during the well installation process will be accurate to 0.1 foot.
6. Surface pour filter pack material into the annulus between the well and the auger stem as the augers are gradually withdrawn from the borehole. Use a weighted tape to confirm that the level of sand is maintained within the augers at all times. Record material volumes used.
7. After filter pack materials are brought to the required level, surface pour bentonite chips or pellets into the annulus between the well and the auger stem to form the filter pack seal. If necessary to avoid bridging, delayed hydration (coated) pellets may be used. Record the volume of material used.
8. Allow the bentonite chips/pellets to adequately hydrate for approximately 30 to 45-minutes. Cap or cover the well top of riser.
9. Mix cement/bentonite grout to a smooth consistency using a centrifugal or reciprocating pump. Do not hand mix. All water used must be potable quality. Record the volume of water used.
10. Fill the remaining annulus between the well and the auger stem with grout by surface pouring or pumping, and begin withdrawal of the auger string. Periodically top the auger string off with additional grout. If groundwater is present within the annulus above the bentonite chip/pellet seal, cement/bentonite grout will be pressure tremie grouted from bottom to top in order to displace groundwater from the borehole.
11. When the auger string is withdrawn, center the upper portion of the well riser within the borehole, and place drums or barricades around the well for protection while the grout cures. Place and lock a security cap (i.e., J-plug) in the opening of the well riser.
12. Leave the well undisturbed for at least 24 hours to allow the grout to cure. If excessive grout fallback occurs, top off as necessary with bentonite chips or additional grout.

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MONITORING WELL CONSTRUCTION FOR HOLLOW STEM AUGER BOREHOLES

13. Construct the surface completion as shown in the attached Typical Monitoring Well Detail (Figure 1). Select flush completions for all locations in active operational or high traffic areas, or in other areas where an above grade completion would be undesirable. Use aboveground completions in all other areas.
14. Place a dedicated lock on the well or protective casing, and keep well locked when not actively attended.
15. Permanently label the well with the appropriate well identifier as determined by the Project Manager or specified in the Work Plan.
16. Permanently mark a survey location on the north side at the top of the casing with a saw cut. Survey all wells for horizontal location and elevation, using a surveyor licensed by the State of New York. Coordinates and elevations will be provided in a coordinate system consistent with previous well surveys at the Site. Information obtained will include location (x and y) of the well, and elevation (z) of the ground surface, the pad, and the top of riser.
17. Develop the well as described in the **Roux** Field Operating Procedure for Monitoring Well Development.
18. Manage all waste materials generated during well installation and development as described in the **Roux** Field Operating Procedure for Management of Investigation Derived Waste.

ATTACHMENTS

Field Borehole/Monitoring Well Installation Log (sample)
Typical Monitoring Well Detail (Figure 1)



FOP 033.0

MONITORING WELL CONSTRUCTION FOR HOLLOW STEM AUGER BOREHOLES

REFERENCES

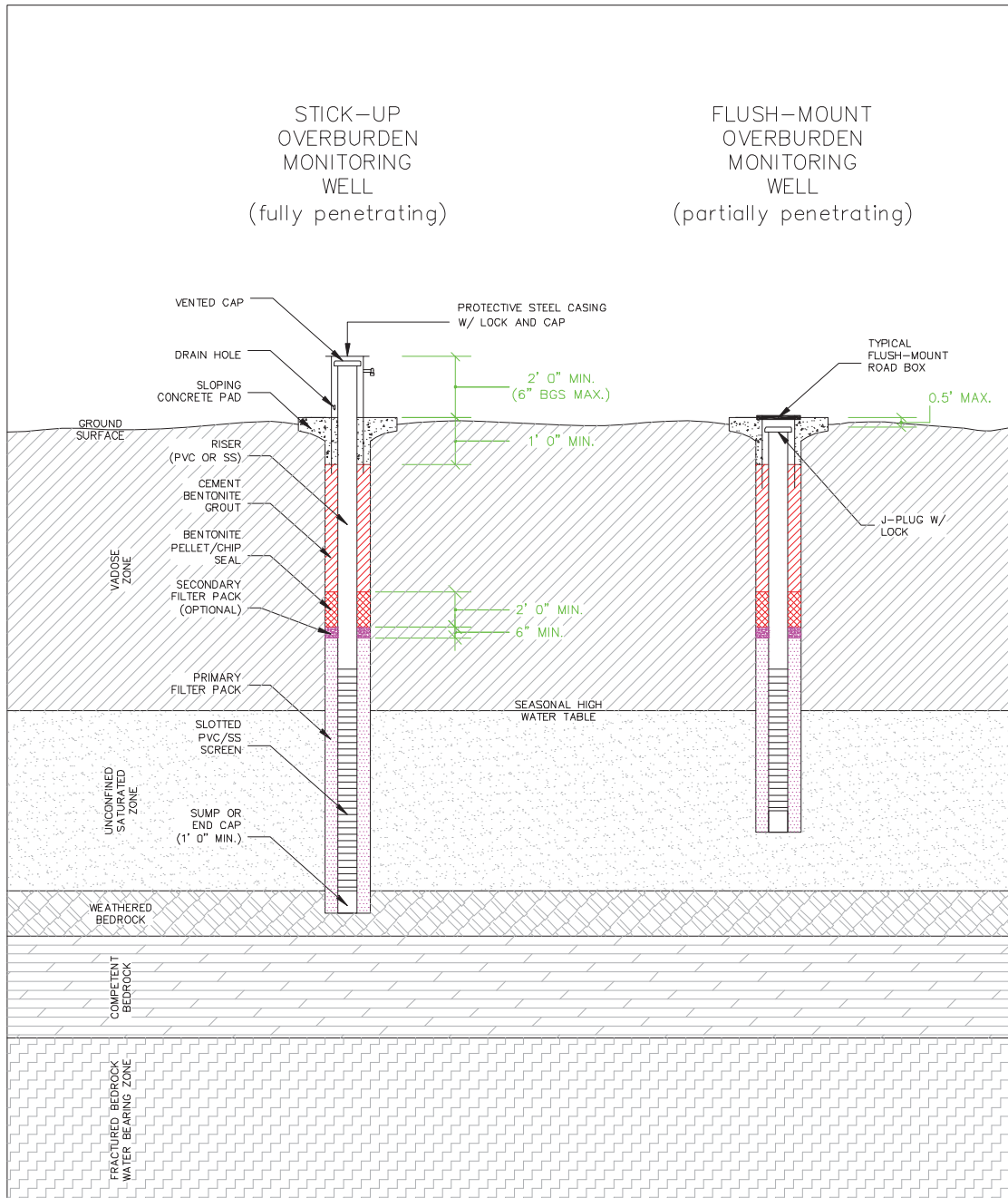
Roux FOPs:

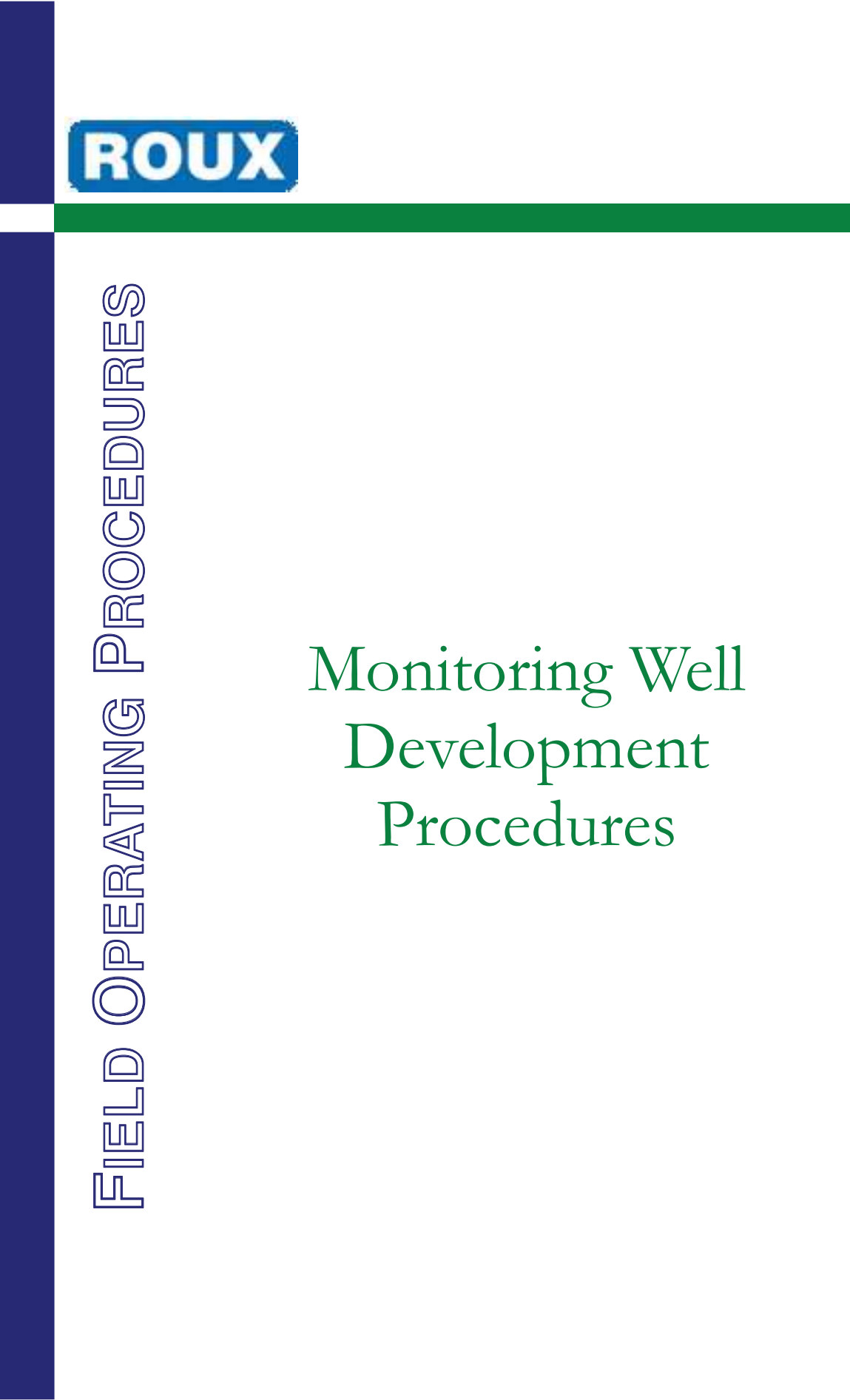
- 015 *Documentation Requirements for Drilling and Well Installation*
- 026 *Hollow Stem Auger Drilling Procedures*
- 032 *Management of Investigation Derived Waste*
- 036 *Monitoring Well Development Procedures*



**MONITORING WELL CONSTRUCTION FOR
HOLLOW STEM AUGER BOREHOLES**

FIGURE 1





ROUX

FIELD OPERATING PROCEDURES

Monitoring Well Development Procedures

MONITORING WELL DEVELOPMENT PROCEDURES

PURPOSE

This procedure describes the methods for the development of newly installed monitoring wells and re-development of existing monitoring wells that have been inactive for an extended period of time (i.e., one year or more). Monitoring wells are developed after installation in order to remove introduced water and drilling fluids, reduce the turbidity of the water, and improve the hydraulic communication between the well and the water-bearing formation. Well development will not commence until the annular grout seal has cured, but will be performed within ten calendar days of well installation.

PROCEDURE

1. All well development will include surge blocking or false bailing with one or more of the following fluid removal methods. Well development activities may include:
 - Bailing
 - Air Lifting
 - Submersible Pumping
 - Other methods as approved by the **Roux** Field Team Leader.
 - The appropriate water removal method will be selected based on water level depth and anticipated well productivity.
2. Assemble and decontaminate equipment (if necessary), and place in the well. Reference the **Roux** Field Operating Procedure for Non-Disposable and Non-Dedicated Sampling Equipment Decontamination.
3. Alternate the use of agitation methods with water removal methods, using the former to suspend solids in the well water, and the latter to remove the turbid water. For example, use a vented surge block to agitate the well, moving up and down within the screened interval and then use a pump to clear the well. A bailer may be used for both purposes, by surging with the bailer (false

MONITORING WELL DEVELOPMENT PROCEDURES

bailing) for a period within the screened interval, then bailing a volume of water from the well.

4. When using surging methods, initiate this activity gradually, with short (2 to 3 feet) strokes. After several passes across the screened interval, increase the speed and length of the surge strokes.
5. Continue development until the following objectives are achieved:
 - Field parameters stabilize to the following criteria:
 - o Dissolved Oxygen: ± 0.3 mg/L
 - o Turbidity: $\pm 10\%$
 - o Specific Conductance: $\pm 3\%$
 - o ORP: ± 10 mV
 - o pH: ± 0.1 units
 - The well will generate non-turbid water during continued pumping typically less than 50 NTU.
 - A minimum of 10 well volumes has been evacuated from the well.
 - In the case of lost water during drilling activities, the volume of water removed exceeds twice the volume of water lost to the formation during the drilling process, as indicated by the water balance.
6. Document the development methods, volumes, field parameter measurements, and other observations on the attached **Roux** Groundwater Well Development Log (sample attached).

ATTACHMENTS

Groundwater Well Development Log (sample)

REFERENCES

Roux FOPs:

040 *Non-Disposable and Non-Dedicated Sampling Equipment Decontamination*



A thick vertical bar on the left side of the slide, colored dark blue at the top and bottom, and green in the middle.

ROUX

FIELD OPERATING PROCEDURES

Non-Aqueous Phase
Liquid (NAPL)
Detection and Sample
Collection Procedure

**NON-AQUEOUS PHASE LIQUID DETECTION
AND SAMPLE COLLECTION PROCEDURE**

PURPOSE

This procedure describes the methods to detect the presence and sample collection of Non-Aqueous Phase Liquid (NAPL) in groundwater monitoring wells prior to purging activities. If NAPL is suspected, all activities should be performed with proper personnel protective equipment (PPE).

DETECTION PROCEDURE

Groundwater monitoring wells suspected of containing NAPL will be sounded with an interface probe, or similar device, in accordance with the following.

1. Inspect the well/piezometer for signs of vandalism or damage and record condition on the Groundwater Field Form (sample attached). Specifically, inspect the integrity of the following: concrete surface seal, lock, protective casing and well cover, well casing and J-plug/cap. Report any irregular findings to the Project Manager.
2. Unlock and remove the well protective cap or cover and place on clean plastic to avoid introducing foreign material into the well.
3. Calibrate the photoionization detector (PID) in accordance with the **Roux** Field Operating Procedure for Calibration and Maintenance of Portable Photoionization Detector.
4. Monitor the well for organic vapors using a PID, as per the Work Plan. If a reading of greater than 5 ppm is recorded, the well should be allowed to vent until levels drop below 5 ppm before proceeding with purging. Record PID measurements on the Groundwater Field Form (sample attached).
5. Slowly lower the interface probe down the well, avoiding contact with the well casing. Upon contact with the static liquid level in the well, the interface

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NON-AQUEOUS PHASE LIQUID DETECTION AND SAMPLE COLLECTION PROCEDURE

probe will signal contact with an audible tone and/or a visible light mounted inside the reel.

Note:

- If the signal is constant, the probe is in contact with groundwater; and
 - If the signal oscillates, the probe is in contact with NAPL.
6. Record the depth, type of liquid encountered (if applicable) and any other related information in the Project Field Book and on a Groundwater Field Form (sample attached).
 7. Slowly lower the interface probe to the well bottom. Record the depth(s) and type(s) of any additional phases encountered.
 8. Slowly raise the interface probe to the surface, avoiding contact with the well casing.
 9. Place the interface probe and storage reel in a plastic bag for subsequent decontamination in accordance with the **Roux's** Field Operating Procedure for Non-Disposable and Non-Dedicated Sampling Equipment Decontamination.

SAMPLE COLLECTION PROCEDURE

All NAPL samples collected from groundwater monitoring wells will be collected in accordance with the following.

1. Place plastic sheeting on the ground around the well to prevent equipment from coming in contact with soil and also to prevent the surface transmission of NAPL.



**NON-AQUEOUS PHASE LIQUID DETECTION
AND SAMPLE COLLECTION PROCEDURE**

2. All sampling personnel will don the appropriate PPE in accordance with the site health and safety plan.
3. Measure the static water level and NAPL level(s) using an interface probe as described in the previous section.
4. Determine depth to NAPL layer and thickness. Record appropriate data in the Project Field Book and on a Groundwater Sample Collection Log form (sample attached).

DNAPL SAMPLE COLLECTION

The following procedure should be used in sampling dense, heavier than water NAPL (i.e., with a high specific gravity) (DNAPL).

1. Collect samples using a translucent double check valve bailer (i.e., a bailer with a ball valve on both the top and bottom) constructed of Teflon, polyethylene or PVC which is connected to polypropylene rope for lowering into the well. All non-dedicated equipment shall be decontaminated in accordance with the **Roux** Field Operating Procedure for Non-Disposable and Non-Dedicated Sampling Equipment Decontamination.
2. Remove wrapping (i.e., aluminum foil, manufacturers packaging etc.), attach bailer to new polypropylene rope and slowly lower the bailer until it contacts the well bottom.
3. Slowly raise and lower the bailer to create a gentle surging action thereby inducing DNAPL into the bailer past the bottom ball valve.
4. Slowly raise the bailer to the surface. Avoid contact of the bailer line with the well casing and/or ground surface.

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NON-AQUEOUS PHASE LIQUID DETECTION AND SAMPLE COLLECTION PROCEDURE

5. Observe the DNAPL through the translucent wall of the bailer and check if the immiscible phases have separated. If not, allow the bailer to stand upright until the phases have separated.
6. Carefully attach a bottom-emptying device with stopcock to the bottom of the bailer and discharge the DNAPL gently down the side of the sample bottle to minimize turbulence.
7. Repeat steps 2 through 6 until a sufficient sample volume is obtained.
8. Cap the sample bottle and label, preserve and ship samples in accordance with the **Roux** Field Operating Procedure for Sample Labeling, Storage and Shipment Procedures.
9. Place the used plastic sheeting, bailer and polyethylene rope in a plastic bag for subsequent decontamination or disposal.
10. Document the sampling procedures and related information in the Project Field Book and on a Groundwater Sample Collection Log form (sample attached).

LNAPL SAMPLE COLLECTION

The following procedure should be used in sampling lighter than water NAPL (i.e., with a low specific gravity) (LNAPL).

1. Collect samples using a translucent double check valve bailer (i.e., a bailer with a ball valve on both the top and bottom) constructed of Teflon, polyethylene or PVC which is connected to polypropylene rope for lowering into the well. All non-dedicated equipment shall be decontaminated in accordance with the **Roux** Field Operating Procedure for Non-Disposable and Non-Dedicated Sampling Equipment Decontamination.



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NON-AQUEOUS PHASE LIQUID DETECTION AND SAMPLE COLLECTION PROCEDURE

2. Remove wrapping (i.e., aluminum foil, manufacturers packaging etc.), attach bailer to new polypropylene rope and slowly lower the bailer down the well into the immiscible phase of LNAPL. Care should be taken to lower the bailer just through the LNAPL layer, but not significantly down into the underlying groundwater.
3. Slowly raise the bailer to the surface. Avoid contact of the bailer line with the well casing and/or ground surface.
4. Observe the LNAPL through the translucent wall of the bailer and check if the immiscible phases have separated. If not, allow the bailer to stand upright until the phases have separated.
5. Carefully attach a bottom-emptying device with stopcock to the bottom of the bailer and decant the denser groundwater portion of the bailer contents into a DOT-approved 55-gallon drum for proper disposal.
6. Discharge the LNAPL gently down the side of the sample bottle to minimize turbulence.
7. Repeat steps 2 through 6 until a sufficient sample volume is obtained.
8. Cap the sample bottle and label, preserve and ship samples in accordance with the **Roux** Field Operating Procedure for Sample Labeling, Storage and Shipment Procedures.
9. Place the used plastic sheeting, bailer and polyethylene rope in a plastic bag for subsequent decontamination or disposal.
10. Document the sampling procedures and related information in the Project Field Book and on a Groundwater Sample Collection Log form (sample attached).

ATTACHMENTS



FOP 039.1

NON-AQUEOUS PHASE LIQUID DETECTION AND SAMPLE COLLECTION PROCEDURE

Groundwater Well Purge & Sample Collection Log (sample)

REFERENCES

Roux FOPs:

- 010 *Calibration and Maintenance of Portable Flame Ionization Detector*
- 011 *Calibration and Maintenance of Portable Photoionization Detector*
- 040 *Non-Disposable and Non-Dedicated Sampling Equipment Decontamination*
- 046 *Sample Labeling, Storage and Shipment Procedures*



FOP 039.1

NON-AQUEOUS PHASE LIQUID DETECTION
AND SAMPLE COLLECTION PROCEDUREGROUNDWATER WELL
PURGE & SAMPLE COLLECTION LOG

Project Name: WELL NUMBER:
Project Number: Sample Matrix:
Client: Weather:

WELL DATA:	DATE:	TIME:
Casing Diameter (inches):		Casing Material:
Screened interval (ft/TOR):		Screen Material:
Static Water Level (ft/TOR):		Bottom Depth (ft/TOR):
Elevation Top of Well Riser (fmsl):		Ground Surface Elevation (fmsl):
Elevation Top of Screen (fmsl):		Stick-up (feet):

PURGING DATA:	DATE:	START TIME:	END TIME:
Method:		Is purge equipment dedicated to sample location?	yes
No. of Well Volumes Purged:		Was well purged to dryness?	yes
Standing Volume (gallons):		Was well purged below top of sand pack?	yes
Volume Purged (gallons):		Condition of Well:	
Purge Rate (gal/min):		Field Personnel:	

VOLUME CALCULATION:	Volume Calculation	Stabilization Criteria	
(A) Total Depth of Well (ft/TOR):	Well Diameter	Parameter	Criteria
(B) Casing Diameter (inches):	1"	pH	+/- 0.1 ur
(C) Static Water Level (ft/TOR):	2"	SC	+/- 3%
One Well Volume (V, gallons):	3"	Turbidity	+/- 10%
$V = 0.0408 \{ (B)^2 \times (A - (C)) \}$	4"	DO	+/- 0.3 m
	5"	ORP	+/- 10 mV
	6"		

* Use the table to the right to calculate one well volume by subtracting C from A, then multiplying by the volume calculation in the table per well diameter.

EVACUATION STABILIZATION TEST DATA:									
Time	Water Level (ft/TOR)	Accumulated Volume (gallons)	pH (units)	Temperature (degrees C)	Specific Conductance (uS/cm)	Turbidity (NTU)	DO (mg/L)	ORP (mV)	Appearance Odor
		initial							

SAMPLING DATA:	DATE:	START TIME:	END TIME:
Method:		Is sampling equipment dedicated to sample location?	yes
Initial Water Level (ft/TOR):		Was well sampled to dryness?	yes
Final Water Level (ft/TOR):		Was well sampled below top of sand pack?	yes
Air Temperature (°F):		Field Personnel:	
Source and type of water used in the field for QC purposes:			

PHYSICAL & CHEMICAL DATA:		
DESCRIPTION OF WATER SAMPLE		
Odor		
Color		
NAPL		
Contains Sediment?	yes	no

WATER QUALITY MEASUREMENTS							
Sample	Time	pH (units)	TEMP. (°C)	SC (uS)	TURB. (NTU)	DO (ppm)	ORP (mV)
initial							
final							

REMARKS:

PREPARED BY:





ROUX

FIELD OPERATING PROCEDURES

Non-Disposable and
Non-Dedicated
Sampling Equipment
Decontamination

FOP 040.1

NON-DISPOSABLE AND NON-DEDICATED SAMPLING EQUIPMENT DECONTAMINATION

PURPOSE

This procedure is to be used for the decontamination of non-disposable and non-dedicated equipment used in the collection of environmental samples. The purpose of this procedure is to remove chemical constituents from previous samples from the sampling equipment. This prevents these constituents from being transferred to later samples, or being transported out of controlled areas.

HEALTH AND SAFETY

Nitric acid is a strong oxidizing agent as well as being extremely corrosive to the skin and eyes. Solvents such as acetone, methanol, hexane and isopropanol are flammable liquids. Limited contact with skin can cause irritation, while prolonged contact may result in dermatitis. Eye contact with the solvents may cause irritation or temporary corneal damage. Safety glasses with protective side shields, neoprene or nitrile gloves and long-sleeve protective clothing must be worn whenever acids and solvents are being used.

PROCEDURE – GENERAL EQUIPMENT

Bailers, split-spoons, steel or brass split-spoon liners, Shelby tubes, submersible pumps, soil sampling knives, and similar equipment will be decontaminated as described below.

1. Wash equipment thoroughly with non-phosphate detergent and potable-quality water, using a brush where possible to remove any particulate matter or surface film. If the sampler is visibly coated with tars or other phase-separated hydrocarbons, pre-wash with acetone or isopropanol, or by steam cleaning. Decontamination will adhere to the following procedure:



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NON-DISPOSABLE AND NON-DEDICATED SAMPLING EQUIPMENT DECONTAMINATION

- a. Rinse with potable-quality water; if the sampling equipment is very oily and use of a solvent is necessary, rinse with pesticide-grade isopropanol.
 - b. Rinse with potable-quality water;
 - c. Rinse with deionized water demonstrated analyte-free, such as distilled water;
 - d. Air dry; and
 - e. Store in a clean area or wrap in aluminum foil (shiny side out) or new plastic sheeting as necessary to ensure cleanliness.
2. All non-dedicated well evacuation equipment, such as submersible pumps and bailers, which are put into the well, must be decontaminated following the procedures listed above. All evacuation tubing must be dedicated to individual wells (i.e., tubing cannot be reused). However, if submersible pump discharge tubing must be reused, the tubing and associated sample valves or flow-through cells used in well purging or pumping tests will be decontaminated as described below:
- a. Pump a mixture of potable water and a non-phosphate detergent through the tubing, sample valves and flow cells, using the submersible pump.
 - b. Steam clean or detergent wash the exterior of the tubing, sample valves, flow cells and pump.
 - c. Pump potable water through the tubing, sample valve, and flow cell until no indications of detergent (e.g. foaming) are observed.
 - d. Double rinse the exterior of the tubing with potable water.
 - e. Rinse the exterior of the tubing with distilled water.



FOP 040.1

NON-DISPOSABLE AND NON-DEDICATED SAMPLING EQUIPMENT DECONTAMINATION

- f. Store in a clean area or wrap the pump and tubing assembly in new plastic sheeting as necessary to ensure cleanliness until ready for use.
3. All unused sample bottles and sampling equipment must be maintained in such a manner that there is no possibility of casual contamination.
4. Manage all waste materials generated during decontamination procedures as described in the **Roux** Field Operating Procedure for Management of Investigation Derived Waste.

PROCEDURE – SUBMERSIBLE PUMPS

Submersible pumps used in well purging or purging tests will be decontaminated thoroughly each day before use as well as between well locations as described below:

Daily Decontamination Procedure:

1. Pre-rinse: Operate the pump in a basin containing 8 to 10 gallons of potable water for 5 minutes and flush other equipment with potable water for 5 minutes.
2. Wash: Operate the pump in 8 to 10 gallons of non-phosphate detergent solution (i.e., Alconox) for 5 minutes and flush other equipment with fresh detergent solution for 5 minutes.
3. Rinse: Operate the pump in a basin of potable water for 5 minutes and flush other equipment with potable water for 5 minutes.
4. Disassemble pump.
5. Wash pump parts with a non-phosphate detergent solution (i.e., Alconox). Scrub all pump parts with a test tube brush or similar device.



FOP 040.1

NON-DISPOSABLE AND NON-DEDICATED SAMPLING EQUIPMENT DECONTAMINATION

6. Rinse pump with potable water.
7. Rinse the inlet screen, the shaft, the suction interconnection, the motor lead assembly, and the stator housing with distilled/deionized water.
8. Rinse the impeller assembly with 1% nitric acid (HNO_3).
9. Rinse the impeller assembly with isopropanol.
10. Rinse the impeller assembly with distilled/deionized water.

Between Wells Decontamination Procedure:

1. Pre-rinse: Operate the pump in a basin containing 8 to 10 gallons of potable water for 5 minutes.
2. Wash: Operate the pump in 8 to 10 gallons of non-phosphate detergent solution (i.e., Alconox) for 5 minutes.
3. Rinse: Operate the pump in a basin of potable water for 5 minutes.
4. Final rinse the pump in distilled/deionized water.

ATTACHMENTS

None

REFERENCES

Roux FOPs:

032 *Management of Investigation-Derived Waste*





ROUX

FIELD OPERATING PROCEDURES

Overburden Casing Installation Procedure

OVERBURDEN CASING INSTALLATION PROCEDURES

PURPOSE

This guideline presents a method for the installation of casing to prevent downhole contamination of hazardous compounds from shallow overburden material. This method is particularly applicable where contaminated strata overlie uncontaminated strata of lower permeability. The method can be used with hollow stem auger drilling or rotary wash drilling (where temporary casing is used). This guideline also presents a method for the evaluation of the integrity of the grout seal around an overburden casing, which has been positioned into a confining layer.

CASING INSTALLATION PROCEDURE

1. Advance boring by appropriate drilling methods, through the contaminated strata a short distance (1 to 2 feet) into an underlying lower permeable unit.
2. Calculate the volume of the borehole base on the bit/auger head or steel casing diameter plus 10% and determine the volume of grout to be emplaced. Generally, the total mixed volume is the borehole volume plus 20%.
3. Identify the equipment to be used for the preparation and mixing of the grout. Ensure the volume of the tanks to be used for mixing has been measured adequately. Document these volumes on the Field Borehole/Monitoring Well Installation Log (sample attached).
4. Identify the source of the water to be used for the grout and determine its suitability for use. In particular, water with high sulfate, or chloride levels or heated water should not be used. These types of waters can cause operational difficulties or modify the set-up for the grout.
5. Identify the equipment to be used for emplacing the grout. Ensure that the pump to be used has adequate pressure to enable complete return to surface.

OVERBURDEN CASING INSTALLATION PROCEDURES

6. Identify the volumes to be pumped at each stage or in total if only one stage is to be used.
7. Begin mixing the grout to be emplaced. Grout specifications generally have mixture ratios as follows:

Grout Slurry Composition (% Weight)

1.5 to 3.0%	-	Bentonite (Quick Gel)
40 to 60 %	-	Cement (Portland Type I)
40 to 60 %	-	Potable Water

8. Record the type and amount of materials used during the mixing operation. Ensure the ratios are within specifications tolerance.
9. Begin pumping the grout through the return line bypass system to confirm all pump and surface fittings are secure.
10. Remove drill rods and center plug (or clean out temporary casing) and insert a tremie pipe to the bottom of the boring. Pump the cement/bentonite grout slurry through the tremie pipe until grout return is observed at grade and no bridging of the slurry is evident. Slowly withdraw the augers (or casing) from the boring while maintaining the grout level at grade. Record the times and volumes emplaced on the Field Borehole/Monitoring Well Installation Log (sample attached).
11. Document the return circulation of grout. This may be facilitated by using a colored dye or other tagging method if a mudded borehole condition exists prior to grout injection.
12. Place a drillable plug (preferably untreated wood) at the downhole end of black steel or other appropriate casing, insert the casing through the slurry, and seat it into the underlying formation.
13. Allow grout to set for 24 to 48 hours.

OVERBURDEN CASING INSTALLATION PROCEDURES

HYDROSTATIC TESTING OF CASING PROCEDURE

1. Following adequate setting time for the grout, drill through the grout inside the casing until the top of the confining layer has been reached (refer to Field Borehole/Monitoring Well Installation Log during casing installation).
2. Fill the casing with potable water and measure the water level within the casing with a water level indicator to the nearest 0.01-foot and record the measurement on the Pipe Leakage Testing Log (sample attached).
3. Monitor the water level for 30 minutes and record the final water level within the casing with a water level indicator to the nearest 0.01-foot and record the measurement on the Pipe Leakage Testing Log (sample attached).
4. Should the water level drop more than the allowable volume calculated using the following equation, the seal shall be regouted at the Subcontractor's expense.

$$Q_{(\text{allowable})} = 2.75 DKH$$

Where:

$Q_{(\text{allowable})}$ = Flow rate during a 30 minute test

D = Inside diameter of overburden casing

K = Confining layer hydraulic conductivity (see Table 1)

H = Head of water applied

Note: Be sure to use consistent units of measure.

ATTACHMENTS

Field Borehole/Monitoring Well Installation Log (sample)

Pipe Leakage Testing Log (sample)

Table 1 – Range of Values of Hydraulic Conductivity and Permeability



FOP 041.0

OVERBURDEN CASING INSTALLATION PROCEDURES

REFERENCES

Freeze, R.A. and J.A. Cherry. 1979. *Groundwater*. Prentice-Hall, Inc., Englewood, New Jersey, 604 p.

Roux FOPs:

018 *Drilling and Excavation Equipment Decontamination Protocols*



FOP 041.0

OVERBURDEN CASING INSTALLATION PRCEДУRES

FIELD BOREHOLE/MONITORING WELL INSTALLATION LOG

PROJECT:										Log of Well No.:																
BORING LOCATION:										ELEVATION AND DATUM:																
DRILLING CONTRACTOR:										DATE STARTED:					DATE FINISHED:											
DRILLING METHOD:										TOTAL DEPTH:					SCREEN INTERVAL:											
DRILLING EQUIPMENT:										DEPTH TO WATER:		FIRST:		COMPL.:		CASING:										
SAMPLING METHOD:										LOGGED BY:																
HAMMER WEIGHT:					DROP:					RESPONSIBLE PROFESSIONAL:					REG. NO.											
Depth (fbs)	SAMPLES						SAMPLE DESCRIPTION										WELL CONSTRUCTION DETAILS AND/OR DRILLING REMARKS									
	Sample No.	Sample	Blows (per 6")	SPT N-Value	Recovery	PID Scan (ppm)	USCS Classification: Color, Moisture Condition, % of Soil Type, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181, 182, 183, 184, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195, 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996, 997, 998, 999, 1000																			
SURFACE ELEVATION (FMSL):																										
Project No:										Figure																



OVERBURDEN CASING INSTALLATION PRCEDEXURES

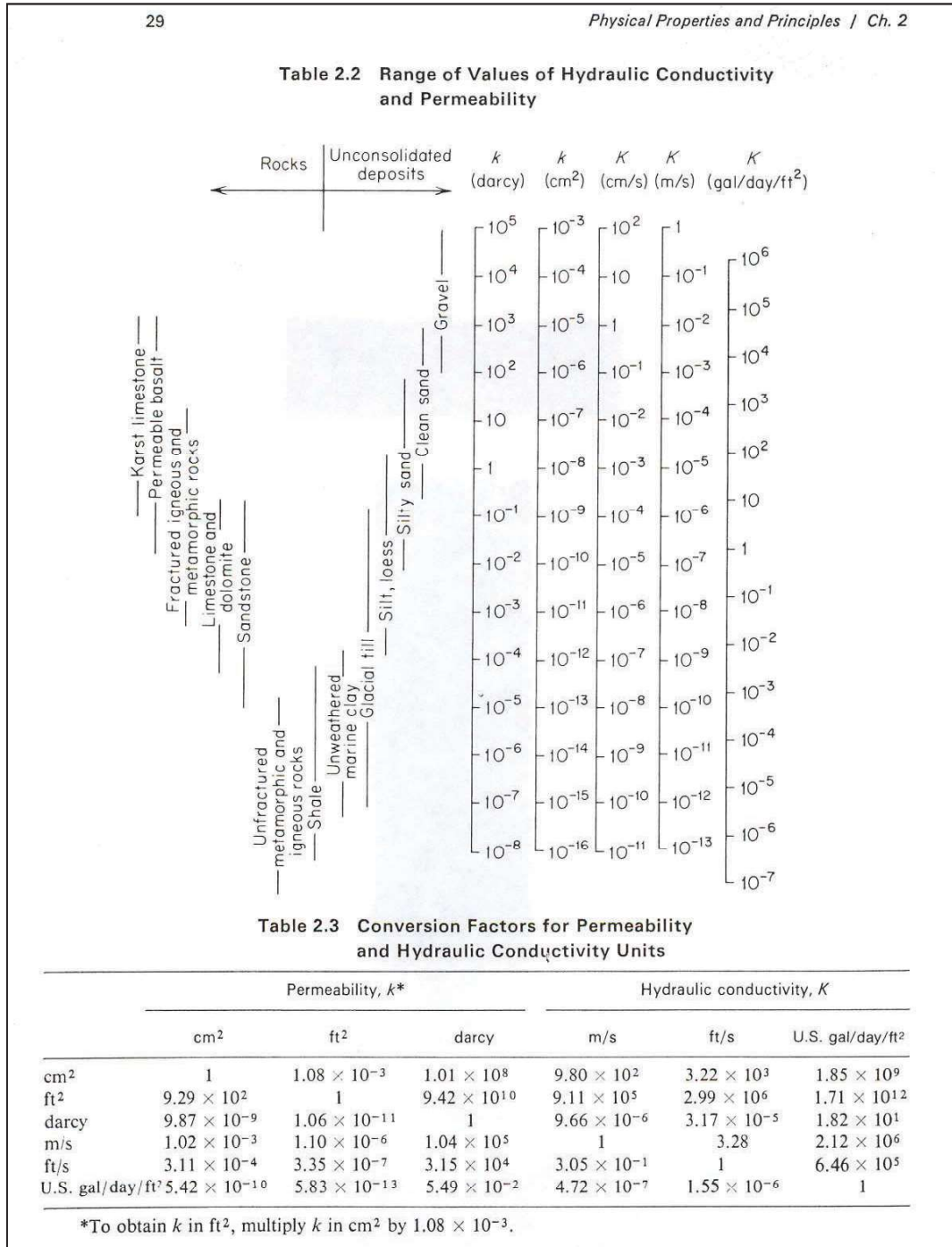
Project:	Location:
Client:	Date:
Job No:	BM Personnel:

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Date:

OVERBURDEN CASING INSTALLATION PROCEDURES

TABLE 1: (From Freeze and Cherry, page 29.)



A thick vertical bar on the left side of the page, colored dark blue at the top and bottom, and green in the middle.The word "ROUX" in white, bold, sans-serif capital letters, set against a blue rectangular background with a slight drop shadow.

ROUX

FIELD OPERATING PROCEDURES

Sample Labeling,
Storage, and Shipment
Procedures

SAMPLE LABELING, STORAGE & SHIPMENT PROCEDURES

PURPOSE

The collection and analysis of samples of environmental media, including soils, groundwater, surface water, and sediment, are the central activities of the field investigation. These samples must be properly labeled to preserve its identity, and properly stored and shipped in a manner that preserves its integrity and chain of custody. This procedure presents methods for these activities.

SAMPLE LABELING PROCEDURE

1. Assign each sample retained for analysis a unique 9-digit alphanumeric identification code or as indicated in the Project Work Plan. Typically, this code will be formatted as follows:

Sample I.D. Example: GW051402047	
GW	Sample matrix GW = groundwater; SW = surface water; SUB = subsurface soil; SS = surface soil; SED = sediment; L = leachate; A = air
05	Month of sample collection
14	Day of sample collection
02	Year of sample collection
047	Consecutive sample number

2. Consecutive sample numbers will indicate the individual sample's sequence in the total set of samples collected during the investigation/sampling event. The sample number above, for example, would indicate the 47th sample retained for analysis during the field investigation, collected on May 14, 2002.

SAMPLE LABELING, STORAGE & SHIPMENT PROCEDURES

3. Affix a non-removable (when wet) label to each sample container. The following information will be written on the label with black or blue ink that will not smudge when wet:
 - Project number
 - Sample ID (see Step 1 above)
 - Date of sample collection
 - Time of sample collection (military time only)
 - Specify “grab” or “composite” sample with an “X”
 - Sampler initials
 - Preservative(s) (if applicable)
 - Analytes for analysis (if practicable)
4. Record all sample label information in the Project Field Book and on a Sample Summary Collection Log (see attached samples), keyed to the sample identification number. In addition, add information regarding the matrix, sample location, depth, etc. to provide a complete description of the sample.

SAMPLE STORAGE PROCEDURE

1. Immediately after collection, placement in the proper container, and labeling, place samples to be retained for chemical analysis into resealable plastic bags.
2. Place bagged samples into an ice chest filled approximately half-full of double bagged ice. Blue ice is not an acceptable substitute for ice.
3. Maintain samples in an ice chest or in an alternative location (e.g. sample refrigerator) as approved by the **Roux** Field Team Leader until time of shipment. Periodically drain melt-water off coolers and replenish ice as necessary.



SAMPLE LABELING, STORAGE & SHIPMENT PROCEDURES

4. Ship samples on a daily basis, unless otherwise directed by the Field Team Leader. **Roux**
5. Maintain appropriate custody procedures on coolers and other sample storage containers at all times. These procedures are discussed in detail in the Project Quality Assurance Project Plan, Monitoring Plan or Work Plan.
6. Samples shall be kept in a secure location locked and controlled (i.e., locked building or fenced area) so that only the Project Field Team Leader has access to the location or under the constant visual surveillance of the same.

SAMPLE SHIPPING PROCEDURE

1. Fill out the chain-of-custody form completely (see attached sample) with all relevant information. The white original goes with the samples and should be placed in a resealable plastic bag and taped inside the sample cooler lid; the sampler should retain the copy.
2. Place a layer of inert cushioning material such as bubble pack in the bottom of cooler.
3. Place each bottle in a bubble wrap sleeve or other protective wrap. To the extent practicable, then place each bottle in a resealable plastic bag.
4. Open a garbage bag (or similar) into a cooler and place sample bottles into the garbage bag (or similar) with volatile organic analysis (VOA) vials near the center of the cooler.
5. Pack bottles with ice in plastic bags. At packing completion, cooler should be at least 50 percent ice, by volume. Coolers should be completely filled, so that samples do not move excessively during shipping.
6. Duct tape (or similar) cooler drain closed and wrap cooler completely in two or more locations to secure lid, specifically covering the hinges of the cooler.

FOP 046.0

SAMPLE LABELING, STORAGE & SHIPMENT PROCEDURES

7. Place laboratory label address identifying cooler number (i.e., 1 of 4, 2 of 4 etc.) and overnight delivery waybill sleeves on cooler lid or handle sleeve (Federal Express).
8. Sign the custody seal tape with an indelible soft-tip marker and place over the duct tape across the front and back seam between the lid and cooler body.
9. Cover the signed custody seal tape with an additional wrap of transparent strapping tape.
10. Place “Fragile” and “This Side Up” labels on all four sides of the cooler. “This Side Up” labels are yellow labels with a black arrow with the arrowhead pointing toward the cooler lid.
11. For coolers shipped by overnight delivery, retain a copy of the shipping waybill, and attach to the chain-of-custody documentation.

ATTACHMENTS

Soil/Sediment Sample Summary Collection Log (sample)
Groundwater/Surface Water Sample Summary Collection Log (sample)
Wipe Sample Summary Collection Log (sample)
Air Sample Summary Collection Log (sample)
Chain-Of-Custody Form (sample)

REFERENCES

None



SAMPLE LABELING, STORAGE & SHIPMENT PROCEDURES

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SAMPLE LABELING, STORAGE & SHIPMENT PROCEDURES

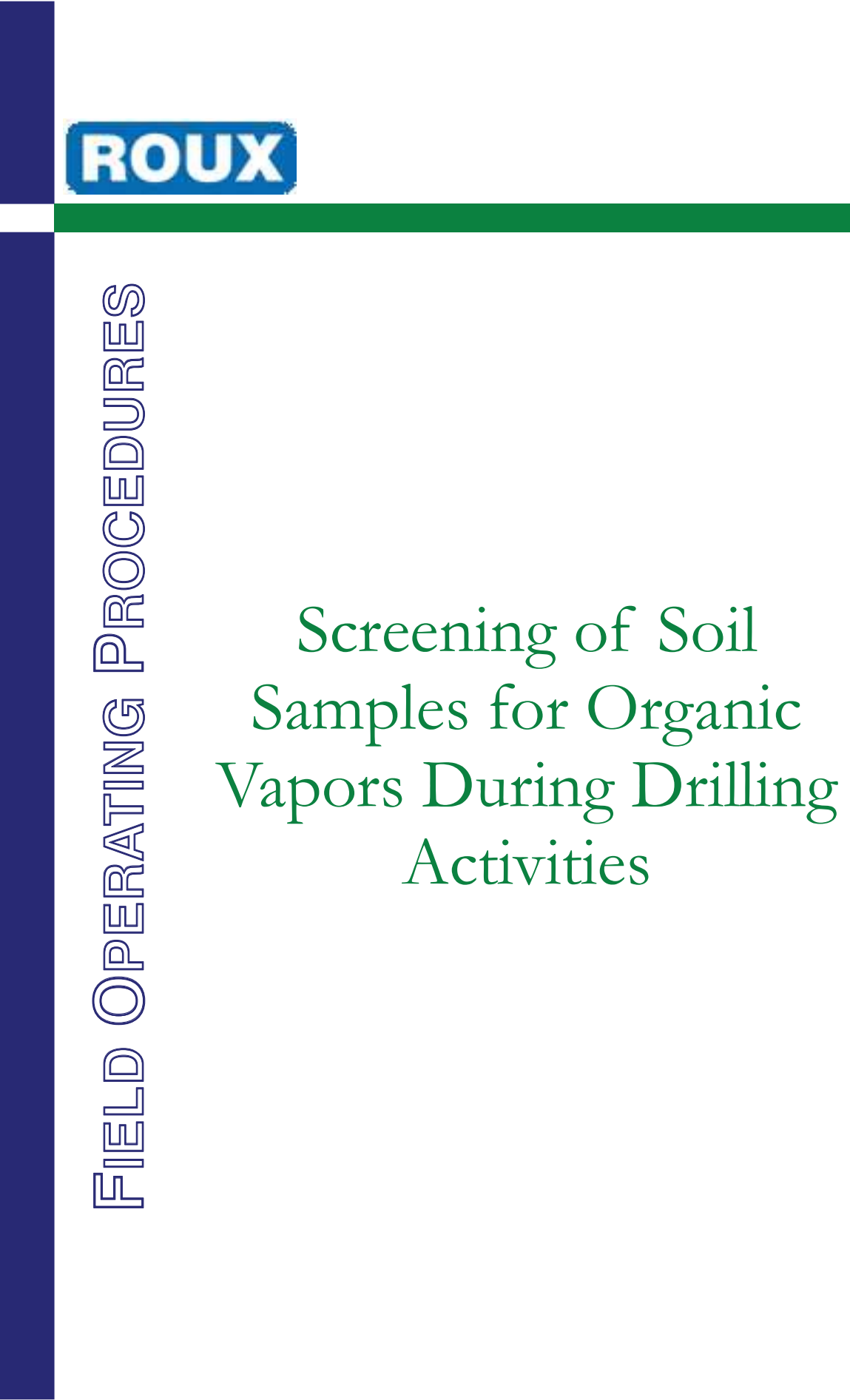
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SAMPLE LABELING, STORAGE & SHIPMENT PROCEDURES

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SAMPLE LABELING, STORAGE & SHIPMENT PROCEDURES

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ROUX

FIELD OPERATING PROCEDURES

Screening of Soil Samples for Organic Vapors During Drilling Activities

**SCREENING OF SOIL SAMPLES FOR ORGANIC
VAPORS DURING DRILLING ACTIVITIES**

PURPOSE

This procedure is used to screen soil samples for the presence of volatile organic constituents (VOCs) using a field organic vapor meter. These meters will be either photoionization detector (PID) or flame-ionization detector (FID) type. This screening is performed at the drilling and sampling location as a procedure for ensuring the health and safety of personnel at the site and to identify potentially contaminated soil samples for laboratory analysis. All soil samples will be field screened to provide a vertical profile of soil contamination by volatile organic substances.

PROCEDURE

1. Calibrate air-monitoring equipment in accordance with the appropriate **Roux's** Field Operating Procedures or manufacturers recommendations for calibration of field meters.
2. Collect split-spoon (or other sampler) samples in accordance with **Roux's** Split Spoon Sampling Procedure FOP.
3. When the split-spoon or other sampler is opened or accessed, shave a thin layer of material from the entire length of the core.
4. Scan the core visually and with the PID or FID noting stratification, visible staining, or other evidence of contamination.
5. Based on this initial scan of the sample, collect approximately 100 milliliters (ml) of soil using a decontaminated or dedicated stainless steel spatula, scoop, or equivalent. Place this soil into a labeled wide-mouth glass jar approximately $\frac{1}{2}$ to $\frac{3}{4}$ full and seal with aluminum foil and a screw top cap. Alternatively, the soil may be placed into a clean, re-sealable plastic bag and sealed. Be sure to leave some headspace above the soil sample within the sealed container.

FOP 047.0

SCREENING OF SOIL SAMPLES FOR ORGANIC VAPORS DURING DRILLING ACTIVITIES

6. Place field screening sample (i.e., jar or bag) in a location where the ambient temperature is at least 70° Fahrenheit.
7. Leave the field screening sample bag for at least 30 minutes, but no more than 60 minutes.
8. Carefully remove the screw top cap from the jar and slowly insert the tip of the organic vapor meter (PID or FID) through the aluminum foil seal making the smallest hole possible. Alternatively, unseal a portion of the plastic bag just big enough to insert the probe of a calibrated PID.
9. Record the maximum reading in parts per million by volume (ppmv) on the Field Borehole Log or Field Borehole/Monitoring Well Installation Log form (see attached samples) (see Documentation Requirements for Drilling and Well Installation FOP), at the depth interval corresponding to the depth of sample collection.

ATTACHMENTS

Field Borehole Log (sample)

Field Borehole/Monitoring Well Installation Log (sample)

REFERENCES

Roux FOPs:

- 010 *Calibration and Maintenance of Portable Flame Ionization Detector*
- 011 *Calibration and Maintenance of Portable Photoionization Detector*
- 015 *Documentation Requirements for Drilling and Well Installation*
- 058 *Split Spoon Sampling Procedures*

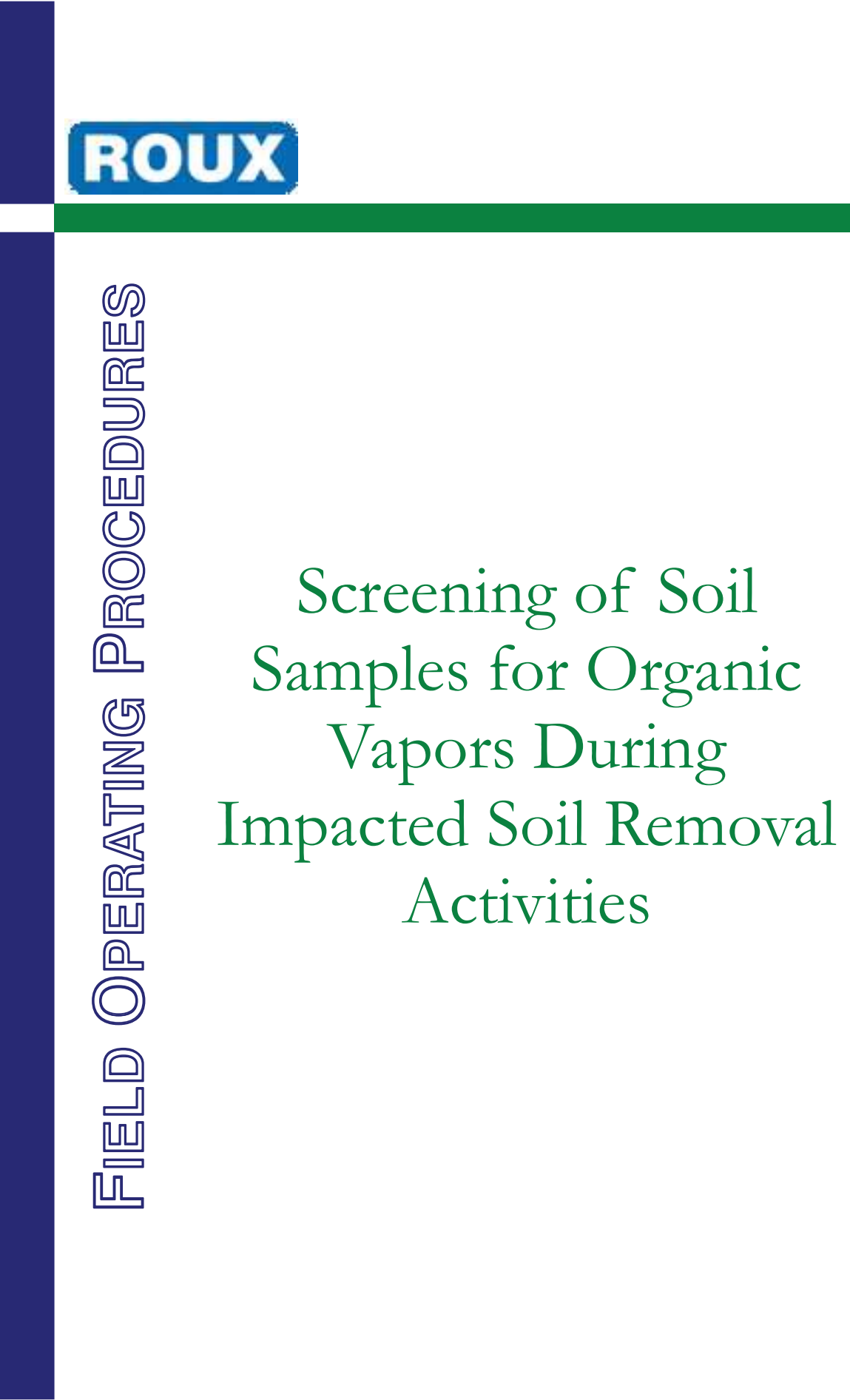


SCREENING OF SOIL SAMPLES FOR ORGANIC VAPORS DURING DRILLING ACTIVITIES

[illegible]

SCREENING OF SOIL SAMPLES FOR ORGANIC VAPORS DURING DRILLING ACTIVITIES

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ROUX

FIELD OPERATING PROCEDURES

Screening of Soil
Samples for Organic
Vapors During
Impacted Soil Removal
Activities

**SCREENING OF SOIL SAMPLES FOR ORGANIC
VAPORS DURING IMPACTED SOIL REMOVAL ACTIVITIES**

PURPOSE

This procedure is used to screen soil samples for the presence of volatile organic constituents (VOCs) using a field organic vapor meter. The field meter should either be a photoionization detector (PID) or flame-ionization detector (FID) type. This type of screening is generally performed during underground storage tank (UST) and/or impacted soil removal activities as a procedure for ensuring the health and safety of the community and personnel at the site as well as to identify potential VOC-impacted soil samples for laboratory analysis (i.e., confirmatory or verification samples). Soil samples are also screened in the field to provide assessment criteria to determine horizontal and vertical extents of VOC-impacts in order to ensure soils that may have been impacted by volatile organic substances are removed.

PROCEDURE

1. Calibrate air-monitoring equipment in accordance with the appropriate **Roux's** Field Operating Procedures or manufacturers recommendations for calibration of field meters.
2. Perform community air monitoring in accordance with the Project Work Plan and/or **Roux's** FOP: Real-Time Air Monitoring During Intrusive Activities.
3. Upon proper removal of any identified UST in accordance with NYSDEC Division of Environmental Remediation, Spill Response Unit or Bulk Storage Unit guidelines and/or **Roux's** FOP: Underground Storage Tank Removal Procedures; examine the four sidewalls and bottom of the excavation for visually impacted (i.e., stained) soils.

**SCREENING OF SOIL SAMPLES FOR ORGANIC
VAPORS DURING IMPACTED SOIL REMOVAL ACTIVITIES**

4. If visually impacted soils are identified, direct the excavating equipment operator to scrape the impacted area (i.e., sidewall or bottom of the excavation) and present the scraped soil for evaluation. NOTE: Under no circumstances should anyone enter an excavation greater than 4 feet in depth, unless absolutely necessary. Excavation entry may only occur under strict confined space entry procedures following implementation of specific engineering controls (i.e., continuous air monitoring, excavation shoring, trench box installation, benching).
5. Visually inspect and perform an open air PID/FID scan of the scraped soil sample noting stratification, visible staining, or other evidence of impact (i.e., presence of non-aqueous phase liquid, NAPL).
6. Collect a representative sample (approximately 100 milligrams (mg)) of soil using a decontaminated or dedicated stainless steel sampling tool (i.e., spoon, spatula, scoop, or approved equivalent), for field headspace determination of VOC-impact. Place the representative soil sample into a labeled wide-mouth glass jar approximately $\frac{1}{2}$ to $\frac{3}{4}$ full and seal with aluminum foil and a screw top cap. Alternatively, the soil sample may be placed into a clean, re-sealable plastic bag and sealed. Be sure to leave adequate headspace above the soil sample within either sealed container.
7. Place the field screening sample (i.e., jar or bag) in a location where the ambient temperature is at least 70° Fahrenheit for at least 15 minutes, but no more than 60 minutes.
8. Carefully remove the screw top cap from the jar and slowly insert the tip of the organic vapor meter (PID or FID) through the aluminum foil seal making the smallest hole possible. Alternatively, unseal a portion of the plastic bag just big enough to insert the probe of a calibrated PID.
9. Record the depth, sample location (i.e., sidewall, bottom) and maximum reading in parts per million by volume (ppmv) in the Project Field Book and Impacted Soil Excavation Log (sample attached), at the depth interval corresponding to the depth of sample collection.

**SCREENING OF SOIL SAMPLES FOR ORGANIC
VAPORS DURING IMPACTED SOIL REMOVAL ACTIVITIES**

10. The representative soil samples collected from the excavation will be used to assess the vertical and horizontal limits of VOC-impact and guide the impacted soil removal activities in accordance with project requirements (i.e., PID scans less than 20 ppm will not require removal unless laboratory analytical results exceed regulatory limits).
11. Collect verification/confirmation samples in accordance with NYSDEC Division of Environmental Remediation, Spill Response Unit or Bulk Storage Unit guidelines and/or **Roux's** FOP: Surface and Subsurface Soil Sampling Procedures.

ATTACHMENTS

Impacted Soil Excavation Log (sample)

REFERENCES

Roux FOPs:

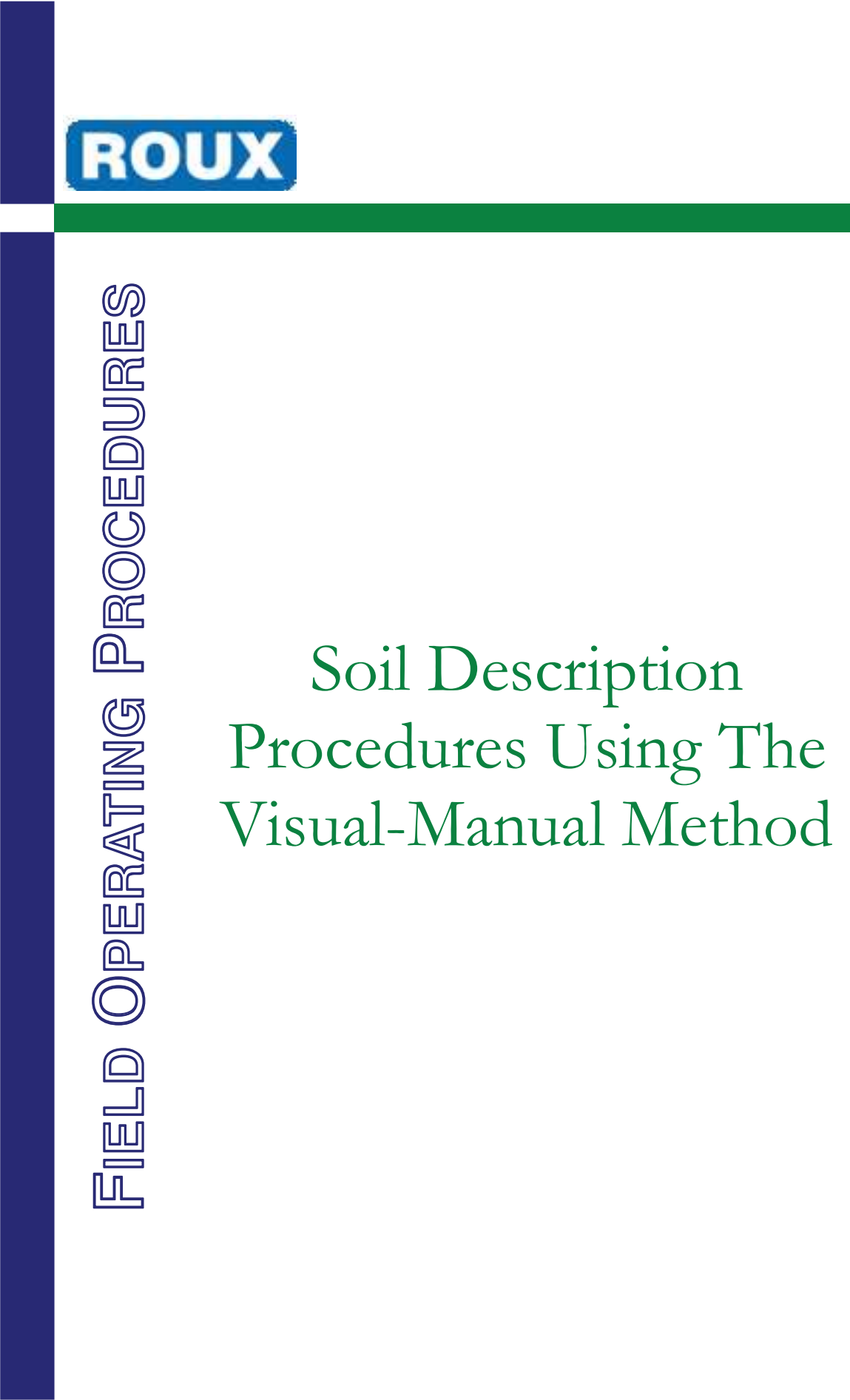
- 010 *Calibration and Maintenance of Portable Flame Ionization Detector*
- 011 *Calibration and Maintenance of Portable Photoionization Detector*
- 063 *Surface and Subsurface Soil Sampling Procedures*
- 073 *Real-Time Air Monitoring During Intrusive Activities*
- 074 *Underground Storage Tank Removal Procedures*



SCREENING OF SOIL SAMPLES FOR ORGANIC VAPORS DURING IMPACTED SOIL REMOVAL ACTIVITIES

Project:	EXCAVATION I.D.:
Project No.:	Excavation Date:
Client:	Excavation Method:
Location:	CQA Observer:

[illegible]



ROUX

FIELD OPERATING PROCEDURES

Soil Description Procedures Using The Visual-Manual Method

**SOIL DESCRIPTION PROCEDURES
USING THE VISUAL-MANUAL METHOD**

PURPOSE

This guideline presents a means for insuring consistent and proper field identification and description of collected soils during a project (via, split-spoon (barrel) sampler, hand auger, test pit etc.). The lithology and moisture content of each soil sample will be physically characterized by visual-manual observation in accordance with ASTM Method D2488, Standard Practice for Description and Identification of Soils (Visual-Manual Procedure). When precise classification of soils for engineering purposes is required, the procedures prescribed in ASTM Method D2487 (Standard Practice for Classification of Soils for Engineering Purposes [Unified Soil Classification System, USCS]) will be used. The method of soil characterization presented herein describes soil types based on grain size, liquid and plastic limits, and moisture content based on visual examination and manual tests. When using this FOP to classify soil, the detail of description provided for a particular material should be dictated by the complexity and objectives of the project. However, more often than not, “after the fact” field information is required later in the project, therefore, every attempt to describe the soil as completely as possibly should be made.

Intensely weathered or decomposed rock that is friable and can be reduced to gravel size or smaller by normal hand pressure should be classified as a soil. The soil classification would be followed by the parent rock name in parenthesis. Projects requiring depth to bedrock determinations should always classify weathered or decomposed bedrock as bedrock (i.e., landfill siting). The project manager should always be consulted prior to making this determination.

FOP 054.2

SOIL DESCRIPTION PROCEDURES USING THE VISUAL-MANUAL METHOD

PROCEDURE

Assemble necessary equipment and discuss program requirements with drilling contractor.

1. Calibrate air-monitoring equipment in accordance with the appropriate **Roux's** Field Operating Procedures or manufacturers recommendations for calibration of field meters.
2. Collect desired soil sample in accordance with appropriate **Roux** FOP (i.e., split-spoon sampling, hand augering, test pitting etc.).
3. Shave a thin layer off the entire length of the sample to expose fresh sample.
4. Photograph and scan the sample with a photoionization detector (PID) at this time, if applicable, in accordance with **Roux's** Screening of Soil Samples for Organic Vapors During Drilling Activities FOP.
5. Describe the sample using terminology presented in the Descriptive Terms section below.
6. Record all pertinent information in the Project Field Book and Field Borehole Log (sample attached) or Field Borehole/Monitoring Well Installation Log (sample attached).
7. After the sample has been described, place a representative portion of the sample in new, precleaned jars or self-sealing plastic bags for archival purposes (if required). Label the jar or bag with the sample identification number, sample interval, date, project number and store in a secure location.
8. If the soil is to be submitted to a laboratory for analysis, collect the soil sample with a dedicated stainless steel sampling tool, place the sample into the appropriate laboratory-supplied containers, and store in an ice-chilled cooler staged in a secure location in accordance with **Roux's** Sample Labeling, Storage and Shipment Procedures FOP.



**SOIL DESCRIPTION PROCEDURES
USING THE VISUAL-MANUAL METHOD**

9. All remaining soil from soil sample collection activities shall be containerized in accordance with **Roux's** Management of Investigative-Derived Waste (IDW) FOP and/or the Project Work Plan.

DESCRIPTIVE TERMS

All field soil samples will be described using the Unified Soil Classification System (USCS) presented in Figures 1 and 2 (attached). In addition to ASTM Method D2488, Method D1586, Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils (a.k.a., Standard Penetration Test, STP), when implemented, can also be used to classify the resistance of soils. In certain instances, it is desirable to supplement the USCS classification with a geologic interpretation of the soil sample that is supported by the soil descriptive terms presented in this section. The project manager should be consulted when making any geologic interpretation. Field test methods are provided to assist field personnel in classifying soil and are identified by a bold blue **FTM** and shaded. Classification of sampled soils will use the following ASTM descriptive terms and criteria:

- **Group Name** (USCS, see Figure 2)
- **Group Symbol** (USCS, see Figure 2) – only use if physical laboratory testing has been performed to substantiate. The USCS can be applied to most unconsolidated materials, and is represented by a two-letter symbol, except Peat (Pt).
 - The first letter includes: G (gravel), S (sand), M (silt), C (clay), and O (organic).
 - The second letter includes: P (poorly graded or uniform particle sizes), W (well graded or diversified particle sizes), H (high plasticity), and L (low plasticity).
 - Examples:
 - GW = well graded gravels and gravel-sand mixtures, little or no fines
 - GP = poorly graded gravels and gravel-sand mixtures, little or no fines
 - GM = silty gravels, gravel-sand-silt mixtures

**SOIL DESCRIPTION PROCEDURES
USING THE VISUAL-MANUAL METHOD**

- GC = clayey gravels, gravel-sand-clay mixtures
 - SW = well graded sands and gravelly sands, little or no fines
 - SP = poorly graded sands and gravelly sands, little or no fines
 - SM = silty sand, sand-silt mixtures
 - SC = clayey sand sand-clay mixtures
 - ML = inorganic silts, very fine sands, rock flour, silty or clayey fine sands
 - CL = inorganic clays of low to medium plasticity, gravelly/sandy/silty/lean clays
 - OL = organic silts and organic silty clays of low plasticity
 - MH = inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts (very rare)
 - CH = inorganic clays of high plasticity, fat clays
 - OH = organic clays of medium to high plasticity
 - Pt = peat, muck, and other highly organic soils
- **Angularity** (ASTM D2488; Table 1)
 - Angular – particles have sharp edges and relatively planar sides with unpolished surfaces
 - Subangular – particles are similar to angular description but have rounded edges
 - Subrounded – particles have nearly planar sides but have well-rounded corners and edges
 - Rounded – particles have smoothly curved sides and no edges
 - **Particle Shape** (ASTM D2488; Table 2)
 - Flat – particles with width/thickness > 3
 - Elongated – particles with length/width > 3
 - Flat and Elongated – particles meet criteria for both flat and elongated
 - **Moisture Condition** (ASTM D2488; Table 3)
 - 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
 - **Reaction with Hydrochloric Acid (HCL)** (ASTM D2488; Table 4)
 - None – no visible reaction

**SOIL DESCRIPTION PROCEDURES
USING THE VISUAL-MANUAL METHOD**

- Weak – some reaction, with bubbles forming slowly
- Strong – violent reaction, with bubbles forming immediately
- **Consistency of Cohesive Soils** (ASTM D2488; Table 5)
 - Very soft – squeezes between fingers when fist is closed; easily penetrated several inches by fist (SPT = 2 or less)
 - Soft – easily molded by fingers; easily penetrated several inches by thumb (SPT = 2 to 4)
 - Firm – molded by strong pressure of fingers; can be penetrated several inches by thumb with moderate effort (SPT = 4 to 8)
 - Stiff – dented by strong pressure of fingers; readily indented by thumb but can be penetrated only with great effort (SPT = 8 to 15)
 - Very stiff – readily indented by thumbnail (SPT = 15 to 30)
 - Hard – indented with difficulty by thumbnail (SPT >30)
- **Cementation** (ASTM D2488; Table 6)
 - Weak – crumbles or breaks with handling or slight finger pressure
 - Moderate – crumbles or breaks with considerable finger pressure
 - Strong – will not crumble or break with finger pressure
- **Structure (Fabric)** (ASTM D2488; Table 7)
 - Varved – alternating 1 mm to 12 mm (0.04 – 0.5 inch) layers of sand, silt and clay
 - Stratified – alternating layers of varying material or color with the layers less than 6 mm (0.23 inches) thick; note thickness
 - Laminated – alternating layers of varying material or color with the layers less than 6 mm (0.23 inches) thick; note thickness
 - Fissured – contains shears or separations along planes of weakness
 - Slickensided – shear planes appear polished or glossy, sometimes striated

**SOIL DESCRIPTION PROCEDURES
USING THE VISUAL-MANUAL METHOD**

- 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 or Massive – same color and appearance throughout
- **Inorganic Fine-Grained Soil Characteristics** (ASTM D2488; Table 12)

Several field tests can be performed to determine the characteristics of fine-grained soils (material passing the No. 40 sieve), such as dry strength, dilatency, and toughness. These field testing methods are described below.

- **Dry Strength** (ASTM D2488; Table 8)

FTM (Dry Strength): Select enough material and moisten with water until it can be molded or shaped without sticking to your fingers (slightly below the sticky limit) into a ball about 1 inch in diameter. From this ball, form three balls about ½ inch in diameter and allow to dry in air, or sun, or by artificial means (temperature not to exceed 60° C (140° F)). Soil containing natural dry lumps about ½ inch in diameter may be used in place of molded balls, however the dry strengths are usually lower. Test the strength by crushing the dry balls or lumps between your fingers using the descriptions below.

- None – the dry specimen crumbles with the slightest pressure of handling
 - Low – the dry specimen crumbles 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. The specimen will break into pieces between the thumb and a hard surface.
 - Very High – the dry specimen cannot be broken between the thumb and a hard surface
- **Dilatency** (ASTM D2488; Table 9)

FTM (Dilatency): Place enough material in your hand to form a ball approximately ½ inch in diameter and moisten with water until it can be

**SOIL DESCRIPTION PROCEDURES
USING THE VISUAL-MANUAL METHOD**

molded or shaped without sticking to your fingers (slightly below the sticky limit). Smooth the ball in the palm of one hand with the blade of a knife or small spatula. Shake horizontally, striking the side of the hand vigorously against the other several times. Note the reaction of water appearing on the surface of the soil. The soil is said to have given a reaction to this test if, when it is shaken, water comes to the surface of the sample producing a smooth, shiny appearance. Squeeze the sample between the thumb and forefinger and note the reaction as follows:

- None – no visible change in the specimen
 - Slow – water slowly appears on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing
 - Rapid – water quickly appears on the surface of the specimen during shaking and disappears upon squeezing
- **Toughness** (ASTM D2488; Table 10)

FTM (Toughness): Following the dilatency test above, shape the test specimen into an elongated pat and roll by hand on a smooth surface or between palms into a thread about 1/8 inch in diameter. Fold the sample threads and re-roll repeatedly until the thread crumbles at a diameter of about 1/8 inch (e.g., near the plastic limit). Note the pressure required to roll the thread near the plastic limit as well as the strength of the thread. After the thread crumbles, lump the pieces together and knead the lump until it crumbles. Describe the toughness as follows:

- Low – only slight pressure is required to roll the thread near the plastic limit. The thread and the lump are weak and very soft.
- Medium – medium pressure is required to roll the thread to near the plastic limit. The thread and the lump are soft.
- High – considerable pressure is required to roll the thread to near the plastic limit. The thread and the lump are firm.

Using the results of the dry strength, dilatency, and toughness test described above, classify the soil according to the following:

**SOIL DESCRIPTION PROCEDURES
USING THE VISUAL-MANUAL METHOD**

Soil Symbol	Dry Strength	Dilatency	Toughness
Silt (ML)	None to low	Slow to rapid	Low or thread cannot be formed
Lean clay (CL)	Medium to high	None to slow	Medium
Elastic Silt (MH)	Low to medium	None to slow	Low to medium
Fat Clay (CH)	High to very high	None	Low to medium high

- **Plasticity** (ASTM D2488; Table 11)

Two field test methods can be used to determine plasticity of fine-grained soils (material passing the No. 40 sieve): the roll or thread test and the ribbon test. Each test is described below.

FTM (Roll or Thread Test): As with the toughness test above, mix a representative portion of the soil sample with water until it can be molded or shaped without sticking to your fingers (slightly below the sticky limit). Place an elongated cylindrical sample on a nonabsorbent rolling surface (e.g., glass or wax paper on a flat surface) and attempt to roll it into a thread approximately 1/8 inch in diameter. The results of this test are defined below (non-plastic to high plasticity).

FTM (Ribbon Test): Form a roll from a handful of moist soil (slightly below the sticky limit) about 1/2 to 3/4 inches in diameter and about 3 to 5 inches long. Place the material in the palm of your hand and, starting at one end, flatten the roll between your thumb and forefinger to form the longest and thinnest ribbon possible that can be supported by the cohesive properties of the material before breaking. If the soil sample holds together for a length of 6 to 10 inches without breaking, the material is considered to be both highly plastic and highly compressive (Fat Clay, CH). If the soil cannot be ribboned, it is non-plastic (Silt, ML or MH). If it can be ribboned only with difficulty into short lengths, it has low plasticity (Lean Clay, CL). Use the following terms to describe the plasticity of soil:

**SOIL DESCRIPTION PROCEDURES
USING THE VISUAL-MANUAL METHOD**

- Nonplastic (ML or MH) – a 3 mm (0.12 inches) thread cannot be rolled at any water content
- Low Plasticity (CL, ML, or MH) – the thread can barely be rolled, and crumbles easily
- Medium Plasticity (CL) – the thread is easy to roll and not much time is required to reach the plastic limit before crumbling
- High Plasticity (CH) – it takes considerable time rolling and kneading to reach the plastic limit; the thread can be rolled several times before crumbling

Note: A soil with as little as 20% clay will behave as a clayey soil. A soil needs 45% to over 60% medium to coarse sand to behave as a sandy soil. In a soil with 20% clay and 80% sand, the soil will behave as a clayey soil.

- **Relative Density of Cohesionless (Granular) Soils**

- Very loose – easily penetrated 30 cm (1.2 inches) with 13 mm (0.5 inch) rebar pushed by hand (SPT = 0 to 4)
- Loose – easily penetrated several cm with 13 mm (0.5 inch) rebar pushed by hand (SPT = 4 to 10)
- Medium dense – easily to moderately penetrated with 13 mm (0.5 inch) rebar driven by 2.3 kg (6 pound) hammer (SPT = 10 to 30)
- Dense – penetrated 0.3 m (1 foot) with difficulty using 13 mm (0.5 inch) rebar driven by 2.3 kg (6 pound) hammer (SPT = 30 to 50)
- Very dense – penetrated only a few cm with 13 mm (0.5 inch) rebar driven by 2.3 kg (6 pound) hammer (SPT = >50)

- **Color** (use Munsel® Color System, as necessary)

- **Particle Size** (see Figure 3)

- Boulder – larger than a basketball
- Cobble – grapefruit, orange, volleyball
- Coarse Gravel – tennis ball, grape

**SOIL DESCRIPTION PROCEDURES
USING THE VISUAL-MANUAL METHOD**

- Fine Gravel – pea
- Coarse Sand – rock salt
- Medium Sand – opening in window screen
- Fine Sand – sugar, table salt
- Fines (silt and clay) – cannot visually determine size (unaided)
- **Gradation**
 - Well Graded (GW, SW) – full range and even distribution of grain sizes present
 - Poorly-graded (GP, SP) – narrow range of grain sizes present
 - Uniformly-graded (GP, SP) – consists predominantly of one grain size
 - Gap-graded (GP-SP) – within the range of grain sizes present, one or more sizes are missing
- **Organic Material** – Organic soils usually have a dark brown to black color and may have an organic odor. Often, organic soils will change color, for example, black to brown, when exposed to the air. Some organic soils will lighten in color significantly when air-dried. Organic soils normally will not have a high toughness or plasticity. The thread of the toughness test will be spongy.
 - PEAT – 50 to 100 percent organics by volume, primary constituent
 - Organic (soil name) – 15 to 50 percent organics by volume, secondary organic constituent
 - (Soil name) with some organics – 5 to 15 percent organics by volume, additional organic constituents
- **Fill Materials** – All soils should be examined to see if they contain materials indicative of man-made fills. Man-made fill items should be listed in each of the soil descriptions. Common fill indicators include glass, brick, dimensioned lumber, concrete, pavement sections, asphalt, metal, plastics, plaster etc. Other items that could suggest fill include buried vegetation mats, tree limbs, stumps etc. The soil description for a fill material should be followed by the term “FILL”, i.e., for a sandy silt with some brick fragments the description would be “SANDY

**SOIL DESCRIPTION PROCEDURES
USING THE VISUAL-MANUAL METHOD**

SILT (ML), with brick fragments (Fill)”. The size and distribution of fill indicators should be noted. The limits (depth range) of fill material should be determined and identified at each exploration location.

- **Other Constituents/Characteristics**
 - Additional constituents and/or pertinent soil characteristics not included in the previous categories should be described depending on the scope and objectives of the project. Observations that may be discussed include:
 - Oxide staining
 - Odor
 - Origin
 - Presence of root cast
 - Presence of mica
 - Presence of gypsum
 - Presence of calcium carbonate
 - Percent by volume of cobbles & boulders with size description and appropriate rock classification
 - Other pertinent information from the exploratory program should be recorded, if it would be useful from a biddability/constructability perspective. The conditions that should be listed include caving or sloughing, difficulty in drilling and groundwater infiltration.

SOIL DESCRIPTIONS

Generally, soil descriptions collected during most investigations are not intended for civil engineering (construction) purposes, but rather for hydrogeologic and contaminant transport purposes. As such, the ASTM visual-manual assessments are somewhat limited in that they are only performed in order to indicate important information about potential hydraulic properties of a soil. Soil descriptions should be concise, stressing major constituents and

**SOIL DESCRIPTION PROCEDURES
USING THE VISUAL-MANUAL METHOD**

characteristics, and should be given in a consistent order and format. The following order is recommended:

- Soil name. The basic name of the predominant grain size and a single-word modifier indicating the major subordinate grain size (i.e., mostly clay with some silt). The feel test can be used to determine the texture of the soil by rubbing some moist soil between your fingers; sand feels gritty, silt feels smooth, and clays feel sticky. The terms representing percentages of grain size to be used include:
 - 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%
- Color (using Munsell® charts, as necessary). Color is an important property in identifying organic soils, and within a given locality it may also be useful in identifying materials of similar geologic origin. If the sample contains layers or patches of varying colors (e.g., mottled), this shall be noted and all representative colors shall be described. The color shall be described for moist samples, however if the color represents a dry condition, it must be stated as such in the log. Generally, colors become darker as the moisture content increases and lighter as the soil dries. Examples include:
 - Some fine-grained soils (OL, OH) with dark drab shades of brown or gray, including almost black, contain organic colloidal matter.
 - In contrast, clean, bright looking shades of gray, olive green, brown, red, yellow, and white are associated with inorganic soils.
 - Gray-blue or gray- and yellow-mottled colors frequently result from poor drainage.
 - Red, yellow, and yellowish brown result from the presence of iron oxides.

**SOIL DESCRIPTION PROCEDURES
USING THE VISUAL-MANUAL METHOD**

- White to pink may indicate considerable silica, calcium carbonate, or aluminum compounds.
- Field moisture condition as dry, moist, or wet;
- Gradation or Plasticity. Granular soils (i.e., sands or gravels) should be described as well-graded, poorly graded, uniform, or gap-graded, depending on the gradation of the minus 3-inch fraction. Cohesive soils (i.e., silts and clays) should be described as non-plastic, low, medium, or high, depending on the results of the manual evaluation for dry strength, dilatency, toughness, and plasticity discussed previously.
- Consistency/Density. An estimate of consistency of a cohesive soil or density of a granular soil, usually based on the SPT results (see Descriptive Terms section of this FOP);
- Soil Structure or Mineralogy. Description of discontinuities, inclusions, and structures, including joints, fissures, and slickensides.
- Odor. Describe the odor if organic or unusual. Soils containing a significant amount of organic material usually have a distinctive odor of decaying vegetation. This is especially apparent in fresh samples, but if the samples are dried, the odor may often be revived by heating a moistened sample. If the odor is unusual (petroleum, chemical, etc.), it should be noted in the log.
- Other important geologic information such as consolidation, gravel size and shape, visible internal structure, root holes, mica, odors, etc.

The first step when describing soil is to determine if the sample is predominantly fine-grained or coarse-grained (see Figures 3 and 4). Coarse-grained soils are relatively easy to identify, however descriptions of fine-grained soils can be more difficult, requiring additional field tests to assist the field geologist arrive at the proper soils classification (see **FTMs** under Descriptive Terms above). These tests are explained in detail in the ASTM Standard D2488 and briefly herein. Generally, the differentiation between silt and clay is based on plasticity and “texture”. However, tests for dry strength and dilatency, along with plasticity,

**SOIL DESCRIPTION PROCEDURES
USING THE VISUAL-MANUAL METHOD**

can be very helpful and are recommended in the ASTM Standard. If additional tests are performed, in addition to plasticity, to classify the fines, record them with the soil description on the logs. Doing this will assist the reader (i.e., Project Manager) to follow the logic used to describe a soil (e.g., medium plasticity, low dry strength = elastic silt [MH]; not a lean clay [CL]).

Fines described in the classification should be modified by their plasticity (e.g., non-plastic fines, low plasticity fines, etc.) reserving the words “silt” and “clay” for the soil name.

In summary, adhering to the ASTM Standard and the guidelines outlined in this FOP will provide uniformity in soil descriptions provided by all field personnel. Prior to mobilization to the field, field staff should make sure to have laminated copies of the ASTM Standard flow charts and tables as well as this FOP (as necessary). Some examples of complete soil descriptions are as follows:

Coarse-grained Soil

POORLY GRADED FINE SAND w/ SILT: Dark grey, wet, mostly fine sand with some non-plastic fines, some iron-stained mottling, laminated, medium dense

Fine-grained Soil

LEAN CLAY: Dark reddish/brown, moist, mostly fines, medium plasticity, firm, no dilatency, medium dry strength, root holes.

Soil/Fill (option 1) – visual evidence of fill

FILL: Black, moist, mostly fines with some fine sand, slag, cinders, metal, brick, non-plastic, loose when disturbed, strong odor

**SOIL DESCRIPTION PROCEDURES
USING THE VISUAL-MANUAL METHOD**

Soil/Fill (option 2) – no visual evidence of fill, suspected reworked material

FILL (reworked): Black, moist, mostly fines with some fine sand and few coarse angular gravel, non-plastic, hard, loose when disturbed, mild odor

BORING AND MONITORING WELL INSTALLATION LOGS

Currently, **Roux** utilizes WinLoG software to construct subsurface logs and a template of the log is included in this FOP as an example. One of the most important functions of a boring/monitoring well installation log, besides transmitting the soil description, is to indicate where the “data” (soil samples) were collected, giving the reader an idea of how reliable or representative the description is. On each sample log, depths of attempted and recovered or non-recovered interval are shown. Odor, if noted, should be considered subjective and not necessarily indicative of specific compounds or concentrations.

Remember: all field logs should be NEAT, ACCURATE, and LEGIBLE. Don’t forget that the well completion diagram completed for each well requires details of the surface completion (i.e., flush-mount, stick-up etc.). It is the responsibility of the field staff to double-check each log (i.e., soil names, classifications, well construction details etc.) prior to implementing into a final report. A registered professional (i.e., professional engineer, PE or professional geologist, PG) must review each log and will be ultimately responsible for its content and accuracy.

REQUIRED EQUIPMENT

- Knife
- Engineer’s rule/measuring tape



**SOIL DESCRIPTION PROCEDURES
USING THE VISUAL-MANUAL METHOD**

- Permanent marker
- Pre-cleaned wide-mouth sample jars (typically provided by the driller)
- Pre-cleaned wide-mouth laboratory sample jars (provided by the laboratory)
- Stainless steel sampling equipment (i.e., spoons, spatulas, bowls etc.)
- 10x hand lens
- Hydrochloric acid
- ASTM D2488 flow charts (preferably laminated)
- ASTM D2488 test procedures (Tables 1 through 12) (preferably laminated)
- Camera (disposable, 35 mm or digital)
- Munsell soil color chart (as necessary)
- Project Field Book/field forms

ATTACHMENTS

Figure 1; Field Guide for Soil and Stratigraphic Analysis

Figure 2; USCS Soil Classification Flow Chart (modified from ASTM D2488)

Figure 3; Illustration of Particle Sizes

Figure 4; Grain-Size Scale (Modified Wentworth Scale)

Field Borehole Log (sample)

REFERENCES

American Society for Testing and Materials, 2008a. *ASTM D1586: Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils.*

American Society for Testing and Materials, 2010. *ASTM D2487: Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System).*

American Society for Testing and Materials, 2009a. *ASTM D2488: Standard Practice for Description and Identification of Soils (Visual-Manual Procedure).*

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SOIL DESCRIPTION PROCEDURES USING THE VISUAL-MANUAL METHOD

State of California, Department of Transportation, Engineering Service Center,
Office of Structural Foundations, August 1996. *Soil & Rock Logging Classification Manual
(Field Guide)*, by Joseph C. de Larios.

Roux FOPs:

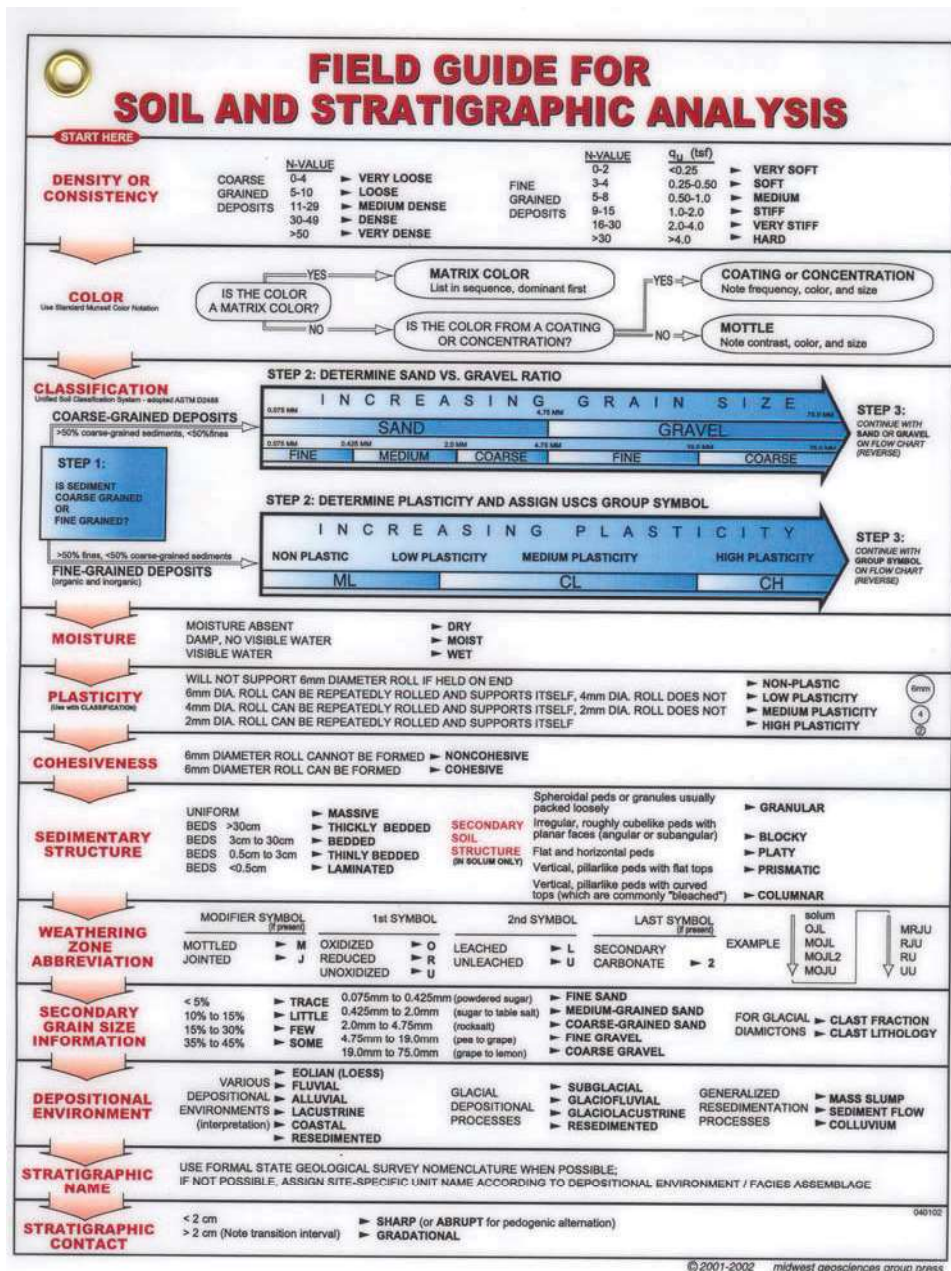
- 010 *Calibration and Maintenance of Portable Flame Ionization Detector*
- 011 *Calibration and Maintenance of Portable Photoionization Detector*
- 015 *Documentation Requirements for Drilling and Well Installation*
- 025 *Hand Augering Procedures*
- 032 *Management of Investigation-Derived Waste*
- 046 *Sample Labeling, Storage and Shipment Procedures*
- 047 *Screening of Soil Samples for Organic Vapors During Drilling Activities*
- 058 *Split-Spoon Sampling Procedures*
- 065 *Test Pit Excavation and Logging Procedures*



SOIL DESCRIPTION PROCEDURES USING THE VISUAL-MANUAL METHOD

FIGURE 1

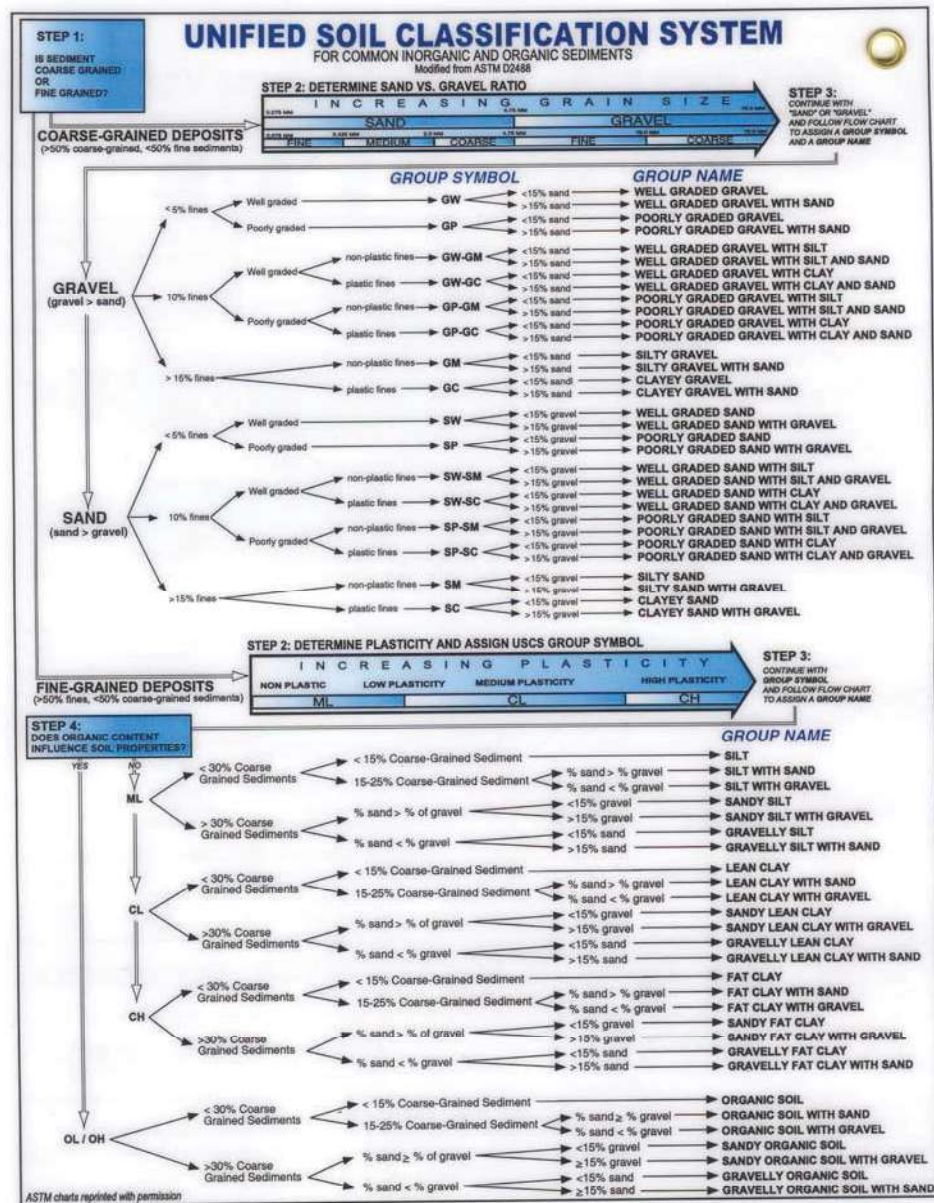
FIELD GUIDE FOR SOIL AND STRATIGRAPHIC ANALYSIS



SOIL DESCRIPTION PROCEDURES USING THE VISUAL-MANUAL METHOD

FIGURE 2

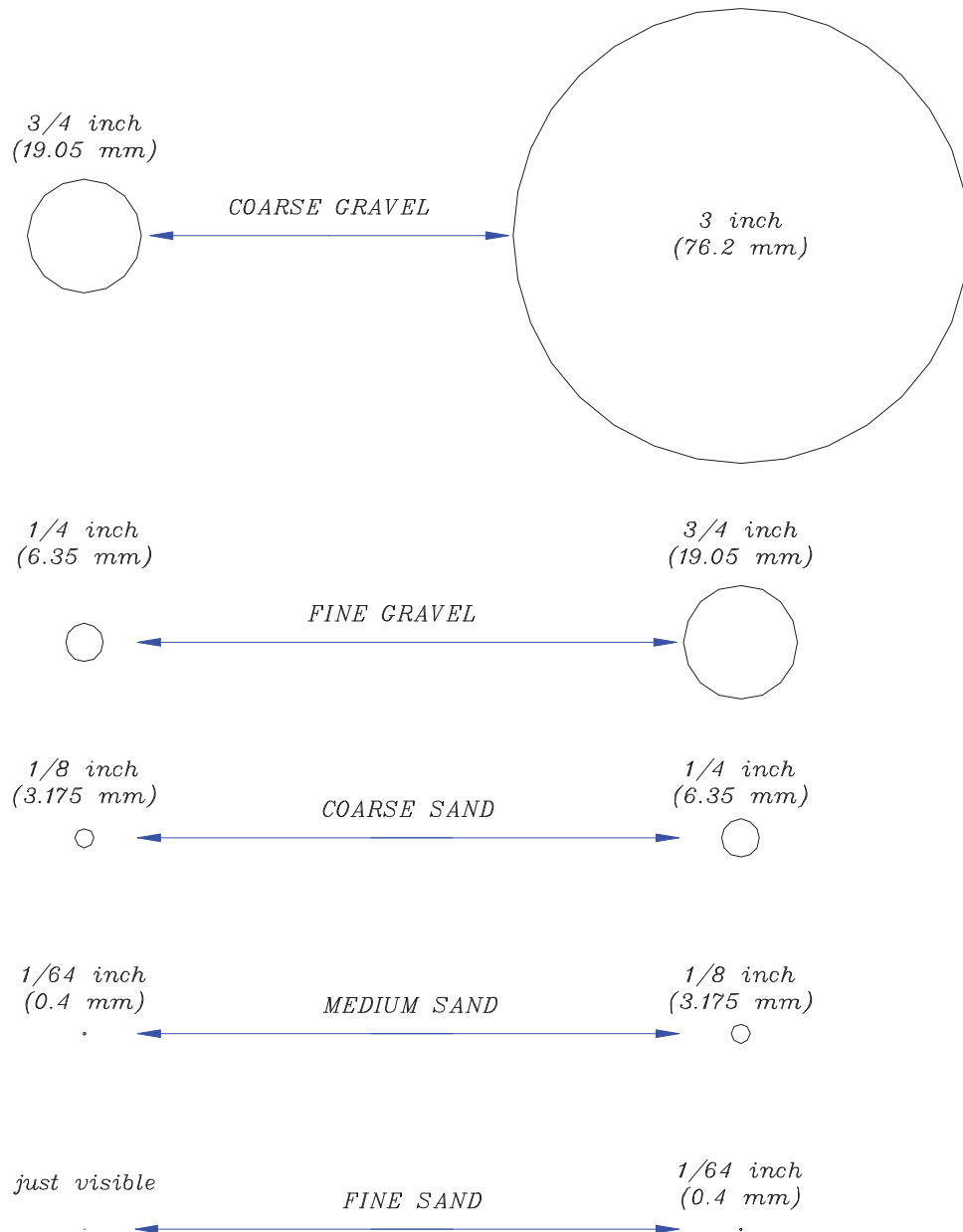
USCS SOIL CLASSIFICATION FLOW CHART (MODIFIED FROM ASTM D2488)



SOIL DESCRIPTION PROCEDURES
USING THE VISUAL-MANUAL METHOD

FIGURE 3

ILLUSTRATION OF PARTICLE SIZES



SOIL DESCRIPTION PROCEDURES USING THE VISUAL-MANUAL METHOD

FIGURE 4

GRAIN-SIZE SCALE (MODIFIED WENTWORTH SCALE)

Grain size refers to the physical dimensions of particles of rock or other solid. This is different from the crystallite size, which is the size of a single crystal inside the solid (a grain can be made of several single crystals). Grain sizes can range from very small colloidal particles, through clay, silt, sand, and gravel, to boulders. Size ranges define limits of classes that are given names in the Wentworth scale used in the United States. The Krumbein *phi* (φ) scale, a modification of the Wentworth scale created by W. C. Krumbein, is a logarithmic scale computed by the equation: $\varphi = -\log_2(\text{grain size in mm})$.

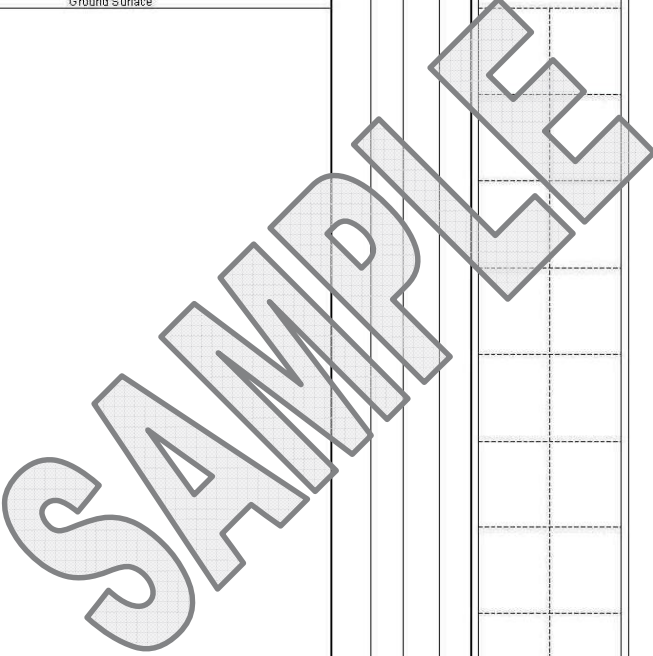
φ scale	Size range (metric)	Size range (approx. inches)	Aggregate name (Wentworth Class)
< -8	> 256 mm	> 10.1 in	Boulder
-6 to -8	64–256 mm	2.5–10.1 in	Cobble
-5 to -6	32–64 mm	1.26–2.5 in	Very coarse gravel
-4 to -5	16–32 mm	0.63–1.26 in	Coarse gravel
-3 to -4	8–16 mm	0.31–0.63 in	Medium gravel
-2 to -3	4–8 mm	0.157–0.31 in	Fine gravel
-1 to -2	2–4 mm	0.079–0.157 in	Very fine gravel
0 to -1	1–2 mm	0.039–0.079 in	Very coarse sand
1 to 0	$\frac{1}{2}$ –1 mm	0.020–0.039 in	Coarse sand
2 to 1	$\frac{1}{4}$ – $\frac{1}{2}$ mm	0.010–0.020 in	Medium sand
3 to 2	125–250 μm	0.0049–0.010 in	Fine sand
4 to 3	62.5–125 μm	0.0025–0.0049 in	Very fine sand
8 to 4	3.90625–62.5 μm	0.00015–0.0025 in	Silt
> 8	< 3.90625 μm	< 0.00015 in	Clay
< 10	< 1 μm	< 0.000039 in	Colloid

In some schemes "gravel" is anything larger than sand (> 2.0 mm), and includes "granule", "pebble", "cobble", and "boulder" in the above table. In this scheme, "pebble" covers the size range 4 to 64 mm (-2 to -6 φ).

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SOIL DESCRIPTION PROCEDURES
USING THE VISUAL-MANUAL METHOD

Project No:		Borehole Number:		 Benchmark Environmental Engineering & Science, PLLC 726 Exchange Street, Suite 624 Buffalo, NY (716) 856-0599	
Project:		Logged By:			
Client:		Checked By:			
Site Location:					

SUBSURFACE PROFILE			SAMPLE				PID VOCs	Lab Sample	Well Completion Details or Remarks
Elev. /Depth	Symbol	Description (ASTM D2488: Visual-Manual Procedure)	Sample No.	SPTN-Value	Recovery (ft)	Symbol			
0.0 0.0		Ground Surface					0 ppm 25 50		
									

Drilled By: Drill Rig Type: Drill Method: Drill Date(s):	Hole Size: Stick-up: Datum: Sheet: 1 of 1
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A thick vertical bar on the left side of the page, colored dark blue at the top and bottom, and green in the middle.The word "ROUX" in white, bold, sans-serif capital letters, set against a blue rectangular background with a slight drop shadow.

ROUX

FIELD OPERATING PROCEDURES

Soil Sample Collection
for VOC Analysis
(EnCore Sampling)

**SOIL SAMPLE COLLECTION FOR VOC
ANALYSIS – ENCORE SAMPLING**

BACKGROUND AND PURPOSE

This procedure describes the methods for collecting soil samples for VOC analysis to ensure that the sample adequately represents the VOC concentrations in the soil in accordance with SW-846 Method 5035A (effective July 1, 2002). These compounds tend to volatilize from the soil after disturbance or introduction to the atmosphere. Therefore, care must be exercised to ensure that the sample collected is not altered during the collection and storage procedures. A variety of sampling options are allowed and Appendix A of Method 5035A provides details regarding the many options available for sample collection. The collection and preservation procedures are intended to prevent loss of VOCs during sample transport, handling and analysis.

Method 5035A is a method designed for volatile sample collection and analysis of soils and solid wastes for volatile organic compounds. This method is described in Update III to the Third Edition of SW-846, *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*, and is required for all analytical methods using purge and trap techniques (8021, 8015B, and 8260B). Alternative protocols may be used in some states (including New York), however this method is strongly recommended.

The volatile analysis is performed over two ranges:

	<u>GC/MS (µg/kg)</u>	<u>GC (µg/kg)</u>
Low Level	5 – 300	Not Available
High Level	>250	>20

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SOIL SAMPLE COLLECTION FOR VOC ANALYSIS – ENCORE SAMPLING

The different levels require different sampling techniques. The low level method can only handle samples within a specific concentration range (these samples CANNOT be diluted), therefore a high level sample MUST be collected to ensure that all the target analytes can be quantified.

Naturally occurring carbonates in some soils may cause effervescence (foaming) on contact with the sodium bisulfate (NaHSO₄) solution used as preservative for the low-level preparation. This interference makes it necessary for the laboratory to use the high-level prep or an alternative technique for low level. Check with the NYSDEC to discuss acceptable options.

Typically, analytical laboratories will support the following options for the two levels:

Option	No. of Containers	Sample Size (g)	Holding Time (days)
A – Low Level EnCore™ Samplers	3*	5	14**
B – High Level EnCore™ Sampler	1*	5	14**
C – High Level Methanol vial w/syringe	1	10	14
* Additional EnCore™ Samplers are required for MS/MSD.			
** The sample MUST be extracted and preserved in sodium bisulfate or methanol within 48 hours of collection.			

NOTE: The EnCore™ Sampler is disposable – it can only be used ONCE. It CANNOT be cleaned and/or reused. The samplers MUST be used in conjunction with an EnCore™ T-handle.



**SOIL SAMPLE COLLECTION FOR VOC
ANALYSIS – ENCORE SAMPLING**

PROCEDURE

The preferred method for collecting and storing a soil sample for VOC analysis is using the EnCore™ method. This field procedure is described in this FOP.

1. The sampling team should reference the manufacturers' directions prior to sample collection (attached).
 - a. Ensure that the EnCore™ Sampler is present at the sampling location before collecting the sample from the borehole or surface sample location. The necessary parts of the EnCore™ Sampler will consist of three disposable coring bodies, three disposable caps, and a reusable stainless steel T-handle.
 - b. Retrieve the sampling tool from the borehole or sample location.
 - c. Expose a surface of the soil sample. For Shelby tube samples, this would require the extrusion of the sample. For split spoon samples, this would require the spoon be disassembled and opened. If liners are being used in conjunction with a split spoon or solid barrel sampler, this would require the removal of the liners from the sampler, so that the soil at the liner's end is exposed.
 - d. Following the manufacturer's directions for the use of the EnCore™ Sampler (attached), collect three aliquots of soil from the exposed soil surface, using the three coring bodies. After the collection of each aliquot, cap and label each aliquot. The manufacturer's direction for use of the EnCore™ Sampler are attached
2. If the use of the EnCore™ Sampler is not possible due to soil texture (e.g. gravels) the sample must be field preserved with acid and methanol in accordance with SW-846 Method 5035A.

FOP 057.0

SOIL SAMPLE COLLECTION FOR VOC ANALYSIS – ENCORE SAMPLING

3. If the soil material is too coarse for sampling with the EnCore™ Sampler and contains excessive calcium carbonate material that reacts with the acid preservative, the sample will be retained in the brass or stainless steel liner of the split-spoon sampler or similar device. The ends of these liners will be covered with Teflon™ rounds, capped and sealed with tape.
4. Record all information associated with sample collection in the Project Field Book.
5. The samples will be labeled, stored and shipped in accordance with the **Roux** Field Operating Procedure for Sample Labeling, Storage and Shipment Procedures.

ATTACHMENTS

EnCore™ Sampling Procedure (manufacturers instructions)

REFERENCES

Roux FOPs:

046 *Sample Labeling, Storage and Shipment Procedures*



SOIL SAMPLE COLLECTION FOR VOC ANALYSIS – ENCORE SAMPLING

ATTACHMENT

EnCore™ Sampling Procedure (manufacturers instructions)

Disposable
EnCore® Sampler



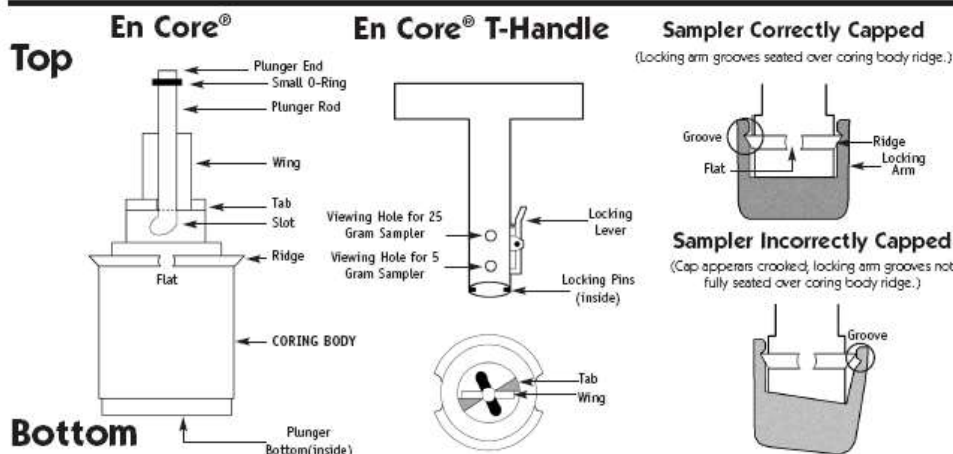
En Novative Technologies, Inc.
1241 Bellevue Street
Green Bay, WI 54302
Phone: 920-465-3960 • Fax: 920-465-3963
Toll Free: 888-411-0757
www.ennovativetech.com

Sampling Procedures

Using The En Core® T-Handle

NOTE:

1. En Core® Sampler is a SINGLE USE device. It cannot be cleaned and/or reused.
2. En Core® Sampler is designed to store soil. Do not use En Core Sampler to store solvent or free product!
3. En Core® Sampler must be used with En Core® T-Handle and/or En Core® Extrusion Tool exclusively. (These items are sold separately.)



BEFORE TAKING SAMPLE:

1. Hold coring body and push plunger rod down until small o-ring rests against tabs. This will assure that plunger moves freely.

2. Depress locking lever on En Core T-Handle. Place coring body, plunger end first, into open end of T-Handle, aligning the (2) slots on the coring body with the (2) locking pins in the T-Handle. Twist coring body clockwise to lock pins in slots. Check to ensure Sampler is locked in place. Sampler is ready for use.

TAKING SAMPLE:

3. Turn T-Handle with T-up and coring body down. This positions plunger bottom flush with bottom of coring body (ensure that plunger bottom is in position). Using T-Handle, push Sampler into soil until coring body is completely full. When full, small o-ring will be centered in T-Handle viewing hole. Remove Sampler from soil. Wipe excess soil from coring body exterior.

4. Cap coring body while it is still on T-handle. *Push* cap over flat area of ridge *and twist* to lock cap in place. **CAP MUST BE SEATED TO SEAL SAMPLER** (see diagram).

PREPARING SAMPLER FOR SHIPMENT:

5. Remove the capped Sampler by depressing locking lever on T-Handle while twisting and pulling Sampler from T-Handle.
6. Lock plunger by rotating extended plunger rod fully counter-clockwise until wings rest firmly against tabs (see plunger diagram).
7. Attach completed tear-off label (from En Core Sampler bag) to cap on coring body.
8. Return full En Core Sampler to zipper bag. Seal bag and put on ice.



SOIL SAMPLE COLLECTION FOR VOC ANALYSIS – ENCORE SAMPLING

Disposable EnCore® Sampler EXTRUSION PROCEDURES

USING THE EnCore® EXTRUSION TOOL

CAUTION! Always use the Extrusion Tool to extrude soil from the En Core Sampler. If the Extrusion Tool is not used, the Sampler may fragment, causing injury.

1. Use a pliers to break locking arms on cap of En Core Sampler. Do not remove cap at this time. (CAUTION: Broken edges will be sharp.)
2. To attach En Core Sampler to En Core Extrusion Tool: Depress locking lever on Extrusion Tool and place Sampler, plunger end first, into open end of Extrusion Tool, aligning slots on coring body with pins in Extrusion Tool. Turn coring body clockwise until it locks into place. Release locking lever.
3. Rotate and gently push Extrusion Tool plunger knob clockwise until plunger slides over wings of coring body. (When properly positioned plunger will not rotate further.)
4. Hold Extrusion Tool with capped Sampler pointed upward so soil does not fall out when cap is removed. To release soil core, remove cap from Sampler and push down on plunger knob of En Core Extrusion Tool. Remove and properly dispose of En Core Sampler.

Warranty and Disclaimers

IMPORTANT: FAILURE TO USE THE EN CORE® SAMPLER IN COMPLIANCE WITH THE WRITTEN INSTRUCTIONS PROVIDED HEREIN VOIDS ALL EXPRESS AND IMPLIED WARRANTIES, INCLUDING WARRANTY OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

PRINCIPLE OF USE. The En Core Sampler Cartridge System is a volumetric sampling system designed to collect, store and deliver a soil sample. The En Core Sampler comes in two sizes for sample volumes of approximately 25 or 5 grams. There are four components: the cartridge with a movable plunger; a cap with two locking arms; a T-handle (purchased separately); and an extrusion handle (purchased separately). NOTE: The En Core Sampler is designed to store soil. It is not designed to store solvent or free product.

The soil is stored in a sealed headspace-free state. The seals are achieved by three special Viton® * o-rings, two located on the plunger and one on the cap of the Sampler. At no time and under no condition should these o-rings be removed or disturbed.

QUALITY CONTROL. The cartridge is sealed in an airtight package to prevent contamination prior to use. Due to the stringent quality control requirements associated with the use of this system, the disposable cartridge is designed to be used only once.

WARRANTY. En Novative Technologies, Inc. ("En Novative Technologies") warrants that the En Core Sampler shall perform consistent with the research conducted under En Novative Technologies' approval, within thirty (30) days from the date of delivery, provided that the Customer gives En Novative Technologies prompt notice of any defect or failure to perform and satisfactory proof thereof. THIS WARRANTY DOES NOT APPLY TO THE FOLLOWING, AS SOLELY DETERMINED BY EN NOVATIVE TECHNOLOGIES: (a) Damage caused by accident, abuse, mishandling or dropping; (b) Samplers that have been opened, taken apart or mishandled; (c) Samplers not used in accordance with the directions; and (d) Damages exceeding the cost of the sampler. Seller warrants that all En Core Samplers shall be free from defects in title. THE FOREGOING WARRANTIES ARE IN LIEU OF ALL OTHER WARRANTIES, WHETHER ORAL, WRITTEN, EXPRESSED, IMPLIED OR STATUTORY, INCLUDING ANY INFORMATION PROVIDED BY SALES REPRESENTATIVES OR IN MARKETING LITERATURE. IMPLIED WARRANTIES OF FITNESS AND MERCHANTABILITY SHALL NOT APPLY. En Novative Technologies' warranty obligations and Customer's remedies, except as to title, are solely and exclusively as stated herein.

LIMITATION OF LIABILITY. IN NO EVENT SHALL EN NOVATIVE TECHNOLOGIES

BE LIABLE FOR ANTICIPATED PROFITS, INCIDENTAL, SPECIAL OR CONSEQUENTIAL DAMAGES, INCLUDING, BUT NOT LIMITED TO, DAMAGES FOR LOSS OF REVENUE, DOWNTIME, REMEDIATION ACTIVITIES, REMOBILIZATION OR RESAMPLING, COST OF CAPITAL, SERVICE INTERRUPTION OR FAILURE OF SUPPLY, LIABILITY OF CUSTOMER TO A THIRD PARTY, OR FOR LABOR, OVERHEAD, TRANSPORTATION, SUBSTITUTE SUPPLY SOURCES OR ANY OTHER EXPENSE, DAMAGE OR LOSS, INCLUDING PERSONAL INJURY OR PROPERTY DAMAGE. En Novative Technologies' liability on any claim of any kind shall be replacement of the En Core Sampler or refund of the purchase price. En Novative Technologies shall not be liable for penalties of any description whatsoever. In the event the En Core Sampler will be utilized by Customer on behalf of a third party, such third party shall not occupy the position of a third-party beneficiary of the obligation or warranty provided by En Novative Technologies, and no such third party shall have the right to enforce same. All claims must be brought within one (1) year of shipment, regardless of their nature.



En Novative Technologies, Inc.

1241 Bellevue Street
Green Bay, WI 54302
Phone: 920-465-3960 • Fax: 920-465-3963
Toll Free: 888-411-0757
www.ennovativetech.com

The En Core™ Sampler is covered by One or More of the Following U.S. Patents: 5,343,771; 5,505,098; 5,517,868; 5,522,271. Other U.S. and Foreign Patents Pending.

* Viton® is a registered trademark of DuPont Dow Elastomers.





FIELD OPERATING PROCEDURES

Split-Spoon Sampling Procedures

SPLIT-SPOON SAMPLING PROCEDURES

PURPOSE

This guideline presents the methods for using a split-spoon sampler for collecting soil samples from a boring and for estimating the relative in-situ compressive strength of subsurface materials (ASTM D 1586). Representative samples for lithologic description, geochemical analysis, and geotechnical testing will be collected from the subsurface materials using the split-spoon sampler.

PROCEDURE

1. Place plastic sheeting on a sturdy surface to prevent the split-spoon and its contents from coming in contact with the surface (several layers of sheeting may be placed on the surface so that they may be removed between each sample or as needed).
2. Lower the sampling string to the base of the borehole. Measure the portion of the sampling string that extends above surrounding grade (i.e. the stickup). The depth of sampling will equal the total length of the string (sampler plus rods) minus the stickup length.
3. Measure sampling depths to an accuracy of 0.1 feet. If field measurements indicate the presence of more than 0.3 feet of disturbed materials in the base of the borehole (i.e. slough), the sampler will be used to remove this material, after which a second sampling trip will be made.
4. Select additional sampler components as required (i.e., leaf spring core retainer for clays or a sand trap for non-cohesive sands). If a retainer or trap is not used, a spacer ring will be used to hold the liners in position inside the sampler.
5. For driving samples, attach the drive head sub and hammer to the drill rods without the weight resting on the rods. For pushing samples using the rig hydraulics, skip to Step 9.

SPLIT-SPOON SAMPLING PROCEDURES

6. Mark four 6-inch intervals on the drill rods relative to a reference point on the drill rig. With the sampler resting on the bottom of the hole, drive the sampler with the 140 lb. hammer falling freely over a 30-inch fall until 24 inches have been penetrated or 50 blows applied.
7. Record the number of blows per 6 inches. Determine the “N” value by adding the blows for the 6 to 12-inch and 12 to 18-inch intervals of each sample drive.
8. After penetration is complete, remove the sampling string. Avoid removing sampling string by hitting up on the string with the hammer as this can cause the sample to fall from the bottom of the split-spoon sampler. The sampling string should be removed via cable lifting or rig hydraulics. If sample retention has been poor, let the sampling string rest in place for at least 3 minutes, then rotate clockwise at least 3 times before removing from the borehole.
9. For pushed samples (i.e., using rig hydraulics), mark four 6-inch intervals on the drill rods relative to a reference point on the rig. Use the rig pull-down to press the sampler downward until 24 inches have been penetrated or no further progress can be made with the full weight of the rig on the sampler.
10. Remove the split-spoon sampler from the sampling string and place on the plastic-covered surface.
11. Open the split-spoon sampler only when the **Roux** field geologist is prepared to describe and manage the sample.
12. Describe the sample in accordance with the Unified Soil Classification System in accordance with the **Roux** FOP: Soil Description Procedures Using the Unified Soil Classification System (USCS).
13. Record all information in accordance with **Roux's** FOP: Documentation Requirements for Drilling and Well Installation.

FOP 058.0

SPLIT-SPOON SAMPLING PROCEDURES

14. Collect a portion of the sample for field screening as described in the **Roux** FOP: Screening of Soil Samples for Organic Vapors During Drilling Activities.
15. If applicable, collect soil samples for volatile organic constituents (VOCs). If applicable, collect sample for semi-volatile, metals, geotechnical, or other off-site analysis.
16. The samples will be labeled, stored and shipped in accordance with the **Roux's** FOP: Sample Labeling, Storage and Shipment Procedures.

ATTACHMENTS

none

REFERENCES

Roux FOPs:

- 015 *Documentation Requirements for Drilling and Well Installation*
- 046 *Sample Labeling, Storage and Shipment Procedures*
- 047 *Screening of Soil Samples for Organic Vapors During Drilling Activities*
- 054 *Soil Description Procedures Using the Unified Soil Classification System (USCS)*





FIELD OPERATING PROCEDURES

Surface and Subsurface
Soil Sampling
Procedures

FOP 063.2

SURFACE AND SUBSURFACE SOIL SAMPLING PROCEDURES

PURPOSE

This procedure describes the methods for sampling surface soil and subsurface soil samples for physical and chemical laboratory analysis during intrusive activities such as test pitting, hand augering, drilling, surface soil sampling etc. Typical health and safety related issues should be addressed in the Project Health and Safety Plan.

PRE-SAMPLING PROCEDURES

1. Review project objectives and the Project Health and Safety Plan (HASP).
2. Conduct tailgate health and safety meeting with project team and/or subcontractor(s) by completing the Tailgate Safety Meeting Form (sample attached).
3. Calibrate air-monitoring equipment in accordance with the appropriate **Roux's** Field Operating Procedures or manufacturers recommendations for calibration of field meters.
4. Commence intrusive activities in accordance with specific **Roux** FOPs (test pitting, hand augering, drilling etc.) or as directed by the Project Work Plan.
5. Conduct air monitoring as required by the HASP, Project Work Plan or **Roux's** FOP Real-Time Air Monitoring During Intrusive Activities. Record all results on the Real Time Air Monitoring Log (sample attached).
6. Decontaminate all non-dedicated stainless steel (or Pyrex glass) equipment in accordance with **Roux's** Non-disposable and Non-dedicated Sampling Equipment Decontamination procedures.
7. Collect soil samples in accordance with the following sections.



FOP 063.2

SURFACE AND SUBSURFACE SOIL SAMPLING PROCEDURES

SURFACE SOIL/FILL SAMPLING PROCEDURES

Collection of surface soil/fill samples facilitates the evaluation of potential health risks to current site receptors that may be exposed to soil/fill via direct contact, incidental ingestion, or inhalation of airborne particulates. The following procedure is in accordance with NYSDEC sampling protocol of surface soil/fill material.

1. Collect all soil samples using dedicated (or decontaminated non-dedicated) sampling tools (i.e., spoons, trowels, bowls etc.), preferably constructed of stainless steel.
2. If the sample area is vegetated, then collect the surface soil sample from 0 to 2 inches below ground surface (bgs) following removal of the sod.
3. If there is no soil present within the sample area (i.e., only slag, concrete, mixed with fines), excavate an area 12 inches by 12 inches by 6 inches deep, screen the material to less than 1/8 inch (No. 4 sieve), and submit the screened material for analysis. If there is not enough material to completely fill the sample jar, then expand the excavation 3 inches in all four directions screening the additional material. Expand the excavation in this manner until sufficient sample volume is obtained. Volatile organic analysis of surface soil/fill utilizing this method will yield negatively biased results and should not be performed.

SURFACE/SUBSURFACE SOIL SAMPLING PROCEDURES

1. Collect all soil samples using dedicated (or decontaminated non-dedicated) sampling tools (i.e., spoons, trowels, bowls etc.), preferably constructed of stainless steel.

Surface soil samples are typically collected from 0 to 6 inches below ground surface (bgs). Subsurface soils are typically sampled from varying depths greater than 6-inches bgs based on field observations and as directed by the Project Work Plan.



FOP 063.2

SURFACE AND SUBSURFACE SOIL SAMPLING PROCEDURES

2. Transfer samples for chemical (VOC, SVOC, Metals etc.) and physical (i.e., Atterberg Limits, Grain Size, Permeability etc.) analytical testing by direct grab (i.e., directly from the bucket of the excavation equipment, split-spoon sampler, hand auger etc.) using the dedicated (or decontaminated non-dedicated) sampling tools into appropriate laboratory-supplied containers and seal. The chemical or physical laboratory selected to perform the analysis should determine minimum sample volume for analysis.
3. Prepare collected samples in accordance with **Roux's** FOP: Sample Labeling, Storage and Shipment Procedures. Do not allow the chemical soil samples to freeze during storage and shipping. It should be noted, ice is not required for physical soil samples and all physical soil samples should be kept at the collected soil moisture by securing with a tight sealing lid. Do not allow physical soil samples to gain or lose moisture from the collected soil moisture prior to analysis.
4. Record all sampling details (i.e., depth and location) in the Project Field Book; appropriate **Roux** log sheets depending on method of intrusion (i.e., drilling, test pitting, hand augering etc.); and on the Soil/Sediment Sample Collection Summary Log (sample attached).

PARAMETER-SPECIFIC PROCEDURES

1. Volatile Organic Compound (VOCs): Transfer sufficient soil volume to fill the laboratory-supplied container (typically 4 ounces) by packing the soil sample with the sampling tool to the top of the container leaving no headspace. At no time should a gloved hand (i.e., latex, nitrile etc.) be used to pack the sample into the sample container as the sample may be compromised via cross-contamination.
2. All Other Parameters: All other parameters include, but are not limited to, Semi-VOCs (SVOCs), polychlorinated biphenyls (PCBs), herbicides, pesticides, total metals etc. Transfer sufficient soil volume to fill the laboratory-supplied container by packing the soil sample with the sampling



FOP 063.2

SURFACE AND SUBSURFACE SOIL SAMPLING PROCEDURES

tool to the top of the container. Unless otherwise indicated by the laboratory or the Project Work Plan, the sample jar for all other parameters does not have to be packed completely leaving no headspace as with the VOC containers.

ATTACHMENTS

Tailgate Safety Meeting Form (sample)
Soil/Sediment Sample Collection Summary Log (sample)
Real Time Air Monitoring Log (sample)

REFERENCES

Roux FOPs:

- 006 *Calibration and Maintenance of Combustible Gas/Oxygen Meter*
- 010 *Calibration and Maintenance of Portable Flame Ionization Detector*
- 011 *Calibration and Maintenance of Portable Photoionization Detector*
- 040 *Non-disposable and Non-dedicated Sampling Equipment Decontamination*
- 046 *Sample Labeling, Storage and Shipment Procedures*
- 073 *Real-Time Air Monitoring During Intrusive Activities*



FOP 063.2

SURFACE AND SUBSURFACE SOIL SAMPLING PROCEDURES

TAILGATE SAFETY MEETING FORM

Project Name: _____ Date: _____ Time: _____
Project Number: _____ Client: _____
Work Activities: _____

HOSPITAL INFORMATION:

Name: _____
Address: _____ City: _____ State: _____ Zip: _____
Phone No.: _____ Ambulance Phone No. _____

SAFETY TOPICS PRESENTED:

Chemical Hazards: _____

Physical Hazards: _____ Slips, Trips, Falls

PERSONAL PROTECTIVE EQUIPMENT:

Activity: _____	PPE Level: _____	A	B	C	D
Activity: _____	PPE Level: _____	A	B	C	D
Activity: _____	PPE Level: _____	A	B	C	D
Activity: _____	PPE Level: _____	A	B	C	D
Activity: _____	PPE Level: _____	A	B	C	D

New Equipment: _____

Other Safety Topic (s): _____ Environmental Hazards (aggressive fauna)
_____ Eating, drinking, use of tobacco products is prohibited in the Exclusion Zone (EZ)

ATTENDEES

Name Printed	Signatures
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

Meeting conducted by: _____



SURFACE AND SUBSURFACE SOIL SAMPLING PROCEDURES

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ROUX

FIELD OPERATING PROCEDURES

Test Pit Excavation and Logging Procedures

TEST PIT EXCAVATION & LOGGING PROCEDURES

PURPOSE

This procedure describes the methods for completing test pits, trenches, and other excavations that may be performed to expose subsurface soils or materials. In most cases, these pits will be mechanically excavated, using a backhoe, trackhoe, or other equipment. Because pits and other excavations can represent a substantial physical hazard, it requires a particular focus on safety procedures. The Project Health and Safety Plan identifies practices related to excavation permits, entry, and control that must be incorporated into excavation activities.

EXCAVATION PROCEDURE

1. Review project objectives and the Project Health and Safety Plan (HASP).
2. Perform excavation equipment safety checks with the operator. Specific concerns should include, but not limited to, no leaking hydraulic lines, fire extinguisher on board of the excavation equipment, operator experience etc.
3. Conduct tailgate health and safety meeting with project team and excavation operator(s) by completing the Tailgate Safety Meeting Form (sample attached).
4. Calibrate air-monitoring equipment in accordance with the appropriate **Roux's** Field Operating Procedures or manufacturers recommendations for calibration of field meters.
5. Conduct air monitoring as required by the HASP and/or Project Work Plan. Record all results on the Real Time Air Monitoring Log (sample attached).
6. Mobilize the excavation equipment to the site and position over the required location.
7. Select excavation locations, which provide necessary information for achieving objectives. Check locations with owner/operator to ensure excavation

TEST PIT EXCAVATION & LOGGING PROCEDURES

operations will not interfere with site operations, and select appropriate access routes.

8. Stake locations in the field and measure distance from locations to nearest landmarks. Survey location, if required.
9. Obtain clearances from appropriate utilities and, if buried waste/metallic objects are suspected, screen location with appropriate geophysical methods, as necessary.
10. Decontaminate excavation equipment in accordance with **Roux's** Drilling and Excavation Equipment Decontamination procedures.
11. Excavate pits. In uncontrolled areas, excavate only as many test pits as can be backfilled during the same day. Generally, allow equal time for excavation and backfilling. To the extent practicable, no pits should be left open overnight in an uncontrolled area. If sudden weather changes or other unforeseen events necessitate this, pits will be covered and/or barricaded and flagged with caution/hazard tape. These pits should be backfilled as soon as possible.
12. The **Roux** field geologist or experienced professional should determine the depth of excavation. The depth is generally limited by the safe reach of the selected equipment, but may also be limited by the stability of the excavated materials (i.e. wall stability).
13. Excavate the test pits in compliance with applicable safety regulations. In no case should a pit deeper than 4 feet be entered without first stabilizing the sidewalls by using forms, or by terracing or sloping (2:1 slope maximum) the sidewalls.
14. Excavated spoils must be placed no closer than 2 feet from the open excavation.
15. Collect soil samples from pit sidewalls in accordance with **Roux's** Surface and Subsurface Soil Sampling Procedures. If the test pit is greater than 4 feet in depth, it will not be entered for sampling. In this event, collect

TEST PIT EXCAVATION & LOGGING PROCEDURES

samples using the backhoe bucket, then fill sample containers from the center of the bucket using the stainless steel sampling equipment (i.e., spoon, spade, trowel etc.) or drive a Shelby tube or EnCore™ sampler for VOCs.

16. Record excavation observations in the Project Field Book or Test Pit Excavation Log form (sample attached). Information recorded should include:
 - Physical dimension of the pit;
 - A scaled sketch of one side of the pit showing any lithologic contacts, zones of groundwater seepage, other special features (jointing, boulders, cobbles, zones of contamination, color abnormalities, etc.)
 - General information such as project number, pit designation number, depth, date, name of responsible professional (i.e., geologist), type of excavating equipment utilized, time of excavation and backfilling, method of collecting samples and amount of sample collected (if applicable);
 - Rate of groundwater inflow, depth to groundwater and time of measurement; and
 - Unified Soil Classification System (USCS) designation of each distinctive unit.
17. Photograph each excavation, highlighting unique or important features. Use a ruler or other suitable item for scale. Include a label with the pit designation so the developed picture will be labeled.
18. Backfill pit to match the existing grade compacting in 2 to 3 foot lifts. Since the excavated material should be cover soil, the excess soil will be placed back into the hole. The **Roux** Field Team Leader will provide direction on whether excavated soils may be used as fill, or these materials are to be containerized as investigation derived waste.

FOP 065.1

TEST PIT EXCAVATION & LOGGING PROCEDURES

ATTACHMENTS

Tailgate Safety Meeting Form (sample)
Real Time Air Monitoring Log (sample)
Test Pit Excavation Log (sample)

REFERENCES

Roux FOPs:

006 *Calibration and Maintenance of Combustible Gas/Oxygen Meter*
010 *Calibration and Maintenance of Portable Flame Ionization Detector*
011 *Calibration and Maintenance of Portable Photoionization Detector*
018 *Drilling and Excavation Equipment Decontamination*
063 *Surface and Subsurface Soil Sampling Procedures*



TEST PIT EXCAVATION & LOGGING PROCEDURES

Form 065.1-01 (Rev. 01/2017)

TAILGATE SAFETY MEETING FORM

Project Name: _____ Date: _____ Time: _____
 Project Number: _____ Client: _____
 Work Activities: _____

HOSPITAL INFORMATION:

Name: _____
 Address: _____ City: _____ State: _____ Zip: _____
 Phone No.: _____ Ambulance Phone No.: _____

SAFETY TOPICS PRESENTED:

Chemical Hazards: _____

Physical Hazards: Slips, Trips, Falls _____

PERSONAL PROTECTIVE EQUIPMENT:

Activity:	PPE Level:	A	B	C	D
Activity:	PPE Level:	A	B	C	D
Activity:	PPE Level:	A	B	C	D
Activity:	PPE Level:	A	B	C	D
Activity:	PPE Level:	A	B	C	D
Activity:	PPE Level:	A	B	C	D

New Equipment: _____

Other Safety Topic(s): Environmental Hazards (aggressive fauna)
 Eating, drinking, use of tobacco products is prohibited in the Exclusion Zone (EZ)

ATTENDEES

Name Printed

Signatures

_____	_____
_____	_____
_____	_____
_____	_____
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_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

Meeting conducted by: _____



FOP 065.1

TEST PIT EXCAVATION & LOGGING PROCEDURES

TEST PIT EXCAVATION LOG

Project:		TEST PIT I.D.:	
Project No.:		Excavation Date:	
Client:		Excavation Method:	
Location:		Logged / Checked By:	

Test Pit Location: <i>NOT TO SCALE</i>		Test Pit Cross Section:		
TIME	Length:	(approx.)		
Start:	Width:	(approx.)		
End:	Depth:	(approx.)		

Depth (fbgs)	USCS Symbol & Soil Description	BFS Scan (ppm)	Photos Y / N	Samples Collected (fbgs)

COMMENTS:			
GROUNDWATER ENCOUNTERED:	yes	no	If yes, depth to GW:
VISUAL IMPACTS:	yes	no	Describe:
OLFACTORY OBSERVATIONS:	yes	no	Describe:
NON-NATIVE FILL ENCOUNTERED:	yes	no	Describe:
OTHER OBSERVATIONS:	yes	no	Describe:
SAMPLES COLLECTED:	yes	no	Sample I.D.:
			Sample I.D.:
			Sample I.D.:





FIELD OPERATING PROCEDURES

Well/Piezometer
Construction Materials
and Design

**WELL/PIEZOMETER CONSTRUCTION MATERIALS
AND DESIGN**

PURPOSE

This guideline presents construction materials and design requirements for monitoring well/piezometer installations in accordance with NYSDEC recommended specifications (6NYCRR Part 360).

CONSTRUCTION MATERIALS

1. Well Screen and Riser – Only new flush threaded screen and riser materials will be used. Screen and riser materials, well dimensions, screen slot opening size and length to be determined based on formation characteristics and suspect water quality or as specified by the project geologist/hydrogeologist. A vented cap or J-plug should be placed over the riser. A V-slot cut in the riser or permanent marking, both placed on the north side of the riser, will act as a monitoring reference point.
2. Bentonite Well Seal – The bentonite should be from a commercial source free of chemical additives (granular or powdered for grout and pelletized for seal).
3. Concrete – Low heat of hydration concrete should be used for grout and cementing protective casing if well construction materials are composed of PVC (ASTM Type II or Type IV Portland Cement).
4. Water – Water should be from a potable source of known chemistry and free of chemical constituents which may compromise integrity of installation.
5. Grout – Mixture of bentonite, cement and water in accordance with the following specifications. Premix bentonite and water prior to adding cement.

Grout Slurry Composition (% Weight)

1.5 to 3.0%	-	Bentonite (Quick Gel)
40 to 60 %	-	Cement (Portland Type I)
40 to 60 %	-	Potable Water



**WELL/PIEZOMETER CONSTRUCTION MATERIALS
AND DESIGN**

6. Filter Pack – The filter pack should consist of clean, inert, siliceous, rounded to subrounded particles. Filter pack particle size is dependent on the formation and the slot size of the screen.

A secondary filter about 6-inches thick may be placed between filter pack and the bentonite seal and potentially between the bentonite seal and the grout backfill, to minimize grout penetration of the seal. A uniformly graded fine sand (100% passing No. 30 sieve) should be used as a secondary filter.

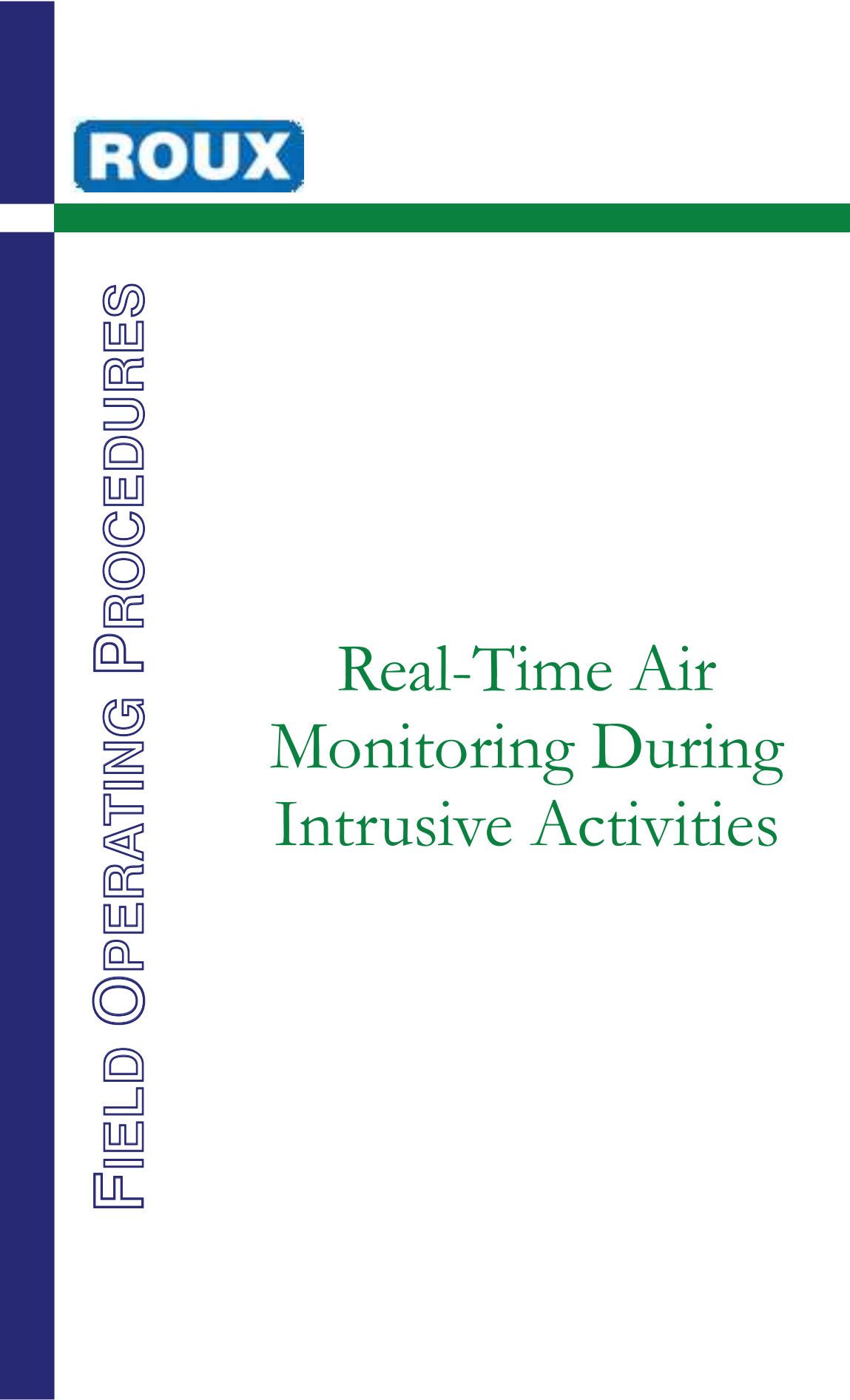
7. Protective Casing, Locking Cap and Lock – Protective casing with a lockable cap should be cemented in place around the riser. The inside diameter of the protective casing should be a minimum of 2-inches larger than the outside diameter of the well riser. The annular space between the casing and the riser should be filled with pea gravel or coarse sand. A weep hole should be drilled near the base of the casing to facilitate drainage of standing water. If more than one well is installed, all locks should be keyed alike.
8. A sample of all cement, bentonite and sand used in well construction should be saved in a labeled, Teflon-sealed, precleaned glass jar.

REFERENCES

New York State Department of Environmental Conservation, July 1988, *Drilling and Monitoring Well Installation Guidance Manual*.

Driscoll, F.G., 1987, *Groundwater and Wells*, Johnson Division, St. Paul, Minnesota, p. 1089.

Sara, M. N., *Proposed Recommended Practice for Design and Installation of Ground Water Monitoring Wells in Aquifers: ASTM Subcommittee D18.21*.



ROUX

FIELD OPERATING PROCEDURES

Real-Time Air Monitoring During Intrusive Activities

FOP 073.2

REAL-TIME AIR MONITORING DURING INTRUSIVE ACTIVITIES PROCEDURE

PURPOSE

This guideline presents requirements for real-time community air monitoring and required responses during all project required intrusive activities, such as drilling, test pitting, earthwork construction etc. This procedure is consistent with the requirements for community air monitoring for all intrusive projects, including projects conducted at remediation sites, as established by the New York State Department of Health (NYSDOH) and the New York State Department of Environmental Conservation (NYSDEC). Accordingly, it follows procedures and practices outlined under NYSDEC's DER-10 (May 2010) Appendix 1A (NYSDOH's Generic Community Air Monitoring Plan) and Appendix 1B (Fugitive Dust and Particulate Monitoring).

This FOP requires real-time monitoring for constituents of concern (COC) (i.e., volatile organic compounds (VOCs), lower explosive limit (% LEL), particulates (i.e., dust) etc.) at the upwind and downwind perimeter as well as the exclusion zone of a project site during all intrusive activities. This FOP is not intended for use in establishing action levels for worker respiratory protection (see Project Health and Safety Plan (HASP) for worker protection action levels). Rather, its intent is to provide a measure of protection for the surrounding community from potential airborne contaminant releases as a direct result of investigative and remedial work activities. The community, as referenced in this document, includes any off-site residences, public buildings/grounds and commercial or industrial establishments adjacent to the project site. The action levels specified herein require increased monitoring, corrective actions to abate emissions, and/or work shutdown. Additionally, this FOP helps to confirm that work activities did not spread contamination off-site through via air transport mechanisms. Community air monitoring shall be integrated with the construction



FOP 073.2

REAL-TIME AIR MONITORING DURING INTRUSIVE ACTIVITIES PROCEDURE

worker personal exposure-monitoring program contained in the project and site-specific HASP.

Depending upon the nature of known or potential contaminants at each site, real-time air monitoring for volatile organic compounds (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 NYSDEC/NYSDOH staff.

MONITORING & MITIGATION PROCEDURE

Real-time air monitoring perimeter locations for monitoring stations will be established based on the location of the exclusion zone (i.e., immediate work area) and wind direction. Where wind direction is shifting or winds are calm, the downwind monitoring location will default to the perimeter location nearest the most sensitive receptor (i.e., residential property). All downwind receptors being equal, the downwind monitoring location will default to the perimeter location downwind of the prevailing winds at the site. Although additional site specific COCs may be monitored during real-time air monitoring activities, the most common COCs are discussed in this FOP, including organic vapors (i.e., VOCs), airborne particulates (i.e., fugitive dust) and combustible gases (i.e., methane) and oxygen.



**REAL-TIME AIR MONITORING DURING INTRUSIVE
ACTIVITIES PROCEDURE**

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

ORGANIC VAPORS

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. 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

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capable of calculating 15-minute running average concentrations, which will be compared to the levels specified below.

- 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.
- 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.
- If the organic vapor level is above 25 ppm at the perimeter of the work area, activities must be shutdown.
- All 15-minute readings must be recorded and be available for State (DEC and DOH) personnel to review. Instantaneous readings, if any, used for decision purposes should also be recorded.
- **Special Requirements for Work Within 20 Feet of Potentially Exposed Individuals or Structures**
 - When work areas are within 20 feet of potentially exposed populations or occupied structures, the continuous monitoring locations for VOCs and



**REAL-TIME AIR MONITORING DURING INTRUSIVE
ACTIVITIES PROCEDURE**

particulates must reflect the nearest potentially exposed individuals and the location of ventilation system intakes for nearby structures. The use of engineering controls such as vapor/dust barriers, temporary negative-pressure enclosures, or special ventilation devices should be considered to prevent exposures related to the work activities and to control dust and odors. Consideration should be given to implementing the planned activities when potentially exposed populations are at a minimum, such as during weekends or evening hours in non-residential settings.

- If total VOC concentrations opposite the walls of occupied structures or next to intake vents exceed 1 ppm, monitoring should occur within the occupied structure (s). Background readings in the occupied spaces must be taken prior to commencement of the planned work. Any unusual background readings should be discussed with NYSDOH prior to commencement of the work.
- If total particulate concentrations opposite the walls of occupied structures or next to intake vents exceed 150 mcg/m³, work activities should be suspended until controls are implemented and are successful in reducing the total particulate concentration to 150 mcg/m³ or less at the monitoring point.
- Depending upon the nature of contamination and remedial activities, other parameters (e.g., explosivity, oxygen, hydrogen Sulfide, carbon monoxide) may also need to be monitored. Response levels and actions should be pre-determined, as necessary, for each site.

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Additionally, if following the cessation of work and efforts to abate the emission source are unsuccessful, and if sustained organic vapor levels exceed 25 ppm above background within the 20-foot zone for more than 30 minutes, then the **Major Vapor Emission Response Plan** (see below) will automatically be placed into effect.

Major Vapor Emission Response Plan

Upon activation of Major Vapor Emission Response Plan, the following activities will be undertaken:

1. All Emergency Response Contacts as listed below and in the Site-Specific Health and Safety Plan will be contacted.
2. The local police authorities will immediately be contacted by the Site Safety and Health Officer and advised of the situation.
3. The Site Safety and Health Officer will determine if site workers can safely undertake source abatement measures. Abatement measures may include covering the source area with clean fill or plastic sheeting, or consolidating contaminated materials to minimize surface area. The Site Safety and Health Officer will adjust worker personal protective equipment as necessary to protect workers from over-exposure to organic vapors.

The following personnel are to be notified by the Site Safety and Health Officer in the listed sequence if the Major Vapor Emission Response Plan is activated:

Contact	Phone
Police/Fire Department	911
New York State DOH	(518) 402-7860
New York State DEC Region 8	(585) 226-2466, switchboard



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New York State DEC Region 9

(716) 851-7220

State Emergency Response Hotline

(800) 457-7362

In addition, the Site Safety and Health Officer will provide these authorities with a description of the apparent source of the contamination and abatement measures being taken by the contractor, if any.

AIRBORNE PARTICULATES

Fugitive dust suppression and airborne particulate monitoring shall be performed during any intrusive activities involving disturbance or handling of site soil/fill materials. Fugitive dust suppression techniques will include the following minimum measures:

- Spraying potable water on all excessively dry work areas and roads.
- All fill materials leaving the site will be hauled in properly covered containers or haul trailers.
- Additional dust suppression efforts may be required as discussed below.

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



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of the action level. In addition, fugitive dust migration should be visually assessed during all work activities.

- If the downwind PM-10 particulate level is 100 micrograms per cubic meter ($\mu\text{g}/\text{m}^3$) 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 $\mu\text{g}/\text{m}^3$ above the upwind level and provided that no visible dust is migrating from the work area.
- If, after implementation of dust suppression techniques, downwind PM-10 particulate levels are greater than 150 $\mu\text{g}/\text{m}^3$ 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 $\mu\text{g}/\text{m}^3$ of the upwind level and in preventing visible dust migration.
- All readings must be recorded and be available for State (DEC and DOH) personnel to review.

Visual Assessment

In conjunction with the real-time monitoring program, TurnKey personnel and any subcontractors thereof will be responsible for visually assessing fugitive dust migration from the site. If airborne dust is observed leaving the site, the work will be stopped until supplemental dust suppression techniques are employed in those areas.

Supplemental Dust Suppression

Supplemental dust suppression techniques may include but are not necessarily limited to the



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REAL-TIME AIR MONITORING DURING INTRUSIVE ACTIVITIES PROCEDURE

following measures:

- Reducing the excavation size, number of excavations or volume of material handled.
- Restricting vehicle speeds.
- Applying water on buckets during excavation and dumping.
- Wetting equipment and excavation faces.
- Wetting haul roads.
- Restricting work during extreme wind conditions.
- Use of a street sweeper on paved haul roads, where feasible.

Work can resume using supplemental dust suppression techniques provided that the measures are successful in reducing the sustained downwind particulate concentration to below 150 ug/m³ of the upwind level, and in preventing visible dust migration off-site.

COMBUSTIBLE GASES & OXYGEN

Ambient combustible gas and oxygen concentrations should be measured prior to commencing intrusive activities each workday and a minimum of every 30-minutes thereafter. Air monitoring activities should be performed using equipment appropriate to measure combustible gases in percent lower explosive limit (LEL) and percent oxygen and calibrated daily. All combustible gas and oxygen readings must be recorded in the Project Field Book and/or Real-Time Air Monitoring Logs (sample attached) and, if applicable, be made available for State (DEC and DOH) personnel to review.



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REAL-TIME AIR MONITORING DURING INTRUSIVE ACTIVITIES PROCEDURE

Mitigation upon the detection of various action levels of organic vapors are presented below:

Combustible Gas:

- If the sustained ambient air concentration of combustible gas at the downwind perimeter of the site exceeds a reading of 10 to 25% LEL, work activities must be temporarily halted and monitoring continued. If the total organic vapor level readily decreases (per instantaneous readings) below 10% LEL, work activities can resume with continued monitoring.
- If sustained combustible gas levels at the downwind perimeter of the site persist at levels in excess of 25% LEL, work activities must be halted, the source of explosion hazards identified, corrective actions taken to abate emissions and monitoring continued. Following combustible gas mitigation, work activities can resume provided that the sustained total organic vapor level 200 feet downwind of the exclusions 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 a sustained value of 10% LEL.

Oxygen:

- If the sustained ambient oxygen concentration at the downwind perimeter of the site measures a reading between 19.5% - 21% oxygen, work activities can continue with extreme caution, however attempts to determine the potential source of oxygen displacement must be conducted.
- If the sustained oxygen level readily decreases below 19.5% LEL, work activities should be discontinued and all personnel must leave the area immediately.
- If the sustained oxygen level at the downwind perimeter of the site persists at levels between 21-25%, work activities can resume with caution.
- If the sustained oxygen level at the downwind perimeter of the site persists at levels exceeding 25% (fire hazard potential), work activities should be discontinued and all personnel must leave the area immediately.



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REAL-TIME AIR MONITORING DURING INTRUSIVE ACTIVITIES PROCEDURE

ATTACHMENTS

Real-Time Air Monitoring Log (sample)

REFERENCES

TurnKey FOPs:

- 006 *Calibration and Maintenance of Combustible Gas/Oxygen Meter*
- 010 *Calibration and Maintenance of Flame Ionization Detector*
- 011 *Calibration and Maintenance of Portable Photoionization Detector*
- 084 *Calibration and Maintenance of Portable Particulate Meter*



**UNDERGROUND STORAGE TANK
EXCAVATION AND REMOVAL PROCEDURES**

PURPOSE

This procedure describes the methods for conducting underground storage tank (UST) removal activities. In most cases, the USTs will be mechanically excavated, using a backhoe, trackhoe, excavator or other equipment. Because the pits and other excavations created during UST exhumation can represent a substantial physical hazard, it requires a particular focus on safety procedures. The Project Health and Safety Plan and/or Project Work Plan should identify practices related to excavation permits, entry, and control that must be incorporated into UST excavation activities.

PRE-EXCAVATION PROCEDURES

1. Conduct a Phase I Site Assessment in accordance with ASTM E 1527 “Standard Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process” or at a minimum conduct an EDR search of the subject property to obtain some information about the number and location of potential USTs.
2. Review project objectives outlined in the Project Work Plan and the Project Health and Safety Plan (HASP).
3. Check locations with owner/operator to ensure excavation operations will not interfere with site operations, and select appropriate access routes.
4. Stake locations in the field and measure distance from locations to nearest landmarks. Survey location, if required.
5. Obtain clearances from appropriate utilities and, if buried waste/metallic objects are suspected, screen location with appropriate geophysical methods, as necessary. Utility clearances are required 72 hours prior to commencing intrusive activities. Typically, the UST contractor will obtain the required utility clearances and permits.

**UNDERGROUND STORAGE TANK
EXCAVATION AND REMOVAL PROCEDURES**

6. Conduct a pre-construction meeting, as necessary. Include the client, state and/or federal regulatory agencies (as necessary) and the UST contractor.
7. Become familiar with the site by conducting a site reconnaissance. Note and identify the following: the prevailing wind direction; adjacent property zones (i.e., residential, commercial or industrial); any potential for unauthorized site access by onlookers; overhead utilities; temporary staging areas for impacted soils and USTs; and any other site features that may inhibit the progress of work.
8. During the site recon, locate the surface fill ports, if applicable, and determine the approximate size, liquid type and liquid quantity of the UST. Determine tank size (diameter and capacity) and liquid quantity by sticking the tank through the fill port with a long measuring stick. Determine the type of liquid contained within the UST; keeping in mind this may involve sample collection and profile characterization by a laboratory.

EXCAVATION PROCEDURES

1. Perform excavation equipment safety checks with the operator. Specific concerns should include, but not limited to, no leaking hydraulic lines, fire extinguisher on board of the excavation equipment, operator experience etc.
2. Conduct tailgate health and safety meeting with project team and excavation operator(s) by completing the Tailgate Safety Meeting Form (sample attached).
3. Discuss with excavation contractor personnel the scope of work and what will be expected of them.
4. Calibrate air-monitoring equipment in accordance with the appropriate **Roux's** Field Operating Procedures or manufacturers recommendations for calibration of field meters.

**UNDERGROUND STORAGE TANK
EXCAVATION AND REMOVAL PROCEDURES**

5. Conduct air monitoring as required by the HASP and/or Project Work Plan in accordance with **Roux's** FOP: Real-Time Air Monitoring During Intrusive Activities. Record all results on the Real Time Air Monitoring Log (sample attached).
6. Decontaminate excavation equipment in accordance with **Roux's** Drilling and Excavation Equipment Decontamination procedures as necessary.
7. Mobilize the excavation equipment to the site and position over the required UST location.
8. If liquid was encountered in the UST during the initial site reconnaissance, purge, contain and dispose of the UST contents in accordance with state and federal regulations as well as **Roux's** FOP: Management of Investigation-Derived Waste (IDW).
9. Excavate the UST(s) in compliance with applicable safety regulations and NYSDEC Division of Environmental Remediation, Spill Response Unit or Bulk Storage Unit guidelines and/or this FOP. In uncontrolled areas, UST excavations being conducted over several days and/or time allowed for laboratory analytical results to be returned will be covered and/or barricaded and flagged with caution/hazard tape. These open pits should be backfilled with clean fill as soon as possible.
10. Each UST contractor has their own means and methods of exhuming USTs and impacted soil and **Roux** personnel should not direct the contractor's activities, however, the methods performed by the contractor should be monitored closely to ensure safety is a priority. Typically, the UST fill ports will be unearthed and the top of the tank will be exposed to determine the exact size of the tank. Once the size is determined, the UST contractor will excavate along one side to the bottom of the tank and roll the tank on its side.

**UNDERGROUND STORAGE TANK
EXCAVATION AND REMOVAL PROCEDURES**

11. Once the UST is “loosened”, the contractor should remove the tank with webbing or chains, while keeping the tank in its original horizontal position, and place the exhumed tank on a polyethylene tarp.
12. The UST contractor will then clean and dispose of the tank in accordance with state and federal regulations.
13. The **Roux** field geologist or experienced professional will determine the horizontal and vertical limits of excavation based upon soil scans with a calibrated photoionization detector (PID) in accordance with **Roux's** FOP: Screening of Soil Samples for Organic Vapors During UST Removal Activities.

The depth is generally limited by the safe reach of the selected equipment, but may also be limited by the stability of the excavated materials (i.e. wall stability). Excavation depths exceeding the practical limits of the machine may be required as long as the groundwater table has not been encountered. Terminate all excavations at the first water bearing zone and consult the Project Manager. Typically, groundwater remediation will be required (i.e., pump and treat).

14. At no time should an excavation deeper than 4 feet be entered without first stabilizing the sidewalls by using forms, or by terracing or sloping (2:1 slope maximum) the sidewalls.
15. During impacted soil removal activities, record all required transportation information on an Impacted Soil Transportation Log (sample attached).
16. Collect a representative soil sample from each of the four sidewalls and one from the bottom and scan with a PID (i.e., initial surface scan and headspace determination) until excavated soils PID results fall below the project-required limit, typically 20 ppm. Sidewall samples shall be collected from a depth equal to the bottom and no higher than the middle of the pre-exhumation UST position.

**UNDERGROUND STORAGE TANK
EXCAVATION AND REMOVAL PROCEDURES**

17. Upon determining the limits of impact, collect one confirmation/verification soil sample from each of the four sidewalls and bottom of the excavation in accordance with Roux's Surface and Subsurface Soil Sampling Procedures. Sidewall samples shall be collected from a depth equal to the bottom and no higher than the middle of the pre-exhumation UST position.

If the test pit is greater than 4 feet in depth, it will not be entered for sampling. In this event, collect samples using the excavation equipment filling laboratory-provided sample containers from the center of the bucket using the stainless steel sampling equipment (i.e., spoon, spade, trowel etc.) or drive a Shelby tube or EnCore™ sampler for VOCs.

18. If excessive water enters the excavation, via perched groundwater or precipitation, it shall be purged and contained as IDW until proper disposal can be determined (i.e., pumped through granular activated carbon vessels and discharged to the sanitary sewer). The Project Manager and NYSDEC representative should be consulted upon detection of excess water to determine proper disposal methods. On the other hand, minor amounts of water within the excavation that can be sufficiently mixed with excavated soil material is an acceptable disposal method.
19. Record UST excavation observations in the Project Field Book and/or an Impacted Soil Excavation Log (sample attached). Information recorded should include:
- Physical dimension of the pit;
 - A scaled sketch of one side of the excavation showing the position of the UST and any lithologic contacts, zones of groundwater seepage, other special features (jointing, boulders, cobbles, zones of contamination, color abnormalities, etc.);
 - General information such as project number, excavation designation number, depth, date, name of responsible professional (i.e., geologist), type of excavating equipment utilized, time of excavation and

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UNDERGROUND STORAGE TANK EXCAVATION AND REMOVAL PROCEDURES

backfilling, method of collecting samples and amount of sample collected (if applicable);

- General information about the UST such as diameter, length, quantity of liquid removed, construction material etc.;
 - Rate of groundwater inflow, depth to groundwater and time of measurement, as necessary; and
 - Unified Soil Classification System (USCS) designation of each distinctive unit in accordance with **Roux's** FOP: Soil Description Procedures Using the Unified Soil Classification System (USCS).
20. Photograph the progress of UST exhumation, impacted soil excavation and clean fill backfilling, highlighting unique or important features. Use a ruler or other suitable item for scale. Include a label with the excavation designation so the developed picture will be labeled, as necessary.
21. Backfill the excavation to match the existing grade compacting in 2 to 3 foot lifts with clean fill and as directed in the Project Work Plan. Excavated soils designated as “clean” via PID scan can be placed back into the hole. The **Roux** Field Team Leader will provide direction on whether excavated soils may be used as fill, or these materials are to be containerized as investigation derived waste.

ATTACHMENTS

Tailgate Safety Meeting Form (sample)
Real Time Air Monitoring Log (sample)
Impacted Soil Excavation Log (sample)
Impacted Soil Transportation Log (sample)



**UNDERGROUND STORAGE TANK
EXCAVATION AND REMOVAL PROCEDURES**

REFERENCES

Roux FOPs:

- 006 *Calibration and Maintenance of Combustible Gas/Oxygen Meter*
- 010 *Calibration and Maintenance of Portable Flame Ionization Detector*
- 011 *Calibration and Maintenance of Portable Photoionization Detector*
- 018 *Drilling and Excavation Equipment Decontamination*
- 032 *Management of Investigation-Derived Waste (IDW)*
- 048 *Screening of Soil Samples for Organic Vapors During UST Removal Activities*
- 054 *Soil Description Procedures Using the Unified Soil Classification System (USCS)*
- 063 *Surface and Subsurface Soil Sampling Procedures*
- 073 *Real-Time Air Monitoring During Intrusive Activities*

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UNDERGROUND STORAGE TANK EXCAVATION AND REMOVAL PROCEDURES

TAILGATE SAFETY MEETING FORM

Project Name: _____ Date: _____ Time: _____
Project Number: _____ Client: _____
Work Activities: _____

HOSPITAL INFORMATION:

Name: _____
Address: _____ City: _____ State: _____ Zip: _____
Phone No.: _____ Ambulance Phone No. _____

SAFETY TOPICS PRESENTED:

Chemical Hazards: _____

Physical Hazards: _____ Slips, Trips, Falls

PERSONAL PROTECTIVE EQUIPMENT:

Activity:	Hard Hat	Eye Protection	Hand Protection	Foot Protection	Other
Activity: _____	A	B	C	D	
Activity: _____	A	B	C	D	
Activity: _____	A	B	C	D	
Activity: _____	A	B	C	D	
Activity: _____	A	B	C	D	

New Equipment: _____

Other Safety Topic (s): _____ Environment (e.g. sensitive fauna)
_____ Smoking and tobacco products is prohibited in the Exclusion Zone (EZ)

ATTENDEES

Name Printed	Signatures
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

Meeting conducted by: _____



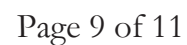
UNDERGROUND STORAGE TANK EXCAVATION AND REMOVAL PROCEDURES

Date:
 Project Name:
 Project Number:
 Project Location:
 Client:
 Purpose of Air Monitoring:

Time of Day:	A.M.	P.M.
Ambient Air Temp.:		
Wind Direction:		
Wind Speed:		
Precipitation:		

[illegible]

Prepared By: _____ Date: _____



UNDERGROUND STORAGE TANK EXCAVATION AND REMOVAL PROCEDURES

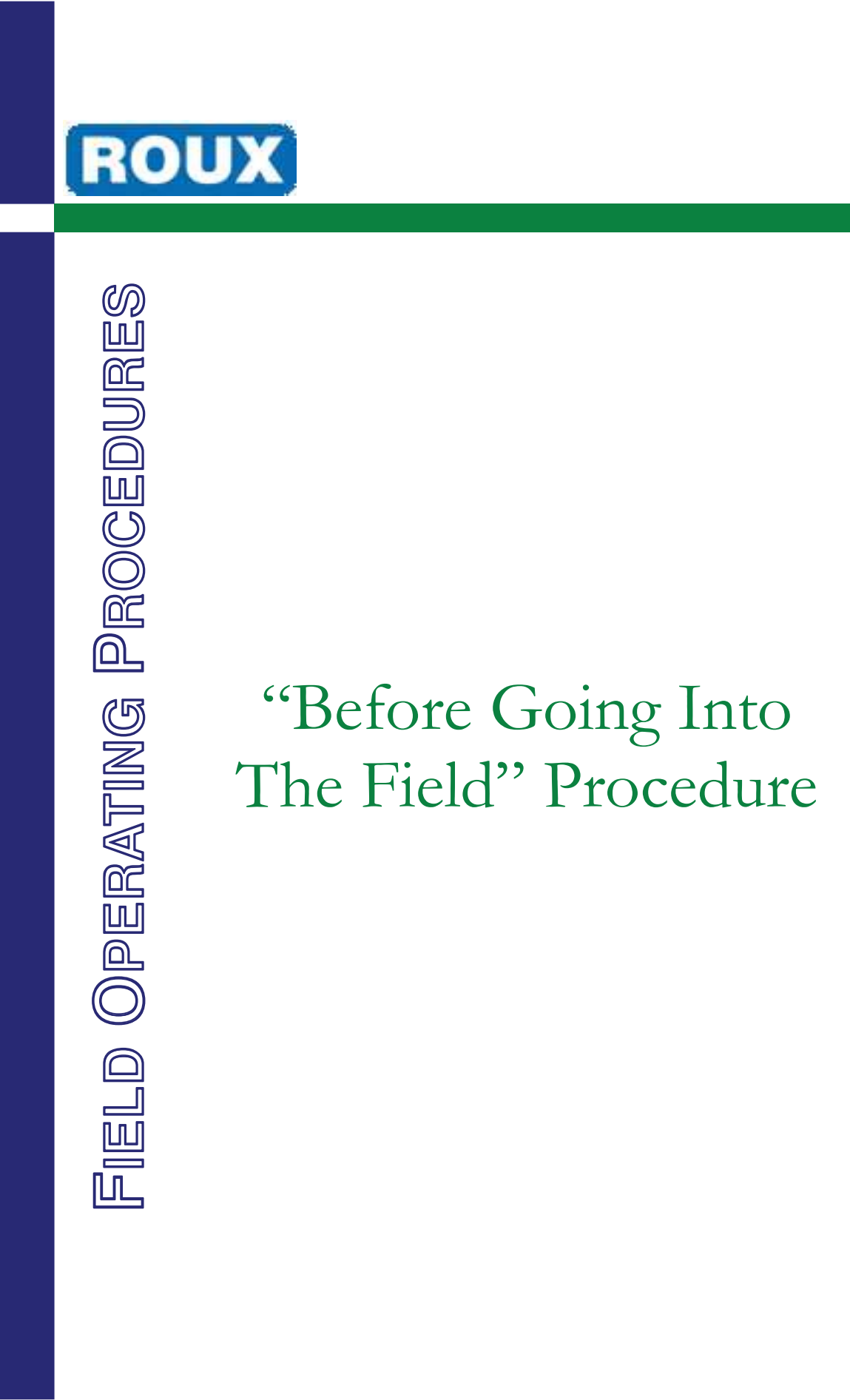
Project:	EXCAVATION ID:
Project No.:	Excavation Date:
Client:	Excavation Method:
Location:	CQA Observer:

[illegible]

UNDERGROUND STORAGE TANK EXCAVATION AND REMOVAL PROCEDURES

Date:	
Project:	Licensed Transport
Job N:	Destination:
Client:	Waste Profile No.:

PREPARED BY: _____ DATE: _____



ROUX

FIELD OPERATING PROCEDURES

“Before Going Into
The Field” Procedure

**“BEFORE & AFTER”
PROJECT PROCEDURES FOR FIELD PERSONNEL**

PURPOSE

This procedure describes the required field and office activities to be preformed “before and after” project assignments by field personnel. Field activities may include, but are not limited to, drilling oversight, excavation contractor oversight, matrix sample collection (e.g., soil, sediment, groundwater, surface water, wipe, and/or air), third party oversight, and site reconnaissance to name a few. Office activities may include, but are not limited to, photocopying field book entries, completing all field forms, tabulating collected field and laboratory data, and preparation of report text.

The primary goal of this procedure is to eliminate delays and unnecessary budgetary “strain” due to a lack of preparedness and knowledge of the site by the field team members. This procedure also seeks to streamline the preparation and transfer of field information/data from field personnel to the Project Manager upon field work completion.

PROJECT ASSIGNMENT

During the initial meeting with the Project Manager, several questions should be raised by the field team member and answered by the Project Manager. A pad of paper and pen should be in hand to record all pertinent job information. At a minimum, the following questions should be answered:

1. *What is the job number?*
2. *Who is the client and the on-site representative (if applicable)?*
3. *What is the name of the project?*
4. *What are the job responsibilities and how should they be accomplished?*
5. *How much time do I have to complete the assigned tasks?*
6. *Are there any project required documents? What are they?*

Any deviation from the above questions should be approved by the Project Manager prior to contravention, not at the end of the day or following the project completion.

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“BEFORE & AFTER” PROJECT PROCEDURES FOR FIELD PERSONNEL

“BEFORE” CHECKLISTS

Checklists should be developed and used so that all of the required steps prior to going into the field are undertaken. A good checklist will include:

- Adequate review of the documents listed in this FOP
- Any documents, equipment, and supplies presented in this FOP
- Providing adequate notification to the laboratory (so that holding times are not exceeded) and to the owner of the site and the primary regulatory agency (usually in writing) that a round of sampling is to commence in order to facilitate sampling and allow for a sampling audit or split sampling.
- Specifying and documenting the equipment maintenance and calibration undertaken prior to going into the field relative to the sampling event.
- Checking and calibrating the equipment.
- Listing the documents, equipment, and supplies required to collect samples at the site as presented in this FOP.

Prior to going into the field, sampling personnel should reacquaint themselves with the sampling plan. The review is undertaken so that the required specific protocol such as sampling from the least to the most contaminated wells, knowing where quality control samples are to be taken, knowing the disposition of purge water, etc., is understood and followed.

The amount of equipment maintenance and calibration required prior to going into the field should be clearly specified in the presampling equipment maintenance and calibration checklists, which are based on the manufacturer’s recommendations, sampling objectives, and prior experience. Maintenance and calibration performed before sampling must be



**“BEFORE & AFTER”
PROJECT PROCEDURES FOR FIELD PERSONNEL**

documented to provide evidence that the equipment was adequately maintained and calibrated and to keep a permanent record of equipment servicing and performance.

A list of all the documents, equipment, and supplies required for the sampling event should be prepared and used. It can be frustrating and time consuming to forget equipment and supplies, so some up-front preparation is warranted. The following sections provide a list of the documentation, equipment, and supplies, which should assist in preparing a site-specific equipment and supply checklist. Once prepared, the checklist and project requirements should be reviewed with the Project Manager.

“BEFORE” DOCUMENTATION SUMMARY

Prior to going into the field, the field team should review and understand all of the project documents including, but not limited to:

- The Health and Safety Plan (HASP)
- The Site Analytical Plan (SAP), Sampling Plan, or similar document
- The Quality Assurance Project Plan (QAPP)
- The Work Plan
- Project specific Field Operating Procedures and field forms
- Site Maps
- Equipment operation manuals
- Chain-of-Custody forms
- Shipping labels and custody seals
- Any reference materials (i.e., conversion tables, volume calculation, etc.). The Pocket Ref, Third Edition by Thomas Glover is a great source for the field.

If at any time, the field team does not understand the project required protocol, procedures, sample locations, etc.; the Project Manager should be consulted for clarification.

**“BEFORE & AFTER”
PROJECT PROCEDURES FOR FIELD PERSONNEL**

“BEFORE” EQUIPMENT SUMMARY

Prior to going into the field, the field team should review the following equipment checklist, noting that project specific equipment may not be included in this list:

- Water level indicator
- Pumps, sample tubing, flow controllers, power cord(s), batteries, compressors, generators, etc.
- Bailers (disposable, PVC, stainless steel, glass), rope
- Flow-through cell
- Field meters with adequate calibration solutions (pH/Eh meter, conductivity meter, dissolved oxygen meter, turbidity meter, batteries, etc.)
- Garden hose
- Explosive gas meter and/or photoionization detector (PID) with calibration supplies
- Complete set of hand tools including a sharp knife, screw drivers, pliers, hacksaw, flashlight, large pipe wrench, hammer, bolt cutters, and replacement locks
- Fish hook with weight and string
- Field filtering equipment and supplies
- Decontamination supplies, such as scrub brushes, Alconox®, distilled water, potable water, 5-gallon bucket, paper towels, aluminum foil
- 5-gallon bucket(s)
- Measuring cup
- Sample bottles/containers (with extras) and preservatives
- Stainless steel spoons, trowels, shovels
- Shipping containers (i.e., coolers)
- Clipboard
- Calculator
- Water resistant clock or watch with second hand
- First aid kit

**“BEFORE & AFTER”
PROJECT PROCEDURES FOR FIELD PERSONNEL**

“BEFORE” SUPPLIES SUMMARY

Prior to going into the field, the field team should review the following supplies checklist, noting that project specific supplies may not be included in this list:

- Laboratory grade non-phosphate detergent (Alconox®)
- Appropriate personal protective equipment appropriate to the contaminants of concern, such as nitrile gloves, Tyvek, boots, hardhat, safety glasses, hearing protection, etc.
- Bags of ice
- Plastic garbage bags
- Plastic sheeting
- Sufficient quantities of potable and laboratory grade deionized water for cleaning and equipment blanks
- Methanol
- Isopropyl alcohol
- Clean rags and paper towels
- Electrical tape, duct tape, and wide transparent tape
- Hand soap
- Regular, ballpoint, and indelible pens
- Hollow braid polyethylene rope

After providing adequate notification (lab, state and/or federal agencies), performing the presampling maintenance and calibration, obtaining the site and well keys, and packing the supplies and equipment, the field activities are ready to be performed.

“AFTER” – PROJECT FILE REVIEW & CREATION

It is the responsibility of each field crew member to review his/her own field notes and time sheet for accuracy and completeness. All errors to the field notes should be corrected, dated, and initialed for Project Manager review. Once reviewed by the field team member, the Project Field Book, all field forms, photographs, chain-of-custodies etc. must be

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“BEFORE & AFTER” PROJECT PROCEDURES FOR FIELD PERSONNEL

photocopied, scanned (if required), downloaded, etc. and then given to the Project Manager in an organized file folder in a timely manner. Avoiding delay during this step is critical, especially when there are severe time constraints for the project.

REFERENCES

1. Wilson, Neal. *Soil Water and Ground Water Sampling*, 1995





FIELD OPERATING PROCEDURES

Geoprobe Drilling Procedures

GEOPROBE DRILLING PROCEDURES

PURPOSE

This guideline presents a method for direct-push drilling a borehole through unconsolidated materials, including soils or overburden.

PROCEDURE

The following procedure will be used to drill a borehole for sampling and/or well installation, using direct-push methods and equipment.

1. Follow **Roux's** Field Operating Procedure (FOP) for Drill Site Selection Procedure prior to implementing any drilling activity.
2. Perform drill rig safety checks with the driller by completing the Drilling Safety Checklist form (sample attached).
3. Conduct tailgate health and safety meeting with project team and drillers by completing the Tailgate Safety Meeting Form (sample attached).
4. Calibrate air-monitoring equipment in accordance with the appropriate **Roux's** FOPs or manufacturers recommendations.
5. Ensure all drilling equipment (i.e., rods, 4-foot sampler, dedicated PVC sleeves) appear clean and free of soil prior to initiating any subsurface intrusion. Decontamination of drilling equipment should be in accordance with **Roux's** Drilling and Excavation Equipment Decontamination Procedures FOP.
6. Mobilize the Geoprobe™ rig to the site and position over the borehole.
7. Level and stabilize the rig and recheck the rig location against the planned drilling location.

GEOPROBE DRILLING PROCEDURES

8. Fully advance the sampler into the subsurface using an ATV-mounted direct-push Geoprobe™ drill rig and 1.5-inch diameter sampler, typically 4-feet in length and fitted with a dedicated PVC sleeve, for each four-foot core of soil.
9. Retrieve the 4-foot sample core from the driller, place on a piece of polyethylene tarp, and cut open using a sharp utility knife.
10. Visually characterize each 4-foot soil core using the Unified Soil Classification System (USCS) in accordance with **Roux's** Soil Description Procedures Using the USCS FOP.
11. Scan each 4-foot core for total volatile organic vapors with a calibrated Photovac 2020 PID equipped with a 10.6 eV lamp, and report any visual and/or olfactory observations. Record PID scan measurements in the Project Field Book and appropriate field forms.
12. If required, collect a representative soil sample for headspace determinations. In general, soil samples representative of each 4-foot core interval are collected, placed in a sealable plastic bag, and kept at or near room temperature (approximately 65-70° F) for a minimum of 15 minutes prior to measurement. Record PID headspace determination measurements in the Project Field Book and appropriate field forms.
13. Check sampler and rods periodically during drilling to ensure the boring is plumb. Adjust rig position as necessary to maintain plumb.
14. Continue drilling until reaching the assigned total depth, or until sampler refusal occurs. Sampler refusal is when the drilling penetration drops below 0.1 feet per 2 minutes, with the full weight of the rig on the sampler.
15. Plug and abandon boreholes not used for temporary well installation in accordance with **Roux's** Field Operating Procedure for Abandonment of Borehole. Boreholes to be used as temporary wells should be completed in accordance with **Roux's** Temporary Well (Piezometer) Construction Procedures FOP.

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GEOPROBE DRILLING PROCEDURES

16. Decontaminate all non-dedicated drilling tools between boring locations using potable tap water and a phosphate-free detergent (i.e., Alconox™) in accordance with **Roux's** Drilling and Excavation Equipment Decontamination Procedures FOP.

OTHER PROCEDURAL ISSUES

- Borings will not be over drilled (rat holed) without the express permission of the **Roux** field supervisor. All depth measurements should be accurate to the nearest 0.1 foot, to the extent practicable.
- Potable water may be placed in the sampler stem if critically necessary for borehole control or to accomplish sampling objectives. This will be performed only with the express permission of the **Roux** field supervisor.

ATTACHMENTS

Drilling Safety Checklist (sample)
Tailgate Safety Meeting Form (sample)

REFERENCES

Roux FOPs:

- 001 *Abandonment of Borehole Procedures*
- 017 *Drill Site Selection Procedure*
- 018 *Drilling and Excavation Equipment Decontamination Procedures*
- 054 *Soil Description Procedures Using the USCS*
- 077 *Temporary Well (Piezometer) Construction Procedures*



GEOPROBE DRILLING PROCEDURES

DRILLING SAFETY CHECKLIST

Project: **Supplemental Phase II RFI/ICMs**

Date:

Project No.: **0041-009-500**

Drilling Company:

Client: **RealCo., Inc.**

Drill Rig Type:

ITEMS TO CHECK	OK	ACTION NEEDED
"Kill switches" installed by the manufacturer are in operable condition and all workers at the drill site are familiar with their location and how to activate them?		
"Kill switches" are accessible to workers on both sides of the rotating stem? NOTE: Optional based on location and number of switches provided by the manufacturer.		
Cables on drill rig are free of kinks, frayed wires, "bird cages" and worn or missing sections?		
Cables are terminated at the working end with a proper eye splice, either swage coupling or using cable clamps?		
Cable clamps are installed with the saddle on the live or load side? Clamps should be alternated and should be of the correct size and number for the cable size to which they are installed. Clamps are complete with no missing parts?		
Hooks installed on hoist cables are the safety type with a functional latch to prevent accidental separation?		
Safety latches are functional and completely span the entire throat of the hook. They have positive action to close the throat except when manually opened to disconnect a load?		
Drive shafts, belts, chain drives and universal joints are properly guarded to prevent accidental insertion of hands and fingers or tools?		
Outriggers shall be extended prior to and while the rig is used on a grade. Hydraulic outriggers must maintain pressure to keep the rig level and stabilize the drill rig even while unattended.		
Outriggers shall be properly supported and sunk into the ground to prevent settling into the soil.		
Controls are properly labeled and have freedom of movement. Controls should not be blocked or locked in any position.		
Safeties on any device shall be properly maintained.		
Controls shall be operated smoothly and carefully and lifting devices shall not be jerked or operated erratically to overcome resistance.		
Slings, chokers and lifting devices are inspected before using and are in proper working order? Damaged units are removed from service and are properly tagged?		
Shackles and clevises are in proper working order and pins and screws are fully inserted before placing under a load?		
High-pressure hoses have a safety (chain, cable or strap) at each end of the hose section to prevent whipping in the event of a failure?		
Rotating parts of the drill string shall be free of sharp projections or hooks, which could entrap clothing or foreign objects?		
Wire ropes should not be allowed to bend around sharp edges without cushion material.		
The exclusion zone is centered over the borehole and the radius is equal or greater than the boom height?		

ITEMS TO CHECK	OK	ACTION NEEDED
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FOP 078.0

GEOPROBE DRILLING PROCEDURES

DRILLING SAFETY CHECKLIST

Project: **Supplemental Phase II RFI/ICMs**

Date:

Project No.: **0041-009-500**

Drilling Company:

Client: **RealCo., Inc.**

Drill Rig Type:

ITEMS TO CHECK	OK	ACTION NEEDED
The work area around the borehole shall be kept clear of trip hazards and walking surfaces should be free of slippery material.		
Workers shall not proceed higher than the drilling deck without a fall restraining device and must attach the device in a manner to restrict fall to less than 6 feet.		
A fire extinguisher of appropriate size shall be immediately available to the drill crew. The drill crew shall have received annual training on proper use of the fire extinguisher.		
29 CFR 1910.333 © (3) Except where electrical distribution and transmission lines are energized and visibly grounded, drill rigs will be operated proximate to, under, by, or over power lines only in accordance with the following: 1910.333 © (3) (ii) 50 kV or less - minimum clearance is 10 feet For 50 kV or over - 10ft. Plus ½ in. For each additional 10kV. Roux Policy: Maintain 20 feet clearance		
29 CFR 1910.333 © (3) (iii) While the rig is in operation, the minimum clearance from energized power lines will be maintained as follows: Less than 50 kV - 4 feet 50 to 365 kV - 10 feet 365 to 720 kV - 16 feet		

Name: _____ (printed)

Signed: _____ Date: _____



FOP 078.0

GEOPROBE DRILLING PROCEDURES

TAILGATE SAFETY MEETING FORM

Project Name: _____ Date: _____ Time: _____
Project Number: _____ Client: _____
Work Activities: _____

HOSPITAL INFORMATION:

Name: _____
Address: _____ City: _____ State: _____ Zip: _____
Phone No.: _____ Ambulance Phone No. _____

SAFETY TOPICS PRESENTED:

Chemical Hazards: _____

Physical Hazards: _____ Slips, Trips, Falls

PERSONAL PROTECTIVE EQUIPMENT:

Activity:	Head	Eye	Hand	Foot	Other
Activity: _____	A	B	C	D	
Activity: _____	A	B	C	D	
Activity: _____	A	B	C	D	
Activity: _____	A	B	C	D	
Activity: _____	A	B	C	D	

New Equipment: _____

Other Safety Topic (s): _____

_____ (aggressive fauna)

_____ tobacco products is prohibited in the Exclusion Zone (EZ)

ATTENDEES

Name Printed	Signatures
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

Meeting conducted by: _____





FIELD OPERATING PROCEDURES

Stockpile Sampling
Procedures for
Chemical Analysis

**STOCKPILE SAMPLING PROCEDURES
FOR CHEMICAL ANALYSIS**

PURPOSE

This guideline presents a method for collecting representative soil samples from stockpiled borrow source material for chemical analysis.

GENERAL

In general, off-site soil that is brought to a Site for use as supplemental fill is subject to Quality Assurance sampling and analysis. If QA is required, all off-site soil proposed for use as Site backfill shall be documented by the subcontractor in writing to have originated from locations having no evidence of disposal or release of hazardous, toxic or radioactive substances, wastes or petroleum products. If the subcontractor designates a source as “virgin” soil, it shall be further documented in writing to be native soil material having not supported any known past industrial or commercial development or agricultural use. Borrow soils can be used as backfill once concentrations are confirmed to meet project designated criteria for the Constituents of Primary Concern (COPCs) and NYSDEC TAGM HWR-94-4046 recommended soil cleanup objectives (SCOs) or NYSDEC 6NYCRR Part 375 SCOs.

Sample collection equipment will include stainless steel mixing bowls, stainless steel mixing spoons, and a stainless steel hand auger with extension rods or a stainless steel spade or equivalent. It may be necessary to use a backhoe or drilling rig to facilitate sample collection.

**STOCKPILE SAMPLING PROCEDURES
FOR CHEMICAL ANALYSIS**

SAMPLING PLAN

1. Virgin Sources – Virgin borrow sources will be confirmed acceptable for use as site backfill through collection of a single composite soil sample representative of the borrow pit or stockpile.
2. Non-Virgin Sources – Prior to sampling, determine the amount of soil that will be sampled. The soil will be tested via collection of one composite sample per 250 cubic yards of material from each source area. If more than 1,000 cubic yards of soils are excavated from a given off-site source area and all samples of the first 1,000 cubic yards meet project designated criteria, the sample collection frequency may be reduced to one composite for each additional 1,000 cubic yards of soils from the same source area, up to 5,000 cubic yards. For borrow sources greater than 5,000 cubic yards, sampling frequency may be reduced to one sample per 5,000 cubic yards, providing all earlier samples meet project designated criteria. Sampling procedure for non-virgin sources is described in the next section.

SAMPLE COLLECTION AND HANDLING

The following procedure will be used to collect representative soil samples from a non-virgin soil stockpile.

1. Using a stainless steel spade (or hand auger), a backhoe, or drilling rig, penetrate the pile to a depth of approximately 2 to 3 feet and collect four (4) representative grab samples of approximate equal volume from the top, middle, and bottom.
2. Transfer each grab into a small stainless steel mixing bowl.
3. **VOC Analysis:** Using a clean stainless steel spoon, transfer equal amounts from each small mixing bowl into a laboratory-supplied, 4 oz. VOC sample jar. This should be performed by randomly transferring several small aliquots from each bowl, taking care to minimize disturbance of the soil.

**STOCKPILE SAMPLING PROCEDURES
FOR CHEMICAL ANALYSIS**

4. **Other COPCs:** Transfer equal aliquots from each small bowl into a large mixing bowl and homogenize the sample. Fill the remaining laboratory-supplied jars with the homogenized soil for all other project required COPCs (i.e., SVOCs, PCBs, Pesticides, Herbicides, inorganics, etc.).
5. Label each set of jars with the following information:
 - Project and site name
 - Sample Code
 - Project Number
 - Date/Time
 - Sample type (soil composite or grab)
 - Sampler's initials
 - Sample Preservation
 - Required analysis

The sample code will consist of a unique, alphanumeric identification code keyed to the sampling location. Identify the sampling location on a field sketch.

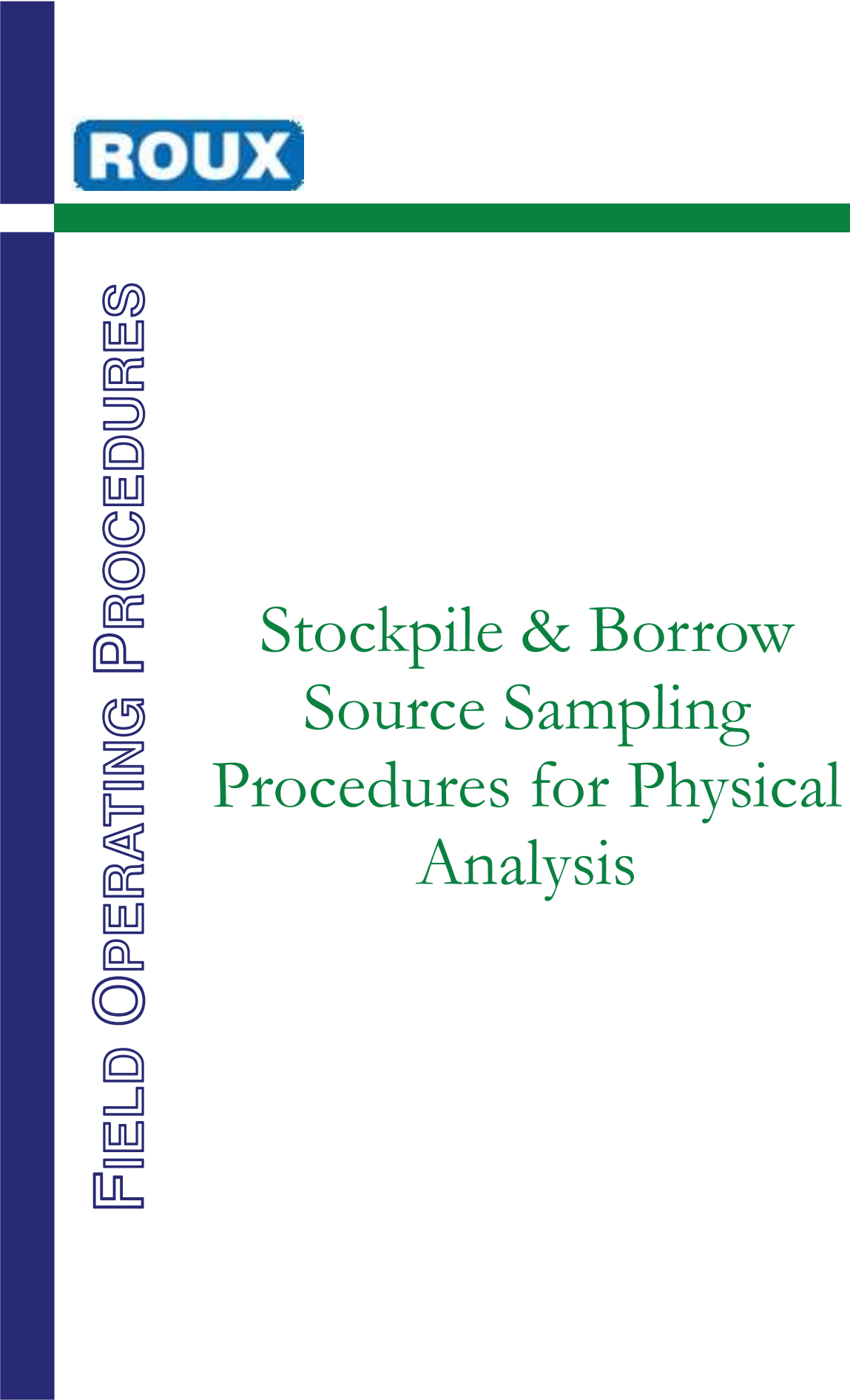
6. Record all information associated with sample collection in the Project Field Book.
7. Label, store, and ship the samples in accordance with the Roux Field Operating Procedure for Sample Labeling, Storage and Shipment Procedures.
8. Clean the sampling and mixing equipment with Alconox and deionized water and repeat steps 1 through 7 for the remaining samples.

REFERENCES

Roux FOPs:

046 *Sample Labeling, Storage and Shipment Procedures*





ROUX

FIELD OPERATING PROCEDURES

Stockpile & Borrow
Source Sampling
Procedures for Physical
Analysis

**STOCKPILE & BORROW SOURCE SAMPLING PROCEDURES
FOR PHYSICAL ANALYSIS**

PURPOSE

This guideline presents a method for collecting representative soil samples from stockpiled borrow source material for physical analysis.

GENERAL

Generally, one of two methods will be utilized to collect soil samples for analysis. One method is to collect the samples by digging a series of representative test pits at the borrow source area and obtaining samples from those test pits. The other method involves collecting samples from representative stockpiles (normally after the material has been mechanically screened). Both procedures are discussed within this method.

Sample collection equipment will include stainless steel mixing bowls, stainless steel mixing spoons, and a stainless steel hand auger with extension rods or a stainless steel spade or equivalent. It may be necessary to use a backhoe or drilling rig to facilitate sample collection.

STOCKPILED SOIL SAMPLING METHOD

As shown in the attached Figure 1, twelve (12) samples of approximate equal volume should be collected from the top, middle and bottom of each 1000 CY stockpile by CQA personnel and composited in the field to give one representative aliquot per 1000 CY.

Stockpile Sampling Procedure

1. Using a shovel or backhoe, penetrate the pile to a depth of about two to three feet.
2. Collect a sample using the shovel.



**STOCKPILE & BORROW SOURCE SAMPLING PROCEDURES
FOR PHYSICAL ANALYSIS**

3. Transfer the sample to a specially prepared mixing area.
4. Repeat Steps 1 through 3 at each 1,000 CY stockpile.
5. Mix subsamples using shovel into one homogenous mass and place in a properly labeled 5-gallon bucket. Fill each bucket completely and cover.
6. Attach a label to each container and record location referencing the stockpile identification number. The label may be made with permanent marker on the side (not top) of the container or using adhesive-back paper labels affixed to the side of the container. At a minimum, the labels should be identified with the following information:
 - Project Name
 - Sample number.
 - Initials of CQA inspector or sample collection personnel.
 - Date of collection.
 - Location of collection (i.e. stockpile I.D.)
7. Return remaining contents of composite sample to stockpile.
8. Deliver the samples to the laboratory for analysis as soon as possible.
9. All information pertinent to each sampling event should be recorded by sampling personnel in the field at the time of sample collection. Each report should correspond to each stockpile and will contain the following information:
 - Project Name
 - Sample number or numbers collected
 - Field observations.
 - Climatologic conditions.
 - Date and time of collection.
 - Approximate location of test pit.
 - Name of person who collected sample.

BORROW AREA TEST PIT SAMPLING METHOD

Prior to obtaining representative soil samples, test holes should be excavated at the borrow area to determine the actual depth and lateral extent of the borrow source soil material. A base line should then be established and a grid system staked in the field. Five samples

**STOCKPILE & BORROW SOURCE SAMPLING PROCEDURES
FOR PHYSICAL ANALYSIS**

should be collected at equidistant locations for each 5000 cubic yards (CY) of soil designated for use in the borrow areas (at approximately mid-depth).

Borrow Area Sampling Procedure

1. Using a shovel, collect a representative sample at approximately mid-depth at each of the sampling locations representing 1000 CY of the proposed excavation area.
2. Transfer each sample into a labeled separate 5-gallon bucket. Fill each bucket completely and cover.
3. Attach a label to each container and record location referencing the established grid system in the borrow area. The label may be made with permanent marker on the side (not top) of the container or using adhesive-back paper labels affixed to the side of the container. At a minimum, the labels should be identified with the following information:
 - Project Name
 - Sample number.
 - Initials of CQA inspector or sample collection personnel.
 - Date of collection.
 - Location of collection (i.e. location of borrow area grid system location)
4. Deliver the samples to the laboratory for analysis as soon as possible.
5. All information pertinent to each sampling event should be recorded by sampling personnel in the field at the time of sample collection. Each report should correspond to each test pit and will contain the following information:
 - Project Name
 - Sample number or numbers collected
 - Field observations.
 - Climatologic conditions.
 - Date and time of collection.
 - Approximate location of test pit.
 - Name of person who collected sample.

ATTACHMENTS

Figure 1; Stockpile Sampling Methodology



FOP 080.0

**STOCKPILE & BORROW SOURCE SAMPLING PROCEDURES
FOR PHYSICAL ANALYSIS**

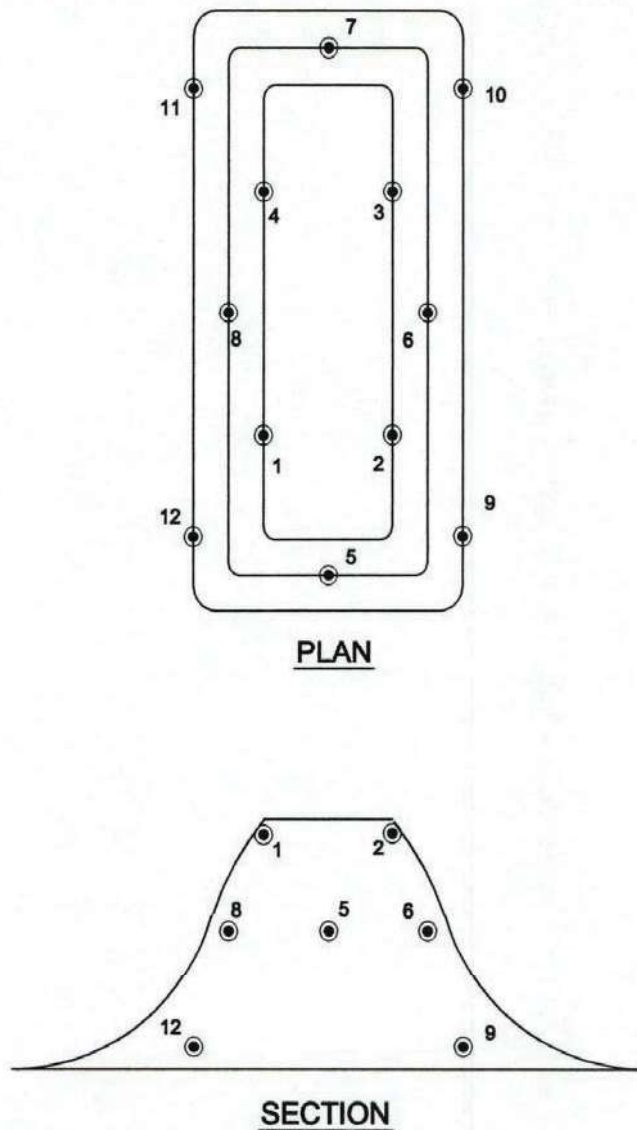
REFERENCES

None

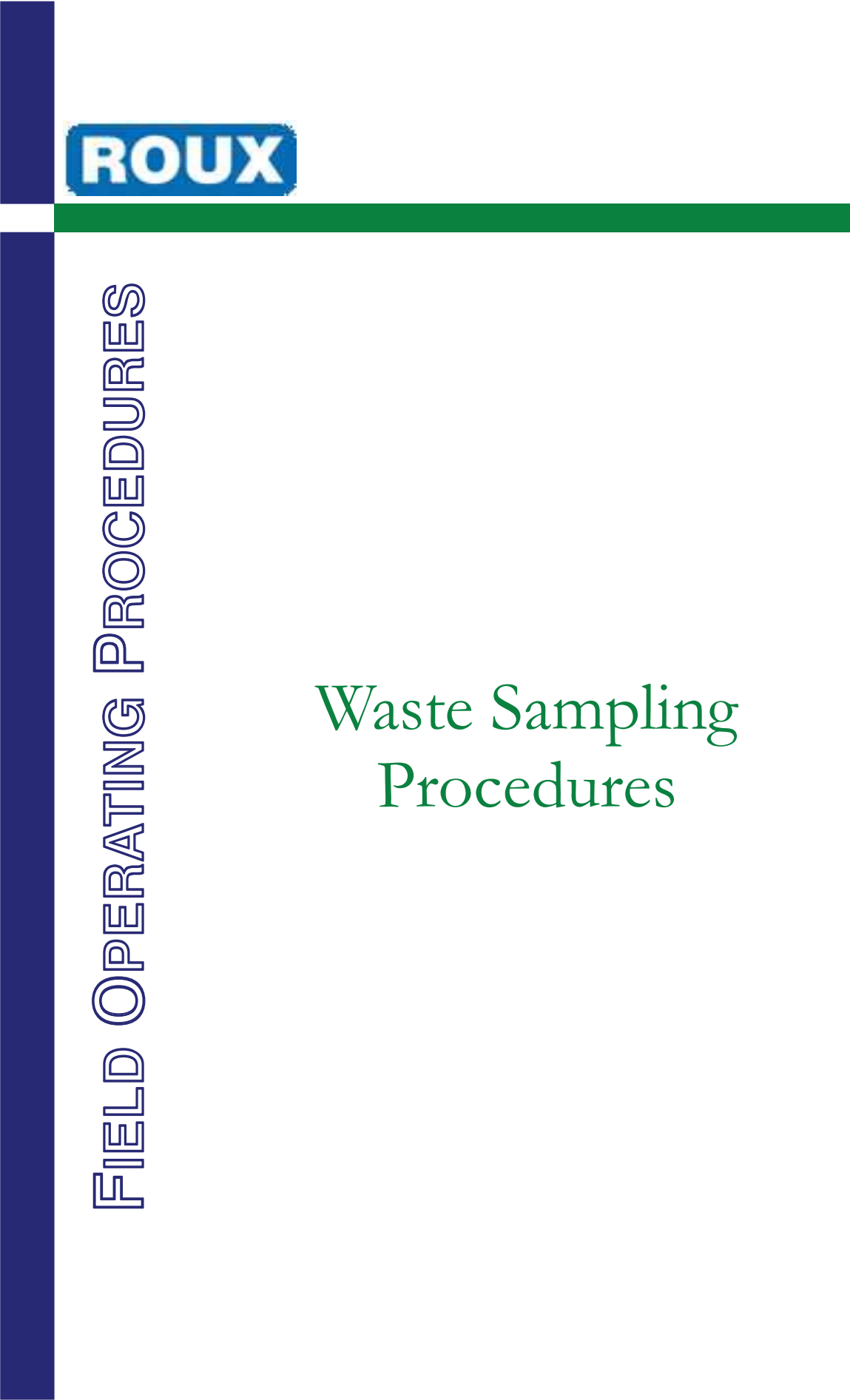


STOCKPILE & BORROW SOURCE SAMPLING PROCEDURES
FOR PHYSICAL ANALYSIS

FIGURE 4
1,000 CY STOCKPILE SAMPLING METHODOLOGY



Note: All locations are approximate and for illustration only.



ROUX

FIELD OPERATING PROCEDURES

Waste Sampling Procedures

WASTE SAMPLING PROCEDURES

PURPOSE

This guideline describes the equipment and procedures that can safely be used to collect waste samples from open and closed units.

INTRODUCTION

Hazardous wastes are regulated by the USEPA under 40 CFR Parts 260-265. Therefore, many of the methods that are used to manage, store, treat, and dispose hazardous wastes and potential hazardous wastes are of concern to both the regulators and the regulated community. Samples are often required of regulated or potentially regulated materials. While it is understood that each facility and waste stream may present its own unique sampling and analytical challenges, this procedure will list equipment and enumerate procedures that have been used by the USEPA to safely and successfully sample specific waste units.

SAFETY

Sampling of waste units should be assessed for potential hazards by both the Project Manager (PM) and the site safety officer (SSO). It is the SSOs responsibility to enforce the site Health and Safety Plan (HASP), and to ensure that procedures used during waste sampling are in accordance with current company protocol. Sampling equipment contaminated during waste sampling investigations should be cleaned with laboratory detergent and rinsed with tap water prior to returning the equipment from the field. Contaminated sampling equipment that is to be discarded must be disposed of properly in accordance with the site-specific Work Plan.

It should be noted that although **Roux** does not readily perform field activities with highly hazardous materials, we do occasionally oversee contractors who do. Therefore, it is prudent on our part to recognize those situations and be prepared to ensure the activities of



WASTE SAMPLING PROCEDURES

our subcontractors comply with the site-specific HASP as well as those procedures discussed herein. Any reference within this procedure to personal protective equipment (PPE) upgrades above a modified level C (i.e., Tyvek, nitrile gloves, and full-face respirator) relates solely to our subcontractors.

QUALITY CONTROL PROCEDURES

In some instances, special decontamination procedures will be necessary and should be developed on a case-by-case basis according to the specific material encountered. Any cleaning procedures and equipment repairs conducted in the field deviating from those specified in the associated FOPs or the site-specific Work Plan, should be discussed with the Project Manager, and thoroughly documented in the Project Field Book.

All air monitoring and field analytical/screening equipment (i.e., photoionization detectors) should be checked and calibrated per manufacturer's specifications before being used to collect any waste stream unit sample (open or closed). The Field Team Leader should record all calibration results on appropriate field forms.

WASTE UNIT TYPES

Waste management units can be generally categorized into two types: open and closed. In general, open units are larger than closed units and include waste piles and surface impoundments whereas closed units include containers and tanks as well as ancillary tank equipment. Besides containers and tanks, sumps may also be considered closed units because they are designed to collect the spillage of liquid wastes and are sometimes configured as a confined space.

Although both may pose hazards, units that are open to the environment are generally less hazardous than closed units. Sampling of closed units is considered a higher hazard risk

WASTE SAMPLING PROCEDURES

because of the potential of exposure to toxic gases and flammable/explosive atmospheres. Because closed units prevent the dilution of the wastes by environmental influences, they are more likely to contain materials that have concentrated levels of hazardous constituents. While opening closed units for sampling purposes, investigators/contractor's shall use Level B PPE, air monitoring instruments to ensure that the working environment does not contain hazardous levels of flammable/explosive gasses or toxic vapors, and follow the appropriate safety requirements stipulated in the site-specific HASP.

Buried waste materials should be located and excavated with extreme caution. Once the buried waste is uncovered, the appropriate safety and sampling procedures utilized will depend on the type of waste unit.

Open Units

While open units may contain many types of wastes and come in a variety of shapes and sizes, they can be generally regarded as either waste piles or surface impoundments.

Definitions of these two types of open units from 40 CFR Part 260.10 are:

- Waste pile -- any non-containerized accumulation of solid, non-flowing hazardous waste that is used for treatment or storage and that is not a containment building.
- Surface impoundment -- "...a facility or part of a facility which is a natural topographic depression, man-made excavation, or diked area formed primarily of earthen materials (although it may be lined with man-made materials), which is designed to hold the accumulation of liquid wastes or wastes containing free liquids, and which is not an injection well. Examples of surface impoundments are holding, storage, settling and aeration pits, ponds, and lagoons."

One of the distinguishing features between waste piles and surface impoundments is the state of the waste. Waste piles typically contain solid or non-flowing materials whereas liquid wastes are usually contained in surface impoundments. The nature of the waste will also determine the mode of delivering the waste to the unit. Wastes are commonly pumped

WASTE SAMPLING PROCEDURES

or gravity fed into impoundments while heavy equipment or trucks may be used to dump wastes in piles. Once the waste has been placed in an open unit, the state of the waste may be altered by environmental factors (e.g., temperature, precipitation, etc.).

Surface impoundments may contain several phases such as floating solids, liquid phase(s), and sludges. Waste piles are usually restricted to solids and semi-solids. All of the potential phases contained in a waste unit should be considered in developing the sample design to meet the study's objective.

Closed Units

There are a variety of designs, shapes, sizes, and functions of closed units. In addition to the challenges of the various designs and the safety requirements for sampling them, closed units are difficult to sample because they may contain liquid, solid, semi-solid/sludge, or any combination of phases. Based on the study's design, it may be necessary to obtain a cross sectional profile of the closed unit in an attempt to characterize the unit. The following are definitions of types of closed waste units described in 40 CFR Part 260.10:

- Container-- any portable device in which a material is stored, transported, treated, disposed, or otherwise handled. Examples of containers are drums, overpacks, pails, totes, and roll-offs.
- Tank-- a stationary device, designed to contain an accumulation of hazardous waste constructed primarily of non-earthen materials, which provide structural support.

Portable tanks, tank trucks, and tank cars vary in size and may range from simple to extremely complex designs. Depending on the unit's design, it may be convenient to consider some of these storage units as tanks for sampling purposes even though they meet the definition of a container.

WASTE SAMPLING PROCEDURES

- Ancillary equipment (tank)-- any device including, but not limited to, such devices as piping, fittings, flanges, valves, and pumps that is used to distribute, meter, or control the flow of hazardous waste from its point of generation to a storage or treatment tank(s), between hazardous waste storage and treatment tanks to a point of disposal on-site, or to a point of shipment for disposal off-site.
- Sump-- any pit or reservoir that meets the definition of a tank and those troughs/trenches connected to it that serve to collect hazardous wastes.

Note: some outdoor sumps may be considered open units/surface impoundments.

Although any of the closed units may not be completely sealed and may be partially open to the environment, the unit needs to be treated as a closed unit for sampling purposes until a determination can be made. Once a closed unit is opened, a review of the proposed sampling procedures and level of protection can be performed to determine if the (PPE) is suitable for the site conditions.

Samples collected from different waste units should not be composited into one sample container without additional analytical and/or field screening data to determine if the materials are compatible and will not cause an inadvertent chemical reaction.

EQUIPMENT

Selecting appropriate equipment to sample wastes is a challenging task due to the uncertainty of the physical characteristics and nature of the wastes. It may be difficult to separate, homogenize and/or containerize a waste due to its physical characteristics (viscosity, particle size, etc.). In addition, the physical characteristics of a waste may change with temperature, humidity, or pressure. Waste streams may vary depending on how and when a waste was generated, how and where it was stored/disposed, and the conditions under which it was

WASTE SAMPLING PROCEDURES

stored/disposed. Also, the physical location of the wastes or the unit configuration may prevent the use of conventional sampling equipment.

Given the uncertainties that a waste may present, it is desirable to select sampling equipment that will facilitate the collection of samples that will meet the study's objective, and that will not unintentionally bias the sample by excluding some of the sample population that is under consideration. However, due to the nature of some waste matrices or the physical constraints of some waste units, it may be necessary to collect samples knowing that a portion of the desired population was omitted due to limitations of the equipment. Any deviations from the study plan or difficulties encountered in the field concerning sample collection that may have an effect on the study's objective should be documented in a log book, reviewed with the analytical data, and presented in the report.

WASTE SAMPLING EQUIPMENT

Waste sampling equipment should be made of non-reactive materials that will neither add to nor alter the chemical or physical properties of the material that is being sampled. The attached Table 1 lists some conventional equipment for sampling waste units/phases and some potential limitations of the equipment. Another reference for selecting sampling equipment is the ASTM, Standard Guide for Selection of Sampling Equipment for Wastes and Contaminated Media Data Collection Activities, D6232-98.

WASTE SAMPLING PROCEDURES

Waste Piles

Waste piles vary in size, shape, composition, and compactness, and may vary in distribution of hazardous constituents and characteristics (strata). These variables will affect safety and access considerations. The number of samples, the type of sample(s), and the sample location(s) should be based on the study's objectives. Commonly used equipment to collect

WASTE SAMPLING PROCEDURES

samples from waste piles are listed in Table 1. All equipment should be compatible with the waste and should have been cleaned to prevent any cross contamination of the sample.

Surface Impoundments

Surface impoundments vary in size, shape, and waste content, and may vary in distribution of hazardous constituents and characteristics (strata). The number of samples, the type of sample(s), and the sample location(s) should be based on the study's objectives. Commonly used equipment to collect samples from surface impoundments are listed in Table 1. All equipment should be compatible with the waste and should have been cleaned to prevent any cross contamination of the sample.

Because of the potential danger of sampling waste units suspected of containing elevated levels of hazardous constituents, personnel should never attempt to sample surface impoundments used to manage potentially hazardous wastes from a boat. All sampling should be conducted from the banks or piers of surface impoundments. Any exception must be approved by the appropriate site safety officer and/or the Occupational Health and Safety Designee (OHSD).

Drums

Drums are the most frequent type of containers sampled by field investigators for chemical analyses and/or physical testing. Caution should be exercised by the field investigators when sampling drums because of the potential presence of explosive/flammable gases and/or toxic vapors. Therefore, the following procedures should be used when collecting samples from drums of unknown material:

1. Visually inspect all drums that are being considered for sampling for the following:
 - pressurization (bulging/dimples);
 - crystals formed around the drum opening;
 - leaks, holes, stains;

WASTE SAMPLING PROCEDURES

- labels, markings;
- composition and type (steel/poly and open/bung);
- condition, age, rust
- sampling accessibility

Drums showing evidence of pressurization and crystals should be furthered assessed to determine if remote drum opening is needed. If drums cannot be accessed for sampling, heavy equipment is usually necessary to stage drums for the sampling activities. Adequate time should be allowed for the drum contents to stabilize after a drum is handled.

2. Identify each drum that will be opened (e.g., paint sticks, spray paint, cones, etc).

LEVEL "B" PROTECTION IS REQUIRED FOR THE FOLLOWING PROCEDURES.

3. Before opening, ground each metal drum that is not in direct contact with the earth using grounding wires, alligator clips, and a grounding rod or metal structure. If a metal drum is in an overpack drum, the metal drum should be grounded.
4. Touch the drum opening equipment to the bung or lid and allow an electrical conductive path to form. Slowly remove the bung or drum ring and/or lid with spark resistant tools (brass/beryllium).
5. Screen drums for explosive gases and toxic vapor with air monitoring instruments as bung or drum lid is removed. Depending on site conditions screen for one or more of the following:
 - radioactivity
 - cyanide fumes
 - halogen vapors
 - pH
 - flash point (requires sample for testing)

Note the state, quantity, phases, and color of the drum contents. Record all relevant results, observations, and information in a logbook.

WASTE SAMPLING PROCEDURES

6. Select the appropriate sampling equipment based on the state of the material and the type of container. Sampling equipment should be made of non-reactive materials that will meet the study's objective(s).
7. Place oil wipe (as necessary), sampling equipment, and sample containers near drum(s) to be sampled.

AIR MONITORING FOR TOXIC VAPORS AND EXPLOSIVE GASES AND OXYGEN DEFICIENT ATMOSPHERES SHOULD BE CONDUCTED DURING DRUM SAMPLING.

Liquids -- Slowly lower the COLIWASA or drum thief to the bottom of the container. Close the COLIWASA with the inner rod or create a vacuum with the sampler's gloved thumb on the end of the thief and slowly remove the sampling device from the drum. Release the sample from the device into the sample container. Repeat the procedure until a sufficient sample volume is obtained.

Solids/Semi-Solids -- Use a push tube, bucket auger, or screw auger or if conditions permit a pneumatic hammer/drill to obtain the sample. Carefully use a clean stainless steel spoon to place the sample into container(s) for analyses.

8. Close the drums when sampling is complete. Segregate contaminated sampling equipment and investigative derived wastes (IDW) containing incompatible materials as determined by the drum screening procedure (Step #5). At a minimum, contaminated equipment should be cleaned with laboratory detergent and rinsed with tap water prior to returning it from the field.

Tanks

Sampling tanks is considered hazardous due to the potential for them to contain large volumes of hazardous materials and therefore, appropriate safety protocols must be followed. Unlike drums, tanks may be compartmentalized or have complex designs.

WASTE SAMPLING PROCEDURES

Preliminary information about the tank's contents and configuration should be reviewed prior to the sampling operation to ensure the safety of sampling personnel and that the study's objectives can be achieved.

In addition to having discharge valves near the bottom of tanks and bulk storage units, most tanks have hatches at the top. It is desirable to collect samples from the top hatch because of the potential for the tank's contents to be stratified. Additionally, when sampling from the discharge valve, there is a possibility of a stuck or broken valve which could cause an uncontrolled release. Investigators should not utilize valves on tanks or bulk storage devices unless they are operated by the owner or operator of the facility, or a containment plan is in place should the valve stick or break. If the investigator must sample from a tank discharge valve, the valving arrangement of the particular tank must be clearly understood to insure that the compartment(s) of interest is sampled.

Because of the many different types of designs and materials that may be encountered, only general sampling procedures that outline sampling a tank from the top hatch are listed below:

1. All relevant information concerning the tank such as the type of tank, the tank capacity, markings, condition, and suspected contents should be documented in a logbook.
2. The samplers should inspect the ladder, stairs, and catwalk that will be used to access the top hatch to ensure that they will support the samplers and their equipment.

LEVEL "B" PROTECTION IS REQUIRED FOR THE FOLLOWING PROCEDURES.

3. Before opening, ground each metal tank using grounding wires, alligator clips, and a grounding rod or metal structure.

WASTE SAMPLING PROCEDURES

4. Any vents or pressure release valves should be slowly opened to allow the unit to vent to atmospheric pressure. Air monitoring for explosive/flammable gases and toxic vapors should be conducted during the venting with the results recorded in a log book. If dangerous concentrations of gases evolve from the vent or the pressure is too great, leave the area immediately.
5. Touch tank opening equipment to the bolts in the hatch lid and allow electrical conductive path to form. Slowly remove bolts and/or hatch with spark resistant tools (brass/beryllium). If a pressure build up is encountered or detected, cease opening activities and leave the area.
6. Screen tanks for explosive/flammable gases and toxic vapors with air monitoring instruments. Depending on the study objectives and site conditions, conduct characteristic screening (e.g., pH, halogen, etc.) as desired. Collect a small volume of sample for flash point testing, if warranted. Note the state, quantity, number of phases, and color of the tank contents. Record all relevant results, observations, and information in a logbook. Compare the screening results with any pre-existing data to determine if the tank should be sampled.
7. Select the appropriate sampling equipment based on the state of the material and the type of tank. Sampling equipment should be constructed of non-reactive materials that will meet the study's objective(s).
8. Place oil wipe (as necessary), sampling equipment, and sample containers near tanks(s) to be sampled.

AIR MONITORING FOR TOXIC VAPORS, EXPLOSIVE GASES AND OXYGEN DEFICIENT ATMOSPHERES SHOULD BE CONTINUOUS DURING TANK SAMPLING.

Liquids -- Slowly lower the bailer, bacon bomb, Dipstick™, COLIWASA, or Teflon® tubing to the desired sampling depth. (NOTE: In work areas where explosive/flammable atmospheres could occur, peristaltic pumps powered by 12 V. batteries should not be used.) Close the sampling device or create a vacuum and slowly remove the sampling device from

WASTE SAMPLING PROCEDURES

the tank. Release the sample from the device into the sample container. Repeat the procedure until a sufficient sample volume is obtained.

Solids/Semi-Solids - Use a push tube, bucket auger, screw auger, Mucksucker™, or if conditions permit a pneumatic hammer/drill to obtain the sample. Carefully extrude the sample from the sampling device or use a clean stainless steel spoon to place the sample into containers for analyses.

9. Close the tank when sampling is complete. Segregate contaminated sampling equipment and investigative derived wastes (IDW) containing incompatible materials as determined by the screening procedure (Step #6). At a minimum, contaminated equipment should be cleaned with laboratory detergent and rinsed with tap water prior to returning it from the field. IDW should be managed according to Section 5.15, and Region 4's Contaminated Media Policy.

Miscellaneous Contaminated Materials

Sampling may be required of materials or equipment (e.g., documents, building materials, equipment, etc.) to determine whether or not various surfaces are contaminated by hazardous constituents, or to evaluate the effectiveness of decontamination procedures.

Wipe or swab samples may be taken on non-absorbent, smooth surfaces such as metal, glass, plastic, etc. The wipe materials must be compatible with the solvent used and the analyses to be performed, and should not come apart during use. The wipes are saturated with a solvent; methylene chloride, hexane, isopropanol or analyte free water depending on the parameters to be analyzed. The laboratory performing the analyses can provide the appropriate solvent. Wipe samples should not be collected for volatile organic compounds analysis. Sampling personnel should be aware of hazards associated with the selected solvent and should take appropriate precautions to prevent any skin contact or inhalation of these solvents. All surfaces and areas selected for sampling should be based on the study's

WASTE SAMPLING PROCEDURES

objectives. Typically, 10 cm by 10 cm templates are prepared from aluminum foil which are secured to the surface of interest. The prepared (saturated with solvent) wipe(s) is removed from its container with tongs or gloves, and used to wipe the entire area with firm strokes using only one side of the wipe. The goal is to systematically wipe the whole area. The wipe is then folded with the sample side inward and placed into the sample container. This procedure is repeated until the area is free of visible contamination or no more wipes remain. Care should be taken to keep the sample container tightly sealed to prevent evaporation of the solvent. Samplers must also take care to not touch the used side of the wipe.

For items with porous surfaces such as documents (usually business records), insulation, wood, etc., actual samples of the materials are required. It is therefore important, that during the collection and/or analyses of the sample that evidentiary material is not destroyed.

All secondary containing pails will be secured in the vehicles while transporting the samples from the field to the laboratory for analyses. In addition, each pail should indicate when protective equipment is recommended to handle the actual waste/sample material

REFERENCES

United States Environmental Protection Agency. November 2001. *Environmental Investigations Standard Operating Procedures and Quality Assurance Manual*.

Roux FOPs:

- 011 *Calibration and Maintenance of Portable Photoionization Detector*
- 046 *Sample Labeling, Storage and Shipment Procedures*



WASTE SAMPLING PROCEDURES

TABLE 1
SAMPLING EQUIPMENT for VARIOUS WASTE UNITS

Equipment	Waste Units/Phases	Limitations
scoop with bracket/conduit	impoundments, piles, containers, tanks/liquids, solids, sludges	Can be difficult to collect deeper phases in multiphase wastes. Depth constraints.
spoon	impoundments, piles, containers/solids, sludges	Similar limitations as the scoop. Generally not effective in sampling liquids.
push tube	piles, containers/cohesive solids, sludges	Should not be used to sample solids with dimensions $> \frac{1}{2}$ the diameter of the tube. Depth constraints
auger	impoundments, piles, containers / solids	Can be difficult to use in an impoundment or a container, or for solidified wastes.
sediment sampler	impoundments, piles/solids, sludges	Should not be used to sample solids with dimensions $> \frac{1}{2}$ the diameter of the tube.
ponar dredge	impoundments/solids, sludges	Must have means to position equipment to desired sampling location. Difficult to decon.
COLIWASA or drum	impoundments, containers,	Not good with viscous wastes. Devices $> 7'$
thief	tanks/liquids	Require 2 samplers to use effectively.
Dipstick™ /	impoundments, containers,	Not recommended for tanks > 11 feet deep.
Mucksucker™	tanks/liquids, sludges	Devices $> 7'$ require 2 samplers to use effectively
bacon bomb	impoundments, tanks/liquids	Not good with viscous wastes.
bailer	impoundments, tanks/liquids	Only if waste is homogeneous. Not good with viscous wastes
peristaltic pump with vacuum jug assembly	impoundments, tanks/liquids	Cannot be used in flammable atmospheres. Not good with viscous wastes
back-hoe bucket	piles/solids, sludges	May be difficult to access desired sampling location. Difficult to decon. Can lose volatiles.
split-spoon	piles/solids	Requires drill rig or direct push equipment.
roto-hammer	piles, containers/solids	Physically breaks up sample. May release volatiles. Not for flammable atmospheres.



FIELD OPERATING PROCEDURES

Calibration & Maintenance of Portable Particulate Meter

**CALIBRATION AND MAINTENANCE OF PORTABLE
PARTICULATE METER**

PURPOSE

This guideline describes a method for calibration of a portable particulate meter, specifically the Thermo Electron Corporation MIE DataRAM 4 (Model DR-4000). The DataRAM 4 measures the concentration of airborne particulate matter (liquid or solid), as well as mean particle size, air temperature, and humidity, providing direct and continuous readout as well as electronic recording of the information. This parameter is of interest both as a general indicator of air quality, and because of its pertinence to community air monitoring typically required at most construction/remediation/investigation sites. The DataRAM covers a wide measurement range from 0.0001 mg/m³ to 400 mg/m³. With its large capacity internal data logging capabilities with data retrieval on screen or downloaded, the DataRAM can store up to 50,000 data points, including individual point averages, particle size, temperature, and humidity with time stamp as well as overall average and maximum concentration.

Because the DataRAM meter must be factory calibrated once a year, this guideline presents a method for start-up, operation, and maintenance, which is performed to verify instrument function. All field instruments will be calibrated, verified and recalibrated at frequencies required by their respective operating manuals or manufacturer's specifications, but not less than once each year. Field personnel should have access to all operating manuals for the instruments used for the field measurements. This procedure also documents critical maintenance activities for this meter. The user should reference the manufacturer's instruction manual prior to operating this unit.

ACCURACY & PRECISION

The calibrated accuracy of the DataRAM 4 particulate meter is within $\pm 2\%$ of reading $\pm$ precision over the temperature range of -4° to 158° F (-10° to 50° C) and 10 to 95% relative humidity (non-condensing). The precision is $\pm 1\%$ of reading or ± 0.001 mg/m³, whichever

**CALIBRATION AND MAINTENANCE OF PORTABLE
PARTICULATE METER**

is greater (1-second averaging) and $\pm 0.3\%$ of reading or $\pm 0.0003 \text{ mg/m}^3$, whichever is greater (10-second averaging).

INSTRUMENT PANEL VIEW

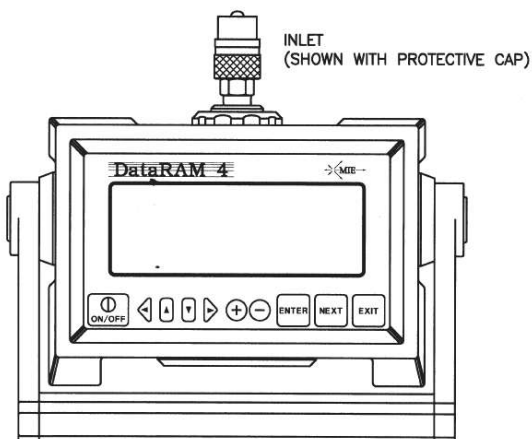


FIGURE 1. FRONT-PANEL VIEW OF DataRAM

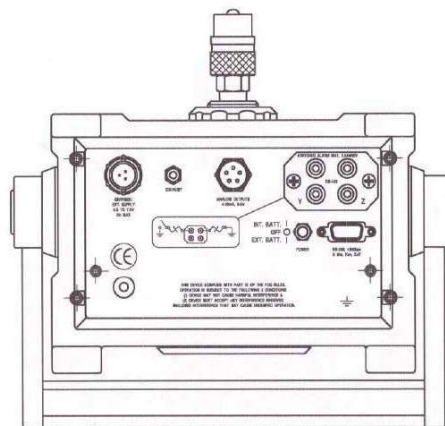


FIGURE 2. BACK-PANEL VIEW OF DataRAM

MAINTENANCE

General Guidelines

The DataRAM 4 is designed to be repaired at the factory. No user serviceable components are inside the metal enclosure of the DataRAM 4 with exception of the filter cartridge or the analytic filter holder. Access to the internal components of the unit by others than authorized MIE personnel voids warranty.

Unless a MALFUNCTION message is displayed, or other operational problems occur, the DataRAM 4 should be returned to the factory once every two years for routine check out, test, cleaning and calibration check.

Battery Charging and Cycling

If the DataRAM 4 is to be operated without its charger/power supply, i.e., deriving power from its internal battery, this battery should be fully charged before initiating a run. The

**CALIBRATION AND MAINTENANCE OF PORTABLE
PARTICULATE METER**

DataRAM 4 charger/power supply can be connected continuously to the instrument whether the DataRAM 4 is on or off. If the charger/power supply is not connected, the internal battery will discharge very slowly depending on storage temperature. Low storage temperature reduces battery capacity. High storage temperatures, however, reduce battery life which is of the order of 8 years at 20°C (68°F), and only 2 years at 40°C (104°F).

In general, the user should maintain the battery charge as high as possible in order to extend its charge/discharge cycling capacity (this characteristic differs from that of nickel-cadmium batteries).

Instrument Storage

If the DataRAM 4 is to be stored for an extended period of time (i.e., 3 months or more), place the 3-position switch on the back panel in its OFF position (mid-position), in order to minimize gradual battery discharge. This will have no effect on data retention or internal clock function. It is recommended, however, that the battery be recharged every 3 months in order to prolong battery life.

During storage always snap on quick-connect cap over the instrument inlet to protect the sensing optics from gradual dust contamination. Store DataRAM 4 in a dry environment.

Filter Replacement

To replace either of two types of filters used with DataRAM 4, place the instrument on its back rubber feet (front panel facing upward). On the bottom surface of the DataRAM, locate the large threaded plastic filter cover and holding the cross bar, rotate this cover counterclockwise. Remove cover and the filter holder within the open cavity.

HEPA Filter Cartridge Replacement

The DataRAM 4 is shipped from the factory with the HEPA filter cartridge installed. This cartridge can be identified by its metallic cover. Remove this cartridge. Clean the internal black rubber gasket against which the cartridge is normally compressed. Install new HEPA-type cartridge (MIE part no. MSA-95302) by inserting its wider ridged end first. Reposition threaded plastic cover engaging threads carefully; rotate cover clockwise, hand tightening firmly. Properly dispose of used cartridge to prevent inadvertent re-use.

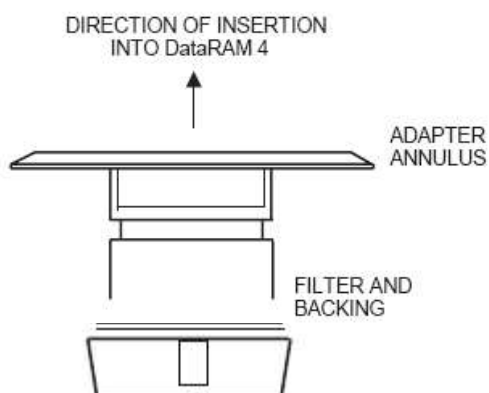
**CALIBRATION AND MAINTENANCE OF PORTABLE
PARTICULATE METER**

Analytic Filter Installation/Replacement

In order to install or replace the analytical filter holder, proceed as follows. Remove the HEPA cartridge normally in place. Remove (separate) the inlet cover (with the blue plug) of the Millipore plastic filter holder from the rest of that holder assembly containing the white membrane filter. Insert firmly the gray plastic adapter annulus into the open face of the filter holder assembly. Remove the red plastic plug from the exhaust nipple of the filter holder assembly. Ensure that all three components of the holder assembly are fully compressed to preclude any leafage. Insert the assembly into the filter cavity of the DataRAM 4 with the gray plastic adapter annulus bearing against the internal black gasket (adapter annulus inserted first). Reposition threaded plastic cover and hand-tighten carefully and firmly. Set aside HEPA cartridge for future use.

In order to remove and/or to replace the membrane filter within its holder, remove the gray plastic adapter annulus and separate (pry apart) the two transparent plastic rings that compress the membrane filter. Make sure to remove and replace only the membrane filter (using tweezers), leaving the white backing disc in the holder. A new membrane filter should then be placed over that backing and the sealing ring should then be inserted to trap and compress the filter and backing discs. For storage, the inlet cap with the blue plug should be inserted as well as the red plug on the back of the filter holder.

Analytical filter holder with adapter annulus inserted



**CALIBRATION AND MAINTENANCE OF PORTABLE
PARTICULATE METER**

Cleaning of Optical Sensing Chamber

Although the DataRAM 4 incorporates filtered air shielding of the critical optical sensing surfaces, continued sampling of airborne particles at high concentrations may result in gradual build-up of contamination on those interior surfaces of the sensing chamber components. This may cause an excessively high optical background level. If this background level does become excessive, the DataRAM 4 will alert the user at the completion of the zeroing sequence by the display of a BACKGROUND HIGH message. If this message is presented, the DataRAM 4 can continue to be operated providing accurate measurements. However, it is then advisable to clean the front surfaces of the optical lenses within the sensing chamber at the first convenient opportunity, as described below. The tools required for this cleaning are: an intense concentrated light source (e.g., flash light) to view the inside of the sensing chamber, denatured alcohol, a soft lint-free cloth, and the special cleaning tool provided with the DataRAM 4 consisting of a cut-off cotton swab inserted in a plastic sleeve and held by a right-angle Allen wrench.

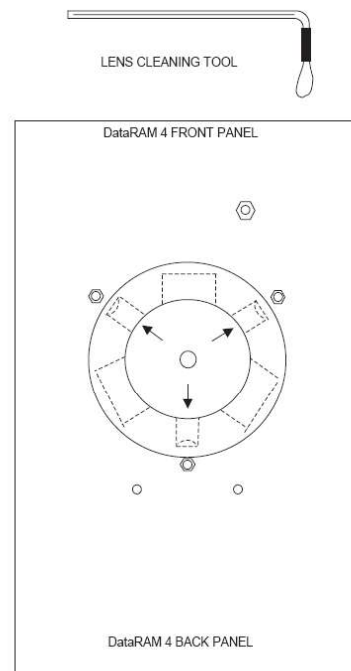
Proceed as follows to clean the lens surfaces within the sensing chamber:

- **Make sure to shut off power completely before proceeding with cleaning**
- Install the stainless steel cover on the inlet of the DataRAM 4 to protect this fitting.
- Place the DataRAM 4 upside down on a table, resting the instrument on the inlet cover and the rear protective bumper.
- Unscrew the gray plastic cover of the filter cavity on the bottom surface of the DataRAM 4.
- Remove the filter cartridge from its cavity.
- Carefully clean the black soft filter-sealing gasket within the filter cavity by wiping it with the lint-free soft cloth. Use alcohol if necessary.
- Shine the concentrated light source into the sensing chamber located about 3 cm (1¼ in.) beyond the soft-sealing gasket in the filter cavity.
- Locate the three smaller side cavities inside the sensing chamber, identified by the arrows on that figure (see page 6). These three cavities contain the lenses of the two sources and the common detector of the DataRAM 4. The frontal surfaces of these lenses are likely to require cleaning if the instrument indicates BACKGROUND HIGH.
- Wet the cotton swab of the lens-cleaning tool with alcohol (e.g., methanol, ethanol, or rubbing alcohol).

**CALIBRATION AND MAINTENANCE OF PORTABLE
PARTICULATE METER**

- Holding the cleaning tool by its long handle, insert this tool into the sensing chamber without touching the walls of this chamber.
- Direct the cotton swab tip towards the opening of one of the three smaller cavities as indicated by the arrows of the figure below, and insert the cotton tip into this cavity as far as it will go. Gently wipe that internal surface touched by the swab tip by a rotating motion. Carefully withdraw the swab tip from the cavity.
- Repeat previous cleaning step for the other two small cavities.
- Carefully remove the cleaning tool from the sensing chamber. Allow the alcohol to dry leaving the filter cavity open for about 15 minutes.
- Re-insert the filter cartridge into its cavity and close it with its gray plastic cover, hand-tightening it firmly. Remove the inlet cap and store on its pod on the back panel.
- Place the DataRAM 4 right side up and key ON. Proceed to check its optical background by running the ZERO/INITIALIZE check as. The message READY! should appear at the end of this check indicating that the lens contamination has been eliminated. Should the message BACKGROUND HIGH persist after completion of the above-described lens cleaning procedure, please contact the factory.

Lens cleaning tool and bottom view of open filter cavity showing location of sensor chamber lens cavities (arrows).



**CALIBRATION AND MAINTENANCE OF PORTABLE
PARTICULATE METER**

FACTORY CALIBRATION

For mass concentration measurements, each DataRAM 4 is factory calibrated against a set of reference monitors that, in turn, are periodically calibrated against a gravimetric standard traceable to the National Institute of Standards and Testing (NIST).

The primary factory reference method consists of generating a dust aerosol by means of a fluidized bed generator, and injecting continuously the dust into a mixing chamber from which samples are extracted concurrently by two reference filter collectors and by two master real-time monitors that are used for the routine calibration of every DataRAM 4.

The primary dust concentration reference value is obtained from the weight increase of the two filters due to the dust collected over a measured period of time, at a constant and known flow rate. The two master real-time monitors are then adjusted to agree with the reference mass concentration value (obtained from averaging the measurements of the two gravimetric filters) to within $\pm 1\%$.

Three primary, NIST traceable, measurements are involved in the determination of the reference mass concentration: the weight increment from the dust collected on the filter, the sampling flow rate, and the sampling time. Additional conditions that must be met are: a) suspended dust concentration uniformity at all sampling inlets of the mixing chamber; b) identical sample transport configurations leading to reference and instrument under calibration; and c) essentially 100% collection efficiency of filters used for gravimetric reference for the particle size range of the test dust.

FOP 084.0

CALIBRATION AND MAINTENANCE OF PORTABLE PARTICULATE METER

The test dust used for the MIE factory calibration of the DataRAM 4 is SAE Fine (ISO Fine) supplied by Powder Technology, Inc. It has the following physical characteristics (as dispersed into the mixing chamber):

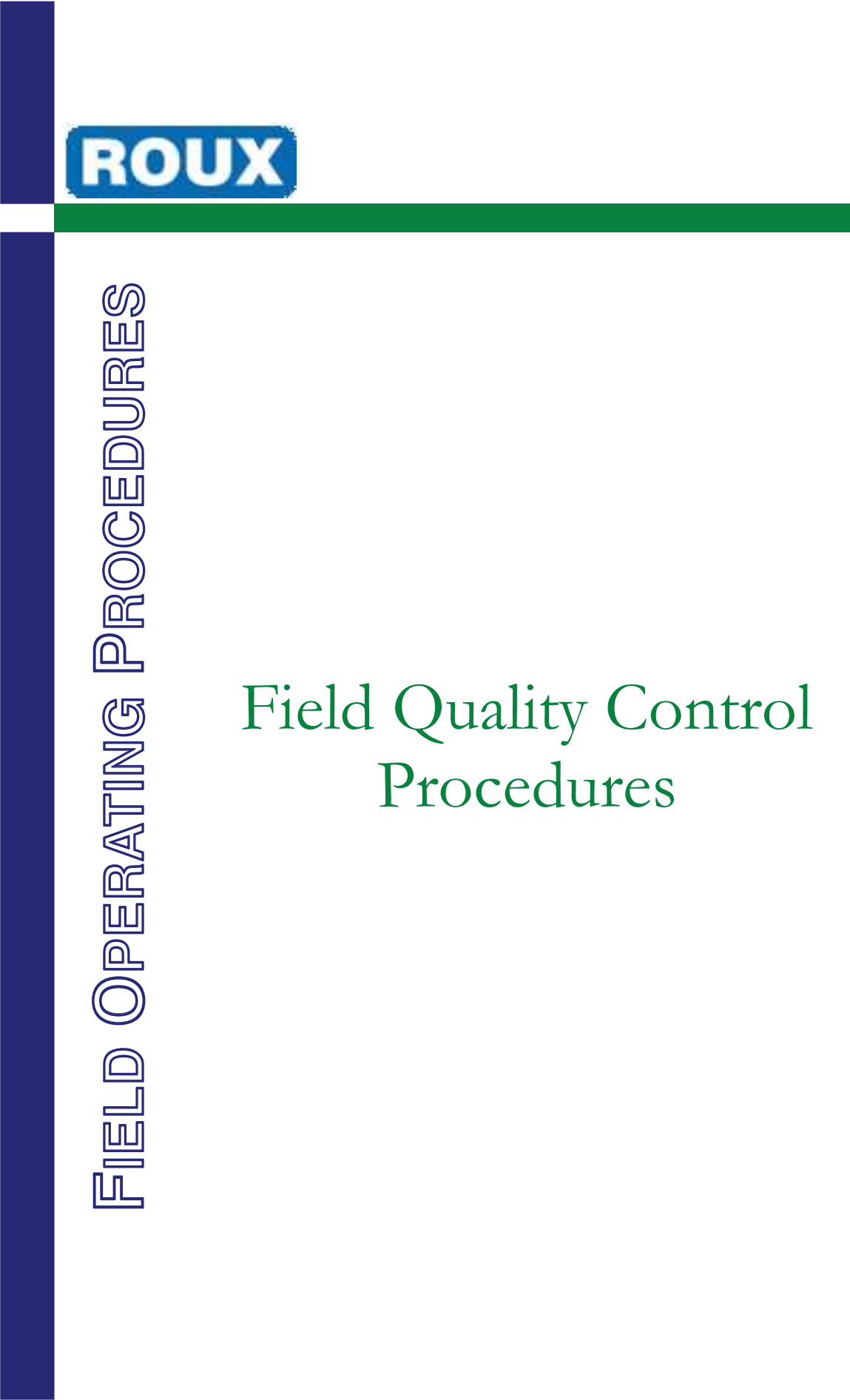
- Mass median aerodynamic particle diameter: 2 to 3 μm
- Geometric standard deviation of lognormal size distribution: 2.5
- Bulk density: 2.60 to 2.65 g/cm³
- Refractive index: 1.54

In addition to the mass calibration described above, the DataRAM 4 is factory calibrated using a gas with known scattering coefficient in order to adjust the relative scattering irradiance at the two source wavelengths.

ATTACHMENTS

None





ROUX

FIELD OPERATING PROCEDURES

Field Quality Control Procedures

FIELD QUALITY CONTROL PROCEDURES

PURPOSE

In addition to traditional environmental samples (e.g., soil, groundwater, wipe, vapor etc.) described in each project work plan, site-specific field quality assurance/quality control (QA/QC) samples are typically collected and analyzed to support the required third-party data usability assessment effort of a project. Site-specific QA/QC samples generally include matrix spikes, matrix spike duplicates, blind duplicates (where appropriate), and trip blanks which accompany aqueous volatile organic compound (VOC) samples only.

The number of QA/QC field samples (blind duplicate, matrix spike/matrix spike duplicate, trip blank, field blank, or equipment blank) will be designated prior to field mobilization, but final QC sample locations will be contingent upon field conditions. This procedure outlines and discusses each QA/QC sample that may be required during a project.

PROCEDURE

A brief summary of each QA/QC sample identified above is presented below. Where appropriate, the procedure to be used to collect these samples is also presented.

- **Trip Blanks** – A sufficient number of trip blanks for VOC analysis must be prepared by the laboratory and delivered to the sampling team prior to a sampling event, typically two or three 40-ml VOA vials with organic free reagent water. One sealed blank will be carried into the field per day along with the sample containers for each day that water matrix volatile organic samples are collected. Trip blanks will be transported and handled in the same manner as the actual samples. The results of the trip blank analysis will be reviewed to evaluate if the potential for sample contamination during transportation and handling exists. The trip blanks will be analyzed for the same VOCs (and method) as the project groundwater samples.
- **Blind Duplicate** – One blind duplicate must be collected and analyzed per 20 samples collected per matrix (i.e., soil, groundwater, soil vapor, etc.). The location

FIELD QUALITY CONTROL PROCEDURES

of the sample collection point will not be disclosed to the analytical laboratory, therefore the field sample containers will be returned to the laboratory identified only as the “blind duplicate.” The well or sample location will be recorded in the Project Field Book or handheld RuggedReader® Pocket PC and on the field data sheets, and the results will be compared to review analytical precision. Sample analysis will be identical to the original sample per the project work plan. The Blind Duplicate sample must be collected simultaneously from the same source under identical conditions as the original sample.

- **Matrix Spike/Matrix Spike Duplicate (MS/MSD)** – A sufficient volume of sample will be collected at one sampling location per sampling event for MS/MSD analysis per matrix (i.e., soil and groundwater only). The laboratory will report the results of the MS/MSD analysis, which will be reviewed for sampling and analysis precision and accuracy. Sample analysis will be identical to the original sample per the project work plan. The MS/MSD sample must be collected simultaneously from the same source under identical conditions as the original sample.
- **Equipment (Rinsate) Blank** – In general, dedicated sampling equipment is used to minimize field decontamination time and avoid the need for equipment blanks; however there may be instances where the use of non-dedicated equipment cannot be avoided. An equipment blank will be collected for each day of sampling activity when non-dedicated sampling equipment is used. These equipment blank samples will be used as a QC check of the decontamination procedures for sampling equipment. Sample analysis for the equipment blank will consist of the most comprehensive parameter list used for risk assessment in which the non-dedicated equipment was used for environmental sample collection. During most projects, every effort to use dedicated sampling equipment should be made in order to minimize field decontamination time and avoid the need for equipment blanks. Equipment Blank sampling procedure is as follows:
 - Non-dedicated equipment are to be decontaminated in accordance with **Roux's** Non-disposable and Non-dedicated Sampling Equipment Decontamination procedures prior to use in the field. If organic-free

FIELD QUALITY CONTROL PROCEDURES

- deionized water (generally provided by the laboratory) is not available for decontamination, equipment will be allowed to thoroughly air dry.
- Once properly rinsed or allowed to air dry, analyte-free water (provided by the laboratory) is poured appropriately over or through the decontaminated sample collection device, collected in a sample container, and returned to the laboratory as a sample.
 - **Field Blank** – A field blank is a sample of the unused final decontamination rinse water that is collected at the sampling site and returned to the laboratory as a sample. Sample analysis for the field blank will consist of the most comprehensive parameter list used during the investigation.
 - **Split Sample** – A split sample is a sample that has been portioned into two or more containers from a single sample container or sample mixing container. Samples for VOC analysis should never be mixed prior to splitting.
 - **Blank Wipe Samples** – There are two types of blank wipe samples, an equipment blank and a field blank that may be required per the project work plan, both are described below:
 - Equipment Blank – Required only if reusable templates are used for wipe sample collection. The decontaminated template is wiped with a hexane saturated swab. The swab is placed in the appropriate sample container and returned to the laboratory as a sample.
 - Field Blank – Clean disposable gloves are wiped with a hexane saturated swab. The swab is placed in the appropriate sample container and returned to the laboratory as a sample.

REFERENCES

Roux FOPs:

040 *Non-disposable and Non-dedicated Sampling Equipment Decontamination*



The logo for Roux, featuring the word "ROUX" in white, bold, sans-serif capital letters inside a blue rectangular box with a slight drop shadow.

ROUX

A thick, solid dark blue vertical bar that runs the full height of the page, positioned on the left side.

FIELD OPERATING PROCEDURES

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Underground Piping Decommissioning Procedures

UNDERGROUND PIPING DECOMMISSIONING PROCEDURES

PURPOSE

This procedure describes the method for the excavation and removal of underground piping requiring decommissioning that may contain hazardous or flammable material. Prior to each day or as necessary, the project Health and Safety Plan (HASP) will be reviewed with field personnel (e.g., tailgate safety meeting). It is the responsibility of field personnel to ensure all field equipment is in proper working order and calibrated according to manufacturer's recommendations.

PROCEDURE

1. Review project objectives and the Project HASP with the Contractor.
2. Perform excavation equipment safety checks with the operator. Specific concerns should include, but not limited to, no leaking hydraulic lines, fire extinguisher on board of the excavation equipment, operator experience etc.
3. Conduct tailgate health and safety meeting with project team and excavation operator(s) by completing the Tailgate Safety Meeting Form (sample attached). Discuss with excavation contractor personnel the scope of work and what will be expected of them.
4. Calibrate air-monitoring equipment in accordance with the appropriate TurnKey's Field Operating Procedures or manufacturers recommendations for calibration of field meters.
5. Conduct community air monitoring as required by the HASP and/or Project Work Plan. Record all results on the Real Time Air Monitoring Log (sample attached), as necessary.
6. Mobilize the excavation equipment to the site and position over the required location.

UNDERGROUND PIPING DECOMMISSIONING PROCEDURES

7. Pre-stake locations in the field and measure distance from locations to nearest landmarks or survey the location using a handheld GPS unit, as required.
8. Wear appropriate protective gear (i.e., latex gloves, safety glasses), as required in the project HASP.
9. Excavate and expose underground piping requiring decommissioning in accordance with TurnKey's Test Pit Excavation & Logging Procedures FOP. Great care should be taken to avoid damaging the pipe and allowing the contents, if any, to be released to the environment.
10. Once exposed, over excavate the area around the section of pipe to be cut and place a container below the pipe. Tap two test holes in the top of the pipe using an intrinsically safe drill with non-sparking drill bit approximately 15 feet from the open end of the pipe (above the container).
11. Continue monitoring the ambient air space within the excavation for worker safety until work is complete. Refer to the project HASP for action levels.
12. Remove any solids and/or liquids within the first 15 to 20 feet of exposed pipe to the extent practicable.
13. Insert an appropriately sized double pipe seal apparatus into the open end of the pipe.
14. Using a single pipe seal apparatus attached to a steel rod, push the double pipe seal into the pipe beyond the tap holes (approximately 16 feet or so). Be sure to capture any residuals flowing out of the two tap holes with the previously mentioned container.
15. Retract the single pipe seal and push rod leaving an approximate 1 to 2 foot void space between the single and double pipe seal.
16. Through one of the tap holes, test the ambient air quality of the newly created void space between seals with an oxygen meter and explosimeter. If the air quality within the pipe indicates 0% oxygen on the oxygen meter and less than

UNDERGROUND PIPING DECOMMISSIONING PROCEDURES

10% Lower Explosive Limit (LEL) on the explosimeter, proceed with cutting the pipe into workable sections.

17. If the void space air quality exceeds either of those levels, inject nitrogen (or approved other inert gas) through the tap holes into the void air-space until safe levels are achieved. Nitrogen is 3% less dense than ambient air.
18. Cut the pipe into manageable sections (typically 15 feet) while periodically monitoring the ambient air within the pipe and injecting additional nitrogen (or approved other inert gas), as necessary.
19. Once section of pipe is removed, proceed with final cleaning activities in accordance with the project Work Plan and any local, state, and/or federal regulations.
20. Record all observations in the Project Field Book, including but not limited to length of recovered pipe, air monitoring observations, depths, diameters, etc.

ATTACHMENTS

Tailgate Safety Meeting Form (sample)
Real Time Air Monitoring Log (sample)

REFERENCES

TurnKey FOPs:

- 006 *Calibration and Maintenance of Combustible Gas/Oxygen Meter*
065 *Test Pit Excavation & Logging Procedures*



UNDERGROUND PIPING DECOMMISSIONING PROCEDURES

TAILGATE SAFETY MEETING FORM

Project Name: Date: Time:
 Project Number: Client:
 Work Activities:

HOSPITAL INFORMATION:

Name:
 Address: City: State: Zip:
 Phone No.: Ambulance Phone No.:

SAFETY TOPICS PRESENTED:

Chemical Hazards:
 Physical Hazards: Slips, Trips, Falls

PERSONAL PROTECTIVE EQUIPMENT:

Activity:	PPE Level: A	B	C	D
Activity:	PPE Level: A	B	C	D
Activity:	PPE Level: A	B	C	D
Activity:	PPE Level: A	B	C	D
Activity:	PPE Level: A	B	C	D

New Equipment:

Other Safety Topic(s): Environmental Hazards (aggressive fauna)
 Eating, drinking, use of tobacco products is prohibited in the Exclusion Zone (EZ)

ATTENDEES

Name Printed

Signatures

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.....	

Meeting conducted by:



The logo for Roux, featuring the word "ROUX" in white, bold, sans-serif capital letters inside a blue rectangular box with a slight drop shadow.

ROUX

FIELD OPERATING PROCEDURES

Outdoor Ambient Air
VOC Sample
Collection Procedure

OUTDOOR AMBIENT AIR VOC SAMPLE COLLECTION PROCEDURE

PURPOSE

This procedure describes the methods for collecting outdoor ambient air samples for volatile organic compound (VOC) analysis via USEPA Method TO-15 using Summa® canisters (or approved other). Typically, outdoor air samples are collected to characterize and document site-specific VOCs that may be present in outdoor ambient air. For sample collection associated with intrusive activities that may potentially release VOCs to the ambient air, sample location(s) typically are collected downwind of the intrusive activity at the perimeter of the work area and/or exclusion zone for the Site. Upwind sample location(s) may be utilized if regional facilities (e.g. gasoline service station, factories) are located proximate to the Site to assess off-site ambient VOC contributions (background).

SAMPLE COLLECTION PROCEDURES

The following actions should be taken to document conditions during outdoor air sampling and ultimately to aid in the interpretation of the analytical results:

- A site map should be prepared to indicate the outdoor ambient air sample locations including all site improvements (e.g., buildings, access roads, etc.), public roads/streets (if applicable), the location of potential VOC contributors (e.g., gasoline stations, factories, lawn movers, etc.), compass orientation (north), and scale.
- Weather conditions (e.g., precipitation, wind speed, outdoor temperature, and barometric pressure) should be reported on the Air Canister Field Record (sample attached); and
- 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) should be recorded.

OUTDOOR AMBIENT AIR VOC SAMPLE COLLECTION PROCEDURE

The following describes the outdoor air sampling procedure:

1. Typically, a 6-liter, passivated (inert), stainless steel, evacuated sampling sphere (e.g., Summa canister) (or approved other) will be supplied by the laboratory that will be conducting the analysis. The canister should be received from the laboratory, certified clean, evacuated, and prepared for sampling.
2. Sampling will take place in accordance with the project work plan. Selected sample locations will be sufficiently spaced to allow location(s) to be field modified, if necessary.
3. The number of Summa canisters required as well as the flow rate of the constant differential low volume flow controllers will be supplied by the laboratory in accordance with the project work plan.
4. Prior to placement, complete an Air Canister Field Record (sample attached) of each canister, which includes: project information, field staff, weather conditions, canister serial number, flow controller number, sample date(s)/time(s), shipping date(s), canister lab vacuum, field vacuum check, initial field vacuum, final field vacuum, and duration of sample collection.
5. The pressure in the canisters must be monitored with the laboratory provided pressure gauge at the beginning and the end of the sampling period as well as before and after shipment of the canisters at the laboratory. The **target final field vacuum must be approximately 5 inches of mercury. Samples with a final field vacuum of greater than 10 inches of mercury, or equal to zero, will be flagged** and usability of the data will depend on the sample volume and reporting limits that can be achieved.
6. Canisters may be placed on the ground provided there is a clear plastic sheet beneath it to prevent cross contamination. The intake tubing, however, must be positioned at a height of approximately 3 to 5-feet above grade to collect air at an elevation representative of ambient air within the breathing zone. Typically, the canister is chained and locked to a secure step ladder with the intake tubing tethered to the ladder.

OUTDOOR AMBIENT AIR VOC SAMPLE COLLECTION PROCEDURE

7. Ship the canisters to the laboratory under chain-of-custody command within three days of sample collection so that no sample will exceed the 30-day holding time (since receipt from the lab) per USEPA TO-15.
8. Air samples will be analyzed by Gas Chromatography/Mass Spectroscopy (GC/MS) in accordance with EPA Method TO-15, or as specified. Analytical results will be reported as concentrations of each VOC at each location during each sampling event, typically in parts per billion by volume (ppbv).
9. Sample collection should take place on warm, dry days. If rain or high humidity conditions develop during sampling, the sampling event should be suspended. Temperature, barometric pressure, and wind speed should be monitored during the sampling event, for use in analysis of the results. The combination of sampling location, height, and meteorological conditions will assure that sampling will measure VOCs at their highest concentrations.

QUALITY ASSURANCE / QUALITY CONTROL (QA/QC)

Extreme care should be taken during all aspects of sample collection to ensure that sampling error is minimized and high quality data are obtained. The sampling team members should avoid actions (e.g., fueling vehicles, using permanent marking pens, and wearing freshly dry-cleaned clothing or personal fragrances), which can cause sample interference in the field. Appropriate QA/QC protocols must be followed for sample collection and laboratory analysis, such as use of certified clean sample devices, meeting sample holding times and temperatures, sample accession, chain of custody, etc. Samples should be delivered to the analytical laboratory as soon as possible after collection. In addition, laboratory accession procedures must be followed including field documentation (sample collection information and locations), chain of custody, field blanks, field sample duplicates, and laboratory duplicates, as appropriate.

OUTDOOR AMBIENT AIR VOC SAMPLE COLLECTION PROCEDURE

Some methods require collecting samples in duplicate to assess errors. Duplicate and/or split samples should be collected in accordance with the requirements of the sampling and analytical methods being implemented.

For certain regulatory programs, a Data Usability Summary Report (DUSR) may be required to determine whether or not the data, as presented, meets the site or project specific criteria for data quality and data use. This requirement may dictate the level of QC and the category of data deliverable to request from the laboratory. Guidance on preparing a DUSR is available by contacting the NYSDEC's Division of Environmental Remediation.

New York State Public Health Law requires laboratories analyzing environmental samples collected from within New York State to have current Environmental Laboratory Approval Program (ELAP) certification for the appropriate analyte and environmental matrix combinations. If ELAP certification is not currently required for an analyte (e.g., trichloroethene); then the analysis should be performed by a laboratory that has ELAP certification for similar compounds in air and uses analytical methods with detection limits similar to background (e.g., tetrachloroethene via EPA Method TO-15).

ATTACHMENTS

Air Canister Field Record (sample)

REFERENCES

United States Environmental Protection Agency. *Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air*. Second Addition (EPA/625/R-96/010b). January 1999.

OUTDOOR AMBIENT AIR VOC SAMPLE COLLECTION PROCEDURE

AIR CANISTER FIELD RECORD

PROJECT INFORMATION:

Project:

Job No:

Location:

Field Staff:

Client:

SAMPLE I.D.:

WEATHER CONDITIONS:

Ambient Air Temp. - A.M.:

Ambient Air Temp. - P.M.:

Wind Direction:

Wind Speed:

Precipitation:

Size of Canister:

Canister Serial No.:

Flow Controller No.:

Sample Date(s):

Shipping Date:

Sample Type: ☐ Indoor Air ☐ Outdoor Air☐ Subslab, complete section below ☐ Soil Gas

Soil Gas Probe Depth:

FIELD SAMPLING INFORMATION:

READING	TIME	VACUUM (inches Hg) or PRESSURE (psig)	DATE	INITIALS
Lab Vacuum (on tag)				
Field Vacuum Check ¹				
Initial Field Vacuum ²				
Final Field Vacuum ³				
Duration of Sample Collection				

LABORATORY CANISTER PRESSURIZATION:

Initial Vacuum (inches Hg and psia)	
Final Pressure (psia)	
Pressurization Gas	

SUBSLAB SHROUD:

Shroud Helium Concentration:

Calculated tubing volume: x 3 =

Purged Tubing Volume Concentration:

Is the purged volume concentration less than or equal to 10% in shroud?

☐ YES, continue sampling☐ NO, improve surface seal and retest**NOTES:**¹ Vacuum measured using portable vacuum gauge (provided by Lab)² Vacuum measured by canister gauge upon opening valve³ Vacuum measured by canister gauge prior to closing valve

COMPOSITE TIME (hours)	FLOW RATE RANGE (ml/min)
15 Min.	316 - 333
0.5 Hours	158 - 166.7
1	79.2 - 83.3
2	39.6 - 41.7
4	19.8 - 20.8
6	13.2 - 13.9
8	9.9 - 10.4
10	7.92 - 8.3
12	6.6 - 6.9
24	3.5 - 4.0

Signed:



Soil Vapor/Indoor Air Matrix D

February 2024

Analytes Assigned:

Benzene, ethylbenzene, naphthalene, cyclohexane, isooctane (2,2,4-trimethylpentane), 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, o-xylene

SUB-SLAB VAPOR CONCENTRATION of COMPOUND (mcg/m ³)	INDOOR AIR CONCENTRATION of COMPOUND (mcg/m ³)		
	< 2	2 to < 10	10 and above
< 60	1. No further action	2. No Further Action	3. IDENTIFY SOURCE(S) or RESAMPLE or MITIGATE
60 to < 600	4. No further action	5. MONITOR	6. MITIGATE
600 and above	7. MITIGATE	8. MITIGATE	9. MITIGATE

mcg/m³ = micrograms per cubic meter

No further action: No additional actions are recommended to address human exposures.

Identify Source(s) or Resample or Mitigate: We recommend that reasonable and practical actions be taken to identify the source(s) affecting the indoor air quality and that actions be implemented to reduce indoor air concentrations to within background ranges. For example, if an indoor or outdoor air source is identified, we recommend the appropriate party implement actions to reduce the levels. In the event that indoor or outdoor sources are not readily identified or confirmed, resampling (which might include additional sub-slab vapor and indoor air sampling locations) is recommended to demonstrate that SVI mitigation actions are not needed. Based on the information available, mitigation might also be recommended when soil vapor intrusion cannot be ruled out.

Monitor: We recommend monitoring (sampling on a recurring basis), including but not necessarily limited to sub-slab vapor, basement air and outdoor air sampling, to determine whether concentrations in the indoor air or sub-slab vapor have changed and/or to evaluate temporal influences. Monitoring might also be recommended to determine whether existing building conditions (e.g., positive pressure heating, ventilation, and air-conditioning systems) are maintaining the desired mitigation endpoint and to determine whether changes are needed. The type and frequency of monitoring is determined based on site-, building- and analyte-specific information, taking into account applicable environmental data and building operating conditions. Monitoring is an interim measure required to evaluate exposures related to soil vapor intrusion until contaminated environmental media are remediated.

Mitigate: We recommend mitigation to minimize current or potential exposures associated with soil vapor intrusion. The most common mitigation methods are sealing preferential pathways in conjunction with installing a sub-slab depressurization system and changing the pressurization of the building in conjunction with monitoring. The type, or combination of types, of mitigation is determined on a building -specific basis, taking into account building construction and operating conditions. Mitigation is considered a temporary measure implemented to address exposures related to soil vapor intrusion until contaminated environmental media are remediated.

These general recommendations are made with consideration being given to the additional notes on page 2.

MATRIX D Page 1 of 2

ADDITIONAL NOTES FOR MATRIX D

This matrix summarizes actions recommended to address current and potential exposures related to soil vapor intrusion. To use the matrix appropriately as a tool in the decision-making process, the following should be noted:

- [1] The matrix is generic. As such, it may be appropriate to modify a recommended action to accommodate analyte-specific, building-specific conditions (e.g., dirt floor in basement, crawl spaces, thick slabs, current occupancy, etc.), and/or factors provided in Section 3.2 of the guidance (e.g., current land use, environmental conditions, etc.). For example, collection of additional samples may be recommended when the matrix indicates "no further action" for a particular building, but the results of adjacent buildings (especially sub-slab vapor results) indicate a need to take actions to address exposures related to soil vapor intrusion. Mitigation might be recommended when the results of multiple contaminants indicate monitoring is recommended. Proactive actions may be proposed at any time. For example, the party implementing the actions may decide to install sub-slab depressurization systems on buildings where the matrix indicates "no further action" or "monitoring." Such an action might be undertaken for reasons other than public health (e.g., seeking community acceptance, reducing costs, etc.). However, actions implemented *in lieu* of sampling will typically be expected to be captured in the final engineering report and site management plan, and might not rule out the need for post-implementation sampling (e.g., to document effectiveness or to support terminating the action).
- [2] Actions provided in the matrix are specific to addressing human exposures. Implementation of these actions does not preclude investigating possible sources of soil vapor contamination, nor does it preclude remediating contaminated soil vapor or the source of soil vapor contamination.
- [3] Appropriate care should be taken during all aspects of sample collection to ensure that high quality data are obtained. Since the data are being used in the decision-making process, the laboratory analyzing the environmental samples must have current Environmental Laboratory Approval Program (ELAP) certification for the appropriate analyte and environmental matrix combinations. Furthermore, samples should be analyzed by methods that can achieve a minimum reporting limit of 1 microgram per cubic meter for indoor and outdoor air samples. For sub-slab vapor samples and dirt floor soil vapor samples, a minimum reporting limit of 1 microgram per cubic meter is recommended.
- [4] Sub-slab vapor and indoor air samples are typically collected when the likelihood of soil vapor intrusion to occur is considered to be the greatest (i.e., worst-case conditions). If samples are collected at other times (typically, samples collected outside of the heating season), then resampling during worst-case conditions might be appropriate to verify that actions taken to address exposures related to soil vapor intrusion are protective of human health.
- [5] When current exposures are attributed to sources other than soil vapor intrusion, the agencies should be given documentation (e.g., applicable environmental data, completed indoor air sampling questionnaire, digital photographs, etc.) to support a proposed action other than that provided in the matrix box and to support agency assessment and follow-up.
- [6] The party responsible for implementing the recommended actions will differ depending upon several factors, including but not limited to the following: the identified source of the volatile chemicals, the environmental remediation program, and analyte-specific, site-specific and building-specific factors.

Soil Vapor/Indoor Air Matrix E

February 2024

Analytes Assigned:

m,p-xylene, heptane, hexane

SUB-SLAB VAPOR CONCENTRATION of COMPOUND (mcg/m ³)	INDOOR AIR CONCENTRATION of COMPOUND (mcg/m ³)		
	< 6	6 to < 20	20 and above
< 200	1. No further action	2. No Further Action	3. IDENTIFY SOURCE(S) or RESAMPLE or MITIGATE
200 to < 2,000	4. No further action	5. MONITOR	6. MITIGATE
2,000 and above	7. MITIGATE	8. MITIGATE	9. MITIGATE

mcg/m³ = micrograms per cubic meter

No further action: No additional actions are recommended to address human exposures.

Identify Source(s) or Resample or Mitigate: We recommend that reasonable and practical actions be taken to identify the source(s) affecting the indoor air quality and that actions be implemented to reduce indoor air concentrations to within background ranges. For example, if an indoor or outdoor air source is identified, we recommend the appropriate party implement actions to reduce the levels. In the event that indoor or outdoor sources are not readily identified or confirmed, resampling (which might include additional sub-slab vapor and indoor air sampling locations) is recommended to demonstrate that SVI mitigation actions are not needed. Based on the information available, mitigation might also be recommended when soil vapor intrusion cannot be ruled out.

Monitor: We recommend monitoring (sampling on a recurring basis), including but not necessarily limited to sub-slab vapor, basement air and outdoor air sampling, to determine whether concentrations in the indoor air or sub-slab vapor have changed and/or to evaluate temporal influences. Monitoring might also be recommended to determine whether existing building conditions (e.g., positive pressure heating, ventilation, and air-conditioning systems) are maintaining the desired mitigation endpoint and to determine whether changes are needed. The type and frequency of monitoring is determined based on site-, building- and analyte-specific information, taking into account applicable environmental data and building operating conditions. Monitoring is an interim measure required to evaluate exposures related to soil vapor intrusion until contaminated environmental media are remediated.

Mitigate: We recommend mitigation to minimize current or potential exposures associated with soil vapor intrusion. The most common mitigation methods are sealing preferential pathways in conjunction with installing a sub-slab depressurization system and changing the pressurization of the building in conjunction with monitoring. The type, or combination of types, of mitigation is determined on a building -specific basis, taking into account building construction and operating conditions. Mitigation is considered a temporary measure implemented to address exposures related to soil vapor intrusion until contaminated environmental media are remediated.

These general recommendations are made with consideration being given to the additional notes on page 2.

MATRIX E Page 1 of 2

ADDITIONAL NOTES FOR MATRIX E

This matrix summarizes actions recommended to address current and potential exposures related to soil vapor intrusion. To use the matrix appropriately as a tool in the decision-making process, the following should be noted:

- [1] The matrix is generic. As such, it may be appropriate to modify a recommended action to accommodate analyte-specific, building-specific conditions (e.g., dirt floor in basement, crawl spaces, thick slabs, current occupancy, etc.), and/or factors provided in Section 3.2 of the guidance (e.g., current land use, environmental conditions, etc.). For example, collection of additional samples may be recommended when the matrix indicates "no further action" for a particular building, but the results of adjacent buildings (especially sub-slab vapor results) indicate a need to take actions to address exposures related to soil vapor intrusion. Mitigation might be recommended when the results of multiple contaminants indicate monitoring is recommended. Proactive actions may be proposed at any time. For example, the party implementing the actions may decide to install sub-slab depressurization systems on buildings where the matrix indicates "no further action" or "monitoring." Such an action might be undertaken for reasons other than public health (e.g., seeking community acceptance, reducing costs, etc.). However, actions implemented *in lieu* of sampling will typically be expected to be captured in the final engineering report and site management plan, and might not rule out the need for post-implementation sampling (e.g., to document effectiveness or to support terminating the action).
- [2] Actions provided in the matrix are specific to addressing human exposures. Implementation of these actions does not preclude investigating possible sources of soil vapor contamination, nor does it preclude remediating contaminated soil vapor or the source of soil vapor contamination.
- [3] Appropriate care should be taken during all aspects of sample collection to ensure that high quality data are obtained. Since the data are being used in the decision-making process, the laboratory analyzing the environmental samples must have current Environmental Laboratory Approval Program (ELAP) certification for the appropriate analyte and environmental matrix combinations. Furthermore, samples should be analyzed by methods that can achieve a minimum reporting limit of 1 microgram per cubic meter for indoor and outdoor air samples. For sub-slab vapor samples and dirt floor soil vapor samples, a minimum reporting limit of 1 microgram per cubic meter is recommended.
- [4] Sub-slab vapor and indoor air samples are typically collected when the likelihood of soil vapor intrusion to occur is considered to be the greatest (i.e., worst-case conditions). If samples are collected at other times (typically, samples collected outside of the heating season), then resampling during worst-case conditions might be appropriate to verify that actions taken to address exposures related to soil vapor intrusion are protective of human health.
- [5] When current exposures are attributed to sources other than soil vapor intrusion, the agencies should be given documentation (e.g., applicable environmental data, completed indoor air sampling questionnaire, digital photographs, etc.) to support a proposed action other than that provided in the matrix box and to support agency assessment and follow-up.
- [6] The party responsible for implementing the recommended actions will differ depending upon several factors, including but not limited to the following: the identified source of the volatile chemicals, the environmental remediation program, and analyte-specific, site-specific and building-specific factors.

Soil Vapor/Indoor Air Matrix F

February 2024

Analytes Assigned:

Toluene

SUB-SLAB VAPOR CONCENTRATION of COMPOUND (mcg/m ³)	INDOOR AIR CONCENTRATION of COMPOUND (mcg/m ³)		
	< 10	10 to < 50	50 and above
< 300	1. No Further Action	2. No Further Action	3. IDENTIFY SOURCE(S) or RESAMPLE or MITIGATE
300 to < 3,000	4. No Further Action	5. MONITOR	6. MITIGATE
3,000 and above	7. MITIGATE	8. MITIGATE	9. MITIGATE

mcg/m³ = micrograms per cubic meter

No further action: No additional actions are recommended to address human exposures.

Identify Source(s) or Resample or Mitigate: We recommend that reasonable and practical actions be taken to identify the source(s) affecting the indoor air quality and that actions be implemented to reduce indoor air concentrations to within background ranges. For example, if an indoor or outdoor air source is identified, we recommend the appropriate party implement actions to reduce the levels. In the event that indoor or outdoor sources are not readily identified or confirmed, resampling (which might include additional sub-slab vapor and indoor air sampling locations) is recommended to demonstrate that SVI mitigation actions are not needed. Based on the information available, mitigation might also be recommended when soil vapor intrusion cannot be ruled out.

Monitor: We recommend monitoring (sampling on a recurring basis), including but not necessarily limited to sub-slab vapor, basement air and outdoor air sampling, to determine whether concentrations in the indoor air or sub-slab vapor have changed and/or to evaluate temporal influences. Monitoring might also be recommended to determine whether existing building conditions (e.g., positive pressure heating, ventilation, and air-conditioning systems) are maintaining the desired mitigation endpoint and to determine whether changes are needed. The type and frequency of monitoring is determined based on site-, building- and analyte-specific information, taking into account applicable environmental data and building operating conditions. Monitoring is an interim measure required to evaluate exposures related to soil vapor intrusion until contaminated environmental media are remediated.

Mitigate: We recommend mitigation to minimize current or potential exposures associated with soil vapor intrusion. The most common mitigation methods are sealing preferential pathways in conjunction with installing a sub-slab depressurization system and changing the pressurization of the building in conjunction with monitoring. The type, or combination of types, of mitigation is determined on a building -specific basis, taking into account building construction and operating conditions. Mitigation is considered a temporary measure implemented to address exposures related to soil vapor intrusion until contaminated environmental media are remediated.

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MATRIX F Page 1 of 2

ADDITIONAL NOTES FOR MATRIX F

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- [1] The matrix is generic. As such, it may be appropriate to modify a recommended action to accommodate analyte-specific, building-specific conditions (e.g., dirt floor in basement, crawl spaces, thick slabs, current occupancy, etc.), and/or factors provided in Section 3.2 of the guidance (e.g., current land use, environmental conditions, etc.). For example, collection of additional samples may be recommended when the matrix indicates "no further action" for a particular building, but the results of adjacent buildings (especially sub-slab vapor results) indicate a need to take actions to address exposures related to soil vapor intrusion. Mitigation might be recommended when the results of multiple contaminants indicate monitoring is recommended. Proactive actions may be proposed at any time. For example, the party implementing the actions may decide to install sub-slab depressurization systems on buildings where the matrix indicates "no further action" or "monitoring." Such an action might be undertaken for reasons other than public health (e.g., seeking community acceptance, reducing costs, etc.). However, actions implemented *in lieu* of sampling will typically be expected to be captured in the final engineering report and site management plan, and might not rule out the need for post-implementation sampling (e.g., to document effectiveness or to support terminating the action).
- [2] Actions provided in the matrix are specific to addressing human exposures. Implementation of these actions does not preclude investigating possible sources of soil vapor contamination, nor does it preclude remediating contaminated soil vapor or the source of soil vapor contamination.
- [3] Appropriate care should be taken during all aspects of sample collection to ensure that high quality data are obtained. Since the data are being used in the decision-making process, the laboratory analyzing the environmental samples must have current Environmental Laboratory Approval Program (ELAP) certification for the appropriate analyte and environmental matrix combinations. Furthermore, samples should be analyzed by methods that can achieve a minimum reporting limit of 1 microgram per cubic meter for indoor and outdoor air samples. For sub-slab vapor samples and dirt floor soil vapor samples, a minimum reporting limit of 1 microgram per cubic meter is recommended.
- [4] Sub-slab vapor and indoor air samples are typically collected when the likelihood of soil vapor intrusion to occur is considered to be the greatest (i.e., worst-case conditions). If samples are collected at other times (typically, samples collected outside of the heating season), then resampling during worst-case conditions might be appropriate to verify that actions taken to address exposures related to soil vapor intrusion are protective of human health.
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- [6] The party responsible for implementing the recommended actions will differ depending upon several factors, including but not limited to the following: the identified source of the volatile chemicals, the environmental remediation program, and analyte-specific, site-specific and building-specific factors.

Remedial Investigation Work Plan
Haverstraw Chair Factory Site, Haverstraw, New York

APPENDIX F

Community Air Monitoring Program (CAMP)

Appendix F

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 $150 \text{ mcg}/\text{m}^3$ 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 $150 \text{ mcg}/\text{m}^3$ 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 $150 \text{ mcg}/\text{m}^3$ 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 C2

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° C (14 to 122° 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.