

NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION

Division of Environmental Remediation, Region 8
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January 7, 2020

Mr. Michael J. Piehler
Bonitatem LLC
770 Panorama Trail South
Rochester, NY 14625

**Re: Remedial Investigation Work Plan
1560 Lake Avenue
Rochester, New York
NYSDEC Site #C828213**

Dear Mr. Piehler;

The New York State Departments of Environmental Conservation (NYSDEC) and Health (NYSDOH; collectively referred to as the Departments) have completed their review of the document entitled "Remedial Investigation/Remedial Alternatives Analysis Work Plan" (the Work Plan) dated December 3, 2019 and prepared by Day Environmental, Inc. for the 1560 Lake Avenue Brownfield Cleanup Program (BCP) site located in the City of Rochester, Monroe County. In accordance with 6 NYCRR Part 375-1.6, the Departments have determined that the Work Plan substantially addresses the requirements of the Brownfield Cleanup Program. With the following modifications, the Work Plan is hereby approved upon the execution of the Brownfield Cleanup Agreement.

1. Section 2.0, the Departments are aware that in previous environmental studies target analytes were not detected in samples, including MTBE; however, the analytical reports state that the detection limits in multiple sample locations were elevated above guidance values due to the presence of non-target analytes.
2. Section 3.0 states that there are "no current human receptors on-site" and the site being described as "fully fenced and locked". The Department's recent site investigation indicates the site is not fully fenced and does not prevent the public from entering. This section is revised to reflect the partial fencing and possibility for human receptors via the open access to the site. All language stating that the site *is* fully fenced and locked is hereby removed from the approved Work Plan.
3. Section 3.0, the term "environmental receptor" is not clearly defined. The sentence "Based on the type and location of contaminants and the location of the Site, no environmental receptors have been identified" is hereby removed.
4. Section 4.2, it is the Departments' understanding that the proposed plan is to redevelop the entire site with a paved parking area and cover system that meets NYSDEC requirements for commercial use. However, surface soil samples may be required by the Departments during the RI/RAA and redevelopment in the event grossly contaminated soil is encountered. In addition, if the proposed cover and

cap system results in exposed areas of soil on the site, surface soil sampling may be required at that time.

5. Section 4.6, five soil vapor samples are referred to as VP-1 to VP-5 while in other sections are referred to as SV-1 to SV-5 for these sample locations. Soil vapor samples labeled as VP-1 to VP-5 will be relabeled as SV-1 to SV-5, respectively.
6. Section 5.0, the sentence "any required non-analytical data will be submitted within 90 days of being generated" is revised to read "any required non-analytical data will be submitted within monthly progress reports."
7. Figure 3 has been edited to remove the names of private property owners. The edited Figure is attached and will be used in the final approved Work Plan.

With the understanding that the modified Work Plan is agreed to, the Work Plan is hereby approved. If you choose not to accept these modifications, you are required to notify this office within 15 days after receipt of this letter and prior to the start of field activities. In this event, I suggest a meeting be scheduled to discuss your concerns prior to the end of this period.

Please notify me at least 7 days in advance of the start of field activities.

By January 22, 2020, please attach a copy of this letter to the Work Plan and distribute the approved Work Plan as follows:

- Tasha Mumbrue (1 hard copy with an original signature);
- Johnathan Robinson (NYSDOH, electronic file/CD)
- The document repository at the Maplewood Community Library, located at 1111 Dewey Avenue, Rochester, NY 14613 (1 bound hard copy).

If you have questions or concerns, please contact me at (585) 226-5459 or tasha.mumbrue@dec.ny.gov.

Sincerely,



Tasha Mumbrue
Geologist Trainee

cc w/ attachment:

Jeffrey Danzinger, Day Environmental
David Day, Day Environmental
Joseph Biondolillo, City of Rochester
Thomas Walsh, Barclay Damon, LLP
Johnathan Robinson, NYSDOH
Justin Deming, NYSDOH
Michael Cruden, NYSDEC
Dusty Tinsley, NYSDEC
Frank Sowers, NYSDEC

David Pratt, NYSDEC



PROJECT MANAGER	DATE	03-2019
	JAD	03-2019
DRAWN BY	DATE DRAWN	03-2019
	CPS	03-2019
SCALE	DATE ISSUED	03-25-2019
	AS NOTED	03-25-2019

DAY ENVIRONMENTAL, INC.
Environmental Consultants
Rochester, New York 14606
New York, New York 10170

Project Title
**1560 LAKE AVENUE
ROCHESTER, NEW YORK**

BROWNFIELD CLEANUP PROGRAM

Drawing Title
Site with Surrounding Properties

Project No.
5495S-18

FIGURE 3

**REMEDIAL INVESTIGATION/REMEDIAL ALTERNATIVES ANALYSIS
WORK PLAN**

**1560 LAKE AVENUE
ROCHESTER, NEW YORK**

NYSDEC SITE #C828213

Prepared for: Bonitatem LLC
770 Panorama Trail South
Rochester, New York

Prepared by: Day Environmental, Inc.
1563 Lyell Avenue
Rochester, New York

Project No. 5495S-18

Date December 2019

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CERTIFICATION STATEMENT

I, Jeffrey A Danzinger, certify that I am currently a Qualified Environmental Professional as defined in 6 NYCRR Part 375 and that this Remedial Investigation/Remedial Alternatives Analysis Work Plan 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)



QEP

December 3, 2019

DATE

1.0 INTRODUCTION

This Remedial Investigation/Remedial Alternatives Analysis (RI/RAA) Work Plan was prepared by Day Environmental, Inc. (DAY) on behalf of the Brownfield Cleanup Program (BCP) applicant, Bonitatem LLC, for the property at 1560 Lake Avenue, Rochester, New York (Site), which is further described below. The RI/RAA is being conducted under the BCP of the New York State Department of Environmental Conservation (NYSDEC). The Site is currently owned by Bonitatem LLC. A Project Locus map is included as Figure 1. A site-specific Health and Safety Plan (HASP), including a Community Air Monitoring Plan (CAMP), and a Quality Assurance Project Plan (QAPP), are included with this RI/RAA Work Plan as Appendices A and B, respectively.

1.1 Site Description

The Site consists of approximately 2.144 acres of vacant land (Tax ID 090.44-1-1.2), which is covered by soil, gravel, deteriorating pavement and grass. The Site is zoned as C-3 (Regional Destination Center District), which is illustrated on the Site zoning map included as Figure 2. A 25-foot wide strip of land comprised of the northern portion of the former Lapham Street right-of-way, which contains a combined stormwater/sanitary sewer main, is located on the southernmost portion of the Site.

The Site has an automobile dealership, including a service area and gasoline pumps, on it from approximately the 1940s to 2000s. The automobile dealership building has been demolished, and the Site is now vacant. The main features of the Site and surrounding properties are shown on Figure 3. As shown, the Site is bound:

- to the north by Redwood Road with a commercial parking lot, a vacant commercial lot, and some residential property beyond;
- to the east by Lapham Street Extension with residential property beyond;
- to the south by commercial property and residential property; and,
- to the west by Lake Avenue with industrial property and commercial property beyond.

In connection with the historical uses of the Site, there were multiple reported spills and underground storage tanks (USTs). Petroleum impacts were noted in soil, and also groundwater within the overburden and bedrock. Impacts also included detections of methyl tert-butyl ether (MTBE) primarily in the bedrock groundwater with a source not identified on the parcel. Reportedly nine USTs were removed from the Site from the 1960s to the 1980s; however, complete documentation of their closure including confirmatory soil samples is not available. A January 2018 geophysical survey that was conducted across the entire Site identified two magnetic anomalies. Test pits excavated at the two magnetic anomalies did not identify USTs. The former automobile service area had a former grease pit where service work beneath the vehicles was conducted. Prior to closure by filling in-place with flowable fill, standing water in the grease pit was sampled and tested by an analytical laboratory. The samples test results were non-detect for volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs), but did contain lube oil. As such, the water was removed and disposed off-site prior to closure by filling in-place. SVOC and metals impacts, along with minor detections of pesticides, were also detected in soil and urban fill material at the Site.

1.2 Objectives

The objectives of the remedial investigation (RI) work defined in this Work Plan are described below.

- Define the nature and extent of contamination in soil, fill, soil vapor and groundwater.
- Ascertain to the NYSDEC's satisfaction whether the MTBE detected at the Site is solely attributable to an off-site source and that no act of the remedial party contributed to the off-site contamination.
- Characterize the near-surface and subsurface characteristics of the Site, including topography, surface drainage, stratigraphy and depth to groundwater.
- Produce data of sufficient quantity and quality for remedial decision-making.
- Further define the scope of a planned oxygen injection system Interim Remedial Measure (IRM), which could be used to remediate or mitigate the petroleum contamination that has been documented at the Site to a degree that is protective of the reasonable anticipated parking lot use. In conjunction with the oxygen injection system, it is anticipated that institutional controls (e.g., environmental easement, site management plan) and engineering controls (e.g., cover system) will be put in place.
- Describe the volume, concentration, persistence, mobility, state, and other significant characteristics of the contamination at the Site.
- Determine, as practicable, the extent to which natural or anthropogenic barriers currently contain or limit migration or mobility of the contamination.
- Define the extent to which the contaminants have migrated, and whether future migration may pose a threat to human health or the environment.
- Perform an exposure assessment to identify potential routes of exposure, populations, and environmental receptors at risk.
- Define hydrogeological factors (e.g., groundwater flow within overburden and underlying bedrock, depth to the saturated zone, hydrologic gradients, hydraulic conductivity; and proximity to a drinking water aquifer, flood plain, or wetland).
- Describe groundwater characteristics, and current and potential groundwater use, including the identification of private wells, if possible, and public water supply wells in the area.
- Describe the Site's potential contribution to an air, land, water, biota, or bioaccumulation contamination problem.
- Upon completion of the RI, assess the active and potential threats to human health and the environment, including the potential for off-site impacts for the Site's current, intended and reasonably foreseeable use.

The goal of the RI is to obtain sufficient information to evaluate remedial alternatives, and ultimately recommend and select a remedial alternative that is protective of public health and the environment for the Site's current, intended and reasonably foreseeable use.

Upon NYSDEC request or suggestion of Bonitatem LLC, additional investigation activities will be completed in accordance with addenda to this Work Plan until these objectives are successfully achieved.

1.3 Applicable Project Standards, Criteria and Guidance

Bonitatem LLC intends to implement a Track 4 cleanup to attain conditions that are protective of the City of Rochester's future commercial use of the Site as a parking lot. Applicable standards, criteria, and guidance (SCG) values that will be used for this Site are outlined below:

- Appropriate Soil Cleanup Objectives (SCOs) and other guidance related to the BCP as set forth in 6 NYCRR Part 375 (Environmental Remediation Programs) dated December 14, 2006. Appropriate SCOs for this Site are the Protection of Groundwater SCOs and Commercial Use SCOs. Data will also be compared to Unrestricted Use SCOs.
- Appropriate Soil Cleanup Levels (SCLs) and other guidance as set forth in NYSDEC CP-51 Soil Cleanup Guidance dated October 21, 2010.
- Guidelines referenced in the NYSDEC document titled "DER-10 Technical Guidance for Site Investigation and Remediation" dated May 10, 2010.
- Appropriate groundwater standards and guidance values as set forth in the NYSDEC Division of Water Technical and Operational Guidance Series 1.1.1 document titled "Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations" dated June 1998, and amended by a January 1999 Errata Sheet, an April 2000 Addendum, and a June 2004 Addendum (TOGS 1.1.1).
- New York State Department of Health (NYSDOH) document entitled "Guidance for Evaluating Soil Vapor Intrusion in the State of New York" dated October 2006, as amended by subsequent updates, including the ABC Matrices for SVI dated May 2017.
- City of Rochester Sewer Use Permit requirements.

The work described in this Work Plan will be performed in accordance with the SCGs listed above.

2.0 BACKGROUND AND PREVIOUS STUDIES

This section describes the history of the Site and surrounding properties, as well as, a summary of previous environmental site assessments and investigations that have been conducted.

2.1 Site History

The Site was an automobile sales and service facility from the late-1940s to mid-2000s. In the early years, there was a gasoline fueling station on the northwest corner of the Site along Lake Avenue. Between at least 1910 and 1950, some apparent residential dwellings and out buildings were located on the central and/or southern portions of the Site. The southernmost 25 feet of the Site was once part of a now-abandoned portion of Lapham Street. The automobile sales and service operations at the Site ceased by September 2006. The automobile sales and service facility was demolished in January/February 2008.

In connection with these historical uses of the Site, there were multiple reported spills and USTs. Reportedly nine USTs were removed from the 1560 Lake Avenue parcel from the 1960s to the 1980s; however, complete documentation of their closure including confirmatory soil samples is not available. Records indicate that the Site had a large grease pit, an oil water separator within the building, and numerous in-ground lifts. Documentation regarding the closure of these structures is not available.

Given the various former buildings that were present on the Site, the potential exists for building foundations, miscellaneous demolition debris (including materials containing asbestos or lead-based paint), and potentially regulated solid waste to be present on parts of the Site.

Historically sewer lines were present beneath southernmost part of the Site that was formerly part of Lapham Street. In addition, the 1910 and 1918 Plat maps depict a former sewer pipe transecting the Site (refer to Figure 4). Sewer pipes transecting the Site can result in preferential pathways for the movement of contaminants originating from on-site and/or off-site sources, including the adjacent and nearby Eastman Kodak facilities.

Four NYSDEC Spills are listed for the Site, as briefly described below:

- **Spill No. 9703887:** This spill occurred when an ex-employee called in to state that waste fluid was washed down a storm drain. Monroe County investigated and stated that no follow-up action was needed. The spill file was subsequently closed by the NYSDEC; however, the Spill Report Form indicates environmental conditions do not meet standards.
- **Spill No. 9870467:** This spill occurred when an underground waste oil tank (identified as Tank No. 003-A) was being removed. The spill file was closed in 2000 after receiving a report indicating that the residual contamination was limited to the Site and the concentrations were not significant. Additional information is provided in Section 2.3. The spill file was subsequently closed by the NYSDEC; however, the Spill Report Form indicates environmental conditions do not meet standards.
- **Spill No. 9970522:** This spill occurred when impacts were found while removing a 4,000 gallon gasoline tank (identified as Tank No. 001) and a 1,000 gallon waste oil tank (identified as Tank No. 002-A). The NYSDEC closed the spill file following receipt of the confirmatory analytical sampling. Additional information is provided in Section 2.3. The Spill Report Form indicates environmental conditions meet standards.

- **Spill No. 0170480:** This spill was opened when petroleum impacts were found as part of a road improvement project from borings in front of the Site. Subsequently three 2,000 gallon tanks and 40 tons of soil were removed (identified as Tank Nos 007-A, 008-A, and 009-A) from the northwest corner of the Site. Per the spill report, residual contamination remained in the excavation. The spill file was closed in 2002 without a resolution, and the Spill Report Form indicates environmental conditions do not meet standards. Additional information is provided in Section 2.3.

2.2 Surrounding Properties

The Site is bounded: to the north by Redwood Road with a commercial parking lot, a vacant commercial lot, and some residential property beyond; to the east by Lapham Street Extension with residential property beyond; to the south by commercial property and residential property; and to the west by Lake Avenue with industrial property and commercial property beyond.

The surrounding neighborhood contains a mix of residential, commercial, industrial, and park uses, in zoning districts such as R-1 (Low-Density Residential), C-2 (Community Center District), C-3 (Regional Destination Center District), O-S (Open Space District), and PD #12 (Planned Development District, which is currently owned by the Eastman Kodak Company). The nearest residential areas are on the opposite side of Redman Road, Lapham Street Extension and Lapham Street located northeast, east and southeast of the Site. A portion of a zoning map that shows the Site and surrounding area is attached in this BCP Application as Figure 2.

2.3 Previous Environmental Studies

Various environmental studies have been conducted at the Site between 1999 and 2018. The cumulative test locations where field and analytical samples were collected during the previous studies are shown on Figure 4. The overburden cumulative overburden and bedrock monitoring wells installed for this Site during the previous studies are shown on Figure 5.

During the previous environmental studies, petroleum impacts to soil and groundwater have been documented at the Site. The petroleum impacts consist primarily of VOCs. Peak photoionization detector (PID) readings measured on soil samples and total TCL VOCs detected in soil samples from the cumulative previous investigations are shown on Figure 6 and Figure 7, respectively. Total TCL VOCs previously detected in overburden groundwater samples and bedrock groundwater samples are shown on Figure 8 and Figure 9, respectively. The highest concentrations of total TCL VOCs in bedrock groundwater do not align with the highest concentrations of total TCL VOCs in overburden groundwater, total TCL VOCs in soil, or peak PID readings in soil. Figure 10 and Figure 11 provide a comparison of the VOCs benzene and MTBE in overburden groundwater and bedrock groundwater. As shown, MTBE is predominantly in bedrock groundwater. Benzene was detected within some overburden and bedrock samples, and one or more past petroleum releases at the Site may be a contributing source.

In addition, urban soil fill material generally consisting of reworked urban soils (various mixtures of sand, gravel, and silt) with lesser amounts of organics, rock, brick, concrete, glass, coal, sandstone, terracotta, wood, and metal were documented at the Site. Building debris may also be present in proximity to former buildings. The fill material has occasionally been found to contain elevated concentrations of Polycyclic Aromatic Hydrocarbon (PAH) SVOCs and some metals (e.g., lead, mercury).

Further details for each environmental study are provided below.

- Data Package for NYSDEC Spill No. 9870467 prepared by Day Environmental, Inc. for Piehler Pontiac Corporation, dated August 1999. A Phase II Environmental Site Assessment (Phase II ESA) was conducted as a result of impacted soil encountered during removal of a 2,000 gallon UST used to collect overflow from an oil/water separator which was located on the Site. According to this report attempts were made during the removal of the tank to excavate out the impacted material; however, groundwater infiltration that was encountered at 13 feet (ft.) below the ground surface (bgs) made it infeasible. As part of the Phase II ESA, nine soil borings and three temporary groundwater monitoring wells were installed. Four of the investigation locations exhibited evidence of impacts such as odors, staining and elevated PID readings. Three soil and three groundwater samples were submitted for laboratory analysis of petroleum related compounds. One test boring (TB-7) located south of the former UST excavation had seven SVOCs which exceeded NYSDEC SCO criteria. In addition, the VOC 1,2,4-Trimethylbenzene exceeded its Commercial Use SCO. One monitoring well (TB-5) located just south of the former tank location contained four PAH SVOCs above the groundwater standard/guidance values. In one soil sample collected from within the former excavation area (TB-8), no target analytes were detected; however, the report states that the detection limits in this location were elevated due to the presence of non-target analytes. Polychlorinated Biphenyls (PCBs) and Toxicity Characteristic Leaching Procedure (TCLP) metals were also tested in this location, and the results were non-detect for both groups of analytes. The report concluded that the former use of the oil/water separator system had impacted the subsurface and that other analytes not specifically tested for in TB-8 may be present in excess of regulatory standards. No information on the closure of the oil/water separator itself, reportedly located within the north portion of the building, was provided other than a note from the owner stating that it was removed on 12/31/1998.
- Closure Report and Site Assessment prepared by Pump and Tank, Inc. for Piehler Pontiac Corporation, dated December 7, 1999. This report stated that, when a 4,000 gallon gasoline tank and a 1,000 gallon waste oil tank were removed, “slight staining around fills” was observed (Tank No. 001 and 002-A). Per the report, four to six tons of petroleum contaminated soil was removed. This report provided analytical results for confirmatory soil samples and a soil sample collected from stockpiled material. No SVOCs, and only trace detections of petroleum related VOCs, were detected in the confirmatory soil samples.
- Hazardous Waste/Contaminated Materials Investigation Report, for NYS Route 104, West Ridge Road, prepared by Bergmann Associates, P.C., for City of Rochester, dated December 28, 2001. This report included environmental work within the public right-of-way of Lake Avenue immediately west of the Site. A total of four test borings (designated as BH-20, BH-25, BH-26 and BH-27) were advanced in the adjoining public right-of-way. Field evidence of petroleum impact was documented at two of the locations (BH-20 and BH-25). Test results for BH-20 contained some petroleum analytes at concentrations exceeding Protection of Groundwater SCOs. PCB and metals test results were non-detect or below applicable SCOs.
- Test borings and Lab Testing, conducted by DAY, December 2001: To evaluate Site conditions in proximity to the petroleum impact documented by Bergmann in the adjoining Lake Avenue public right-of-way (discussed above), three test borings (designated as TB-01 through TB-03) were advanced on the northwest portion of the Site. Field evidence of petroleum impact, and lab results showing petroleum VOCs at concentrations exceeding Protection of Groundwater SCOs and/or Commercial Use SCOs, was detected soil samples from TB-02 and TB-03, but not TB-01.

- Letter entitled “1560 Lake Avenue, Rochester New York” prepared by Day Environmental, Inc. for Piehler Pontiac Corporation, dated December 3, 2002. This letter summarized sampling that took place in 2002 within a former grease pit structure located beneath a portion of the concrete floor in the service garage portion of the former building on the Site. Two samples of standing water were collected from the grease pit, one was analyzed for PCBs, total petroleum hydrocarbons (TPH), benzene, toluene, ethylbenzene and xylene (collectively “BTEX”), MTBE and PAH SVOCs and the second was analyzed for oil and grease. PCBs, BTEX, MTBE and PAH SVOCs were non-detect. Heavy-weight TPH designated as lube oil, and oil and grease, were detected in the grease pit. The letter estimated that approximately 1,360 gallons of standing water was present in the former grease pit when the sampling event took place. The letter stated that there were concerns regarding the long-term structural integrity of the pit; thus, it was anticipated that it would be closed in-place. The letter recommended that the water be either pre-treated prior to discharge to the on-site oil water separator system or be disposed of off-site. Information reviewed indicated that the impacted water was pumped from the approximately 9’ x 48’ x 8’ grease pit and properly disposed prior to being filled in with flowable fill.

- Underground Storage Tank Closure Report, 1560 Lake Avenue, Rochester, New York prepared by Day Environmental, Inc. for Piehler Pontiac Corporation, dated January 2003. This report pertained to the removal of three 2,000-gallon USTs related to spill number 0170480. The tanks were located on the northwest portion of the Site in the area of Bergmann’s 2001 Lake Avenue right-of-way study test locations adjoining the Site and DAY’s December 2001 test boring TB-02. Each tank was in poor condition and petroleum contaminated soils were encountered in the tank pit. Approximately 33 tons of non-hazardous petroleum-contaminated soil was removed from the tank excavation and disposed at an appropriate regulated landfill facility. Some of the confirmatory soil samples contained petroleum-related VOCs at concentrations that exceeded Protection of Groundwater SCOs, but none of the confirmatory soil samples exceeded Commercial Use SCOs.

- Data Package for NYSDEC Spill No. 0170480 prepared by Day Environmental, Inc. for Piehler Pontiac Corporation, dated March 15, 2012. This report is related to Spill 0170480 that involved petroleum contamination in the area of the three USTs that were closed on the northwest portion of the Site. The investigation was performed to further define the residual contamination associated with this spill. A total of 18 soil borings (designated as B-1 through B-18), six of which were converted to monitoring wells (designated as MW-1 through MW-6) were installed. Petroleum odors and staining were observed in nine boring locations (i.e., B-1, B-3, B-4, B-5, B-6, B-7, B-8, B-9, and B-18) and staining with no odor noted was observed in four other locations (B-13, B-15, B-16, and B-17). The odors/staining were typically observed around the top of the assumed water table and extended to equipment refusal, which was likely due to bedrock (16.3 to 19.8 ft. bgs). Twelve soil samples and seven groundwater samples were analyzed for petroleum-related VOCs and the SVOC naphthalene. Petroleum-related VOCs and/or the SVOC naphthalene were detected in three of the soil samples at concentrations exceeding Protection of Groundwater SCOs, but not Commercial Use SCOs. These locations were below the former building footprint. Petroleum-related VOCs and/or the SVOC naphthalene were also detected in groundwater at three monitoring wells (MW-1, MW-3 and MW-6) at concentrations exceeding groundwater standards or guidance values. MW-1 is located immediately adjacent to the former location of the three USTs, MW-3 is located within the former building footprint southeast of the former USTs, and MW-6 is located along

the eastern Site boundary. MW-6 only had a detection of MTBE above its groundwater standard. MTBE was not detected in other overburden wells, or the soil samples, across the Site.

- Phase I Environmental Site Assessment Report, 1540 and 1560 Lake Avenue, prepared by Stantec for the City of Rochester, dated December 7, 2017. This Phase I Environmental Site Assessment (Phase I ESA) was completed for the Site (1560 Lake Avenue) and also the adjoining property to the south (1540 Lake Avenue). This report identified the following recognized environmental conditions (RECs) for the Site:
 - Historical use of the Site as an automobile dealership with associated automobile repair services;
 - The documented presence of petroleum impacts in soil and groundwater;
 - The historical presence of USTs, a grease pit, and an oil/water separator in conjunction with the lack of documentation for proper closure/removal of these underground structures;
 - The documented presence of fill material and the potential presence of demolition debris and potentially regulated solid waste; and;
 - Historical use of the adjoining properties as a gasoline station, automobile dealer/repair facility, Eastman Kodak industrial facilities and dry cleaners in conjunction with the current/historical presence of sewer lines which could act as a preferential pathway for contaminant migration or releases. Of interest in terms of sewer lines, the 1910 and 1918 Plat Maps showed a 24 inch sewer pipe transecting the middle of the Site from west to east.
- Phase II Environmental Site Assessment Data Package, 1540 and 1560 Lake Avenue, prepared by Stantec for the City of Rochester, dated March 23, 2018. This Phase II ESA was completed for the Site (1560 Lake Avenue) and also the adjoining property to the south (1540 Lake Avenue). This data package identified the following environmental conditions for the Site:
 - A geophysical survey conducted across the Site identified two anomalies on the northwest portion of the Site. Subsequent test pitting did not encounter any USTs, drums or other structures of concern at these two anomaly areas.
 - The depth to the top of groundwater at on-site wells set in the overburden generally range between 5.0 to 8.6 ft. bgs., and depth to the top of groundwater at wells set in bedrock generally range between 6.1 to 18.5 ft. bgs.
 - Petroleum-related compounds were detected in numerous soil samples at concentrations exceeding Protection of Groundwater SCOs and in one sample above Commercial Use SCOs. The VOC MTBE (a gasoline additive) was detected in one of seventeen soil samples tested (i.e., test boring B-100), and only at a concentration of 24 microgram per kilogram (ug/Kg) or parts per billion (ppb), which is below the Protection of Groundwater SCO and the Commercial Use SCO.
 - PAH SVOCs were detected in many urban soil/fill material samples at concentrations exceeding Protection of Groundwater SCOs and/or Commercial Use SCOs. Some metals were also detected in some urban soil/fill material samples at concentrations exceeding Protection of Groundwater SCOs, but not Commercial Use SCOs. Many of these test locations with exceedances contained ash and/or cinders.
 - PCBs were not detected in soil or urban soil/fill material samples.

- The pesticide heptachlor epoxide was detected in one urban soil/fill material sample at a concentration exceeding its Protection of Groundwater SCO, but not its Commercial Use SCO. Some other pesticides were detected in this sample and other soil and urban soil/fill material samples at concentrations that exceeded Unrestricted Use SCOs, but not Protection of Groundwater SCOs or Commercial Use SCOs.
- Petroleum-related compounds were detected in overburden groundwater samples at concentrations exceeding groundwater standards and guidance values. Petroleum-related compounds were also detected in bedrock groundwater samples, which were significantly comprised of MTBE. However, MTBE was only detected in two of twelve overburden groundwater samples at concentrations of 47 and 240 ug/l or ppb. MTBE was detected in four of the five bedrock groundwater samples at concentrations ranging between 580 and 3,900 ug/l or ppb. The highest concentration of MTBE detected in the overburden groundwater was at the downgradient well MW-6 along the east side of the Site where the top of the overburden groundwater table is closest to the top of the bedrock groundwater table, which is an area of the Site where overburden and bedrock groundwater may be comingling.
- Lapham St Extension Groundwater Study Data Package, prepared by Day Environmental, Inc., May and August 2018. In May 2018, five one-inch polyvinyl chloride (PVC) monitoring wells (designated as MW-LE-01 through MW-LW-05) were installed in the tree lawn on the east side of the Lapham Street Extension public right-of-way (i.e., off-site to the east of the Site). May 2018 groundwater samples from the five wells contained petroleum-related VOCs at concentrations ranging between 0.27 and 38 ug/l or ppb. The concentrations of benzene, isopropylbenzene and/or MTBE detected in three of these groundwater samples exceeded NYSDEC groundwater standards or guidance values. Based on May 2018 and August 2018 measurements, groundwater in the overburden generally flows eastward, and groundwater in the bedrock generally flows southward. The top of the groundwater tables in the overburden and bedrock are closest to each other on the east side of the Site, which suggests that contaminants primarily in the bedrock groundwater and other contaminants primarily in the overburden groundwater may be co-mingling east of the Site.

Copies of each of the above reports were included as part of the BCP Application for the Site, which was previously submitted to the NYSDEC.

3.0 CONCEPTUAL SITE MODEL

The preliminary conceptual site model presented in this section identifies and describes: (1) the known or potential sources of contamination; (2) the types of contaminants and affected media; (3) the release mechanisms and potential migration pathways; and (4) the actual/potential human health and environmental receptors. This preliminary conceptual site model was used as the basis for the further studies described herein. The data collected during the RI will be used to refine this model as the project progresses and assist in evaluating remedial options for the Site.

- Known or Potential Sources of Contamination: Known or potential sources of contamination include the former automobile sales and service and filling station operations at the Site. Specific structures that could have been source areas include former UST areas, former oil/water separator components, a former in-ground “grease pit”, and former floor drains, and former in-ground hydraulic lifts. In addition, urban fill material on the Site appears to be a source of PAH SVOC and metals contamination. It is also possible that one or more off-site sources may be contributing to the presence of MTBE that has primarily been documented in bedrock groundwater.
- Types of Contaminants and affected media: Petroleum-related VOCs and the SVOC naphthalene have been documented in overburden deposits and overburden groundwater. Urban fill material generally consisting of reworked urban soils (various mixtures of sand, gravel, and silt) with lesser amounts of organics, rock, brick, concrete, glass, coal, sandstone, terracotta, wood, and metal were documented at the Site. Subsurface building debris may also be present in proximity to former buildings. The fill material occasionally contains elevated concentrations of PAH SVOCs and some metals (e.g., lead, mercury). The gasoline additive MTBE has been primarily detected in deeper bedrock groundwater.
- Release Mechanisms and Potential Migration Pathways: Known on-site release mechanisms include spills associated with former UST systems and the oil/water separator system. Known or potential migration pathways include in groundwater, in or around former or existing buried utilities, and in soil vapor. In addition, active and abandoned buried sewers (i.e., former east-west trending sewer through center of Site, east-west trending sewers in abandoned section of Lapham Street near the southern portion of the Site, and nearby deep combined sewer overflow (CSO) system), may influence groundwater flow direction.
- Actual or Potential Human Health and Environmental Receptors: The Site is vacant land with perimeter fencing and locked gates; thus, there are no current human receptors on-Site. Potential future human receptors include: on-site environmental workers and construction workers associated with the BCP project and/or redevelopment of the Site for commercial use as a parking lot; and 2) occupants of off-site structures (e.g., residential dwellings) primarily on downgradient properties in relation to soil vapor intrusion of petroleum-related VOCs. [Note: City of Rochester Chapter 59 (Health and Sanitation), Article III (Nuisances and Sanitation) § 59-27 (Water Supply) prohibits groundwater within the City limits, including the Site, from being used as a source of potable water. As such, ingestion of groundwater does is not considered a complete exposure pathway].

Based on an internet search, the following churches, schools and child daycare centers are located within one-half mile of the Site.

Name	Address	Relative Location to Site
Rise Community School Not 106	279 West Ridge Road	0.45 miles northwest
Dr. Walter Cooper Academy School No. 10	180 Ridgeway Avenue	0.32 miles west
Nazareth Elementary School	311 Flower City Park	0.32 miles southwest
University Prep Charter	1290 Lake Avenue	0.37 miles south
Church of the Ascension	2 Riverside Street	0.23 miles south
Sacred Heart Cathedral	296 Flower City Park	0.23 miles southwest
Raiza and Deysi's Home Daycare	24 Flower City Park	0.17 miles southeast
iKids Daycare	40 Riverside Street	0.28 miles southeast

The contaminants are generally underground and the Site is in an urban setting. The nearest water body is a pond in the City of Rochester Maplewood Park, which is located approximately 1,000 feet east of the Site. There are significant municipal sewers running in an east-west orientation to the south of the Site along the former Lapham Street road bed and along Ridge Road. In addition, there are significant municipal sewers running in a north-south orientation to the immediate west of the Site along Lake Avenue. The next closest water body is the Genesee River, which is located approximately 1,800 feet east of the Site. Based on the type and location of contaminants and the location of the Site, no environmental receptors have been identified.

4.0 REMEDIAL INVESTIGATION SCOPE OF WORK

This section presents the RI scope of work to meet the project objectives provided in Section 1.2 of this RI/RAA Work Plan. This work will be completed in accordance with provisions and guidance outlined in the NYSDEC document titled “DER-10 Technical Guidance for Site Investigation and Remediation” dated May 2010, including regular communication with the NYSDEC.

A site-specific HASP attached as Appendix A outlines the policies and procedures to protect workers and the public from potential environmental hazards during activities that have the potential to disturb contaminated environmental media and other subsurface materials. The HASP includes a CAMP that is required for intrusive activities at the Site during this project, and an Emergency Contingency Plan (ECP) should unanticipated emergencies or Site conditions be realized.

A site-specific QAPP included in Appendix B describes the procedures to be used to provide for the integrity of the field data and analytical data to be collected. The QAPP includes specific information pertaining to the handling of samples, analytical methods to be used, Quality Assurance/Quality Control (QA/QC) procedures to be followed, analytical laboratory reporting limits, documentation procedures, project organization, decontamination procedures, sampling procedures, and a sampling and analysis plan.

Further details regarding the RI scope of work are provided in subsections outlined herein.

4.1 Utility Assessment

Identifying potential preferred contamination migration pathways is an objective of the RI, and understanding active and former utility infrastructure at the Site is critical for identifying potential preferred contamination pathways. Publicly available utility records will be requested from the City of Rochester, Monroe County, and Utility Companies that service the Site. Utility records obtained will be reviewed and verified with field observations in order to identify utilities on-site and immediately off-site, including buried sewer systems (e.g., storm, sanitary or combined), electric lines, natural gas lines, water delivery lines, etc.

Depending on the available documentation regarding the depths and locations of sewers, and accessibility, utility field testing may be implemented. Utility field testing may include non-toxic and biodegradable dye testing of smaller sewer pipe systems that may be partially blocked systems, remote video examination of accessible utilities and drains, and/or tracing of accessible drains using a sonde, may be implemented in order to evaluate the flow path, the location, and/or the discharge location and/or integrity of select utilities.

4.2 Soil and Fill Material Evaluation

Numerous test borings, test pits and monitoring wells have been completed/installed at the Site. To supplement and confirm the accuracy of existing data and fill in data gaps associated with the extent of petroleum contamination, a total of twelve direct-push drilled overburden test borings (designated as TB-200 through TB-211) and two rotary-drilled overburden/bedrock test borings (designated TB-212R and TB-213R) will be advanced at the Site. Figure 12 shows the tentative locations where these samples will be collected. DAY’s geographic information system (GIS) coupled with use of its global positioning system (GPS) and/or tape measurements from existing Site features will be used to mark out the test locations. The field investigation results and sample

locations will be placed into the GIS database for later data interpretation and remedial evaluation efforts.

A DAY representative will observe samples of material from test borings for field evidence of possible contamination (e.g., staining, free product, sheen, odors, fill material), screen samples of material for total VOCs using a PID, and log the lithologic conditions, rock quality determinations (where applicable) and water content conditions. This information, as well as other pertinent information, will be recorded on test boring logs. Copies of the logs to be used are provided in the QAPP that is included in Appendix B. Portions of samples will be collected for possible analytical laboratory testing, and samples being considered for VOC testing will be collected using United States Environmental Protection Agency (USEPA) Method 5035.

Surface soil samples will not be collected as part of the RI since the Site is fully fenced and locked (i.e., mitigates exposure to the existing areas of surface soil), and since the entire Site will be redeveloped with a paved parking lot and new green areas that will meet NYSDEC cover system requirements for commercial use. With consideration to redevelopment plans, the scope of the RI includes characterization of the upper two feet of soil/fill material (which includes existing exposed surface soil) which is anticipated to be reworked and re-used on Site. However, if grossly contaminated soil is encountered at a boring location, DAY will collect a discrete sample from this interval for possible analytical laboratory testing with input from the NYSDEC.

The criteria for selection of soil samples to be tested by an analytical laboratory is provided below:

- Potential field evidence of contamination (elevated PID readings, staining, odors, presence of dense non-aqueous phase liquid [DNAPL], a light non-aqueous phase liquid [LNAPL], fill material, etc.). Samples will be collected from the intervals of greatest field evidence of contamination;
- Approximately one to two feet below significant changes in the nature and extent of identified field contamination;
- Immediately above the top of the uppermost groundwater table; and,
- At the bedrock/overburden interface.

Refer to Section 4.6 for a discussion of the analyses that will be performed on these soil samples.

If field observations and/or elevated PID readings suggest the presence of DNAPL or LNAPL, a shake test may be performed on an aliquot of the corresponding soil sample with hydrophobic dye. The sample aliquot, a couple ounces of potable water, and a small amount (i.e., pinch) of Sudan IV or equivalent will be placed in a sealable plastic baggie, agitated, and then noted for pigment staining. If significant organic DNAPL or LNAPL is present, the Sudan IV Pigment should result in pigment staining.

Drill cuttings, drill water, and decontamination water will be handled as investigation-derived waste (IDW) in accordance with Section 4.5.

Direct-Push Test Borings

Direct-push test borings TB-200 through TB-209 will be advanced to equipment refusal using direct-push drilling guidance provided in the QAPP included in Appendix B. Direct-push test borings TB-210 and TB-211 will be advanced to depths of 2 feet bgs. Refer to Figure 12 for the locations of these direct-push test borings. Samples will be collected using a macro-core system from the ground surface to the desired depths identified.

Numerous test borings and test pits have already been conducted at the Site that provide adequate logging and mapping of the vertical and aerial extent of fill material (including historic fill material) across the Site. However, further chemical characterization of soil/fill material within two feet of the ground surface is warranted. To further supplement existing data and logging information, and to evaluate the potential re-use options of the shallow soil/fill material on the Site (i.e., as cover material, or more likely as fill material beneath both pervious and impervious cover material for this Track 4 cleanup), a sample of soil/fill material that represents the entire 0 to 2 foot depth interval will be collected from TB-200 through TB-211 (i.e., twelve samples total, or greater than five samples per acre). The number of borings, and the number of soil/fill material samples to be tested, are based on guidance referenced in Section 3.11 (Historic Fill Material) of DER-10. In addition, a total of thirteen soil/fill material samples will also be collected from depths greater than two feet to supplement existing laboratory data regarding chemical characterization of the Site and delineation of known contaminants. Also, if more than one distinct type of fill material is encountered in a test boring, an additional discrete sample may be collected for possible analysis, subject to NYSDEC approval. The analytical laboratory program for these samples is presented in Section 4.6 of this RI Work Plan.

Direct-push test borings TB-200, TB-208 and TB-209 will be converted into overburden groundwater monitoring wells MW-200, MW-208 and MW-209, respectively. Each overburden well will be constructed with a ten-foot long, 1-inch inner diameter, Schedule 40 PVC, 10-slot screen attached to solid riser piping of the same material that extends at least two feet above the existing ground surface. Each screen will be placed to intercept the top of the uppermost water-bearing zone as determined at the time of drilling. The annulus below, around and at least one foot above each screen will be backfilled with a sand pack. A minimum two-foot thick bentonite seal will be placed in the annulus above the sand pack in each well. The remaining annulus in each well will be backfilled with a Portland cement/bentonite grout. A J-plug or cap will be installed on the top of the PVC riser, and a protective casing with a concrete pad will be installed over each well. Pertinent information for each monitoring well will be documented on an overburden monitoring well construction diagram (refer to copy provided in QAPP in Appendix B). Test borings not converted into groundwater monitoring wells will be backfilled with Portland cement/Bentonite grout. Drill cuttings will be containerized for later disposal in accordance with applicable regulations.

Rotary-Drilled Test Borings

A rotary drill-rig will be used to advance off-site test borings TB-212R and TB-213R in the public right-of-ways of Lake Avenue and Redman Road, respectively. The boring will be converted into bedrock monitoring wells MW-212R and MW-213R (refer to Figure 12). The rotary drilling will be conducted in accordance with guidance provided in the QAPP included in Appendix B. The drilling contractor will construct a temporary decontamination pad, and drilling equipment will be decontaminated using an Alconox and water wash/water rinse or steam cleaning prior to use at each location. Water used from drilling and decontamination will be sourced from a potable public water system, such as the City of Rochester or County of Monroe, New York.

The two overburden/bedrock borings advanced off-site using a rotary drill-rig will subsequently be converted to bedrock groundwater monitoring wells. Continuous split spoon samples will be collected in the overburden ahead of 4.25" inner diameter hollow stem augers via Standard Penetration Test (SPT) methods from the ground surface to auger refusal (i.e., inferred top of bedrock). The borings will be extended at least two feet into competent bedrock using an

appropriate-sized roller bit. A permanent 4" steel casing will then be installed and sealed with appropriate cement mixture into the bedrock and will extend above the ground surface. Ten feet of bedrock will then be cored using HQ-sized coring equipment (or NX-sized coring equipment followed by reaming with a 3-7/8" diameter roller bit). The bedrock underlying the overburden at the Site is anticipated to consist of a possible layer of weathered gray green shale of the Maplewood Formation underlain by light gray to white sandstone of the Thorold (aka Kodak) Formation, which is underlain by red gray siltstone with sandstone interbeds of the Grimsby Formation. The bedrock cores will be photographed and maintained on-site during the RI. Locking caps will be fitted on the top of the permanent 4" steel casings, which will complete the bedrock monitoring wells. Bedrock monitoring well construction diagrams will be prepared for bedrock monitoring wells installed using the template provided in the QAPP in Appendix B.

4.3 Groundwater Evaluation

At least two days subsequent to their installation, DAY will develop the three new overburden monitoring wells MW-200, MW-208 and MW-209, and the two new bedrock monitoring wells MW-212R and MW-213R by removing an equivalent volume of water lost during drilling and up to five additional well casing volumes of groundwater from each well, while taking water quality measurements with a YSI ProDSS water quality meter or similar. Further details are outlined in the QAPP included in Appendix B. The well development work will be recorded on well development logs (copy provided in QAPP in Appendix B).

At least fourteen days following development, the first round of groundwater samples will be collected from each intact monitoring well associated with this Site. DAY will obtain water level measurements, check for LNAPL and DNAPL using an oil/water interface probe, and sample each groundwater monitoring well using a low-flow purge and sample technique, which is outlined in the QAPP in Appendix B. Pertinent information and data associated with the sampling each well will be documented on a low-flow groundwater sampling log (copy provided in QAPP included in Appendix B). The wells to be sampled are shown on Figure 12 and summarized below.

- Overburden monitoring wells MW-1 through MW-6.
- Overburden monitoring wells MW-102, MW-104, MW-105, MW-107, MW-108, and MW-126.
- Overburden monitoring wells MW-LE-01 through MW-LE-05.
- Overburden monitoring wells MW-200, MW-208 and MW-209.
- Bedrock monitoring wells MW-103R, MW-121R, MW-127R, MW-128R, and MW-129R.
- Bedrock monitoring wells MW-212R and MW-213R.

Approximately three months after the first round of groundwater sampling, a second round of groundwater sampling will be completed. The scope of the second round of groundwater sampling (i.e., sample collection method, specific wells to be sampled, analytical parameters to be tested, etc.) will be either the same as the first round, or as determined with input and approval from the NYSDEC and the NYSDOH. To the extent possible and in coordination with the NYSDEC, sampling events will occur during high and low seasonal groundwater table conditions.

Note: If Per- and Polyfluoroalkyl Substances (PFAS) are detected in groundwater at the Site during the first round, then Total Oxidizable Precursor Assay (TOP Assay) sampling and analysis may also be conducted during the second round if deemed necessary by the NYSDEC and NYSDOH.

Prior to use, and between monitoring wells, reusable (non-disposable) groundwater monitoring and sampling equipment will be decontaminated. Water generated from the well sampling and equipment decontamination activities will be containerized as IDW for later disposal. Procedures for managing IDW are provided in Section 4.5.

Well Surveying and Groundwater Potentiometric Surface Evaluation

A licensed surveyor will measure the locations and elevations of the five new monitoring wells and the twenty-two existing monitoring wells that are associated with the Site. During each sampling event, static groundwater measurements will be collected from each monitoring well using an electronic static water level meter or an oil/water interface meter. Static water-level measurements will also be obtained during other portions of the RI, such as during the slug testing activities described below. Groundwater elevations will be calculated for the two groundwater sampling events, and corresponding potentiometric groundwater contour maps will be prepared illustrating the approximate groundwater elevations and groundwater flow direction(s) for each water-bearing unit (i.e., overburden and bedrock). The survey information and groundwater elevations will also be imported into the GIS database for the Site.

Overburden and Bedrock Aquifer Physical Characterization

The hydraulic conductivity of the water-bearing units at the Site will be calculated using falling and rising head (in-situ slug testing) techniques from selected locations approved by the NYSDEC in both the overburden and bedrock aquifers. Each slug test will be conducted by rapidly changing the water level in a monitoring well by the introduction, and subsequent removal, of a non-reactive solid and sealed concrete-filled PVC pipe, “the slug”, and measuring the aquifer’s response to the changing water-level over time. Slug tests will be conducted by both inserting and removing the slug. Removal of the slug will be conducted only after the well has receded to 98% of the original water level. The slug test procedures are described in: Bouwer, H., 1989; The Bouwer and Rice slug test--an update, 1989; Groundwater, vol. 27, no. 3, pp. 304-309; and, the original Bouwer, H and R.C. Rice 1976 article in the Water Resources Research Journal. Slug test data will be imported to specialized software such as SuperSlug to calculate hydraulic conductivity, and transmissivity if appropriate. The hydraulic conductivity data and calculated hydraulic gradient data will also be used to evaluate the local groundwater velocity combined with potentiometric data gathered at the Site.

Slug tests will be conducted from a total of six project monitoring wells following completion of the first round of groundwater sampling. The location and water-bearing units of the slug tests will be suggested based on an evaluation of existing Site data and the RI data, and approved by the NYSDEC. It is anticipated that slug tests will be performed at three monitoring wells in the overburden aquifer and three monitoring wells in the bedrock aquifer at the Site.

4.4 Soil Vapor Evaluation

A soil vapor evaluation will be conducted in accordance with applicable provisions outlined by the New York State Department of Health (NYSDOH) in the document titled Guidance for Evaluating Soil Vapor Intrusion in the State of New York dated October 2006 (Guidance Document), including Section 2.7 (Sampling Protocols) and Section 2.8 (Quality Assurance/Quality Control).

DAY will retain the services of a drilling subcontractor to advance five direct-push borings and complete the borings as soil vapor probes (designated SV-1 through SV-5) in the locations presented on Figure 12. The soil vapor probes will be installed by advancing a direct-push test boring to a depth approximately 1 foot above the assumed top of the groundwater based upon conditions observed in nearby monitoring wells. After reaching the targeted depth, a soil vapor probe (e.g., 6-inch long double woven stainless-steel screen attached to 3/8-inch Teflon lined tubing, or a section of 3/8-inch Teflon lined tubing where the bottom six inches has been perforated) will be installed in the borehole at the targeted depth. The borehole will then be backfilled with clean filter sand to a depth of at least 6 inches above the top of the screened interval of the soil vapor probe. Thereafter the remaining borehole will be backfilled with bentonite. An example soil vapor probe construction diagram is provided in the QAPP included in Appendix B.

Prior to installation of each soil vapor probe, and prior to leaving the Site, reusable drilling equipment will be decontaminated with an Alconox (or similar) wash followed by a potable water rinse.

Prior to sampling, the five soil vapor sample probe locations will be tested for potential surface air infiltration using a helium tracer gas test in accordance with the provisions outlined in the NYSDOH guidance document. Once the soil vapor probes pass the helium tracer test, a soil vapor sample will be collected from each soil vapor probe. In addition, one upwind outdoor air background sample (designated as BG-1) will also be collected. Refer to Section 4.6 for a discussion of the analyses that will be performed on the soil vapor samples and the background outdoor air sample. Further details concerning the installation, helium tracer testing and sampling of the soil vapor probes are provided in the QAPP included in Appendix B.

The results of the soil, groundwater and soil vapor sampling will be discussed with the NYSDEC and the NYSDOH. If a soil vapor intrusion (SVI) study is warranted, a separate SVI study workplan will be submitted to the NYSDEC and the NYSDOH for approval. The SVI study workplan will be prepared in general accordance with the NYSDOH Guidance Document.

4.5 Investigation-Derived Waste

IDW materials will be managed in accordance with DER-10 Section 3.3(e). Displaced soil cuttings, drill fines from coring/reaming, disposable personal protective equipment (PPE), disposable sampling equipment, and other solid IDW materials will be placed in a lined roll-off container and/or New York State Department of Transportation (NYSDOT) approved 55-gallon drums. The container and/or drums will be stored on-site. DAY will collect one or more samples of the solid IDW, which will be analyzed by a NYSDOH Environmental Laboratory Approval Program (ELAP)-certified analytical laboratory (refer to Section 4.6). The laboratory will provide its results in a standard data package using a standard laboratory turnaround time of approximately 10 to 15 business days. The analytical laboratory test results, along with the investigation sample results (if warranted), will be used to obtain proper disposal approvals from a regulated disposal facility. Once approved under a waste profile, the solid IDW will be transported and disposed off-site in accordance with applicable regulations. As an alternative, soil originating from the Site that demonstrates compliance with SCGs as detailed in DER-10, Table 5.4(e)4 and meets the requirements of 6 NYCRR 375-6.7(d), may be re-used on-site to construct a soil cover, site cap system or as excavation backfill.

Liquid IDW consisting of drilling water, decontamination water, well development water and well sampling purge water will be placed in NYSDOT approved 55-gallon drums and/or a poly tank.

The drums and/or poly tank will be stored on-site. DAY will collect a sample of the liquid IDW, which will be analyzed by a NYSDOH ELAP-certified analytical laboratory (refer to Section 4.6). The laboratory will provide its results in a standard data package using a standard laboratory turnaround time of approximately 10 to 15 business days. Liquid IDW will either be discharged to the public system (sanitary or combined) under a sewer use permit with Monroe County, New York (pre-treated if necessary), or be disposed off-site in accordance with applicable regulations.

4.6 Sampling and Analysis

This sampling and analysis plan outlines the location, matrix, number and analyses of field samples and associated QA/QC samples that will be tested as part of the RI. One or more NYSDOH ELAP-certified analytical laboratories will be retained to test samples associated with this project depending upon the matrices and parameters to be tested.

The analytical laboratory will report its results in NYSDEC Analytical services Protocol (ASP) category B deliverables and NYSDEC EQuIS Excel deliverables.

Vali-Data of Western New York, Inc. (Vali-Data) will independently prepare Data Usability Summary Reports (DUSRs) on RI lab packages in accordance with the provisions set forth in Appendix 2B of the NYSDEC “DER-10 Technical Guidance for Site Investigation and Remediation” dated May 2010. The findings of the DUSRs will be incorporated in analytical laboratory tables that will be included in the RI/RAA Report and other associated reports as applicable. Further information is provided in the QAPP in Appendix B.

For the purposes of this RI Work Plan “Full Suite” parameters will include the following:

- Target compound list (TCL) VOCs and tentatively identified compounds (TICs) using USEPA Method 8260.
- USEPA TCL SVOCs and TICs using USEPA Method 8270.
- Target analyte list (TAL) metals using USEPA Methods 6010 and 7471.
- Cyanide using USEPA Method 9012.
- PCBs using USEPA Method 8082.
- Pesticides using USEPA Method 8081.
- Herbicides using USEPA Method 8151.
- 1,4-Dioxane using USEPA Method 8270 in selective ion monitoring (SIM) mode.
- The 21-compound PFAS target analyte list provided by NYSDEC, using Modified USEPA Method 537.

The sampling and analysis plan for this RI is summarized below and is also provided on Table 1 in the QAPP included in Appendix B.

Soil and Fill Material Evaluation

The twelve soil/fill material samples from the 0-2 foot depth interval will be submitted for the following analytical laboratory testing:

- Three field samples will be tested for Full Suite parameters.

- Nine field samples will be tested for USEPA TCL VOCs and TICs using USEPA Method 8260, USEPA TCL SVOCs and TICs using USEPA Method 8270 and TAL metals using USEPA Methods 6010 and 7471.

The twelve soil/fill material samples from depths greater than 2 feet will be submitted for the following analytical laboratory testing:

- Two field samples, one matrix spike/matrix spike duplicate (MS/MSD) sample, and one field blank (equipment rinsate) sample will be tested for Full Suite parameters.
- Ten samples will be tested for USEPA TCL VOCs and TICs using USEPA Method 8260, USEPA TCL SVOCs and TICs using USEPA Method 8270, and TAL metals using USEPA Methods 6010 and 7471.

Groundwater Evaluation

The twenty first round groundwater field samples from overburden monitoring wells will be submitted for the following analytical laboratory testing:

- Four field samples, one MS/MSD sample, and one field blank (equipment rinsate) sample, and one trip blank sample will be tested for Full Suite parameters.
- Sixteen field samples will be tested for USEPA TCL VOCs and TICs using USEPA Method 8260.

The seven first round groundwater field samples from bedrock monitoring wells will be submitted for the following analytical laboratory testing:

- Two field samples, one MS/MSD sample, and one field blank (equipment rinsate) sample, and one trip blank sample will be tested for Full Suite parameters.
- Five field samples will be tested for USEPA TCL VOCs and TICs using USEPA Method 8260.

The scope of the second round of groundwater sampling from overburden and bedrock monitoring wells (i.e., sample collection method, specific wells to be sampled, analytical parameters to be tested, etc.) will be determined with input and approval from the NYSDEC and the NYSDOH.

Soil Vapor Evaluation

The five soil vapor samples (VP-1 through VP-5) and the background outdoor air sample (BG-1) will be submitted for the following analytical laboratory testing:

- VOCs via USEPA Method TO-15.

Characterization of IDW

DAY will collect one or more samples of the solid IDW, which will be submitted for the following analytical laboratory testing:

- Full TCLP parameters using Methods 1311, 8260, 8270, 6010/7470, 8081, and 8151.
- Total TCL VOCs using USEPA Method 8260.
- Ignitability (Flashpoint) using Method 1030, or similar.
- Reactivity using Methods 9012 and 9034, or similar.
- pH using Method 9045, or similar.

DAY will collect one or more samples of the liquid IDW, which will be submitted for the following analytical laboratory testing:

- Purgeable Organic VOCs using USEPA Method 624.
- SVOCs using USEPA Method 625.
- Metals using USEPA Methods 200.7 and 245.1.

4.7 Fish and Wildlife Resource Impact Analysis

An evaluation will be performed using the Fish and Wildlife Resource Impact Analysis (FWRIA) Decision Key to determine whether a FWRIA is needed. If this evaluation concludes that a FWRIA is required, then that document will be prepared and submitted to NYSDEC as part of the work to be implemented in accordance with this Work Plan.

5.0 REMEDIAL INVESTIGATION / REMEDIAL ALTERNATIVES ANALYSIS REPORT

A RI/RAA report will be prepared in accordance with provisions set forth in DER-10. The RI/RAA report will present the findings and conclusion of the RI, the results of the IRM completed, and an analysis and recommendation of remedial alternatives. An executive summary will be included in the RI/RAA report.

The RI portion of the report will include, but will not be limited to, the following components:

- Technical overview and details on the investigative work performed;
- A description of the physical characteristics of the Site, including soil/fill types, hydrogeological characteristics, proximity to a drinking water aquifer, absence of surface water, floodplains, and wetlands for this specific Site, etc.;
- Identification of the nature and extent of contamination, including identification of known or suspected sources of contamination;
- A discussion on contaminant fate and transport, including potential routes of migration, contaminant persistence, and documented contaminant migration, as well as, factors that affect contaminant migration;
- A qualitative human health exposure assessment and, at a minimum, the completion of a FWRIA Decision Key;
- A Summary and Conclusions section, including identification of data limitations and recommendations for future work, if any;
- Identification of recommended Remedial Action Objectives (RAOs);
- A discussion of the IRM implemented at the Site
- Appropriate figures including a project locus map, Site features, sample location figures and results of various testing [e.g., contaminants of concern (if any) detected in soil, groundwater or other media, including isopleth maps and updated interpolation models for VOCs and PID readings], overburden and bedrock potentiometric groundwater contour maps, a figure showing the extent of fill material at the Site, etc.;
- Stratigraphic cross-sections prepared using information and data obtained during the remedial investigation and previous investigations;
- Identification of SCG values that pertain to the Site;
- Data tables including:
 - Lab program table providing specifics on each sample tested (e.g., sample designation; locations specified by New York West NAD 83 coordinates; sample point elevations in feet above mean sea level for surveyed locations, consistent with reference datum to be used for the electronic data deliverable (EDD) submittal; date; time; depth interval; and test parameters;
 - Summary tables comparing detected constituents to appropriate regulatory SCG values;
 - Tables summarizing the nature and extent of constituents detected at the Site; and
 - Tables for other various investigation and/or IRM related data or information.

Although the Site will be remediated to Track 4 conditions that are protective of its future use as a parking lot, the analytical laboratory results for soil samples tested will be compared to: NYSDEC Part 375 Unrestricted Use SCOs, Commercial Use SCOs, and Protection of Groundwater SCOs; and, CP-51 SCLs. The analytical laboratory results for groundwater samples will be compared to NYSDEC Technical and Operational Guidance Series (TOGS) 1.1.1 groundwater standards and guidance values;

- Analytical laboratory reports and associated QA/QC evaluation (e.g., DUSRs) as an electronic appendix in .pdf format;
- Field logs and data, including test boring logs, monitoring well construction diagrams, well development logs, well sampling logs, soil vapor probe construction diagrams, soil vapor sampling logs, hydraulic conductivity testing data, PID readings from soil screening, and any CAMP monitoring logs;
- Photographs;
- Conclusions and recommendations regarding the extent of the areas of concern, identification of any remaining complete or potentially complete exposure pathways, and recommendations for future work (e.g. none, additional investigation, or an evaluation of remedial alternatives);
- An updated conceptual site model; and
- Other information as deemed appropriate.

Data generated as part of the RI will be submitted to the NYSDEC in the appropriate EDD format. Analytical data will be submitted when a DUSR is received, but no later than 90 days after receipt of the laboratory data package. Any required non-analytical data will be submitted within 90 days of being generated.

The RAA portion of the report will be prepared in accordance with the applicable provisions of DER-10 Chapter 4, and will discuss potential remediation options for addressing impacts documented in the RI portion of the report. A detailed evaluation will be conducted for each selected remedial alternative, taking into consideration factors identified in DER-10. Evaluation criteria include, but are not limited to:

- Overall protection of human health and the environment, including potential exposures;
- Compliance with SCG values;
- Long-term effectiveness and permanence;
- Short-term impact and effectiveness;
- Reduction of toxicity, mobility and/or volume;
- Implementability;
- Land use;
- Community acceptance,
- Green remediation, and
- Cost effectiveness.

Applicable general response actions will be developed on a medium-specific basis, similar to the development of RAOs. For each medium addressed, the volumes or areas to be remediated will be identified and characterized with respect to requirements for protectiveness, taking into account the chemical and physical characterization.

Selected technology types for each general response action associated with an impacted media will be screened for appropriateness. The technologies that appear feasible and capable of meeting the goal of a Track 4 cleanup protective of the Site's use as a parking lot, and also controlling or mitigating off-site migration of contaminants attributable to the Site, will be used in development of remedial alternatives for the Site. The technologies will then be assembled into site-wide remedial alternatives. The following components of each alternative will be discussed: size and configuration of processes; anticipated remediation duration; remedial reagents; spatial requirements; disposal options; permit requirements; and beneficial or adverse impacts on fish and wildlife.

An Unrestricted Use alternative and a No Action alternative will also be developed and evaluated for the Site. At least one other alternative will be developed that considers the following hierarchy of preference:

- Source removal: Free product, concentrated solid or semi-solid hazardous substances, DNAPL, LNAPL and/or grossly contaminated media will be removed and/or treated to the extent feasible.
- Containment of source: Any source remaining following removal and/or treatment shall be contained to the extent feasible.
- Eliminate/limit exposures to the source to the extent feasible.
- Treatment at point of exposure as a last resort.

The selected remedial alternatives will be compared to the evaluation criteria, the goal of a Track 4 cleanup that is protective of the Site's use as a parking lot, and the goal of controlling or mitigating off-site migration of contaminants attributable to the Site. Subsequently, a comparative analysis will be completed. Based on the remedial alternative analysis, a remedial alternative for the Site will be recommended, which will include a discussion on the reasons for selection. The criteria of community acceptance will be evaluated upon completion of the public comment period.

The objectives of the RAA for this Site are to identify, evaluate, and select a remedy or alternative remedies to address the contamination identified by the RI in accordance with the provision of Chapter 4 of DER-10 to attain the goal of a Track 4 cleanup that is protective of the Site's use as a parking lot, and can control or mitigate off-site migration of contaminants that are attributable to the Site. This includes:

1. Identifying RAOs for the protection of public health and the environment.
2. Evaluating baseline considerations associated with:
 - a. protection of public health and the environment;
 - b. addressing sources of contamination;
 - c. bulk storage tank and containment vessels; and
 - d. groundwater protection and control measures.

3. Evaluating other considerations associated with remedial alternatives to address the contamination on the Site to the extent applicable, such as the potential for soil vapor intrusion, and impacts on adjacent properties.
4. Evaluating the need for a cover system, such as a soil or pavement cover.
5. Evaluating the alternatives in relation to threshold criteria and primary balancing criteria listed in Section 4.2 of DER-10.

The RI/RAA Report will be submitted to the NYSDEC for review and comment. Following review and comment from the NYSDEC, the RI/RAA Report will be finalized, stamped and signed by a currently-registered New York State Licensed Professional Engineer (P.E.) prior to approval by the NYSDEC. The final RI/RAA Report will include an electronic copy in the appropriate PDF format required by the NYSDEC. Based on the findings of the RI/RAA Report, the NYSDEC will prepare a Decision Document (DD) summarizing the remedy for the Site.

6.0 PROJECT SCHEDULE

The project schedule for the RI/RAA scope of work described in this Work Plan is presented on Figure 13. The specific tasks, task duration, and completion dates shown on Figure 13 are summarized below.

Task	Duration (weeks)	Completion Date *
Approval of Work Plan	0	- -
4.1 Utility Assessment	3	3
4.2 Soil and Fill Material Evaluation	6	8
4.3 Groundwater Evaluation	8	22
4.4 Soil Vapor Evaluation	4	8
4.5 Investigation-Derived Waste	12	30
4.6 Sampling and Analysis	19	28
4.7 Fish and Wildlife Resource Impact Analysis	3	19
5.0 RI/RAA Report	39	45

* Weeks following NYSDEC approval of the RI/RAA Work Plan.

** Refer to IRM Work Plan for IRM project schedule.

This schedule will be monitored during implementation of the project, and the status of the work will be described in monthly progress reports that will be submitted to NYSDEC. Laboratory data that can be in the form of summary packages, will be included in monthly progress reports once the data is received, and will not be held until after data validation.

7.0 REFERENCES

Division of Water Technical and Operational Guidance Series 1.1.1 document titled "Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations" (TOGS 1.1.1), New York State Department of Environmental Conservation, June 1998, including April 2000 and June 2004 addendum tables.

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

6 NYCRR Part 375 Environmental Remediation Programs, New York State Department of Environmental Conservation, December 14, 2006.

CP-51/Soil Cleanup Guidance, New York State Department of Environmental Conservation, October 21, 2010.

DER-10 Technical Guidance for Site Investigation and Remediation, New York State Department of Environmental Conservation, May 3, 2010.

Chapter 59, Article III § 59-27 of the current Charter and Code of the City of Rochester, New York (Rochester Charter).

Data Package, 1560 Lake Avenue, August 1999, Day Environmental, Inc.

Closure Report and Site Assessment, 1560 Lake Avenue, B&D Pump and Tank, December 7, 1999.

Summary Report, 1540 and 1560 Lake Avenue, Bergman Associates, November 13, 2001.

Data Package for TB-01 thru TB-03, 1560 Lake Avenue, Day Environmental, Inc., December 13, 2001.

Excerpts from Hazardous Waste/Contaminated Materials Investigation Report, NYS Rte. 104, W Ridge Rd, Bergmann Associates, December 28, 2001.

Grease Pit Letter, 1560 Lake Avenue, Day Environmental, Inc., December 3, 2002.

Underground Storage Tank Closure Report, 1560 Lake Avenue, Day Environmental, Inc., January 2003.

Data Package, Environmental Assessment, 1560 Lake Avenue, Day Environmental, Inc., March 15, 2012.

Phase I ESA Report, 1540 & 1560 Lake Avenue, Stantec, December 7, 2017.

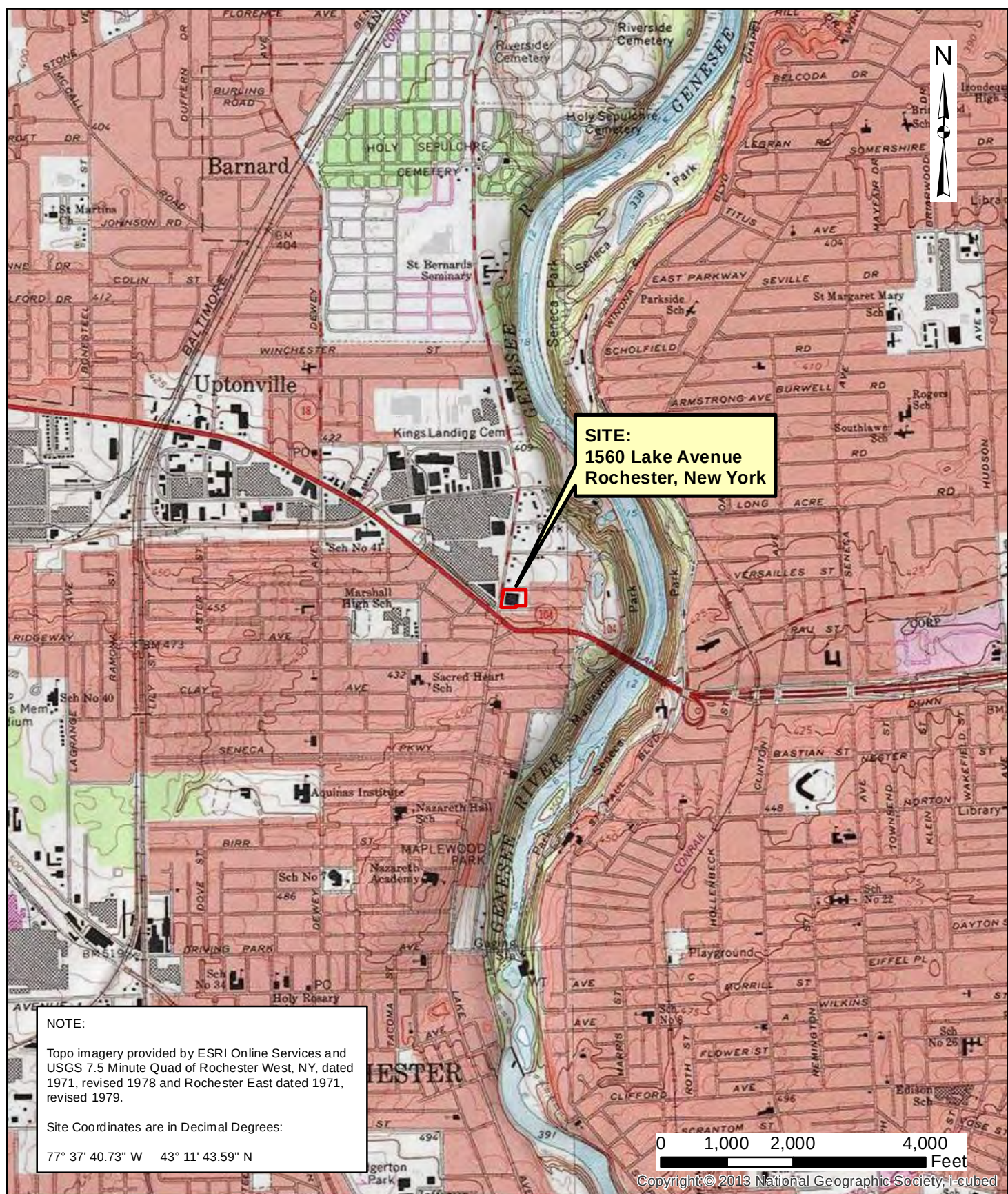
Phase II ESA Data Package, 1540 & 1560 Lake Avenue, Stantec, March 23, 2018 (includes ASP Category B deliverables).

Lapham St Extension Groundwater Study, 1560 Lake Avenue, Day Environmental, Inc. May and August 2018 (includes ASP Category B deliverables).

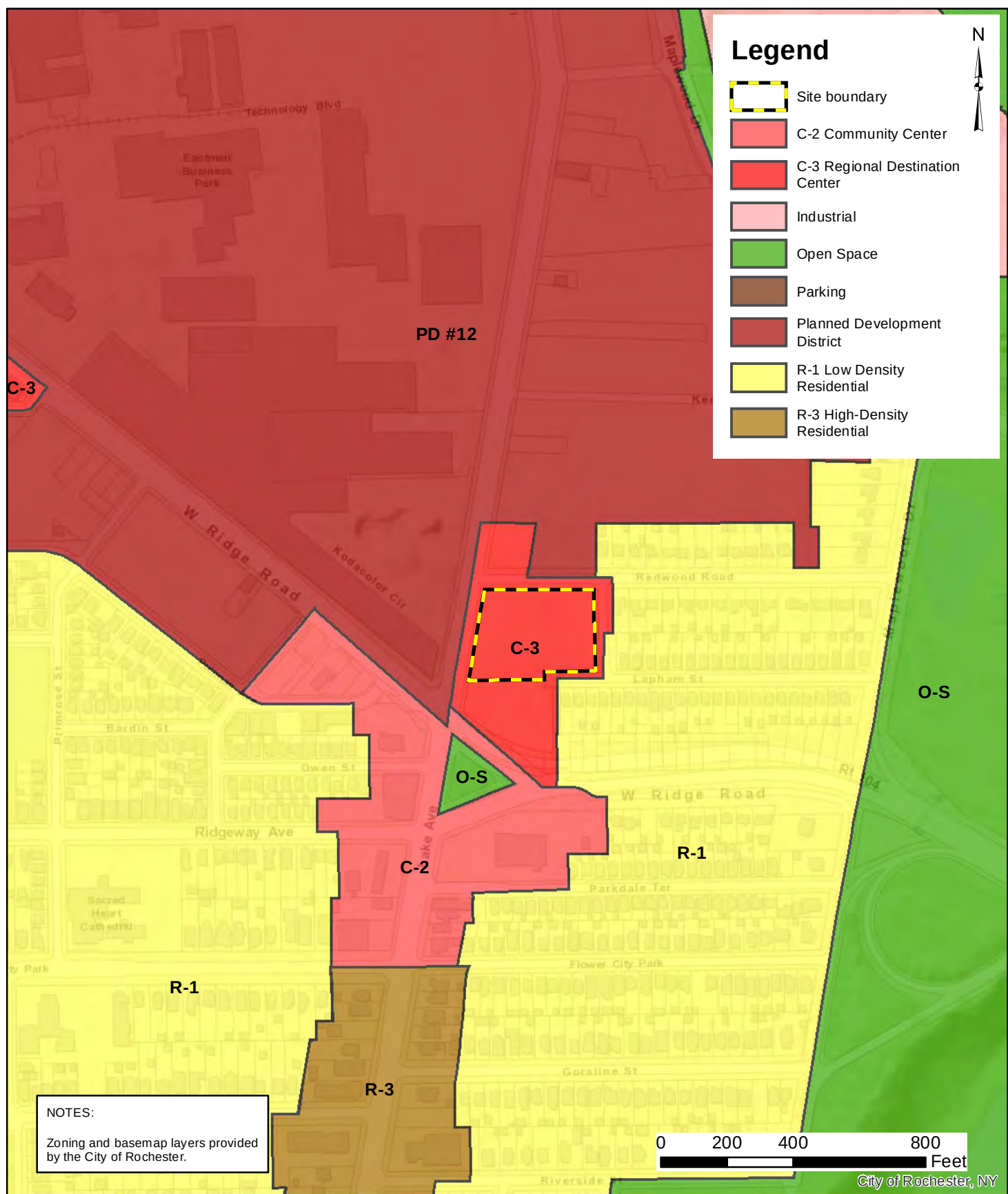
8.0 ACRONYMS AND ABBREVIATIONS

ASP	Analytical Services Protocol
BCP	Brownfield Cleanup Program
BGS	Below the Ground Surface
BTEX	Benzene, Toluene, Ethylbenzene and Xylene
CAMP	Community Air Monitoring Plan
CSO	Combined Sewer Overflow
DAY	Day Environmental, Inc.
DD	Decision Document
DNAPL	Dense Non-Aqueous Phase Liquid
DUSR	Data Usability Summary Report
ECP	Emergency Contingency Plan
EDD	Electronic Data Deliverable
ELAP	Environmental Laboratory Approval Program
GIS	Geographic Information System
GPS	Global Positioning System
FWRIA	Fish and Wildlife Resource Impact Analysis
HASP	Health and Safety Plan
IDW	Investigation-Derived Waste
IRM	Interim Remedial Measure
IRMWP	IRM Work Plan
LNAPL	Light Non-Aqueous Phase Liquid
Matrix	Matrix Environmental Technologies
ug/Kg	micrograms per kilogram
ug/l	micrograms per liter
MS/MSD	Matrix Spike/Matrix Spike Duplicate
MTBE	Methyl tert-butyl ether
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
NYSDOT	New York State Department of Transportation
PAH	Polycyclic Aromatic Hydrocarbons
PCB	Polychlorinated Biphenyl
PFAS	Per- and Polyfluoroalkyl Substances
Phase I ESA	Phase I Environmental Site Assessment
Phase II ESA	Phase II Environmental Site Assessment
PID	Photoionization Detector
PPB	Parts Per Billion
PPE	Personal Protective Equipment
PVC	Polyvinyl Chloride
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
RAO	Remedial Action Objectives
REC	Recognized Environmental Condition
RI	Remedial Investigation
RI/RAA	Remedial Investigation/Remedial Alternatives Analysis
SCG	Standards, Criteria, and Guidance
SCL	Soil Cleanup Level
SIM	Selective Ion Monitoring
SCO	Soil Cleanup Objectives
SPT	Standard Penetration Test
SVI	Soil Vapor Intrusion
SVOC	Semi-Volatile Organic Compound
TAL	Target Analyte List
TCL	Target Compound List
TCLP	Toxicity Characteristic Leaching Procedure
TIC	Tentatively Identified Compound
TOGS	Technical and Operational Guidance Series
TPH	Total Petroleum Hydrocarbons
USEPA	United States Environmental Protection Agency
UST	Underground Storage Tank
VOC	Volatile Organic Compound

FIGURES



Date 03-25-2019 Drawn By CPS Scale AS NOTED	day DAY ENVIRONMENTAL, INC. Environmental Consultants Rochester, New York 14606 New York, New York 10170	Project Title 1560 LAKE AVENUE ROCHESTER, NEW YORK BROWNFIELD CLEANUP PROGRAM Drawing Title Project Locus Map	Project No. 5495S-18 FIGURE 1
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Date	03-25-2019
Drawn By	CPS
Scale	AS NOTED

day
DAY ENVIRONMENTAL, INC.
Environmental Consultants
Rochester, New York 14606
New York, New York 10170

Project Title	1560 LAKE AVENUE ROCHESTER, NEW YORK
Drawing Title	BROWNFIELD CLEANUP PROGRAM Zoning Map

Project No.	5495S-18
	FIGURE 2



PROJECT MANAGER	DATE
JAD	03-2019
DRAWN BY	DATE DRAWN
CPS	03-2019
SCALE	DATE ISSUED
AS NOTED	03-25-2019

day
DAY ENVIRONMENTAL, INC.
Environmental Consultants
Rochester, New York 14606
New York, New York 10170

BROWNFIELD CLEANUP PROGRAM	Site with Surrounding Properties
----------------------------	----------------------------------

FIGURE 3



NOTES:

Locations of monitoring wells and soil borings and test pits installed January 2017 and 2018 were provided by Stantec. These locations are to be considered approximate.

Property boundaries provided by City of Rochester dated 2018.

Aerial imagery provided by the NYS GIS Clearinghouse, dated 2015. This image may not reflect the most recent site conditions.

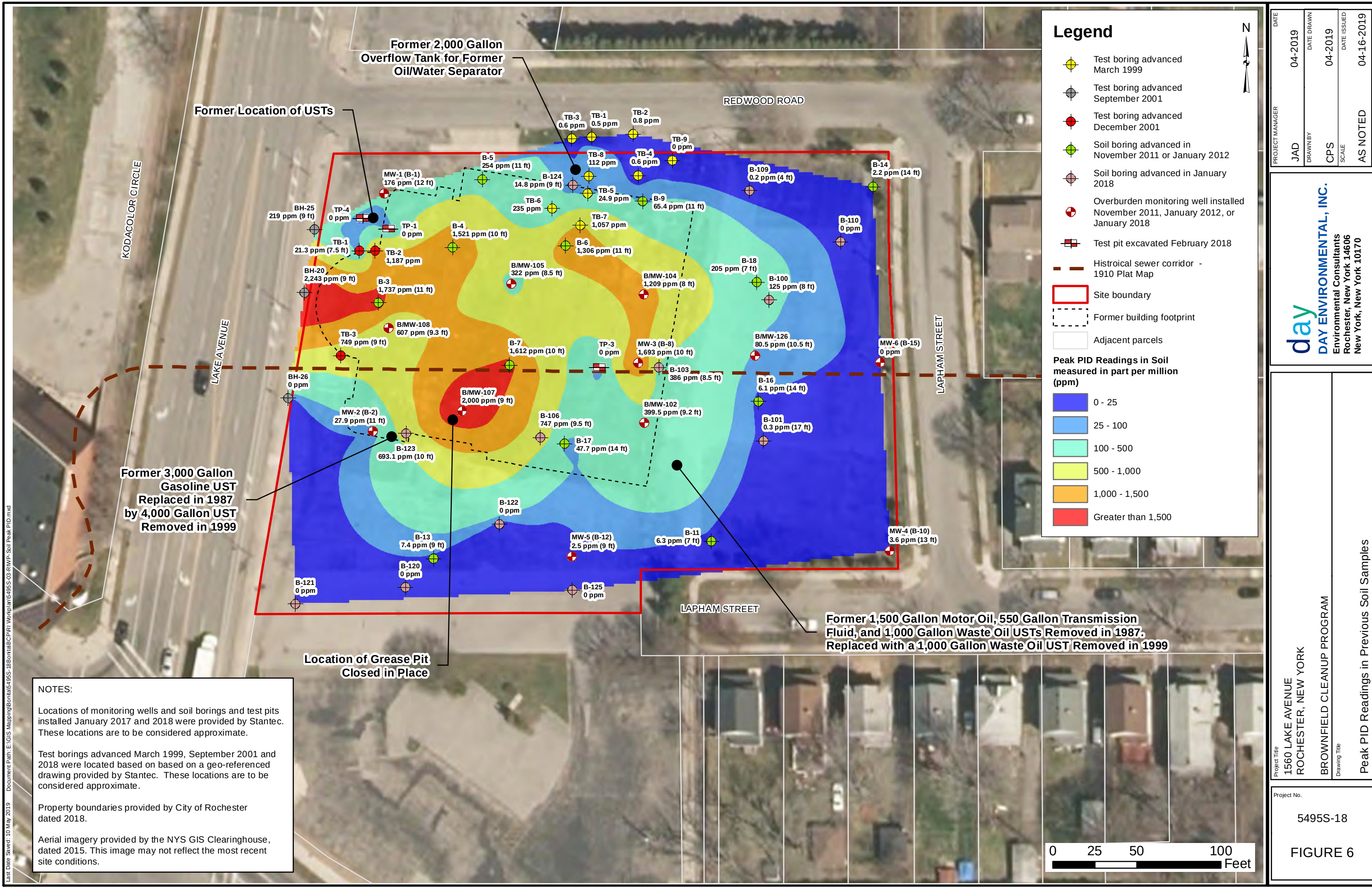
Legend

- Overburden monitoring well installed in November 2011, January 2012, or January 2018
- Bedrock monitoring well installed February 2018
- Overburden monitoring well installed May 2018
- Historical sewer corridor - 1910 Plat Map
- Former building footprint
- Site boundary
- Adjacent parcels

PROJECT MANAGER	DATE	04-2019	
	DRAWN BY	CPS	
PROJECT MANAGER	DATE	04-2019	
	SCALE	AS NOTED	
DATE			04-16-2019

DAY ENVIRONMENTAL, INC.
Environmental Consultants
Rochester, New York 14606
New York, New York 10170

Project Title		Brownfield Cleanup Program
1560 LAKE AVENUE ROCHESTER, NEW YORK		
Drawing Title		Cumulative Monitoring Well Locations
5495S-18		
FIGURE 5		



Legend

- Test boring advanced March 1999
 - Test boring advanced September 2001
 - Test boring advanced December 2001
 - Soil boring advanced in November 2011 or January 2012
 - Soil boring advanced in January 2018
 - Overburden monitoring well installed November 2011, January 2012, or January 2018
 - Test pit excavated February 2018
 - Historical sewer corridor - 1910 Plat Map
 - Site boundary
 - Former building footprint
 - Adjacent parcels
- Peak PID Readings in Soil measured in part per million (ppm)
- 0 - 25
 - 25 - 100
 - 100 - 500
 - 500 - 1,000
 - 1,000 - 1,500
 - Greater than 1,500

NOTES:

Locations of monitoring wells and soil borings and test pits installed January 2017 and 2018 were provided by Stantec. These locations are to be considered approximate.

Test borings advanced March 1999, September 2001 and 2018 were located based on a geo-referenced drawing provided by Stantec. These locations are to be considered approximate.

Property boundaries provided by City of Rochester dated 2018.

Aerial imagery provided by the NYS GIS Clearinghouse, dated 2015. This image may not reflect the most recent site conditions.

DATE	04-2019
PROJECT MANAGER	JAD
DATE DRAWN	04-2019
DRAWN BY	CPS
DATE ISSUED	04-16-2019
SCALE	AS NOTED

day ENVIRONMENTAL, INC.
Environmental Consultants
Rochester, New York 14606
New York, New York 10170

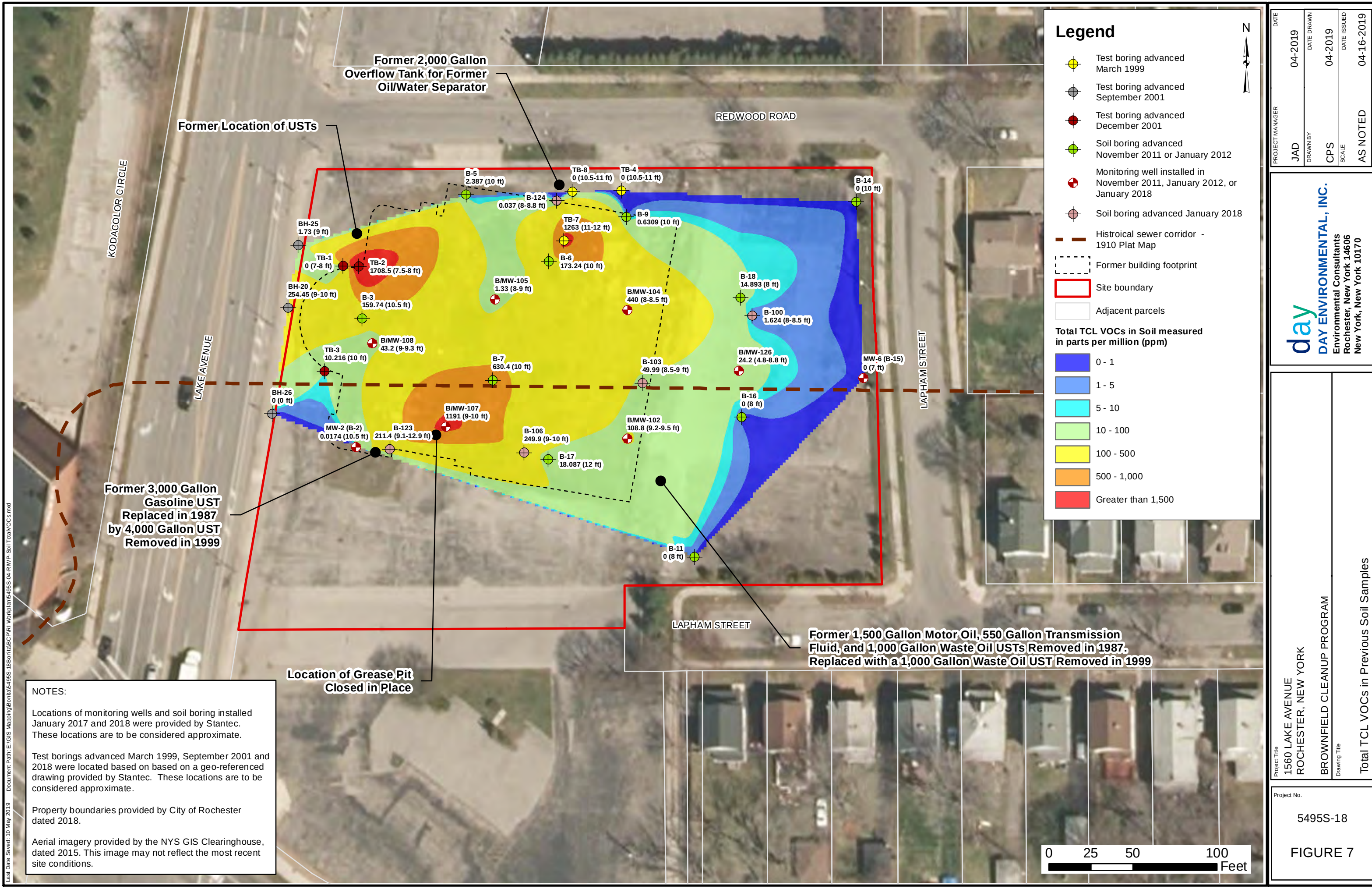
Project Title
1560 LAKE AVENUE
ROCHESTER, NEW YORK

BROWNFIELD CLEANUP PROGRAM

Drawing Title
Peak PID Readings in Previous Soil Samples

Project No.
5495S-18

FIGURE 6



Legend

- Test boring advanced March 1999
 - Test boring advanced September 2001
 - Test boring advanced December 2001
 - Soil boring advanced November 2011 or January 2012
 - Monitoring well installed in November 2011, January 2012, or January 2018
 - Soil boring advanced January 2018
 - Historical sewer corridor - 1910 Plat Map
 - Former building footprint
 - Site boundary
 - Adjacent parcels
- Total TCL VOCs in Soil measured in parts per million (ppm)**
- 0 - 1
 - 1 - 5
 - 5 - 10
 - 10 - 100
 - 100 - 500
 - 500 - 1,000
 - Greater than 1,500

DATE	04-2019
PROJECT MANAGER	JAD
DRAWN BY	CPS
DATE ISSUED	04-16-2019
SCALE	AS NOTED

day
DAY ENVIRONMENTAL, INC.
Environmental Consultants
Rochester, New York 14606
New York, New York 10170

Project Title	1560 LAKE AVENUE ROCHESTER, NEW YORK
Drawing Title	BROWNFIELD CLEANUP PROGRAM
Project No.	5495S-18
Total TCL VOCs in Previous Soil Samples	

FIGURE 7

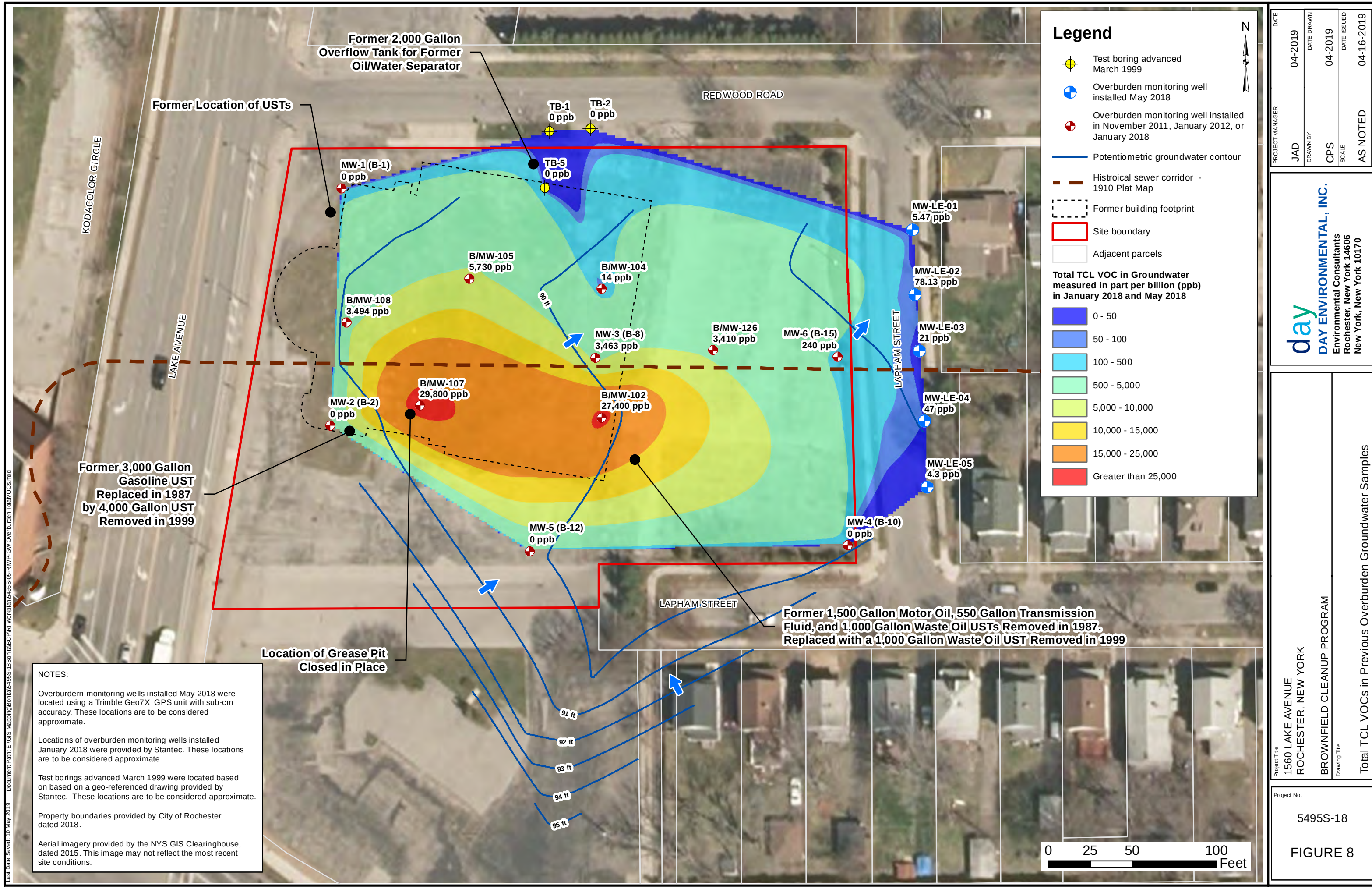
NOTES:

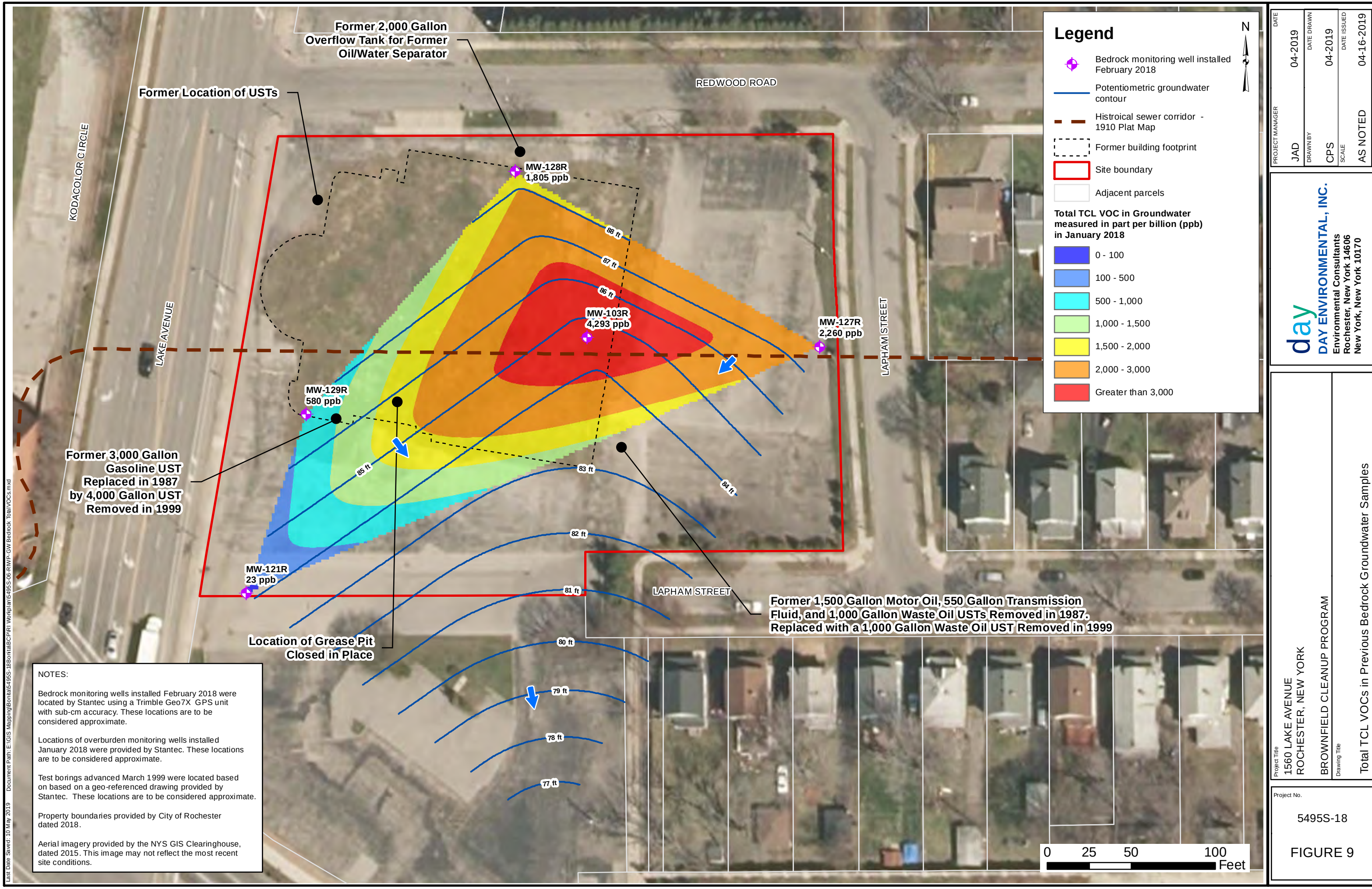
Locations of monitoring wells and soil boring installed January 2017 and 2018 were provided by Stantec. These locations are to be considered approximate.

Test borings advanced March 1999, September 2001 and 2018 were located based on based on a geo-referenced drawing provided by Stantec. These locations are to be considered approximate.

Property boundaries provided by City of Rochester dated 2018.

Aerial imagery provided by the NYS GIS Clearinghouse, dated 2015. This image may not reflect the most recent site conditions.





NOTES:

Bedrock monitoring wells installed February 2018 were located by Stantec using a Trimble Geo7X GPS unit with sub-cm accuracy. These locations are to be considered approximate.

Locations of overburden monitoring wells installed January 2018 were provided by Stantec. These locations are to be considered approximate.

Test borings advanced March 1999 were located based on based on a geo-referenced drawing provided by Stantec. These locations are to be considered approximate.

Property boundaries provided by City of Rochester dated 2018.

Aerial imagery provided by the NYS GIS Clearinghouse, dated 2015. This image may not reflect the most recent site conditions.

Legend

- Bedrock monitoring well installed February 2018
 - Potentiometric groundwater contour
 - Histoical sewer corridor - 1910 Plat Map
 - Former building footprint
 - Site boundary
 - Adjacent parcels
- Total TCL VOC in Groundwater measured in part per billion (ppb) in January 2018
- 0 - 100
 - 100 - 500
 - 500 - 1,000
 - 1,000 - 1,500
 - 1,500 - 2,000
 - 2,000 - 3,000
 - Greater than 3,000

DATE	04-2019
PROJECT MANAGER	JAD
DRAWN BY	CPS
DATE ISSUED	04-16-2019
SCALE	AS NOTED

day DAY ENVIRONMENTAL, INC.
Environmental Consultants
Rochester, New York 14606
New York, New York 10170

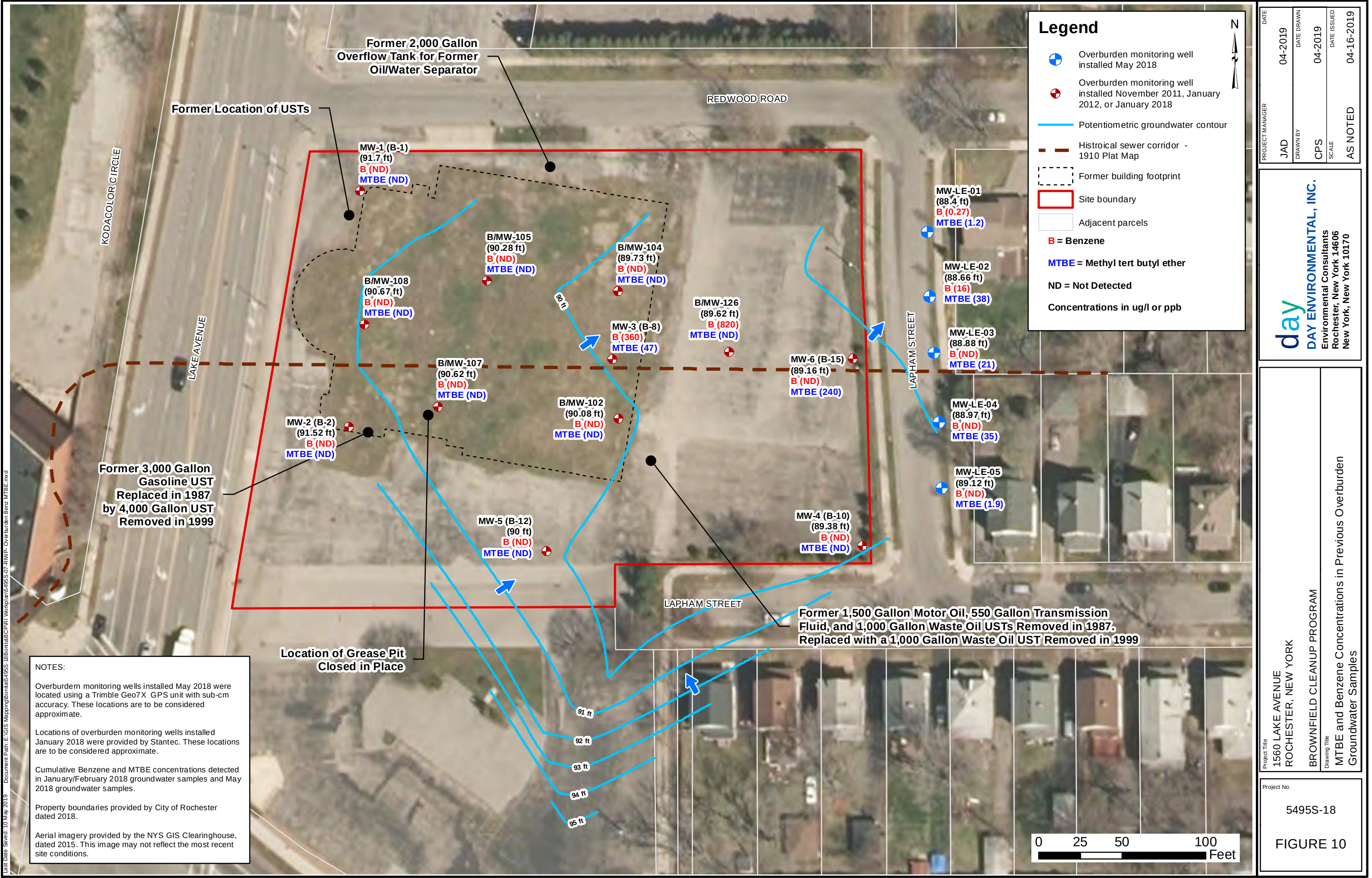
Project Title
1560 LAKE AVENUE
ROCHESTER, NEW YORK

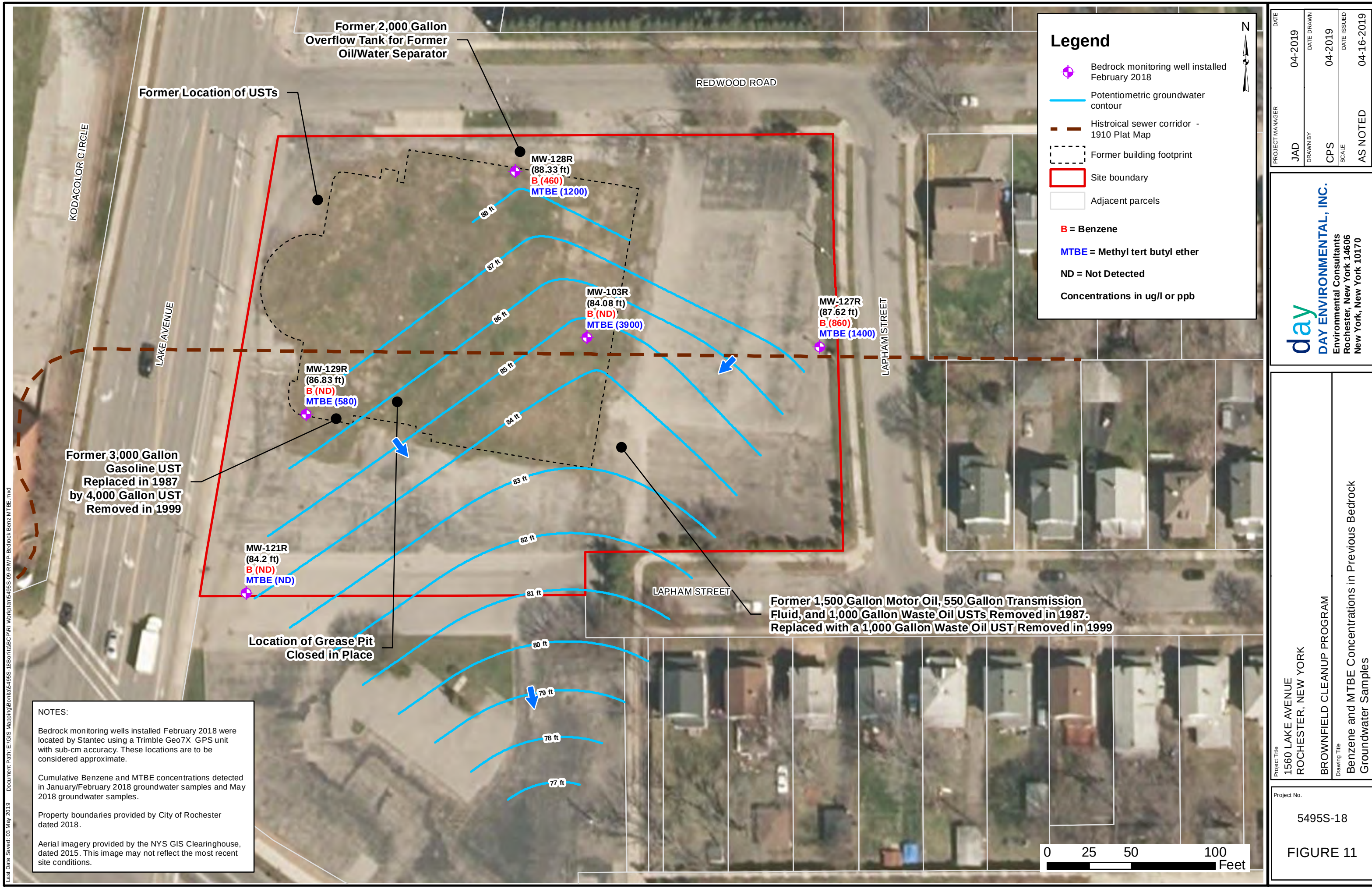
BROWNFIELD CLEANUP PROGRAM

Drawing Title
Total TCL VOCs in Previous Bedrock Groundwater Samples

Project No.
5495S-18

FIGURE 9





PROJECT MANAGER		DATE	
JAD	04-2019	04-2019	

DRAWN BY		DATE DRAWN	
CPS	04-2019	04-2019	

SCALE		DATE ISSUED	
AS NOTED	04-16-2019	04-16-2019	

day DAY ENVIRONMENTAL, INC.

Environmental Consultants
Rochester, New York 14606
New York, New York 10170

Project Title	
1560 LAKE AVENUE ROCHESTER, NEW YORK	

Drawing Title	
BROWNFIELD CLEANUP PROGRAM Benzene and MTBE Concentrations in Previous Bedrock Groundwater Samples	

Project No.	
5495S-18	

FIGURE 11



Legend

- RI Overburden test boring advanced to equipment refusal, and converted to overburden monitoring well set at a desired depth
- RI Overburden test boring advanced to equipment refusal
- RI Bedrock monitoring well
- RI Soil vapor point
- Test boring advanced March 1999
- Test boring advanced September 2001
- Test boring advanced December 2001
- Soil boring advanced November 2011 or January 2012
- Overburden monitoring well installed in November 2011, January 2012, or January 2018
- Soil boring advanced January 2018
- Test pit excavated February 2018
- Bedrock monitoring well installed February 2018
- Overburden monitoring well installed May 2018
- Historical sewer corridor - 1910 Plat Map
- Former building footprint
- Site boundary
- Adjacent parcels

0 25 50 100 Feet

NOTES:

Locations of monitoring wells and soil borings and test pits installed January 2017 and 2018 were provided by Stantec. These locations are to be considered approximate.

Test borings advanced March 1999, September 2001 and 2018 were located based on a geo-referenced drawing provided by Stantec. These locations are to be considered approximate.

Property boundaries provided by City of Rochester dated 2018.

Aerial imagery provided by the NYS GIS Clearinghouse, dated 2015. This image may not reflect the most recent site conditions.

DATE	11-2019
PROJECT MANAGER	JAD
DATE DRAWN	11-2019
DRAWN BY	CPS
DATE ISSUED	11-14-2019
SCALE	AS NOTED

day DAY ENVIRONMENTAL, INC.

Environmental Consultants
Rochester, New York 14606
New York, New York 10170

Project Title	1560 LAKE AVENUE ROCHESTER, NEW YORK
Drawing Title	BROWNFIELD CLEANUP PROGRAM Cumulative Test Locations and Proposed Remedial Investigation Test Locations
Project No.	5495S-18

FIGURE 12

Figure 13

Project Schedule
Remedial Investigation/Remedial Alternative Analysis (RI/RAA)
1560 Lake Avenue, Rochester, New York

Task	Duration (weeks)	Duration (weeks) following NYSDEC approval																																														
		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		
Approval of RI/RAA Work Plan	0																																															
4.1 Utility Assessment	3																																															
4.2 Soil and Fill Material Evaluation	6																																															
4.3 Groundwater Evaluation	4 + 4																																															
4.4 Soil Vapor Evaluation	4																																															
4.5 Investigation-Derived Waste	8 + 4																																															
4.6 Sampling and Analysis	12 + 7																																															
4.7 Fish and Wildlife Resource Impact Analysis	3																																															
5.0 RI/RAA Report	39																																															

APPENDIX A

Health and Safety Plan

HEALTH AND SAFETY PLAN
REMEDIAL INVESTIGATION/CORRECTIVE ACTIONS
1560 LAKE AVENUE
ROCHESTER, NEW YORK

Prepared by: Day Environmental, Inc.
1563 Lyell Avenue
Rochester, New York 14606

Project No.: 5495S-18

Date: April 30, 2019

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ATTACHMENTS

Attachment 1 - Figure 1 - Route for Emergency Services

Attachment 2 – Oxygen Safety Data Sheet

1.0 INTRODUCTION

Day Environmental, Inc. (DAY) prepared this Health and Safety Plan (HASP) to outline policies and procedures to protect workers and the public from potential environmental hazards during investigation and remediation to be conducted at, and in the vicinity of, the property addressed as 1560 Lake Avenue, City of Rochester, County of Monroe, New York (the Site). A Project Locus map presented as Figure 1 shows the general location of the Site.

Although the HASP focuses on the specific work activities planned for the Site, it must remain flexible due to the nature of this work. Conditions may change and unforeseen situations can arise that require deviations from the original HASP.

1.1 SITE LOCATION AND DESCRIPTION

The Site consists of approximately 2.144 acres of vacant land (Tax ID 090.44-1-1.2), is covered by surface comprised of soil, gravel, deteriorating pavement, and grass, and is zoned as C-3 (Regional Destination Center District). A 25-foot wide strip comprising the northern portion of the former Lapham Street right-of way, which contains a combined stormwater/sanitary sewer main, is located on the southernmost portion of the Site. The Site is bound:

- to the north by Redwood Road with a commercial parking lot, a vacant commercial lot, and some residential property beyond;
- to the east by Lapham Street Extension with residential property beyond;
- to the south by commercial property and residential property; and,
- to the west by Lake Avenue with industrial property and commercial property beyond.

1.2 SITE HISTORY/OVERVIEW

The property's environmental history is documented in a Phase I Environmental Site Assessment Report dated December 7, 2017 and a Phase II Environmental Site Assessment Data Package dated March 23, 2018, which are included as PDF enclosures with the BCP Application. In summary, the 1560 Lake Avenue parcel was an automobile sales and service facility from the late 1940s to mid-2000s. The automobile sales and service facility was built on heterogeneous fill, which extends from the ground surface to depths of up to 13 feet below the ground surface (bgs). In connection with the historical uses of the 1560 Lake Avenue parcel, there were multiple reported spills and underground storage tanks. Petroleum impacts to soil were documented. Petroleum impacts were also noted in groundwater within the overburden and bedrock. Impacts also included detections of methyl tert-butyl ether (MTBE) primarily in the bedrock groundwater with a source not identified on the parcel. Reportedly nine underground storage tanks were removed from the 1560 Lake Avenue parcel from the 1960s to the 1980s; however, complete documentation of their closure including confirmatory soil samples were not provided. A geophysical survey was conducted across the entire Site which identified two magnetic anomalies. Test pits excavated at the two magnetic anomalies did not identify

underground storage tanks. The former automobile service area had a former grease pit where personnel could conduct service work beneath the vehicles. Prior to closure by filling in-place with flowable fill, standing water in the grease pit was non-detect for volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs), but did contain lube oil. As such, the water was removed and disposed off-site prior to closure by filling in-place. SVOC and metals impacts were also detected in soil and the heterogeneous fill material (e.g., historical fill material) at the Site.

1.3 PLANNED ACTIVITIES COVERED BY HASP

This HASP is intended to be used during intrusive environmental studies and remedial activities conducted at the Site that have the potential to encounter contaminated materials. Currently, identified activities to be completed at the Site that have the potential to encounter contaminated materials include:

- Site Preparation Activities
- Advancement of test borings and installation of groundwater monitoring wells, oxygen injection points, and oxygen injection system line trenches
- Soil, Groundwater and Soil Vapor sample collection
- Operation of an oxygen injection remedial system
- Installation of a cover system
- Management of Investigation Derived Waste (IDW)

This HASP can be modified to cover other site activities as deemed appropriate. Site personnel implementing the work described above must have the appropriate level of training required by OSHA including 40-hour Hazardous Waste Operations and Emergency Response (HAZWOPER) training and current 8-hour refresher training. The owner of the property, its contractors, and other workers at the Site will be responsible for the development and/or implementation of their own health and safety provisions associated with Site activities.

2.0 KEY PERSONNEL AND MANAGEMENT

The Project Manager (PM) and Site Safety Officer (SSO) are responsible for formulating health and safety requirements, and implementing the HASP.

2.1 PROJECT MANAGER

The PM has the overall responsibility for the project and will coordinate with the SSO to ensure that the goals of the project are attained in a manner consistent with the HASP requirements.

2.2 SITE SAFETY OFFICER

The SSO has responsibility for administering the HASP relative to site activities, and will be in the field while activities are in progress. The SSO's operational responsibilities will be monitoring, including personal and environmental monitoring, ensuring personal protective equipment (PPE) maintenance, and identification of protection levels. The air monitoring data obtained by the SSO will be available for review by regulatory agencies and other on-site personnel.

2.3 EMPLOYEE SAFETY RESPONSIBILITY

Each employee is responsible for personal safety as well as the safety of others in the area. Each employee will use the equipment provided in a safe and responsible manner as directed by the SSO.

2.4 KEY SAFETY PERSONNEL

The following individuals are anticipated to share responsibility for health and safety of DAY representatives at the Site.

DAY Project Manager

Jeffry Danzinger

DAY Site Safety Officer

Nathan Simon, Heather McLennan or
Thomas Roszak

3.0 SAFETY RESPONSIBILITY

Contractors, consultants, state or local agencies, or other parties, and their employees, involved with this project will be responsible for their own safety while on-site. Their employees should be required to understand the information contained in this HASP, and ought to follow the recommendations that are made in this document. Nevertheless, contractors, consultants, state or local agencies, or other parties, and their employees, involved with this project must utilize their own health and safety plan for this project, which plan must also be found acceptable to the New York State Department of Health (NYSDOH), New York State Department of Environmental Conservation (NYSDEC) and/or the Monroe County Department of Public Health (MCDPH).

4.0 JOB HAZARD ANALYSIS

There are many hazards associated with environmental work on a site, and this HASP discusses some of the anticipated hazards for this Site. The hazards listed below deal specifically with those hazards associated with the management of potentially contaminated media (e.g., soil, fill, groundwater, etc.).

4.1 CHEMICAL HAZARDS

Chemical substances can enter the unprotected body by inhalation, skin absorption, ingestion, or injection (i.e., a puncture wound, etc.). A contaminant can cause damage to the point of contact or can act systemically, causing a toxic effect at a part of the body distant from the point of initial contact.

A list of selected constituents that have been detected at the Site at concentrations that exceed soil or groundwater standards, criteria and guidance (SCG) values established by the NYSDEC are presented below. This list also presents the available Occupational Safety and Health Administration (OSHA) permissible exposure limits (PELs), National Institute for Occupational Safety and Health (NIOSH) recommended exposure limits (RELs), and NIOSH immediately dangerous to life or health (IDLH) levels.

CONSTITUENT	OSHA PEL	NIOSH REL	IDLH
Acetone	200 ppm	150 ppm	1500 ppm
Benzene	1 ppm	0.1 ppm	500 ppm
MTBE	NA	NA	NA
Toluene	200 ppm	100 ppm	500 ppm
Ethylbenzene	100 ppm	100 ppm	800 ppm
n-propylbenzene	NA	NA	NA
n-Butylbenzene	NA	NA	NA
Isopropylbenzene	50 ppm	50 ppm	900 ppm
1,2,4-Trimethylbenzene	NA	125 mg/m ³	NA
1,3,5-Trimethylbenzene	NA	25 ppm	NA
m,p-Xylene	100 ppm	100 ppm	900 ppm
o-Xylene	100 ppm	100 ppm	900 ppm
Benz(a)anthracene	0.2 mg/m ³	0.1 mg/m ³	80 mg/m ³
Benzo(a)pyrene	0.2 mg/m ³	0.1 mg/m ³	80 mg/m ³
Benzo(b)fluoranthene	0.2 mg/m ³	0.1 mg/m ³	80 mg/m ³
Benzo(k)fluoranthene	0.2 mg/m ³	0.1 mg/m ³	80 mg/m ³

Indeno(1,2,3-cd)pyrene	NA	NA	NA
Chrysene	0.2 mg/m ³	0.1 mg/m ³	80 mg/m ³
Naphthalene	50 mg/m ³	50 mg/m ³	1250 mg/m ³
Lead	0.05 mg/m ³	0.05 mg/m ³	100 mg/m ³
Mercury	0.1 mg/m ³	0.05 mg/m ³	10 mg/m ³
Selenium	0.2 mg/m ³	0.2 mg/m ³	1 mg/m ³
Arsenic	0.01 mg/m ³	0.002 mg/m ³	5 mg/m ³
Silver	0.01 mg/m ³	0.01 mg/m ³	10 mg/m ³
Endrin	0.1 mg/m ³	0.1 mg/m ³	2 mg/m ³
Lindane	0.5 mg/m ³	0.5 mg/m ³	50 mg/m ³
DDT	1 mg/m ³	0.5 mg/m ³	500 mg/m ³
Dieldrin	0.25 mg/m ³	0.25 mg/m ³	450 mg/m ³

NA = Not Available

ppm = Parts Per Million

mg/m³ = milligrams per cubic meter

The potential routes of exposure for these analytes and chemicals include inhalation, ingestion, skin absorption and/or skin/eye contact. The potential for exposure through any one of these routes will depend on the activity conducted. The most likely routes of exposure for the anticipated environmental activities at the Site include inhalation and skin/eye contact.

4.2 OXYGEN INJECTION SYSTEM HAZARDS

Relatively pure oxygen (90-95%) will be used during the remediation process. Anyone working with or maintaining equipment associated with oxygen should understand each element and section of the Safety Data Sheet (SDS) for oxygen included in Attachment 2. Also, smoking and open flames in or near the oxygen generating trailers is prohibited. Each oxygen injection trailer has signage for “no smoking” and “oxygen in use”.

The attached SDS for oxygen includes specific sections for first aid measures, fire-fighting measures, accidental release measures, handling and storage measures, exposure controls and personal protection. Physical and chemical properties, stability and reactivity, toxicological information, ecological information, disposal considerations, transportation information and regulatory information are also included on the SDS.

4.3 PHYSICAL HAZARDS

There are physical hazards associated with this project, which might compound the chemical hazards. Hazard identification, training, adherence to the planned environmental measures, and careful housekeeping can prevent many problems or accidents arising from physical hazards. Potential physical hazards associated with this project and suggested preventative measures include:

- Slip/Trip/Fall Hazards – Some areas may have wet or frozen surfaces that will greatly increase the possibility of inadvertent slips. Caution must be exercised when using steps, ladders, and stairs due to slippery surfaces in conjunction with the fall hazard. Good housekeeping practices are essential to minimize the trip hazards.
- Small Quantity Flammable Liquids – Small quantities of flammable liquids will be stored in “safety” cans and labeled according to contents.
- Electrical Hazards – Electrical devices and equipment shall be de-energized prior to working near them. All extension cords will be kept out of water, protected from crushing, and observed regularly to ensure structural integrity. Temporary electrical circuits will be protected with ground fault circuit interrupters. Only qualified electricians are authorized to work on electrical circuits. Heavy equipment (e.g., excavator, backhoe, drill rig) shall not be operated within 10 feet of high voltage lines, unless proper protection from the high voltage lines is provided by the appropriate utility company.
- Noise – Work around large equipment often creates excessive noise. The effects of noise can include:
 - Workers being startled, annoyed, or distracted.
 - Physical damage to the ear resulting in pain, or temporary and or/permanent hearing loss.
 - Communication interference that may increase potential hazards due to the inability to warn of danger and proper safety precautions to be taken.

Proper hearing protection will be worn as deemed necessary. In general, feasible administrative or engineering controls shall be utilized when on-site personnel are subjected to noise exceeding an 8-hour time weighted average (TWA) sound level of 90 decibels on the A-weighted scale (dBA). In addition, whenever employee noise exposures equal or exceed an 8-hour TWA sound level of 85 dBA, employers shall administer a continuing, effective hearing conservation program as described in the OSHA Regulation 29 Code of Federal Rules (CFR) Part 1910.95.

- Heavy Equipment – Each morning before start-up, heavy equipment will be checked to ensure safety equipment and devices are operational and ready for immediate use.
- Subsurface and Overhead Hazards – Before any excavation activity, efforts will be made to determine whether underground utilities and potential overhead hazards will be encountered. Underground utility clearance must be obtained prior to subsurface work.

4.4 ENVIRONMENTAL HAZARDS

Environmental factors such as weather, wild animals, insects, snakes and irritant plants can pose a hazard when performing outdoor tasks. The SSO shall make reasonable efforts to alleviate these hazards should they arise.

4.4.1 *Heat Stress*

The combination of warm ambient temperature and protective clothing increases the potential for heat stress. In particular,

- Heat rash
- Heat cramps
- Heat exhaustion
- Heat stroke

Site workers will be encouraged to increase consumption of water or electrolyte-containing beverages such as Gatorade® when the potential for heat stress exists. In addition, workers are encouraged to take rests whenever they feel any adverse effects that may be heat-related. The frequency of breaks may need to be increased upon worker recommendation to the SSO.

4.4.2 *Exposure to Cold*

With outdoor work in the winter months, the potential exists for hypothermia and frostbite. Protective clothing greatly reduces the possibility of hypothermia in workers. However, personnel will be instructed to wear warm clothing and to stop work to obtain more clothing if they become too cold. Employees will also be advised to change into dry clothes if their clothing becomes wet from perspiration or from exposure to precipitation.

5.0 SITE CONTROLS

To prevent migration of contaminants caused through tracking by personnel or equipment, work areas, and associated personal protective equipment staging/decontamination areas, will be specified prior to beginning operations.

5.1 SITE ZONES

In the area where contaminated materials present the potential for worker exposure (work zone), personnel entering the area must wear the mandated level of protection for the area. A "transition zone" shall be established where personnel can begin and complete personal and equipment decontamination procedures. This can reduce potential off-site migration of contaminated media. Contaminated equipment or clothing will not be allowed outside the transition zone (e.g., on clean portions of the Site) unless properly containerized for disposal. Operational support facilities will be located outside the transition zone (i.e., in a "support zone"), and normal work clothing and support equipment are appropriate in this area. If possible, the support zone should be located upwind of the work zone and transition zone.

5.2 GENERAL

The following items will be requirements to protect the health and safety of workers during implementation of activities that disturb contaminated material.

- Eating, drinking, chewing gum or tobacco, smoking, or any practice that increased the probability of hand to mouth transfer and ingestion of contamination shall not occur in the work zone and/or transition zone during disturbance of contaminated material.
- Personnel admitted in the work zone and transition zone be properly trained in health and safety techniques and equipment usage.
- No personnel shall be admitted in the work zone without the proper safety equipment.
- Proper decontamination procedures shall be followed before leaving the transition zone.

6.0 PROTECTIVE EQUIPMENT

This section addresses the various levels of PPE, which are or may be required at this job site. Personnel entering the work zone and transition zone shall be trained in the use of the anticipated PPE to be utilized.

6.1 ANTICIPATED PROTECTION LEVELS

The following table summarizes the protection levels (refer to Section 6.2) anticipated for tasks to be implemented during this project.

TASK	PROTECTION LEVEL	COMMENTS/MODIFICATIONS
Site mobilization	D	
Site preparation	D	
Intrusive work	C/Modified D/D	Based on air monitoring, and SSO discretion.
Decontamination Area	Modified D/D	
Site breakdown and demobilization	D	

It is anticipated that work conducted as part of this project will be performed in Level D or modified Level D PPE. If conditions are encountered that require Level C PPE, the work will be temporarily suspended and the work site will be evaluated to limit exposure prior to implementing Level C PPE. If conditions are encountered that require Level A or Level B PPE, the work will immediately be stopped. The appropriate government agencies (e.g., NYSDEC, NYSDOH, MCDPH, etc.) will be notified and the proper health and safety measures will be implemented (e.g., develop and implement engineering controls, upgrade in PPE, etc.).

6.2 PROTECTION LEVEL DESCRIPTIONS

This section lists the minimum requirements for each protection level. Modifications to these requirements can be made upon approval of the SSO. If Level A, Level B, and/or Level C PPE is required, Site personnel that enter the work zone and/or transition zone must be properly trained and certified in the use of those levels of PPE.

6.2.1 Level D

Level D consists of the following:

- Safety glasses
- Hard hat when working with heavy equipment
- Steel-toed or composite-toed work boots

- Protective gloves during sampling or handling of potentially contaminated media
- Work clothing as prescribed by weather

6.2.2 *Modified Level D*

Modified Level D consists of the following:

- Safety glasses with side shields
- Hard hat when working with heavy equipment
- Steel-toed or composite-toed work boots
- Protective gloves during sampling or handling of potentially contaminated media
- Outer protective wear, such as Tyvek coverall [Tyveks (Sarans) and polyvinyl chloride (PVC) acid gear will be required when workers have a potential to be exposed to impacted liquids or impacted particulates]

6.2.3 *Level C*

Level C consists of the following:

- Air-purifying respirator with appropriate cartridges
- Outer protective wear, such as Tyvek coverall [Tyveks (Sarans) and PVC acid gear will be required when workers have a potential to be exposed to impacted liquids or particulates]
- Hard hat when working with heavy equipment
- Steel-toed or composite-toed work boots
- Nitrile, neoprene, or PVC overboots, if appropriate
- Nitrile, neoprene, or PVC gloves, if appropriate
- Face shield (when projectiles or splashes pose a hazard) and/or safety glasses with side shields.

6.2.4 *Level B*

Level B protection consists of the items required for Level C protection with the exception that an air-supplied respirator is used in place of the air-purifying respirator. Level B PPE is not anticipated to be required during this project. If the need for level B PPE becomes evident, activities in the affected area will be stopped until conditions are further evaluated, and any necessary modifications to the HASP have been approved by the PM and SSO. Subsequently, the appropriate safety measures (including Level B PPE) must be implemented prior to commencing site activities.

6.2.5 *Level A*

Level A protection consists of the items required for Level B protection with the addition of a fully encapsulating, vapor-proof suit capable of maintaining positive pressure. Level A PPE is not anticipated to be required during this project. If the need for level A PPE becomes evident, activities in the affected area will be stopped until conditions are further evaluated, and any necessary modifications to the HASP have been approved by the PM and SSO. Subsequently, the appropriate safety measures (including Level A PPE) must be implemented prior to commencing site activities.

6.3 RESPIRATORY PROTECTION

Any respirator used will meet the requirements of the OSHA 29 CFR 1910.134. Both the respirator and cartridges specified shall be fit-tested prior to use in accordance with OSHA regulations (29 CFR 1910). Air purifying respirators shall not be worn if contaminant levels exceed designated respirator cartridge use concentrations. The workers will wear respirators with approval for: organic vapors less than 1,000 parts per million (ppm); and dusts, fumes and mists with a TWA less than 0.05 milligrams per cubic meter (mg/m³).

No personnel who have facial hair, which interferes with respirator sealing surface, will be permitted to wear a respirator and will not be permitted to work in areas requiring respirator use.

Only workers who have been certified by a physician as being physically capable of respirator usage shall be issued a respirator. Personnel unable to pass a respiratory fit test or without medical clearance for respirator use will not be permitted to enter or work in areas that require respirator protection.

7.0 DECONTAMINATION PROCEDURES

This section describes the procedures necessary to ensure that both personnel and equipment are free from contamination when they leave the work site.

7.1 PERSONNEL DECONTAMINATION

Personnel involved with activities that involve disturbing contaminated media will follow the decontamination procedures described herein to ensure that material which workers may have contacted in the work zone and/or transition zone does not result in personal exposure and is not spread to clean areas of the Site. This sequence describes the general decontamination procedure. The specific stages can vary depending on the Site, the task, and the protection level, etc.

1. Leave work zone and go to transition zone
2. Remove soil/debris from boots and gloves
3. Remove boots
4. Remove gloves
5. Remove Tyvek suit and discard, if applicable
6. Remove and wash respirator, if applicable
7. Go to support zone

7.2 EQUIPMENT DECONTAMINATION

In order to reduce the potential for cross-contamination of samples collected during this project, the following procedures will be implemented to ensure that the data collected (primarily the laboratory data) is acceptable.

It is anticipated that most of the materials used to assist in obtaining samples will be disposable one-time use materials (e.g., sampling containers, bailers, rope, pump tubing, nitrile gloves, etc.). However, when equipment must be re-used (e.g., drill rigs, static water level indicator, split spoon samplers, etc.), it will be decontaminated in the transition zone by at least one of the following methods:

- Steam clean the equipment within a dedicated decontamination area; or
- Rough wash in tap water; wash in mixture of tap water and Alconox-type soap; double rinse with deionized or distilled water; and air dry and/or dry with clean paper towel.

The decontamination area will be set-up in a location to minimize disturbance to properties/areas surrounding the work area.

7.3 DISPOSAL

Disposable clothing will be disposed in accordance with applicable regulations. Liquids (e.g., decontamination water, etc.) or solids (e.g., soil) generated by project activities will be disposed in accordance with applicable regulations.

8.0 AIR MONITORING

During activities that have the potential to disturb contaminated soil, fill material, or groundwater, air monitoring will be conducted in order to determine airborne particulate and contamination levels. This ensures that respiratory protection is adequate to protect personnel against the chemicals that are encountered and that chemical contaminants are not migrating off-site. Additional air monitoring may be conducted at the discretion of the SSO. Readings will be recorded and be available for review.

The following chart describes the direct reading instrumentation that will be utilized and appropriate action levels.

Monitoring Device	Action Level	Response/Level of PPE
PID Volatile Organic Compound Meter	< 1 ppm in breathing zone, sustained 5 minutes	<u>Level D</u>
	1-25 ppm in breathing zone, sustained 5 minutes	Cease work, implement measures to reduce air emissions when the work is performed, etc. If levels can not be brought below 1 ppm in the breathing zone, then upgrade PPE to <u>Level C</u>
	26-250 ppm in breathing zone, sustained 5 minutes	<u>Level B</u> , Stop work, evaluate the use of engineering controls, etc.
	>250 ppm in breathing zone	<u>Level A</u> , Stop work, evaluate the use of engineering controls, etc.
RTAM Particulate Meter	< 100 µg/m ³ above background over an integrated period not to exceed 15 minutes.	Continue working
	> 100 µg/m ³ above background	Cease work, implement dust suppression, change in way work performed, etc. If levels can not be brought below 150 µg/m ³ , then upgrade PPE to <u>Level C</u>

8.1 PARTICULATE MONITORING

During activities where contaminated materials (e.g., soil, fill, etc.) may be disturbed, air monitoring will include real-time monitoring for particulates using a real-time aerosol monitor (RTAM) particulate meter at the perimeter of the work zone in accordance with the Final DER-10 Technical Guidance for Site Investigation and Remediation (DER-10) dated May 2010. DER-

10 uses an action level of 100 µg/m³ (0.10 mg/m³) over background conditions for an integrated period not to exceed 15 minutes. If the action level is exceeded, or if visible dust is encountered, then work shall be discontinued until corrective actions are implemented. Corrective actions may include dust suppression, change in the way work is performed, and/or upgrade of personal protective equipment.

8.2 VOLATILE ORGANIC COMPOUND MONITORING

During activities where contaminated materials may be disturbed, a photoionization detector (PID) will be used to monitor total VOCs in the ambient air. The PID will prove useful as a direct reading instrument to aid in determining if current respiratory protection is adequate or needs to be upgraded. The SSO will take measurements before operations begin in an area to determine the amount of VOCs naturally occurring in the air. This is referred to as a background level. Levels of VOCs will periodically be measured in the air at active work sites, and at the transition zone when levels are detected above background in the work zone.

8.3 COMMUNITY AIR MONITORING PLAN

During activities that have the potential to disturb contaminated soil, fill material, or groundwater, this Community Air Monitoring Plan (CAMP) will be implemented. The CAMP includes real-time monitoring for VOCs and particulates (i.e., dust) at the downwind perimeter of each designated work area when activities with the potential to release VOCs or dust are in progress at the Site. This CAMP is based on the NYSDOH Generic CAMP included as Appendix 1A DER-10. 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/businesses and on-site workers not directly involved with the subject work activities) from potential airborne contaminant releases as a direct result of project activities.

Continuous monitoring will be conducted during ground intrusive activities involving potentially contaminated soil, fill material or groundwater. Ground intrusive activities include, but are not limited to, test pitting or trenching, advancement/installation of test borings/monitoring wells/in-situ remediation components, etc.

Periodic monitoring for VOCs will be conducted during non-intrusive activities involving potentially contaminated soil, fill material or groundwater where deemed appropriate (e.g., during collection of soil samples or groundwater samples, etc.).

8.3.1 VOC Monitoring, Response Levels, and Actions

VOCs must be monitored at the downwind perimeter of the immediate work area (i.e., the work 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 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 ppm above background for the 15-minute average, work activities must be temporarily halted and monitoring must be 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 or 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.

The 15-minute readings must be recorded and made available for NYSDEC and NYSDOH personnel to review. Instantaneous readings, if any, used for decision purposes should also be recorded.

8.3.2 Particulate Monitoring, Response Levels, and Actions

Particulate concentrations should be monitored continuously at the upwind perimeter of the work zone at temporary particulate monitoring stations. Upwind concentrations should be measured at the start of each workday and periodically thereafter to establish background conditions. 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 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.

Readings will be recorded and made available for review.

9.0 EMERGENCY CONTINGENCY PLAN

This section presents the emergency contingency plan (ECP) describing the procedures to be performed in the event of an emergency (e.g., fire, spill, tank/drum release, etc.). To provide first-line assistance to field personnel in the case of illness or injury, the following items will be made immediately available on the Site:

- First-aid kit;
- Portable emergency eye wash; and
- Supply of clean water.

9.1 EMERGENCY TELEPHONE NUMBERS

The following telephone numbers are listed in case there is an emergency at the Site:

Fire/Police Department: 911

Poison Control Center: (800) 222-1222

NYSDEC

Region 8: Environmental Remediation (585) 226-5349

Spill Hotline (800) 457-7362

NYSDOH

Public Health Duty Officer (866) 881-2809

MCDPH

Public Health Engineering (585) 753-5476

Bonitatem LLC.

Michael J. Piehler (585) 310-7000

DAY ENVIRONMENTAL, INC.

Jeffrey Danzinger (585) 454-0210 ext. 114

NEAREST HOSPITAL: Rochester General Hospital
1425 Portland Avenue, Rochester, NY 14621
(585) 922-4000 (Main)
(585) 922-2000 (Emergency Department)

Directions to the Hospital: Head South on Lake Avenue towards West Ridge Road. Take NY-104 E/ Keeler Street Expressway to NY-104 Service Road East. Take the exit towards Carter Street/Portland Avenue from NY-104. Continue on NY-104 Service Road to 1425 Portland Avenue, Rochester, New York (Figure 1).

9.2 EVACUATION

During activities involving potential disturbance of contaminated soil, fill material, or groundwater, a log of each individual entering and leaving the Site will be kept for emergency accounting practices. Although unlikely, it is possible that a site emergency could require evacuating personnel from the Site. If required, the SSO will give the appropriate signal for site evacuation (i.e., hand signals, alarms, etc.).

All personnel shall exit the Site and shall congregate in an area designated by the SSO. The SSO shall ensure that all personnel are accounted for. If someone is missing, the SSO will alert emergency personnel. The appropriate government agencies will be notified as soon as possible regarding the evacuation, and any necessary measures that may be required to mitigate the reason for the evacuation.

9.3 MEDICAL EMERGENCY

In the event of a medical emergency involving illness or injury to one of the on-site personnel, Emergency Medical Services (EMS) and the appropriate government agencies should be notified immediately. The area in which the injury or illness occurred shall not be entered until the cause of the illness or injury is known. The nature of injury or illness shall be assessed. If the victim appears to be critically injured, administer first aid and/or cardio-pulmonary resuscitation (CPR) as needed. If appropriate, instantaneous real-time air monitoring shall be done in accordance with air monitoring outlined in Section 8.0 of this HASP.

9.4 CONTAMINATION EMERGENCY

It is unlikely that a contamination emergency will occur; however, if such an emergency does occur, the specific work area shall be shut down and immediately secured. If an emergency rescue is needed, notify Police, Fire Department and EMS units immediately. Advise them of the situation and request an expedient response. The appropriate government agencies shall be notified immediately. The area in which the contamination occurred shall not be entered until the arrival of trained personnel who are properly equipped with the appropriate PPE and monitoring instrumentation as outlined in Section 8.0 of this HASP.

9.5 FIRE EMERGENCY

In the event of a fire on-site, all non-essential site personnel shall be evacuated to a safe, secure area. The Fire Department will be notified immediately, and advised of the situation and the identification of any hazardous materials involved. The appropriate government agencies shall be notified as soon as possible.

The four classes of fire along with their constituents are as follows:

- Class A: Wood, cloth, paper, rubber, many plastics, and ordinary combustible materials.
- Class B: Flammable liquids, gases and greases.
- Class C: Energized electrical equipment.
- Class D: Combustible metals such as magnesium, titanium, sodium, potassium.

Small fires on-site may be actively extinguished; however, extreme care shall be taken while in this operation. Approaches to the fire shall be done from the upwind side if possible. Distance from on-site personnel to the fire shall be close enough to ensure proper application of the extinguishing material but far enough away to ensure that the personnel are safe. The proper extinguisher shall be utilized for the Class(es) of fire present on the site. If possible, the fuel source shall be cut off or separated from the fire. Care must be taken when performing operations involving the shut-off of valves and manifolds, if present.

Examples of proper extinguishing agent as follows:

- Class A: Water
Water with 1% Aqueous Film Forming Foams (AFFF, a.k.a. Wet Water)
Water with 6% AFFF or Fluorprotein Foam
ABC Dry Chemical
- Class B: ABC Dry Chemical
Purple K
Carbon Dioxide
Water with 6% AFFF Foam
- Class C: ABC Dry Chemical
Carbon Dioxide
- Class D: Metal-X Dry Powder

No attempt shall be made by site personnel against large fires. Such fires shall be handled by the Fire Department.

9.6 SPILL OR AIR RELEASE

In the event of a spill or air release of hazardous materials on-site, the specific area of the spill or release shall be shut down and immediately secured. The area in which the spill or release occurred shall not be entered until the cause can be determined and site safety can be evaluated. Non-essential site personnel shall be evacuated to a safe and secure area. The appropriate government agencies shall be notified as soon as possible. The spilled or released material shall

be immediately indentified and appropriate containment measures shall be implemented, if feasible. Real-time air monitoring shall be implemented as outlined in Section 8.0 of this HASP. If the materials are unknown, Level B protection is mandatory. If warranted, samples of the materials shall be acquired to facilitate identification.

9.7 LOCATING CONTAINERIZED WASTE AND/OR UNDERGROUND STORAGE TANKS

In the event that unanticipated containerized waster (e.g., drums) and/or underground storage tanks (USTs) are located during project activities, the work must be stopped in the specific area until site safety can be evaluated and addressed. Non-essential Site personnel shall not work in the immediate area until conditions including possible exposure hazards are addressed. The appropriate government agencies shall be notified as soon as possible. The SSO shall monitor the area as outlined in Section 8.0 of this HASP.

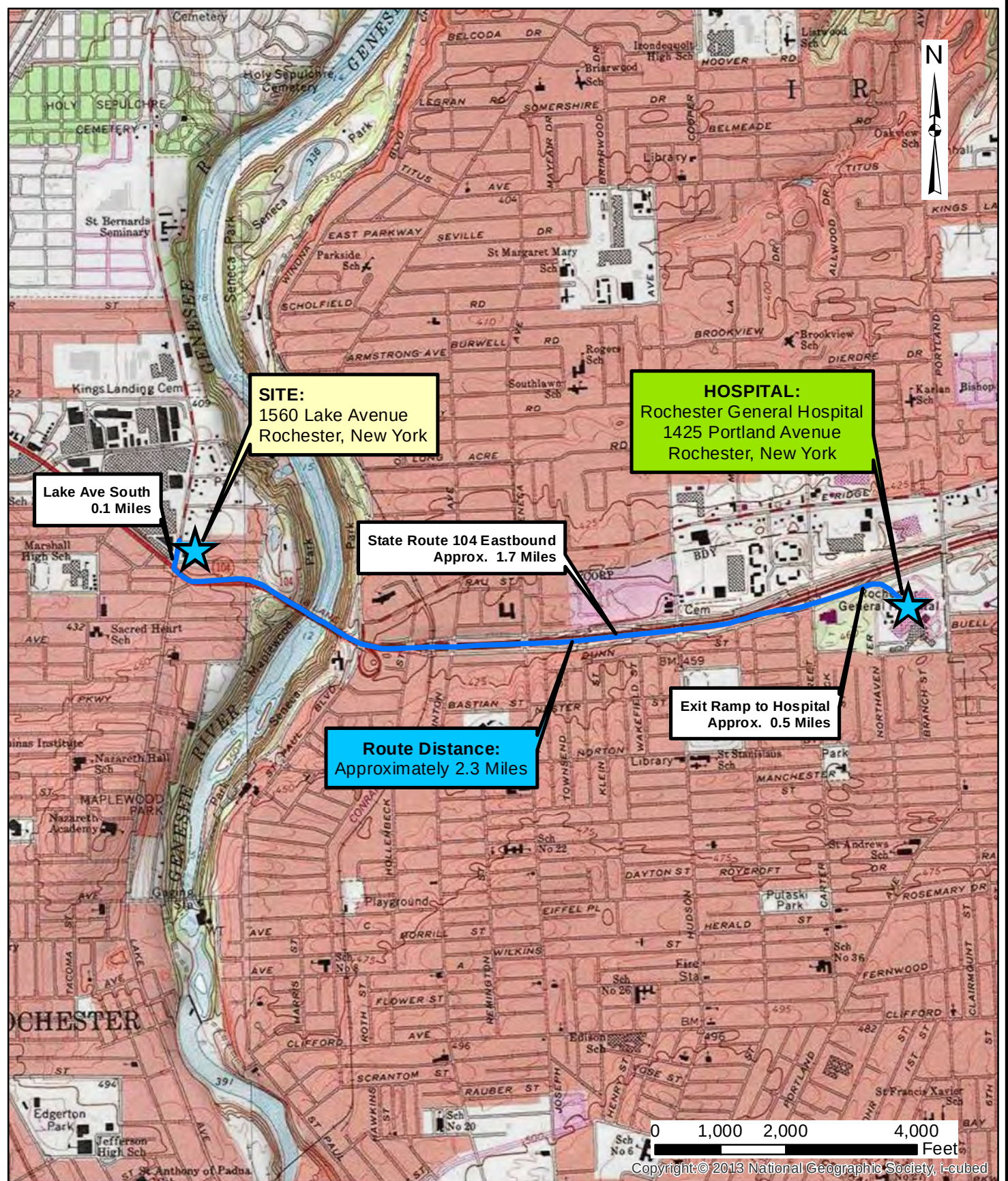
Prior to handling, unanticipated containers will be visually assessed by the SSO to gain as much information as possible about their contents. As a precautionary measure, personnel shall assume that unlabelled containers and/or tanks contain hazardous materials until their contents are characterized. To the extent possible based upon the nature of the containers encountered, actions may be taken to stabilize the area and prevent migration (e.g., placement of berms, etc.). Subsequent to initial visual assessment and any required stabilization, properly trained personnel will sample, test, remove, and dispose of any containers and/or tanks, and their contents. After visual assessment and air monitoring, if the material remains unknown, Level B protection (or higher) is mandatory.

10.0 ABBREVIATIONS

AFFF	Aqueous Film Forming Foams
BGS	Below the Ground Surface
CAMP	Community Air Monitoring Program
CFR	Code of Federal Regulations
CPR	Cardio-Pulmonary Resuscitation
DAY	Day Environmental, Inc.
dBA	Decibels on the A-Weighted Scale
ECP	Emergency Contingency Plan
EMS	Emergency Medical Service
HASP	Health and Safety Plan
HAZWOPER	Hazardous Waste Operations and Emergency Response
IDLH	Immediately Dangerous to Life or Health
IDW	Investigative Derived Waste
MCDPH	Monroe County Department of Public Health
MTBE	Methyl Tert-Butyl Ether
mg/m ³	Milligram Per Meter Cubed
NIOSH	National Institute for Occupational Safety and Health
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
OSHA	Occupational Safety and Health Administration
PEL	Permissible Exposure Limit
PID	Photoionization Detector
PM	Project Manager
PM-10	Particulate Matter Less Than 10 Micrometers In Diameter
PPE	Personal Protection Equipment
ppm	Parts Per Million
PVC	Polyvinyl Chloride
REL	Recommended Exposure Limit
RTAM	Real-Time Aerosol Monitor
SCG	Standards, Criteria and Guidance
SSO	Site Safety Officer
SVOC	Semi-Volatile Organic Compound
TWA	Time-Weighted Average
UST	Underground Storage Tank
µg/m ³	Micrograms Per Meter Cubed
VOC	Volatile Organic Compound

ATTACHMENT 1

Figure 1 – Route for Emergency Services



Date	04-15-2019
Drawn By	CPS
Scale	AS NOTED

day
DAY ENVIRONMENTAL, INC.
Environmental Consultants
Rochester, New York 14606
New York, New York 10170

Project Title	1560 LAKE AVENUE ROCHESTER, NEW YORK
	HEALTH AND SAFETY PLAN
Drawing Title	Route to Emergency Services

Project No.	5495S-19
	FIGURE 1

ATTACHMENT 2

Oxygen Safety Data Sheet

SAFETY DATA SHEET

Oxygen

Airgas
an Air Liquide company

Section 1. Identification

GHS product identifier	: Oxygen
Chemical name	: oxygen
Other means of identification	: Molecular oxygen; Oxygen molecule; Pure oxygen; O ₂ ; UN 1072; Dioxygen; Oxygen USP, Aviator's Breathing Oxygen (ABO)
Product type	: Gas.
Product use	: Synthetic/Analytical chemistry.
Synonym	: Molecular oxygen; Oxygen molecule; Pure oxygen; O ₂ ; UN 1072; Dioxygen; Oxygen USP, Aviator's Breathing Oxygen (ABO)
SDS #	: 001043
Supplier's details	: Airgas USA, LLC and its affiliates 259 North Radnor-Chester Road Suite 100 Radnor, PA 19087-5283 1-610-687-5253
24-hour telephone	: 1-866-734-3438

Section 2. Hazards identification

OSHA/HCS status	: This material is considered hazardous by the OSHA Hazard Communication Standard (29 CFR 1910.1200).
Classification of the substance or mixture	: OXIDIZING GASES - Category 1 GASES UNDER PRESSURE - Compressed gas
GHS label elements	
Hazard pictograms	: 
Signal word	: Danger
Hazard statements	: May cause or intensify fire; oxidizer. Contains gas under pressure; may explode if heated.
Precautionary statements	
General	: Read and follow all Safety Data Sheets (SDS'S) before use. Read label before use. Keep out of reach of children. If medical advice is needed, have product container or label at hand. Close valve after each use and when empty. Use equipment rated for cylinder pressure. Do not open valve until connected to equipment prepared for use. Use a back flow preventative device in the piping. Use only equipment of compatible materials of construction. Open valve slowly. Use only with equipment cleaned for Oxygen service.
Prevention	: Keep away from clothing, incompatible materials and combustible materials. Keep reduction valves, valves and fittings free from oil and grease.
Response	: In case of fire: Stop leak if safe to do so.
Storage	: Protect from sunlight. Store in a well-ventilated place.
Disposal	: Not applicable.
Hazards not otherwise classified	: None known.

Section 3. Composition/information on ingredients

Substance/mixture	: Substance
Chemical name	: oxygen
Other means of identification	: Molecular oxygen; Oxygen molecule; Pure oxygen; O ₂ ; UN 1072; Dioxygen; Oxygen USP, Aviator's Breathing Oxygen (ABO)
Product code	: 001043

CAS number/other identifiers

CAS number : 7782-44-7

Ingredient name	%	CAS number
oxygen	100	7782-44-7

Any concentration shown as a range is to protect confidentiality or is due to batch variation.

There are no additional ingredients present which, within the current knowledge of the supplier and in the concentrations applicable, are classified as hazardous to health or the environment and hence require reporting in this section.

Occupational exposure limits, if available, are listed in Section 8.

Section 4. First aid measures

Description of necessary first aid measures

Eye contact	: Immediately flush eyes with plenty of water, occasionally lifting the upper and lower eyelids. Check for and remove any contact lenses. Continue to rinse for at least 10 minutes. Get medical attention.
Inhalation	: Remove victim to fresh air and keep at rest in a position comfortable for breathing. If not breathing, if breathing is irregular or if respiratory arrest occurs, provide artificial respiration or oxygen by trained personnel. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. Get medical attention if adverse health effects persist or are severe. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband.
Skin contact	: Flush contaminated skin with plenty of water. Remove contaminated clothing and shoes. Get medical attention if symptoms occur. Wash clothing before reuse. Clean shoes thoroughly before reuse.
Ingestion	: As this product is a gas, refer to the inhalation section.

Most important symptoms/effects, acute and delayed

Potential acute health effects

Eye contact	: Contact with rapidly expanding gas may cause burns or frostbite.
Inhalation	: No known significant effects or critical hazards.
Skin contact	: Contact with rapidly expanding gas may cause burns or frostbite.
Frostbite	: Try to warm up the frozen tissues and seek medical attention.
Ingestion	: As this product is a gas, refer to the inhalation section.

Over-exposure signs/symptoms

Eye contact	: No specific data.
Inhalation	: No specific data.
Skin contact	: No specific data.
Ingestion	: No specific data.

Indication of immediate medical attention and special treatment needed, if necessary

Notes to physician	: Treat symptomatically. Contact poison treatment specialist immediately if large quantities have been ingested or inhaled.
Specific treatments	: No specific treatment.

Section 4. First aid measures

- Protection of first-aiders** : No action shall be taken involving any personal risk or without suitable training. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation.

See toxicological information (Section 11)

Section 5. Fire-fighting measures

Extinguishing media

- Suitable extinguishing media** : Use an extinguishing agent suitable for the surrounding fire.
- Unsuitable extinguishing media** : None known.

- Specific hazards arising from the chemical** : Contains gas under pressure. Oxidizing material. This material increases the risk of fire and may aid combustion. Contact with combustible material may cause fire. In a fire or if heated, a pressure increase will occur and the container may burst or explode.

- Hazardous thermal decomposition products** : No specific data.

- Special protective actions for fire-fighters** : Promptly isolate the scene by removing all persons from the vicinity of the incident if there is a fire. No action shall be taken involving any personal risk or without suitable training. Contact supplier immediately for specialist advice. Move containers from fire area if this can be done without risk. Use water spray to keep fire-exposed containers cool. If involved in fire, shut off flow immediately if it can be done without risk.

- Special protective equipment for fire-fighters** : Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

Section 6. Accidental release measures

Personal precautions, protective equipment and emergency procedures

- For non-emergency personnel** : No action shall be taken involving any personal risk or without suitable training. Evacuate surrounding areas. Keep unnecessary and unprotected personnel from entering. Shut off all ignition sources. No flares, smoking or flames in hazard area. Avoid breathing gas. Provide adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Put on appropriate personal protective equipment.
- For emergency responders** : If specialized clothing is required to deal with the spillage, take note of any information in Section 8 on suitable and unsuitable materials. See also the information in "For non-emergency personnel".

- Environmental precautions** : Ensure emergency procedures to deal with accidental gas releases are in place to avoid contamination of the environment. Inform the relevant authorities if the product has caused environmental pollution (sewers, waterways, soil or air).

Methods and materials for containment and cleaning up

- Small spill** : Immediately contact emergency personnel. Stop leak if without risk. Use spark-proof tools and explosion-proof equipment.
- Large spill** : Immediately contact emergency personnel. Stop leak if without risk. Use spark-proof tools and explosion-proof equipment. Note: see Section 1 for emergency contact information and Section 13 for waste disposal.

Section 7. Handling and storage

Precautions for safe handling

Section 7. Handling and storage

- Protective measures** : Put on appropriate personal protective equipment (see Section 8). Contains gas under pressure. Avoid breathing gas. Do not puncture or incinerate container. Use equipment rated for cylinder pressure. Close valve after each use and when empty. Protect cylinders from physical damage; do not drag, roll, slide, or drop. Use a suitable hand truck for cylinder movement.
- Avoid contact with eyes, skin and clothing. Empty containers retain product residue and can be hazardous. Keep away from clothing, incompatible materials and combustible materials. Keep reduction valves free from grease and oil.
- Advice on general occupational hygiene** : Eating, drinking and smoking should be prohibited in areas where this material is handled, stored and processed. Workers should wash hands and face before eating, drinking and smoking. Remove contaminated clothing and protective equipment before entering eating areas. See also Section 8 for additional information on hygiene measures.
- Conditions for safe storage, including any incompatibilities** : Store in accordance with local regulations. Store in a segregated and approved area. Store away from direct sunlight in a dry, cool and well-ventilated area, away from incompatible materials (see Section 10). Cylinders should be stored upright, with valve protection cap in place, and firmly secured to prevent falling or being knocked over. Cylinder temperatures should not exceed 52 °C (125 °F). Separate from reducing agents and combustible materials. Store away from grease and oil. Keep container tightly closed and sealed until ready for use. See Section 10 for incompatible materials before handling or use.

Section 8. Exposure controls/personal protection

Control parameters

Occupational exposure limits

Ingredient name	Exposure limits
oxygen	None.

- Appropriate engineering controls** : Good general ventilation should be sufficient to control worker exposure to airborne contaminants.
- Environmental exposure controls** : Emissions from ventilation or work process equipment should be checked to ensure they comply with the requirements of environmental protection legislation. In some cases, fume scrubbers, filters or engineering modifications to the process equipment will be necessary to reduce emissions to acceptable levels.

Individual protection measures

- Hygiene measures** : Wash hands, forearms and face thoroughly after handling chemical products, before eating, smoking and using the lavatory and at the end of the working period. Appropriate techniques should be used to remove potentially contaminated clothing. Wash contaminated clothing before reusing. Ensure that eyewash stations and safety showers are close to the workstation location.
- Eye/face protection** : Safety eyewear complying with an approved standard should be used when a risk assessment indicates this is necessary to avoid exposure to liquid splashes, mists, gases or dusts. If contact is possible, the following protection should be worn, unless the assessment indicates a higher degree of protection: safety glasses with side-shields.
- Skin protection**
- Hand protection** : Chemical-resistant, impervious gloves complying with an approved standard should be worn at all times when handling chemical products if a risk assessment indicates this is necessary. Considering the parameters specified by the glove manufacturer, check during use that the gloves are still retaining their protective properties. It should be noted that the time to breakthrough for any glove material may be different for different glove manufacturers. In the case of mixtures, consisting of several substances, the protection time of the gloves cannot be accurately estimated.

Section 8. Exposure controls/personal protection

- Body protection** : Personal protective equipment for the body should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.
- Other skin protection** : Appropriate footwear and any additional skin protection measures should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.
- Respiratory protection** : Based on the hazard and potential for exposure, select a respirator that meets the appropriate standard or certification. Respirators must be used according to a respiratory protection program to ensure proper fitting, training, and other important aspects of use. Respirator selection must be based on known or anticipated exposure levels, the hazards of the product and the safe working limits of the selected respirator.

Section 9. Physical and chemical properties

Appearance

- Physical state** : Gas. [Compressed gas.]
- Color** : Colorless. Blue.
- Odor** : Odorless.
- Odor threshold** : Not available.
- pH** : Not available.
- Melting point** : -218.4°C (-361.1°F)
- Boiling point** : -183°C (-297.4°F)
- Critical temperature** : -118.15°C (-180.7°F)
- Flash point** : [Product does not sustain combustion.]
- Evaporation rate** : Not available.
- Flammability (solid, gas)** : Extremely flammable in the presence of the following materials or conditions: reducing materials, combustible materials and organic materials.
- Lower and upper explosive (flammable) limits** : Not available.
- Vapor pressure** : Not available.
- Vapor density** : 1.1 (Air = 1)
- Specific Volume (ft³/lb)** : 12.0482
- Gas Density (lb/ft³)** : 0.083
- Relative density** : Not applicable.
- Solubility** : Not available.
- Solubility in water** : Not available.
- Partition coefficient: n-octanol/water** : 0.65
- Auto-ignition temperature** : Not available.
- Decomposition temperature** : Not available.
- Viscosity** : Not applicable.
- Flow time (ISO 2431)** : Not available.
- Molecular weight** : 32 g/mole

Section 10. Stability and reactivity

- Reactivity** : No specific test data related to reactivity available for this product or its ingredients.
- Chemical stability** : The product is stable.
- Possibility of hazardous reactions** : Hazardous reactions or instability may occur under certain conditions of storage or use. Conditions may include the following:
contact with combustible materials
Reactions may include the following:
risk of causing fire

Section 10. Stability and reactivity

- Conditions to avoid** : No specific data.
- Incompatible materials** : Highly reactive or incompatible with the following materials:
combustible materials
reducing materials
grease
oil
- Hazardous decomposition products** : Under normal conditions of storage and use, hazardous decomposition products should not be produced.

Hazardous polymerization : Under normal conditions of storage and use, hazardous polymerization will not occur.

Section 11. Toxicological information

Information on toxicological effects

Acute toxicity

Not available.

Irritation/Corrosion

Not available.

Sensitization

Not available.

Mutagenicity

Not available.

Carcinogenicity

Not available.

Reproductive toxicity

Not available.

Teratogenicity

Not available.

Specific target organ toxicity (single exposure)

Not available.

Specific target organ toxicity (repeated exposure)

Not available.

Aspiration hazard

Not available.

Information on the likely routes of exposure : Not available.

Potential acute health effects

- Eye contact** : Contact with rapidly expanding gas may cause burns or frostbite.
- Inhalation** : No known significant effects or critical hazards.
- Skin contact** : Contact with rapidly expanding gas may cause burns or frostbite.
- Ingestion** : As this product is a gas, refer to the inhalation section.

Symptoms related to the physical, chemical and toxicological characteristics

Section 11. Toxicological information

Eye contact	: No specific data.
Inhalation	: No specific data.
Skin contact	: No specific data.
Ingestion	: No specific data.

Delayed and immediate effects and also chronic effects from short and long term exposure

Short term exposure

Potential immediate effects	: Not available.
Potential delayed effects	: Not available.

Long term exposure

Potential immediate effects	: Not available.
Potential delayed effects	: Not available.

Potential chronic health effects

Not available.

General	: No known significant effects or critical hazards.
Carcinogenicity	: No known significant effects or critical hazards.
Mutagenicity	: No known significant effects or critical hazards.
Teratogenicity	: No known significant effects or critical hazards.
Developmental effects	: No known significant effects or critical hazards.
Fertility effects	: No known significant effects or critical hazards.

Numerical measures of toxicity

Acute toxicity estimates

Not available.

Section 12. Ecological information

Toxicity

Not available.

Persistence and degradability

Not available.

Bioaccumulative potential

Product/ingredient name	LogP _{ow}	BCF	Potential
oxygen	0.65	-	low

Mobility in soil

Soil/water partition coefficient (K_{oc})	: Not available.
--	------------------

Other adverse effects	: No known significant effects or critical hazards.
------------------------------	---

Section 13. Disposal considerations

Disposal methods

: The generation of waste should be avoided or minimized wherever possible. Disposal of this product, solutions and any by-products should at all times comply with the requirements of environmental protection and waste disposal legislation and any regional local authority requirements. Dispose of surplus and non-recyclable products via a licensed waste disposal contractor. Waste should not be disposed of untreated to the sewer unless fully compliant with the requirements of all authorities with jurisdiction. Empty Airgas-owned pressure vessels should be returned to Airgas. Waste packaging should be recycled. Incineration or landfill should only be considered when recycling is not feasible. This material and its container must be disposed of in a safe way. Empty containers or liners may retain some product residues. Do not puncture or incinerate container.

Section 14. Transport information

	DOT	TDG	Mexico	IMDG	IATA
UN number	UN1072	UN1072	UN1072	UN1072	UN1072
UN proper shipping name	OXYGEN, COMPRESSED	OXYGEN, COMPRESSED	OXYGEN, COMPRESSED	OXYGEN, COMPRESSED	OXYGEN, COMPRESSED
Transport hazard class(es)	2.2 (5.1)  	2.2 	2.2 (5.1)  	2.2 (5.1)  	2.2 (5.1)  
Packing group	-	-	-	-	-
Environmental hazards	No.	No.	No.	No.	No.

“Refer to CFR 49 (or authority having jurisdiction) to determine the information required for shipment of the product.”

Additional information

DOT Classification

: **Limited quantity** Yes.
Quantity limitation Passenger aircraft/rail: 75 kg. Cargo aircraft: 150 kg.
Special provisions A52

TDG Classification

: Product classified as per the following sections of the Transportation of Dangerous Goods Regulations: 2.13-2.17 (Class 2), 2.23-2.25 (Class 5).
Explosive Limit and Limited Quantity Index 0.125
ERAP Index 3000
Passenger Carrying Ship Index 50
Passenger Carrying Road or Rail Index 75
Special provisions 42

IATA

: **Quantity limitation** Passenger and Cargo Aircraft: 75 kg. Cargo Aircraft Only: 150 kg.

Special precautions for user : **Transport within user's premises:** always transport in closed containers that are upright and secure. Ensure that persons transporting the product know what to do in the event of an accident or spillage.

Transport in bulk according to Annex II of MARPOL and the IBC Code : Not available.

Section 15. Regulatory information

U.S. Federal regulations : TSCA 8(a) CDR Exempt/Partial exemption: This material is listed or exempted.

Clean Air Act Section 112 (b) Hazardous Air Pollutants (HAPs) : Not listed

Clean Air Act Section 602 Class I Substances : Not listed

Clean Air Act Section 602 Class II Substances : Not listed

DEA List I Chemicals (Precursor Chemicals) : Not listed

DEA List II Chemicals (Essential Chemicals) : Not listed

SARA 302/304

Composition/information on ingredients

No products were found.

SARA 304 RQ : Not applicable.

SARA 311/312

Classification : Refer to Section 2: Hazards Identification of this SDS for classification of substance.

State regulations

Massachusetts : This material is listed.

New York : This material is not listed.

New Jersey : This material is listed.

Pennsylvania : This material is listed.

International regulations

Chemical Weapon Convention List Schedules I, II & III Chemicals

Not listed.

Montreal Protocol (Annexes A, B, C, E)

Not listed.

Stockholm Convention on Persistent Organic Pollutants

Not listed.

Rotterdam Convention on Prior Informed Consent (PIC)

Not listed.

UNECE Aarhus Protocol on POPs and Heavy Metals

Not listed.

Inventory list

Australia : This material is listed or exempted.

Canada : This material is listed or exempted.

China : This material is listed or exempted.

Europe : This material is listed or exempted.

Japan : **Japan inventory (ENCS)**: Not determined.
Japan inventory (ISHL): Not determined.

Malaysia : Not determined.

New Zealand : This material is listed or exempted.

Philippines : This material is listed or exempted.

Republic of Korea : This material is listed or exempted.

Section 15. Regulatory information

Taiwan	: This material is listed or exempted.
Thailand	: Not determined.
Turkey	: Not determined.
United States	: This material is listed or exempted.
Viet Nam	: Not determined.

Section 16. Other information

Hazardous Material Information System (U.S.A.)

Health	/	0
Flammability		0
Physical hazards		3

Caution: HMIS® ratings are based on a 0-4 rating scale, with 0 representing minimal hazards or risks, and 4 representing significant hazards or risks. Although HMIS® ratings and the associated label are not required on SDSs or products leaving a facility under 29 CFR 1910.1200, the preparer may choose to provide them. HMIS® ratings are to be used with a fully implemented HMIS® program. HMIS® is a registered trademark and service mark of the American Coatings Association, Inc.

The customer is responsible for determining the PPE code for this material. For more information on HMIS® Personal Protective Equipment (PPE) codes, consult the HMIS® Implementation Manual.

National Fire Protection Association (U.S.A.)



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Copyright ©2001, National Fire Protection Association, Quincy, MA 02269. This warning system is intended to be interpreted and applied only by properly trained individuals to identify fire, health and reactivity hazards of chemicals. The user is referred to certain limited number of chemicals with recommended classifications in NFPA 49 and NFPA 325, which would be used as a guideline only. Whether the chemicals are classified by NFPA or not, anyone using the 704 systems to classify chemicals does so at their own risk.

Procedure used to derive the classification

Classification	Justification
OXIDIZING GASES - Category 1 GASES UNDER PRESSURE - Compressed gas	Expert judgment According to package

History

Date of printing	: 2/3/2018
Date of issue/Date of revision	: 2/3/2018
Date of previous issue	: 1/27/2017
Version	: 0.03

Key to abbreviations

: ATE = Acute Toxicity Estimate
: BCF = Bioconcentration Factor
: GHS = Globally Harmonized System of Classification and Labelling of Chemicals
: IATA = International Air Transport Association
: IBC = Intermediate Bulk Container
: IMDG = International Maritime Dangerous Goods
: LogPow = logarithm of the octanol/water partition coefficient
: MARPOL = International Convention for the Prevention of Pollution From Ships, 1973

Section 16. Other information

as modified by the Protocol of 1978. ("Marpol" = marine pollution)
UN = United Nations

References

: Not available.

Indicates information that has changed from previously issued version.

Notice to reader

To the best of our knowledge, the information contained herein is accurate. However, neither the above-named supplier, nor any of its subsidiaries, assumes any liability whatsoever for the accuracy or completeness of the information contained herein.

Final determination of suitability of any material is the sole responsibility of the user. All materials may present unknown hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist.

APPENDIX B

Quality Assurance Project Plan

**QUALITY ASSURANCE PROJECT PLAN
REMEDIAL INVESTIGATION/REMEDIAL ALTERNATIVES ANALYSIS**

**1560 LAKE AVENUE
ROCHESTER, NEW YORK**

Prepared for: Bonitatem LLC
770 Panorama Trail South
Rochester, New York

Prepared by: Day Environmental, Inc.
1563 Lyell Avenue
Rochester, New York

Project No.: 5495S-18

Date: December 3, 2019

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Attachment 1:	Resumes of Key Personnel
Attachment 2:	ASTM Standard Practices for Drilling
Attachment 3:	Field Logs and Construction Diagrams
Attachment 4:	Guidance Documents for Method 5035 VOC Soil Sampling and Analysis, and Emerging Contaminants Sampling and Analysis
Attachment 5:	Table 1 (Sampling and Analysis Plan)

1.0 INTRODUCTION

This project-specific Quality Assurance Project Plan (QAPP) was prepared in accordance with Section 2.4 of the New York State Department of Environmental Conservation (NYSDEC) Technical Guidance, For Site Investigation and Remediation DER-10 dated May 2010. This QAPP provides quality assurance/quality control (QA/QC) protocols and guidance that are to be followed when implementing the Remedial Investigation/Remedial Alternatives Analysis Work Plan (RI/RAA Work Plan) for 1560 Lake Avenue, Rochester, New York (Site) to ensure that data of a known and acceptable precision and accuracy are generated. The QAPP also provides a summary of the project, identifies personnel responsibilities, and provides procedures to be used during sampling of environmental media, other field activities, and the analytical laboratory testing of samples. The components of the QAPP are provided herein.

1.1 PROJECT SCOPE AND PROJECT GOALS

The QAPP applies to the aspects of the project associated with the collection of field data, the collection and analytical laboratory testing of field samples and QA/QC samples, and the evaluation of the quality of the data that is generated. Specifically, the investigation will include a utility assessment, a subsurface soil and fill evaluation, a groundwater evaluation and a soil vapor evaluation. A summary of the anticipated number of analytical samples is provided in Table 1 of this QAPP. Detailed discussions of the project scope and project goals are provided in the RI/RAA Work Plan. In general, the project goal is to obtain sufficient information to characterize the nature and extent of contamination at the Site to sufficiently develop remedial alternatives for the Site to attain the goal of a Track 4 cleanup to conditions protective of the Site's intended use as a parking lot and to control or mitigate off-site migration of contamination that is attributable to the Site.

2.0 PROJECT/TASK ORGANIZATION

Project organization and tentative personnel to implement the work are outlined in this section of the QAPP.

2.1 DAY ORGANIZATION

Information regarding key personnel for Day Environmental, Inc. (DAY) is provided below, and resumes of key personnel are included in Attachment 1.

DAY Principal in Charge

The Principal in Charge is responsible for such things as the review of project documents and ensuring that the project is completed in accordance with relevant work plans. Mr. Raymond L. Kampff, P.G. will serve as DAY's Principle-in-Charge on this project.

DAY Project Manager

The DAY Project Manager has the overall responsibility for implementing the project and ensuring that the project meets the objectives and quality standards as presented in this QAPP. Mr. Jeffrey Danzinger, P.G. will serve as DAY's Project Manager on this project, and will serve as DAY's primary point of contact and control for the project.

DAY Quality Assurance Officer

The Quality Assurance Officer is responsible for QA/QC on this project. The Quality Assurance Officer's responsibilities on this project are not as a project manager or task manager involved with project productivity or profitability as job performance criteria. Ms. Heather McLennan will serve as DAY's Quality Assurance Officer on this project. The Quality Assurance Officer may conduct audits of the operations at the Site to ensure that work is being performed in accordance with the QAPP.

DAY Technical Staff

DAY's technical staff for this project consists of experienced professionals (e.g., professional engineers, engineers-in-training, scientists, technicians, etc.) that possess the qualifications necessary to effectively and efficiently complete the project tasks. The technical staff will be used to gather and analyze data, prepare various project documentation, etc.

2.2 ANALYTICAL LABORATORIES

A New York State Department of Health (NYSDOH) Environmental Laboratory Approval Program (ELAP)-certified analytical laboratory will be utilized for the analytical services work associated with this project. A copy of the laboratory's Quality Assurance Plan or Manual (QAP or QAM) can be provided upon request.

3.0 QUALITY ASSURANCE/QUALITY CONTROL

As part of this QAPP, QA/QC protocol and procedures have been developed and are described below. The objective of the QA/QC protocol and procedures is to ensure that the information, data, and decisions associated with this project are technically sound and properly documented. The QA/QC protocol and procedures also pertain to the collection, evaluation, and review of activities and data that are part of this project. These QA/QC protocol and procedures will be modified in supplemental work plans when deemed appropriate.

3.1 OPERATION AND CALIBRATION OF ON-SITE MONITORING EQUIPMENT

On-site monitoring equipment will play a significant role in meeting the Remedial Investigation (RI) objectives and to determine the appropriate personal protective equipment (PPE) as noted in the Health and Safety Plan (HASP). The on-site monitoring equipment includes volatile organic compound (VOC) monitors, particulate monitors, oil/water interface probes, an electronic static water level indicator, water quality monitors, and global position system (GPS). Operation and calibration of on-site monitoring equipment that are anticipated for use during the RI are discussed below.

3.1.1 VOC Monitoring Equipment

Real-time monitoring for VOCs will be conducted to evaluate the nature and extent of volatile contaminants (e.g., petroleum-type) at the Site and to determine the appropriate PPE as noted in the HASP. The primary field instrument for monitoring VOCs during the RI will be a photoionization detector (PID). It is anticipated that a Minirae 3000 PID (or equivalent) equipped with a 10.6 eV lamp will be used during this project. An accredited firm/testing laboratory will calibrate the equipment on a yearly basis. During fieldwork, the PID will be calibrated on a daily basis in accordance with the manufacturer's specifications. Isobutylene gas will be used to calibrate the PID prior to use and as necessary during fieldwork. Measurements will be collected before operations begin in an area selected to determine the amount of VOCs naturally occurring in the air (i.e., background concentrations).

3.1.2 Particulate Monitoring Equipment

Particulate monitoring will be conducted during intrusive activities as noted in the HASP and Community Air Monitoring Plan (CAMP). It is anticipated that the particulate air monitoring will be conducted using a real-time aerosol monitor (RTAM) particulate meter. It is anticipated that a Thermo Scientific PDR-AN1000 RTAM (or equivalent) will be used during this project. An accredited firm/testing laboratory will calibrate the equipment on a yearly basis. During fieldwork, the particulate meter will be regularly calibrated in accordance with the manufacturer's specifications. Measurements will be collected along the upwind perimeter of the intrusive investigation activities to determine the amount of particulates naturally occurring in the air (i.e., background concentrations) as per the requirements of the CAMP.

3.1.3 Global Positioning System Equipment

A GPS unit will be used to obtain the precise locations of sampling points and significant site features. It is anticipated that a Trimble Geo-7X will be used during this project. Sub-foot GPS location accuracy is the data quality objective for this project. The GPS unit will be calibrated as needed in accordance with the manufacturer's specifications. The GPS location data will conform to the NAD 1983 State Plane New York West coordinate system.

3.1.4 Miscellaneous Field Monitoring Equipment

Several other pieces of miscellaneous field monitoring equipment will be used as part of the project. It is anticipated that the other field monitoring equipment utilized during portions of the project include:

- An electronic static water level indicator;
- An oil/water interface meter; and,
- A YSI ProDSS water quality meter (or similar) that measures pH, specific conductivity, temperature, dissolved oxygen, oxygen-reduction potential, and turbidity.

These meters will be calibrated, operated, and maintained in accordance with the manufacturer's instructions.

3.2 GENERAL DRILLING, SOIL SCREENING AND LOGGING

Direct-push drilling and sampling will be conducted in general accordance with American Society for Testing and Materials (ASTM) D6282-98 Standard Guide for Direct Push Soil Sampling for Environmental Site Characterizations. Rotary drilling and sampling will be conducted in general accordance with ASTM D6151-97 Standard Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling, and ASTM D2113-99 Standard Practice for Rock Core Drilling and Sampling of Rock for Site Investigation. Copies of these ASTM standards are included in Attachment 2.

A DAY representative will: document visual and olfactory observations; screen the surface, split spoon and macro-core samples with a PID; collect selected portions of the samples for possible laboratory analysis; collect other portions of the samples for field observations (and process and screen the headspace of these selected samples with a PID); photograph soil collection activities, and prepare logs that provide pertinent field information.

Pertinent information will be recorded on test boring/soil vapor probe logs (copies included in Attachment 3), which will include:

- Date, test location identification, and project identification;
- Name of individual preparing the log;
- Name of drilling contractor;
- Drill make and model, and auger size;
- Identification of alternative drilling methods used and justification thereof;

- Depths recorded in feet and fractions thereof (tenths of inches) referenced to ground surface;
- Standard penetration test (ASTM D-1586) blow counts (if applicable);
- The length of the sample interval and the percentage of the sample recovered;
- Description of soil type using the Unified Soil Classification System;
- The depth of the first encountered water table (if encountered), along with the method of determination, referenced to ground surface;
- Drilling and borehole characteristics;
- Sequential stratigraphic boundaries and soil types consistent with logging performed on other project elements;
- Well specifications (materials, screened interval, amount of Portland cement, bentonite and water used to mix grout, etc.); and,
- PID screening results of ambient headspace air above selected soil samples.

When VOC analysis on soil samples is going to be performed, the samples will be collected in accordance with United States Environmental Protection Agency (USEPA) Method 5035 (copy of method included in Attachment 4).

3.3 SOIL SAMPLE HEADSPACE SCREENING

The recovered soil samples will be examined by a DAY representative for visual and olfactory evidence of suspect contamination (e.g., staining, unusual odors) and screened with a PID. Portions of the recovered soil samples may be placed in containers for possible analytical laboratory testing. Different portions of the soil samples will be placed in sealable Ziploc®-type plastic baggies, and will be field screened the same day they are collected. Each sample will be agitated and homogenized for at least 30 seconds and allowed to equilibrate for at least three minutes. The ambient headspace air inside the baggie above each sample will be screened for total VOC vapors with the PID equipped with a 10.6 eV lamp. The sampling wand for the PID will be placed in the ambient air headspace inside the bag by opening a corner of the “locked” portion of the bag. The PID will monitor air inside the baggie for a period of at least 15 seconds and the peak readings measured will be recorded on a log sheet or log book.

3.4 NAPL SCREENING SHAKE TEST FOR SOIL SAMPLES

Field evidence of suspect non-aqueous phase liquid (NAPL) will be confirmed in the field utilizing a hydrophobic dye shake test. Field evidence of suspect NAPL include, but not limited to, elevated PID readings [i.e., >1,000 parts per million (ppm)], saturated soil with petroleum or solvent odors or significant staining, and apparent free phase or residual NAPL. The NAPL screening shake test is applicable for both light non-aqueous phase liquid (LNAPL) and dense non-aqueous phase liquid (DNAPL). If field evidence suggests the presence of LNAPL or DNAPL, the DAY representative will perform a shake test on an aliquot of the corresponding soil sample using hydrophobic dye. The sample aliquot will be mixed with approximately two ounces potable water and a pinch of Sudan IV or equivalent hydrophobic dye in a sealable plastic baggie. The sample will be agitated for approximately 10 seconds and then noted for pigment staining. If organic

NAPL is present, the Sudan IV Pigment should result in pigment staining. The NAPL screening shake test results will be documented and, if possible, photographed for documentation purposes. The hydrophobic dye will be handled with care using a new pair of disposable gloves. Following the shake test, the plastic baggie containing the soil-dye moisture and associated PPE should be managed as investigation derived waste (IDW). Soils containing hydrophobic dye and PPE will not be used for confirmatory analytical analyses or headspace readings.

3.5 NAPL SCREENING FOR GROUNDWATER SAMPLES

Field evidence of suspect NAPL will be confirmed in the field utilizing an oil/water interface probe. Alternatively, a peristaltic pump and tubing can be used to look for LNAPL and DNAPL at the top and bottom of the column of liquid in a monitoring well, respectively. A bailer attached to string or poly rope can also be used to check for LNAPL at the top of the column of liquid in a monitoring well. Hydrophobic dye can also be used on an aliquot of liquid sample to determine the presence of NAPL that is otherwise clear of the same color as the groundwater. The NAPL screening results will be documented and, if possible, photographed for documentation purposes.

3.6 MONITORING WELL INSTALLATION

Overburden monitoring wells installed as part of this project will be constructed of a ten-foot long, 1-inch inner diameter, Schedule 40, polyvinyl chloride (PVC), 10-slot screen attached to solid riser piping of the same material that extends at least two feet above the existing ground surface. Each screen will be placed to intercept the top of the uppermost water-bearing zone as determined at the time of drilling. The annulus below, around and at least one foot above each screen will be backfilled with a sand pack. A minimum two-foot thick bentonite seal will be placed in the annulus above the sand pack in each well. The remaining annulus in each well will be backfilled with a Portland cement/bentonite grout. A J-plug or cap will be installed on the top of the PVC riser, and a protective casing with a concrete pad will be installed over each well. Pertinent information for each monitoring well will be documented on an overburden monitoring well construction diagram (copy included in Attachment 3).

Bedrock groundwater monitoring wells will be installed as part of this project. The respective borings will be extended at least two feet into competent bedrock using an appropriate-sized roller bit. A permanent 4" steel casing will then be installed and sealed with appropriate cement mixture into the bedrock and will extend to above the ground surface. Ten feet of bedrock will then be cored using HQ-sized coring equipment (or NX-sized coring equipment followed by reaming with a 3-7/8" diameter roller bit). The bedrock cores will be photographed and maintained on-site during the RI. Locking caps will be fitted on the top of the permanent 4" steel casings; thus, completing the bedrock monitoring well installations. Pertinent information for each monitoring well will be documented on a bedrock monitoring well construction diagram (copy included in Attachment 3).

3.7 WELL DEVELOPMENT

Monitoring wells will be developed by utilizing either a new dedicated disposable bailer with dedicated cord, and/or a pump and dedicated disposable tubing depending on the field conditions. No fluids will be added to the wells during development without prior approval of the NYSDEC, and well development equipment will be decontaminated prior to development of each well.

The well development procedure is listed below:

- Obtain pre-development static water level and oil/water interface reading for presence of LNAPL or DNAPL using a Heron Model HO1.L oil/water interface probe or similar instrument;
- Calculate water/sediment volume in the well;
- Obtain initial field water quality measurements (e.g., pH, specific conductivity, turbidity, temperature, and PID readings). The pH, specific conductivity, turbidity and temperature readings will be obtained using a YSI ProDSS water quality meter (or similar equipment);
- Select development method and set up equipment depending on method used;
- Alternate water agitation methods (e.g., moving a bailer or pump tubing up and down inside the screened interval) and water removal methods (e.g., pumping or bailing) in order to suspend and remove solids from the well;
- Obtain field water quality measurements for every two to five gallons of water removed. Record water quantities and rates removed;
- Stop development when the following water quality criteria are met, or at least five well volumes plus an equivalent volume of any water lost during drilling have been removed;
 - Water is clear and free of sediment and turbidity is less than 50 nephelometric turbidity units (NTUs);
 - pH is ± 0.1 standard unit between readings;
 - Specific conductivity is $\pm 3\%$ between readings;
 - Temperature is $\pm 10\%$ between readings.
 - Obtain post-development water level readings; and,
 - Document development procedures, measurements, quantities, etc.

Pertinent information for each well will be recorded on well development logs (copy included in Attachment 3).

3.8 LOW-FLOW GROUNDWATER PURGING AND SAMPLING

When emerging contaminant testing is going to be performed on samples, the samples will be collected and analyzed in accordance with the following guidance documents, which are included in Attachment 4:

- NYSDEC document titled “Groundwater Sampling for Emerging Contaminants” dated April 2018

- NYSDEC document titled “Collection of Groundwater Samples for Perfluorooctanoic Acid (PFOA) and Perfluorinated Compounds (PFCs) from Monitoring Wells Sample Protocol” dated June 29, 2016
- NYSDEC document titled “Sampling for 1,4-Dioxane and Per- and Polyfluoroalkyl Substances (PFAS) Under DEC’s Part 375 Remedial Programs” dated February 2019
- NYSDEC document titled “Laboratory Guidance for Analysis of Per- and Polyfluoroalkyl Substances (PFAS) in Non-Potable Water and Solids” dated February 2019

The low-flow procedures that will be utilized are outlined below:

- In order to minimize the potential re-suspension of solids in the bottom of the well, well depths will not be measured prior to, or during, low-flow purging and sampling. Well depth information will be obtained from measurements collected during well development or well construction.
- PID readings will be obtained from the well headspace immediately following opening the well. The peak PID readings will be noted on a field logbook.
- Prior to purging and sampling, static water level measurements will be taken from each well using a Heron Model HO1.L oil/water interface probe or similar instrument. The presence or absence of LNAPL will be determined. If present, the thickness of LNAPL will be obtained.
- If necessary to confirm whether NAPL is present in groundwater that contain PID measurements greater than 500 ppm or other field indications of NAPL, hydrophobic dye (i.e., Sudan IV) may be introduced to an aliquot of the sample. If LNAPL or DNAPL is detected, the NYSDEC will be notified to determine whether analytical characterization of the NAPL is warranted.
- A peristaltic pump with a section of new disposable Silicone tubing in its pump housing will be connected to new disposable high density polyethylene (HDPE) tubing that is lowered and positioned at or slightly above the mid-point of the well screen or cored open bedrock when this interval is set in relatively homogeneous material. When the screened interval or cored open bedrock interval is set in heterogeneous materials, the bottom of the HDPE tubing will be positioned adjacent to the zone of highest hydraulic conductivity (as defined by geologic samples). Care will be taken to install and lower the tubing slowly in order to minimize disturbance of the water column.
- The peristaltic pump will be capable of varying pumping rates. An in-line flow-through cell attached to a YSI ProDSS water quality meter (or similar equipment) will be connected to the pump effluent tubing.
- The pump will be started at a low pumping rate of 100 milliliters per minute (ml/min) or less (for pumps that cannot achieve a flow rate this low, the pump will be started at the lowest pump rate possible). The water level in the well will be measured and the pump rate will be adjusted (i.e., increased or decreased) until the drawdown is stabilized. In order to establish the optimum flow-rate for purging and sampling, the water level in the well will be measured on a periodic basis (i.e., every one or two minutes) using an electronic water level meter or the Heron Model HO1.L oil/water

interface meter (or equivalent). When the water level in the well has stabilized (i.e., use goal of < 0.33 feet of constant drawdown), the water level measurements will be collected less frequently.

- While purging the well at the stabilized water level, water quality indicator parameters will be monitored on a three to five-minute basis with a YSI ProDSS water quality meter (or similar equipment). Water quality indicator parameters will be considered stabilized after three consecutive readings for each of the following parameters are generally achieved:
 - pH (± 0.1);
 - specific conductance ($\pm 3\%$);
 - dissolved oxygen ($\pm 10\%$);
 - oxidation-reduction potential (± 10 mV);
 - temperature ($\pm 10\%$); and
 - turbidity ($\pm 10\%$, when turbidity is greater than 10 NTUs).
- Following stabilization of the water quality parameters, the flow-through cell will be disconnected and a groundwater sample will be collected from the pump effluent tubing. The pumping rate during sampling will remain at the established purging rate or it may be adjusted downward to minimize aeration, bubble formation, or turbulent filling of sample containers. A pumping rate below 250 ml/min will be used when collecting VOC samples.
- To minimize the potential for re-suspension of solids in the bottom of the well, the presence of DNAPL will be determined following purging and sampling at each well location using the Heron oil/water interface probe (or equivalent).
- Field observations, real-time parameter readings, and other pertinent information obtained during the sampling effort will be noted in the field logbook and on a low-flow groundwater purge and sample log (copy included in Attachment 3).

3.9 SOIL VAPOR SAMPLING

Soil vapor sampling will be completed in accordance with applicable provisions outlined by the NYSDOH Guidance Document, including Section 2.7 (Sampling Protocols) and Section 2.8 (Quality Assurance/Quality Control). DAY will collect soil vapor samples and a background (i.e., outdoor) air sample for subsequent analytical laboratory testing. Direct-push test borings will be used for installation of soil vapor sample points. Each soil vapor sample point will consist of polyethylene tubing that is installed near the bottom of the boring, but above the water table in the boring, whichever is less, that extends above the ground surface. Either the bottom 6 inches of the tubing in the boring will be perforated to allow infiltration of soil vapor or a 6-inch stainless steel woven screen will be attached to the bottom of the tubing. The annulus between the tubing and the boring wall will be backfilled with clean filter sand to a depth of at least one foot above the top of the shallowest portion of the perforated tubing interval. Thereafter the remaining borehole will be backfilled with bentonite that is hydrated. Pertinent information for each soil vapor probe will be provided on test boring logs and soil vapor probe construction diagrams (copies included in Attachment 3).

Prior to sampling, each soil vapor sample point will be tested for potential surface air infiltration using a helium tracer gas test in accordance with the provisions outlined in the NYSDOH guidance document. If the helium concentration measured in the soil vapor sample point is below 10% of the enriched atmosphere as required by NYSDOH guidance, the soil vapor sample point will be purged of 1 to 3 volumes of air at a flow rate that does not exceed 0.2 liters per minute. Subsequent to purging of the soil vapor sample point, sampling will commence. In the event a soil vapor sample point fails the helium tracer test, the surface seal will be repaired and the test repeated until the helium is measured below the NYSDOH guidance.

Soil vapor samples will be collected using 6-liter Summa canisters equipped with 2-hour regulators. The vacuum readings will be recorded at the start of the test and monitored throughout the test. In the event that cold weather promotes condensation in the sample tubing during sample collection, tube warmers may be used to address this condition. In addition to the soil vapor samples, one background outdoor air sample will be collected approximately three feet off the ground from an upwind location, as determined at the time of sample collection, in a batch certified Summa canister during the same general two-hour period. Following collection, the Summa canisters will be transported under chain-of-custody control to the analytical laboratory for testing. Pertinent information for each sample will be recorded on a soil vapor sampling log (copy included in Attachment 3).

3.10 WASTE CHARACTERIZATION SAMPLING

IDW will be managed in accordance with the guidelines outlined in Section 4.6 of the RI/RAA Work Plan. Supplemental sampling of the IDW is anticipated in order to obtain approvals from appropriate disposal and/or recycling at an authorized solid waste management facility or publicly owned wastewater treatment works (liquids). The following protocols likely apply to IDW sampling:

- The objective of IDW sampling is to characterize a substantial mass of waste requiring disposal. Consequently, the sample should be collected in a manner that is representative of the entire waste mass and not limited to a specific zone of concern or observed contamination.
- Grab samples may be composited for analytical analyses.

4.0 EQUIPMENT DECONTAMINATION PROCEDURES

In order to reduce the potential for cross-contamination of samples collected during this project, the following procedures will be implemented to ensure that the data collected (primarily the laboratory data) is acceptable.

It is anticipated that most of the materials used to assist in obtaining samples will be disposable one-time use materials (e.g., sampling containers, bailers, rope, pump tubing, nitrile gloves, etc.). However, when equipment must be re-used (e.g., drill rigs, static water level indicator, split spoon samplers, etc.), it will be decontaminated by at least one of the following methods:

- Steam clean the equipment within a dedicated decontamination area; or
- Rough wash in mixture of tap water and Alconox-type soap, rinse with tap water, and air dry and/or dry with clean paper towel.

The effectiveness of the equipment decontamination of non-dedicated sampling equipment such as split-spoon samplers will be evaluated via analytical laboratory testing of field blanks (e.g., rinsate samples). Decontamination liquids, disposable equipment and PPE will be containerized and left on-site until a proper disposal method is determined.

5.0 SAMPLE HANDLING AND CUSTODY REQUIREMENTS

During sampling activities, personnel will wear disposable nitrile gloves. Between collection of samples, personnel performing the sampling will discard used nitrile gloves and put on new gloves to preclude cross-contamination between samples. As few personnel as possible will handle samples or be in charge of their custody prior to shipment to the analytical laboratory.

New laboratory-grade sample containers will be used for each sample collected. Sufficient volume will be collected to ensure that the laboratory has adequate sample volume to perform the specified analyses. As required, samples will be kept on ice in a cooler for shipment to the analytical laboratory. Samples will be preserved as specified by the analytical laboratory for the type of parameters and matrices being tested. The required amount of preservatives will be added by the analytical laboratory to the sample containers prior to delivery to the Site.

Chain-Of-Custody

Samples that are collected for subsequent testing as part of this project will be handled using chain-of-custody control. Chain-of-custody documentation will accompany samples from their inception to their analysis, and copies of chain-of-custody documentation will be included with the laboratory's report. The chain-of-custody will include the date and time the sample was collected, the sample identity and sampling location, the requested analysis, and any request for accelerated turnaround time.

Sample Labels

Sample labels for field samples and QA/QC samples with adhesive backing will be placed on sample containers in order to identify the sample. Sample information will be clearly written on the sample labels using waterproof ink. Sufficient sample information will be provided on the label to allow for cross-reference with the field sampling records.

The following information will be provided on each sample label:

- Name of company;
- Initials of sampler;
- Date and time of collection;
- Sample identification;
- Intended analyses; and
- Preservation required.

Custody Seals

Custody seals are preprinted adhesive-backed seals that are designed to break if disturbed. Seals will be signed and dated before being placed on the shipping cooler. Seals will be placed on one or more location on each shipping cooler as necessary to ensure security. Shipping tape will be placed over the seals on the coolers to ensure that the seals are not accidentally broken during shipment. Sample receipt personnel at the laboratory will check and document whether the seals on the shipping coolers are intact when received.

Sample Identification

The following format will be used on the labels affixed to sample containers to identify samples:

Each sample will be numbered in succession using a 3-digit identifier and starting with sample 001. The sample test location will also be provided after the sample number using the following test location designations:

TB-xxx (x-x') Boring soil sample with depth interval in parentheses below ground surface in tenths of a foot (x – x')

TB/MW-xxx Overburden Groundwater sample with monitoring well letter

MW-xxxR Bedrock Groundwater sample with monitoring well letter

SV-xx Soil Vapor Sample

TBxx/xx/xx- Trip Blank sample with day/month/year

FBxx/xx/xx- Field Blank sample (rinsate) with day/month/year

As an example, assuming the first project sample is a soil sample collected from a test boring TB-200 at a depth of 10 feet, the sample will be designated as 001/TB-200(10').

Transportation of Samples

Samples will be handled, packaged and shipped in accordance with applicable regulations, and in a manner that does not diminish their quality or integrity. To the extent practicable, samples will be delivered to the laboratory no later than 48 hours from the day of collection.

6.0 ANALYTICAL QUALITY ASSURANCE/QUALITY CONTROL

Analytical laboratory test results will be reported in NYSDEC Analytical Services Protocol (ASP) Category B deliverable reports. Analytical laboratory test results for soil samples will be reported on a dry-weight basis. The analytical laboratory will make every effort to analyze the samples using the lowest practical quantitation limits (PQLs) possible for soil and groundwater samples. In addition, analytical laboratory results will be provided to the NYSDEC using the NYSDEC's Equis Format.

The analytical laboratory will provide internal QA/QC checks that are required by NYSDEC ASP and/or USEPA contract laboratory protocol (CLP) protocol, such as analyses performed, spike blanks, internal standards, surrogate samples, calibration standards, and reference standards. Laboratory reports will be reviewed as outlined in the laboratories QAP or QAM. Laboratory results will be compared to data quality indicators in accordance with the laboratory's QAP or QAM, and also NYSDEC ASP.

Table 1 in Attachment 5 provides a summary of the analytical samples scheduled for collection and anticipated sampling parameters. The analytical methods to be used for each type of sample and sample matrix are also identified on Table 1. In order to provide control over the collection, analysis, review, and interpretation of analytical laboratory data, the following QA/QC samples will be included as part of this project.

- During the groundwater monitoring for VOCs, one trip blank will be included per set of 20 liquid samples with a minimum of one trip blank per sample shipment. The trip blanks will be analyzed for target compound list (TCL) VOCs.
- One matrix spike/matrix spike duplicate (MS/MSD) for each sample matrix, for each sampling event of 20 samples, or per shipment if less than 20 samples, within a seven-day period. Specific parameters that MS/MSD samples will be tested for is dependent upon the test parameters of the field samples that are being analyzed.
- One field blank (i.e., rinsate sample) will be collected from reusable sampling equipment for each sampling event of 20 samples, or per shipment if less than 20 samples. The field blank(s) will be tested for the suite parameters of the samples obtained using the subject re-useable sampling equipment (e.g., split spoon samplers, oil/water interface probe, etc.).

Data Usability Summary Report

Jodi R. Zimmerman (Vali-Data of Western NY) will complete a data usability summary report (DUSR) on the Category B deliverables analytical laboratory data that is generated as part of the scope of work in the RI/RAA work plan. The DUSR will be conducted in accordance with the provisions set forth in Appendix 2B of DER-10 Technical Guidance for Site Investigation and Remediation dated May 2010. The findings of the DUSR will be incorporated in the final RI/RAA report. A copy of Ms. Zimmerman's resume is included in Attachment 1.

Reporting

Analytical and QC data will be included in the final RI/RAA report. The final report will summarize the environmental work and provide evaluation of the data that is generated, including the validity of the results in the context of QA/QC procedures.

7.0 RECORD KEEPING AND DATA MANAGEMENT

DAY will document project activities in a bound field book on a daily basis. Information that will be recorded in the field book will include:

- Dates and time work is performed;
- Details on work being performed;
- Details on field equipment being used;
- Field evidence of contamination such as staining, odors, degree of saturation, etc.;
- Field meter measurements collected during monitoring activities;
- Sampling locations and depths measured in tenths of feet;
- Measurements of sample locations, and test locations, excavations, etc.;
- Personnel and equipment on-site;
- Weather conditions; and,
- Other pertinent information as warranted.

In addition, the field notes will be converted into logs and construction diagrams for various types of test locations that are completed as part of the RI.

Differential GPS, swing ties from existing surveyed site structures, and/or a licensed surveyor will be used to collect spatial data. The spatial data will be plotted using integrated geographic information system (GIS) and/or computer-aided design (CAD) mapping. Electronic and hard copy files will be maintained by DAY.

As noted above, DAY will utilize its Trimble Geo-7X sub-foot accuracy GPS with ESRI ArcPad installed software with GIS shape files that have been developed for the Site.

8.0 ACRONYMS AND ABBREVIATIONS

ASP	Analytical Services Protocol
ASTM	American Society for Testing and Materials
CAD	Computer-Aided Design
CAMP	Community Air Monitoring Plan
CLP	Contract Laboratory Protocol
DAY	Day Environmental, Inc.
DNAPL	Dense Non-Aqueous Phase Liquid
DUSR	Data Usability Summary Report
ELAP	Environmental Laboratory Approval Program
GIS	Geographic Information System
GPS	Global Positioning System
HASP	Health and Safety Plan
HDPE	High Density Polyethylene
IDW	Investigation-Derived Waste
LNAPL	Light Non-Aqueous Phase Liquid
ML/MIN	Milliliter per Minute
MS/MSD	Matrix Spike/Matrix Spike Duplicate
NAPL	Non-Aqueous Phase Liquid
NTU	Nephelometric Turbidity Units
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
PFAS	Per- and Polyfluoroalkyl Substances
PFC	Perfluorinated Compounds
PFOA	Perfluorooctanoic Acid
PID	Photoionization Detector
PPE	Personal Protective Equipment
PPM	Parts Per Million
PQL	Practical Quantitation Limit
PVC	Polyvinyl Chloride
QAM	Quality Assurance Manual
QAP	Quality Assurance Plan
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
RI	Remedial Investigation
RI/RAA	Remedial Investigation/Remedial Alternatives Analysis
RTAM	Real-Time Aerosol Monitor
TCL	Target Compound List
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compound

ATTACHMENT 1

Resumes of Key Personnel

RAYMOND L. KAMPFF, P.G.

EXPERIENCE

Day Environmental, Inc.: May 1994 to present
Years with Other Firms: 18 years

AREAS OF SPECIALIZATION

- Environmental Site Assessment
- Environmental Restoration
- Geology

EDUCATION

University of Rochester, B. A. Geology 1974
Monroe Community College, Civil Engineering Technology 1976
Various continuing education courses/seminars in environmental regulations, remediation techniques and other technical issues

REGISTRATION/AFFILIATIONS

- 40-Hour OSHA Hazardous Waste Site Worker Training
- 8-Hour OSHA Hazardous Waste Site Supervisor Training
- 8 Hour OSHA Hazardous Waste Site Worker Refresher Training

RESPONSIBILITIES AND PROJECT EXPERIENCE

Mr. Kampff has over 40 years of professional experience and is currently responsible for the overall technical and administrative direction of DAY's Site Evaluation/Environmental Restoration Group. Mr. Kampff's experience includes environmental studies and remediation at inactive hazardous waste sites, industrial facilities, petroleum spill sites, Brownfield sites and municipal properties. Some of his representative projects are described below.

Environmental Site Assessment

Environmental Site Assessment for a Manufacturing Facility: Olean, New York. Responsible for a Phase I Environmental Site Assessment (ESA) and a Limited Phase II ESA for this 14-acre site currently developed with a 280,000 square foot industrial facility. The site was originally developed in the 1890s, and historically it has been used for various purposes including the manufacture of chemicals, metal furniture and industrial coatings. These studies were done to characterize the site in sufficient detail to prepare an application to enter the New York State Brownfield Cleanup Program (BCP).

Site Evaluation and Assessment of PCB Impact: Innis-Arden Golf Course. Reviewed documents and evaluated analytical laboratory data presented as part of a claim that discharges from a nearby railroad line operated by Metro-North Railroad (MNR) caused PCB-impact identified within ponds and streams on the golf course. The evaluation completed determined that nearby industrial facilities, and not MNR, were the responsible for the PCB contamination on the golf course.

Environmental Evaluation, Precast Concrete Facility, Manchester, New York. Responsible for the environmental evaluation of this 105-acre former railroad yard that was re-developed with an approximate 70,500 square foot structure in the late 1980s for use as a pre-cast concrete manufacturing facility. The site assessment studies conducted included testing of soil, groundwater and soil vapors to evaluate areas of potential environmental concern pursuant to the sale of the property. These studies included the delineation of an area of

the site impacted with petroleum that resulted in the New York State Department of Environmental Conservation (NYSDEC) opening a spill file, and another area on the site where groundwater impacted with chlorinated solvents was identified.

Petroleum Spills

Petroleum Spill Remediation and Closure: Metro-North Railroad's Brewster Yard, North White Plains Yard and Harmon Yard in New York. Assisted MNR with the assessment and remediation of various petroleum spills at these railroad yards where petroleum impact from historic operations resulted in the accumulation of several feet of free product in some locations. The work included the design and construction of a combination of active and passive removal systems, design and operation of long-term monitoring networks to document the effectiveness of remedial efforts and, the preparation of status reports for submittal to the NYSDEC to document remedial efforts pursuant to spill closure.

Seneca-Cayuga ARC Spill Remediation: Waterloo, New York. Responsible for site characterization studies to assess the nature and extent of historic petroleum releases resulting from leaking tanks and discharges into septic systems. Subsequently, designed and implemented a remedial action plan to address petroleum impacts and to mitigate vapors in an adjacent building under construction. The remedial activities included the removal of underground storage tanks and petroleum-impacted soil/groundwater, the installation of a sub-slab depressurization system, and the preparation of a Site Management Plan (SMP) to address future impacts (if encountered).

Remedial Action Plan Development and Implementation: Mott Haven Yard, Bronx, New York. Completed site characterization studies to define the nature and extent of petroleum spills resulting from a combination of leaking tanks and discharges from railroad equipment. Based on the findings of the characterization studies, a removal of soil impacted with free product was conducted in accessible areas and systems were designed and implemented to preclude future discharges (e.g., installation of state-of the art fueling system, development of SPCC plans, construction of secondary containment systems). Subsequently, a Remedial Action Plan (RAP) describing methods to be implemented to collect residual free product from the groundwater was prepared for submittal to the NYSDEC.

York Oil Superfund Site RI/FS: Moira, New York. Managed several studies to evaluate on-site contamination and off-site pathways at this former waste oil recycling facility where large quantities of PCB and solvent-laden oils spilled onto the ground and migrated into adjacent wetlands.

Brownfield and RI/FS Projects

Interim Remedial Measure (IRM) Construction, Confidential Industrial Client: Akron, New York. Responsible for construction oversight during the implementation of IRM activities at an approximate 3-acre former waste disposal area used to dispose of hazardous and industrial wastes. Work included construction oversight during waste consolidation and capping activities, coordination with the NYSDEC, implementation of design modifications and preparation of various closure reports. Also, responsible for long term monitoring and the preparation of Periodic Review Reports.

RAYMOND L. KAMPFF, P.G.
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Dry Cleaners: Jamestown, New York: Responsible for studies completed to evaluate the extent of chlorinated solvents in the soil and groundwater at this dry cleaning facility that has operated for the past 50 years. Also developed and implemented remediation system to actively remove more than 200 gallons of Dense Non-Aqueous Liquid (DNAPL), the design and construction of a permeable reactive barrier to preclude off-site migration, and the implementation of in-situ bioremediation to address residual impacts.

Harmon Railroad Yard Former Wastewater Lagoon: Croton-on-Hudson, New York. Responsible for the preparation of the Site Management Plan (SMP), long-term monitoring, preparation of status and Periodic Review Report reports, and implementation of corrective actions for Operation Units OU-I and OU II at this NYSDEC Inactive Hazardous Waste Site.

Manufacturing Facility: Rochester, New York. Responsible for the Remedial Investigation conducted at this facility where groundwater is impacted with elevated concentration of chlorinated solvents and heavy metals. Work includes studies designed to assess the nature and extent of impact with the soil, groundwater and soil vapor (including sub-slab studies within on-site structures and assessment of potential off-site impacts). Studies also included the design and implementation of pilot studies to evaluate bioaugmentation and phytoremediation as potential long-term remedial options.

Environmental Restoration Projects

Remediation of Petroleum Contaminated Soils, DePaul Community Facilities: Rochester, New York. Responsible for the design and construction of a combined active and passive soil vapor extraction system at this facility constructed on the site of a former gasoline station.

Track Platform Assessment and Encapsulation, Grand Central Terminal: New York, New York. Project Manager for a testing program designed to define the extent of PCB contamination and develop a comprehensive remedial program consisting of the initial cleaning of the impacted track area following by a double epoxy coating was required for this site. Due to the location of the site, care was taken to limit potential exposure to the public during remedial activities

Former Dry Cleaners: Canandaigua, New York. Responsible for site characterization studies to define subsurface conditions and the nature and extent of chlorinated solvent impact (tetrachloroethene and breakdown products), implementation of a soil removal interim remedial measure (IRM), installation of a sub-slab vapor mitigation system and implementation of biostimulation to address residual contamination.

Former Gasoline Station: Hornell, New York. Responsible for the completion of site investigations and the development and implementation of remedial options including source removal with the subsequent installation of an air sparging system augmented the injection of microbes designed to expedite the remediation process.

DAY ENVIRONMENTAL, INC.

JEFFREY A. DANZINGER, P.G.

EXPERIENCE

Day Environmental, Inc.: October 1991 to present
Years with Other Firms: 5 years

AREAS OF SPECIALIZATION

- Environmental Site Assessment
- Environmental Restoration/Remediation
- Environmental Computer Modeling
- Risk Assessment/Geology/Hydrogeology

EDUCATION

University of Colorado at Boulder; B.A. Geology; 1986
Various continuing education courses/seminars in environmental studies and remediation

REGISTRATION/AFFILIATIONS

OSHA Hazardous Waste Site Worker and Supervisor Training, and Confined Space Training

RESPONSIBILITIES AND PROJECT EXPERIENCE

Mr. Danzinger has over 30 years of professional experience working on environmental projects as a consultant. Mr. Danzinger is responsible for development and completion of Phase II studies, hydrogeologic studies, environmental restoration, remediation and Brownfield projects and environmental compliance projects for independent clients and government agencies. He also serves as the company Assistant Health and Safety Officer. Mr. Danzinger has performed over 240 Phase I Environmental Site Assessments, over 200 Phase II Environmental Site Assessments and over 25 environmental restoration projects. Examples are provided below:

Niagara County Brownfield Projects: Mr. Danzinger has managed Phase I ESA and Phase II ESA projects under the Niagara County Department of Economic Development Brownfield program that is funded by USEPA brownfield grants. These included: a Phase I ESA with asbestos survey at the Palace Theater in Lockport, New York; a Phase II ESA on an approximate 20.9 acre portion of Tonawanda Island, North Tonawanda, NY that was formerly occupied by a wood and lumber industrial operation; and a Phase I ESA followed by a Phase II ESA at Site in North Tonawanda that was a former gas station that also included former/current automobile-related repair/service operations. Types of Phase II ESA work completed included: a drum and container inventory, advancement of test borings; excavation of test pits; collection and analysis of soil, air, sub-slab, and groundwater samples; asbestos and/or lead-based paint surveys; a radiological survey, evaluation of a former transformer building for polychlorinated biphenyls; a geophysical survey, and data validation. Mr. Danzinger prepared Quality Assurance Project Plans (QAPPs) and reports for the Phase II ESAs, as well as opinions of probable costs associated with addressing environmental conditions at the Sites.

Andrews Street Site, Rochester, New York: DAY was retained by the City of Rochester to perform Demolition-Phase environmental services, Remedial Investigation/Remedial Alternatives Analysis (RI/RAA) services, and Interim Remedial Measure (IRM) services at the Andrews Street Site. Mr. Danzinger managed extensive and specialized investigative studies, including: sampling and monitoring of soil, groundwater and building materials; and preparation of various work plans, safety plans, quality assurance project plans, and associated project reports. Studies completed included: a utility assessment including videotaping; a geophysical survey; test pits; borings; membrane interface probe (MIP) PID and halogen specific detector (XSD) and hydraulic profiling tool (HPT) data collection; installation and monitoring of overburden and bedrock groundwater monitoring wells. As part of DAY's

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services, Mr. Danzinger also managed subcontractor procurement procedures, and interfaced with representatives of the Client and regulatory agencies. Mr. Danzinger played a critical role in the development of specialized innovative GIS interpolation modeling of soil and MIP XSD data that were successful in defining the extent of PCE IRMs, including source area soil removal and subsequent in-situ chemical oxidation using potassium permanganate. The project resulted in the City of Rochester receiving a Certificate of Completion from the New York State Department of Environmental Conservation (NYSDEC).

Slag and Fill Management Project, Greece and Rochester, New York: Project Manager to address fill material containing regulated solid waste (slag) that was generated during a City of Rochester redevelopment project and was inadvertently placed on a vacant residential subdivision parcel in the Town of Greece. Mr. Danzinger's responsibilities included: preparing for and attending meetings with municipalities, regulators, and the general public; development of work plans; coordination and management of field activities; and development of closure reports.

Former Air Force Plant No. 51, Greece, New York: This Site was used for the manufacture of ocean-going ships and cranes during and immediately following World War II, and for the manufacture of B-52 aircraft parts and Talos ground handling equipment during the 1950's. Mr. Danzinger was Project Manager for the investigation of this Site under the NYSDEC Voluntary Cleanup Program (VCP). Fifteen areas of concern (AOCs) were incorporated into seven operable units (OUs). Tasks Mr. Danzinger has managed include: development of environmental work plans and site-specific health and safety plans; inventory, characterization and disposal of abandoned wastes; sampling and dismantling of abandoned wet-type electrical equipment; investigation of, and development of a remedial work plan for a former wastewater treatment lagoon/pond area; investigation of an existing stormwater system and former septic system areas; investigation and remediation of a former underground storage tank area; and monitoring and recovery of dense non-aqueous phase liquid (DNAPL) as an interim remedial measure.

Former Photech Imaging Systems, 1000 Driving Park Avenue, Rochester, New York: Mr. Danzinger was responsible for managing the completion of a SI/RA report (NYSDEC Environmental Restoration Program Site ID B-00016-8) at this Brownfield Site that consisted of 12 vacant buildings of varying degrees of disrepair that were situated on an approximate 12.5-acre parcel. The buildings formerly housed various manufacturing, laboratory, office and warehouse operations. Various underground and aboveground storage tank systems and a wastewater silver recovery system were operated at the Site. Other features at the Site included a burn pit area, and a retention pond basin. The SI/RA identified the nature and extent of contamination and also identified options and associated estimated costs for cleanup.

Former Ford Garage, 2624 Main Street, Gorham, New York: On behalf of the Town of Gorham, New York, Mr. Danzinger managed environmental services at this Brownfield Site under the NYSDEC Environmental Restoration Program (Site ID#B-00153-8). These services included a Phase I ESA report, a Site Investigation/Remedial Alternatives (SI/RA) report, development of a Remedial Work Plan (RWP), Health and Safety Plan (HASP), and Citizen Participation Plan (CPP). The Site was formerly operated as an automobile sales and service facility, and also as a gasoline station. Remediation consisted of a source area soil removal, in-situ bioremediation, institutional controls and engineering controls. Mr. Danzinger managed the preparation of a Final Engineering Report (FER), a Site Management Plan (SMP), an Alta survey, and an Environmental Easement of the project, which resulted in the Town of Gorham receiving a Certificate of Completion from the NYSDEC.

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Former Vogt Manufacturing Facility, 100 Fernwood Ave., Rochester, New York: Under the NYSDEC Brownfield Cleanup Program (BCP Site #C828119), Mr. Danzinger managed remedial investigation and implementation of interim remedial measures at this Brownfield Site. This industrial-zoned Site consists of eleven contiguous parcels totaling approximately 8.14 acres that was originally occupied by Vogt Manufacturing Corporation, which manufactured auto trimmings (e.g., textile trimmings spinning and weaving). The main building was later converted for multi-tenant light industrial/commercial use, including plastic products manufacturer, tool and die makers, machine shops, painters, printers, graphics companies, and sheet metal contractors. Mr. Danzinger was responsible for the development of a Remedial Investigation/Remedial Alternatives Analysis (RI/RAA) report, a Remedial Work Plan (RWP), a Final Engineering Report, and a Site Management Plan (SMP). Mr. Danzinger also assisted in the preparation of an Alta Survey and Environmental Easement for the Sites. As a result of the work completed, the Client received a Certificate of Completion from the NYSDEC.

High-Rise Apartment Complex, 185 Mt. Hope Ave., Rochester, New York: Under the NYSDEC Brownfield Cleanup Program (BCP Site #C828124), Mr. Danzinger managed remedial investigation and implementation of remedial measures at this Brownfield Site. This Site consists of an apartment building with an associated paved parking lot located on approximately 1.106 acres of land. The apartment building houses 202 residential units, totals approximately 143,000 square feet, and consists of a multi-level eight to twelve-story brick and concrete-block, slab-on-grade building constructed in 1975. Prior to the residential development in 1975, former uses at the Site included: rail yards, former Erie Canal feeder, and possibly a portion of a gasoline station. The remedy included: a source area soil removal; in-situ remediation, and preparation of a Final Engineering Report (FER), Site Management Plan, and Environmental Easement. As a result of the work completed, DAY's client received a Certificate of Completion from the NYSDEC, the apartment building was renovated, and exterior Site improvements were constructed.

Low-Rise Apartment Complex, 225-405 Mt. Hope Ave., Rochester, New York: Under the NYSDEC Brownfield Cleanup Program (BCP Site #C828125), Mr. Danzinger managed the remedial investigation and remediation at this Brownfield Site. This Site consists of approximately 6.016 acres of land that was improved with five four-story apartment buildings. The brick and concrete-block, slab-on-grade apartment buildings were constructed in 1975, and these buildings housed 200 units totaling approximately 205,000 square feet. Prior to residential development in 1975, past uses/activities at the Site included commercial, warehouse, feeder canal, rail yards, a work shop, auto repair, car sales, a wagon shop, a junk-yard and iron cutting facility, a brick storage yard, a tannery, and a coal yard. The remedy included abatement of PCB transformers, source area soil removals, in-situ remediation, preparation of a site management plan and environmental easement, and removal of impacted topsoil across the site. As a result of the work completed, the five old apartment buildings were demolished, the Client received a Certificate of Completion from the NYSDEC, and nine new multi-story residential buildings and associated exterior improvements were constructed.

Former Manufactured Gas Plant (MGP), Canandaigua, New York: Mr. Danzinger was involved with the development and implementation of a work plan and health and safety plan to evaluate this Site. Mr. Danzinger managed the associated site studies consisting of test borings/monitoring well installation, soil gas studies, sampling and testing of impacted media (e.g. soil/fill, groundwater, surface waters/sediments) to characterize site conditions and delineate contaminant plumes. Based upon the assessment of site conditions, Mr. Danzinger assisted in the development of a report that summarized the findings of the environmental studies, identified various remedial options consisting of a combination of waste removal/isolation and in-situ treatment, and presented conceptual remedial design schemes with estimated implementation costs.

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80-100 Charlotte Street, Rochester, New York: DAY initially completed Phase I ESA, Phase II ESA and cost estimating services for this Site using City of Rochester funding mechanisms. Through a competitive request for proposal process, the City of Rochester subsequently awarded DAY the Brownfield Cleanup Project for this Site that was funded with a USEPA Brownfield Initiative Grant. DAY's services under the USEPA Brownfields Initiative Grant included: the development of an Analysis of Brownfields Cleanup Alternatives (ABCA) report; review of a Citizens Participation Plan (CPP) that was developed by the City of Rochester; the development of a corrective action plan (CAP) and a health and safety plan (HASP); coordination, management, documentation and implementation of a source area soil removal enhanced by the placement of bioremediation stimulant product in a portion of the excavation; utilization of global positioning system (GPS) and geographical information system (GIS) on the project, installation and monitoring of groundwater wells on a long-term basis; and associated reporting of the work completed at the Site. No further action is required by the NYSDEC for this Site. Mr. Danzinger also managed EMP requirements at this Site during redevelopment that involved construction of a five new multi-story townhouse buildings.

Former Hallman's Auto Dealership, Rochester, New York: Site was formerly used as an automobile dealership and service center for over 50 years. Redevelopment of this Brownfield site included demolition of the service garage, construction of new residential apartments and townhouses, and conversion of a portion of the existing building (including former automobile showroom) into retail/restaurant commercial space. Mr. Danzinger completed an ASTM RBCA risk assessment using site-specific data generated during a Phase II environmental study and the proposed residential and commercial uses of portions of the site. As a result of performing the risk assessment, risk-based corrective measures that were completed in conjunction with redevelopment at this Site included: removal of over 20 underground storage tanks, removal and off-site disposal of petroleum-contaminated soils and fill material containing ash with elevated levels of heavy metals; design and installation of a free product recovery system; design and installation of passive venting systems with a vapor barrier; and design and installation of a soil vapor extraction system. Mr. Danzinger was responsible for developing and implementing an environmental project work plan, a health and safety plan, and an environmental management plan for this redevelopment project. In addition, DAY provided on-site environmental air monitoring services and site documentation services during construction activities that had the potential to disturb contaminated media. After the project was completed, Mr. Danzinger was involved with the development of a closure report for this Site.

Former Railroad Car Shops Site, East Rochester, New York: Mr. Danzinger was responsible for managing subsurface studies and an ASTM RBCA risk assessment on a portion of this former railroad car shop site. The Site was confirmed to be impacted with fill containing elevated heavy metals and weathered petroleum product. Mr. Danzinger was involved with the development and implementation of a health and safety plan and environmental management plan that included the design and monitoring of a passive vapor barrier vent system that was installed beneath a new industrial building that was constructed on this Site. In addition, DAY provided on-site environmental air monitoring services and site documentation services during construction activities that had the potential to disturb contaminated media. This project was successful in identifying pre-existing environmental conditions prior to transfer of ownership while obtaining regulatory agency approvals for the new owner to redevelop the vacant parcel with a new industrial facility.

Former Petroleum Bulk Storage Facility, Mt. Morris, New York: Mr. Danzinger managed an environmental site investigation at this former petroleum bulk storage facility under the New York State Environmental Restoration Bond Act Program. Mr. Danzinger was involved in the preparation and implementation of detailed work plans, implementation of fieldwork, and preparation of a Site Investigation/Remedial Alternatives Report (SI/RAR).

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Residential Care Facility, Rochester, New York: DAY's Client developed this approximate 3-acre property into a residential care facility on property that formerly contained several vehicle repair shops/gasoline stations, the City of Rochester Streets Department maintenance facility and the City of Rochester automobile pound. In addition, a portion of the Erie Canal, later converted to a trolley system, traversed the property. Subsequently, the canal/trolley line was backfilled with various construction-type debris and other assorted material (including petroleum-contaminated material). Mr. Danzinger was involved with development of a health and safety plan and an environmental management plan (EMP), which included the removal of localized areas of petroleum-contaminated soil for treatment via an on-site 4,500 cubic yard biopile, the installation of an active venting system installed beneath the building footprint, and long-term monitoring. DAY also provided on-site environmental air monitoring services and site documentation services during construction activities that had the potential to disturb contaminated media.

Multiple-Parcel Brownfield Site, Rochester, New York: Responsible for the completion of a Phase I ESA for the City of Rochester at a five-parcel Brownfield site. The Site is located within the Western Gateway Zone of the New York State Economic Development Zone (EDZ) Program, and the City of Rochester was evaluating the restoration of these parcels for incorporation into an adjoining industrial park. Site improvements encompassed over 610,000 square feet of floor space in multiple level industrial buildings of varying structural condition. Former uses of the Site included: appliance manufacturing, tool and die shops, printing/lithographing operations, shoe manufacturing, circuit board manufacturing, box manufacturing; cabinet manufacturing; possible foundry operations, chromium plating operations, basket manufacturing, automobile services, welding operations, and warehousing/distribution operations. Mr. Danzinger was also responsible for the management of Phase II Studies on a portion of this Site.

14-60 Charlotte Street, Rochester, New York: This Brownfield Site consisted of seven parcels of underutilized commercial land totaling approximately 1.3 acres. Mr. Danzinger was responsible for managing a Phase I ESA, Phase II studies, and remediation services at the Site. Contamination addressed at this Site was attributable to an on-site UST, on-site former automobile repair operations, on-site fill materials, and off-site dry-cleaning and automobile repair operations. Project deliverables included: a Phase I ESA report, Phase II reports, a Corrective Action Plan (CAP); a Health and Safety Plan (HASp) that included a Community Air Monitoring Plan (CAMP); an Environmental Management Plan (EMP); an exposure assessment with site-specific PSSI calculations; a closure report, and conceptual sub-slab depressurization system (engineering control) designs for use during redevelopment of the Site. Mr. Danzinger also managed EMP requirements at this Site during redevelopment that involved construction of a new multi-story apartment building.

Assessment of Transformer Maintenance Shop at Utility Company, Rochester, New York: A utility company's facility contained a transformer maintenance shop that had been operated since the 1950s. Mr. Danzinger managed the development and implementation of a characterization sampling plan; evaluated the characterization data and identified areas requiring remediation; and developed a report documenting the investigation and proposed remedial actions. This project was conducted in accordance with 40 CFR §§ 761. The USEPA documents titled "Verification of PCB Spill Cleanup by Sampling and Analysis" dated August 1985, "Field Manual for Grid sampling of PCB Spill Sites to Verify Cleanup" dated May 1986, "Wipe Sampling and Double Wash/Rinse Cleanup" dated April 18, 1991, and. Region 1 "Draft" document titled "Standard Operating Procedure For Sampling Concrete in the Field" dated December 1, 1997 were utilized in the sampling protocol.

HEATHER MCLENNAN

EXPERIENCE

Day Environmental Inc.: April 2015 to present
Years with Other Firms: 5 years

AREAS OF SPECIALIZATION

- Environmental Site Assessment
- Environmental Restoration / Remediation

EDUCATION

Seneca College; Graduate Certificate Program, Environment and Site Investigation, 2010
University of Guelph; Bachelor of Science, Honors Chemistry Degree, 2003
Seneca College; Chemical Technology Diploma Program, 1999

REGISTRATIONS/AFFILIATIONS

40-Hour OSHA Hazardous Waste Site Worker Training
Member, Chemical Institute of Canada

RESPONSIBILITIES AND PROJECT EXPERIENCE

Ms. McLennan has five years of professional experience working on environmental projects as a consultant. Ms. McLennan has also performed Phase I and Phase II Environmental Site Assessments, prepared scopes of works, proposals, managed projects and supervised remediation projects while working on projects as a consultant with other firms.

Site Remediation, Toronto, Ontario: Supervised multi-property remediation:

Property 1: Supervised the completion of six-month remedial program including excavation and sampling for the purpose of property transaction compliant with requirements of Ontario Ministry of the Environment and Climate Change Record of Site Condition.

Property 2: Designed and supervised test-pitting and borehole program to sample and characterize stockpiled soils and impacted soil on-site to allow placement of soil consistent with property specific standards during grading activities

Property 3: Completed updated reports for filing and completing Risk Assessment and Record of Site Condition with Ontario Ministry of the Environment and Climate Change following soil and groundwater assessment.

Toronto, Ontario: Supervised the installation of a remedial treatment system including injection wells and injection gallery in 15' trench, for the purpose of remediating chlorinated volatile organic compound plume in groundwater.

Toronto, Ontario: Supervised completion of three-week in-situ chemical reduction program including fracturing of subsurface using nitrogen injections followed by zero-valent iron injections for the purpose of remediating chlorinated volatile organic compound plume in soil and groundwater

Phase I Assessments, Ontario: Conducted Phase I Environmental Site Assessments for the purpose of real estate transactions and financing. These assessments were conducted on a variety of different types of facilities including agricultural, residential, commercial, and industrial properties.

Phase II Assessments, Ontario: Conducted Phase II Environmental Site Assessments for the purpose of contaminant identification and categorization. These assessments were conducted on a variety of different types of facilities including residential, commercial and industrial properties.

HEATHER MCLENNAN
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Site Remediation, Ontario: Supervised in-situ chemical oxidation at various sites in order to remediate impacts in soil and groundwater, supervised various underground storage tank removal programs and remedial excavations.

NATHAN E. SIMON, P.E.

EXPERIENCE

Day Environmental, Inc.: June, 2005 to present

AREAS OF SPECIALIZATION

- Environmental Site Assessment
- Environmental Restoration/Remediation
- Environmental Computer Modeling

EDUCATION

University at Buffalo, B. S. Civil Engineering, 2003

University at Buffalo, M. Eng. Environmental and Hydrosystems, 2005

REGISTRATION/AFFILIATIONS

Registered Professional Engineer in State of New York

40 Hour OSHA Hazardous Waste Site Worker Training

Various continuing education courses/seminars in environmental studies and remediation

RESPONSIBILITIES AND PROJECT EXPERIENCE

Mr. Simon has over 10 years of professional experience working on environmental projects as a consultant. Mr. Simon is responsible for taking a leadership role in completing investigation and remediation projects for private and government agencies. Mr. Simon's experience includes development of work plans in accordance with applicable regulations; corresponding with regulatory agencies and clients; completion of Phase II studies; environmental restoration; and, Brownfield and remediation projects. Specifically, Mr. Simon's responsibility has included environmental investigation field activities and associated field documentation, report preparation, engineering design calculations, data management, remedial alternative evaluation and selection, and project communication. Some of his representative projects are described below.

Dry Cleaners: Jamestown, New York. Responsible for field studies to evaluate the extent of chlorinated solvent contamination in the soil and groundwater from a dry cleaning facility that has operated for the past 50 years. In addition to writing sections of the remedial investigation report, work on this project included: compiling laboratory data from a sampling event and comparing the results to TAGM 4046 (*Determination of Soil Cleanup Objectives and Cleanup Levels*) and TOGS 1.1.1 (*Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations*) to determine the extent of contamination, developing a conceptual model, evaluating hydraulic conductivity testing data using the SuperSlug^R computer modeling program, completing calculations to estimate contaminant flow rates through the overburden and bedrock based on contaminant specific retardation factors and site specific aquifer characteristics, and designed a Zero-Valent Iron Permeable Reactive Barrier to address potential off-site contaminant migration. The project is on-going and currently in the process of designing/conducting a pilot study for in-situ bioremediation.

Former Hazardous Waste Disposal Site: Rochester, New York. Completed hydrogeologic studies to determine the site specific relationship between pumping rate and radius of influence of several bedrock interface extraction wells. Designed an extraction well field to capture the delineated impacted area presented in the Site's Record of Decision (ROD). Determined extraction well specifications and locations using the step drawdown test results, aquifer characteristics and historical site data. Provided significant contributions to the Site's groundwater extraction and treatment remedial design plan. Oversaw the installation of additional bedrock interface wells to verify work

NATHAN E. SIMON, P.E.
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was completed in accordance with the approved NYSDEC remedial design plan. Assisted in the installation, startup and routine maintenance, inspection and testing of a 5-gpm pump-and-treat groundwater remediation system designed to remove volatile organic compounds and chromium. Developed a Health and Safety Plan, Community Air Monitoring Plan and a Quality Assurance and Quality Control program to ensure worker and community safety during remedial system installation and that suitable and verifiable data was obtained throughout the remediation efforts. In addition, Mr. Simon developed a work plan to evaluate indoor air quality in accordance with the NYSDOH document titled “*Final Guidance for Evaluating Soil Vapor Intrusion in the State of New York*”. Conducted a chemical survey and collected confirmatory indoor air samples in accordance with the NYSDOH and NYSDEC approved work plan and presented the results to the client and regulatory agencies.

Brownfield Site, Andrews Street and Evans Street, Rochester, New York. On behalf of the City of Rochester, New York, Mr. Simon is the project’s certifying professional engineer for this Site in which past operations included a bus terminal, a bus maintenance garage, and a dry cleaning maintenance and supply company. Mr. Simon has provided environmental services at this Brownfield Site, a portion of which were performed under the NYSDEC Environmental Restoration Program (Site ID#E828144) including: 1) development and implementation of a Demolition-Phase Environmental Work Plan; 2) development and implementation of a Remedial Investigation/Remedial Alternatives Analysis (RI/RAA) Work Plan, including a Quality Assurance Project Plan (QAPP), and Health and Safety Plan (HASP); and, 3) development and implementation of an Interim Remedial Measure (IRM) addressing grossly-contaminated media in the unsaturated zone. A supplementary IRM Work Plan is proposed to address the overburden groundwater using chemical oxidation. During the various project phases media samples (e.g., groundwater, soil, concrete, etc.) were collected and tested to evaluate disposal/re-use options. In addition, a Membrane Interface Probe/hydraulic profiling tool (MiHPT) was used to collect continuous XSD concentrations (representing halogenated volatile organic compound response), photoionization response and geological data (electrical conductivity, hydraulic profiling tool (HPT) pressure, HPT flow, etc.), to assist in characterizing environmental conditions at the Site prior to, and following, the unsaturated source area excavation. Geographic Information System (GIS) was used to visual and model the XSD data which was incorporated into the Conceptual Site Model used to develop the supplementary chemical oxidation IRM. Remedial alternatives were developed and prepared assuming the Site will be redeveloped for restricted commercial and/or restricted residential purposes.

Underground Storage Tank Closures: Various Clients throughout New York State. Decommissioned numerous Underground Storage Tanks (USTs) throughout New York State in accordance with the New York State Department of Environmental Conservation (NYSDEC) document titled “*Spill Prevention Operations Technology Series, Memo 14 (SPOTS 14)*” and the NYSDEC document titled “*Spill Technology and Remediation Series (STARS) Memo #1 (Petroleum Contaminated Soil Guidance Policy)*”. The work completed generally included developing and submitting a work plan to the NYSDEC, collection of confirmatory samples, documenting closure, compiling/tracking disposal documentation, evaluating analytical laboratory data and discussing the results with client and regulatory agencies.

Phase II Environmental Site Assessments: Various Clients throughout New York State. Completed numerous Phase II Environmental Site Assessments throughout New York State in accordance with requirements of the

American Society for Testing and Materials (ASTM) Practice E 1903-97 (*Standard Guide for Environmental Site Assessments: Phase II Environmental Site Assessment Process*) and the New York State Department of Environmental Conservation (NYSDEC) Division of Environmental Remediation (DER) draft Document DER-10 (*Technical Guidance for Site Investigation and Remediation*). The Phase II projects were completed at various sites including former gasoline stations, metal recycling facilities, commercial facilities, marinas, lumber yards, dry cleaners, former manufactured gas plants and former agricultural sites. Work generally included developing soil and groundwater sampling programs, evaluating and comparing data to applicable regulatory standards, and discussing the results with clients and regulatory agencies.

Indoor Air Evaluations: Various Clients throughout New York State. Completed numerous indoor air, sub-slab vapor, and soil gas evaluations throughout New York State in accordance with the requirements of the New York State Department of Health (NYSDOH) document titled “*Final Guidance for Evaluating Soil Vapor Intrusion in the State of New York*”. The air evaluations were conducted at various sites including manufacturing facilities, commercial facilities, light industrial facilities, former manufactured gas plants, former auto repair facilities, grocery stores and schools. Work generally included developing air sampling programs, conducting an owner interview and chemical survey, evaluating data and discussing the findings with clients and regulatory agencies. In addition, sites in which remediation of indoor was completed, work generally included developing and submitting a work plan to the New York State Department of Environmental Conservation (NYSDEC) and NYSDOH, conducting post-mitigation sampling (confirmatory testing) and post extension testing, and preparing and submitting summary reports to the regulatory agencies.

Subsurface and Indoor Air Evaluation – Commuter Railroad. Developed a test boring and monitoring well program, prior to the client purchasing the Manufactured Gas Plant (MGP) impacted Site, to evaluate the Recognized Environmental Conditions (RECs) identified in a modified Phase I Environmental Site Assessment in conjunction with historical site data and information collected during an EM-61 Geophysical survey. Conducted a supplementary subsurface investigation to delineate MGP-type waste in accordance with DER-10 (*Technical Guidance for Site Investigation and Remediation*), TAGM 4061 (*Management of Coal Tar Waste and Coal Tar Contaminated Soils and Sediments from Former Manufactured Gas Plants*), and the American Society for Testing and Materials (ASTM) Practice E 1903-97 (*Standard Guide for Environmental Site Assessments: Phase II Environmental Site Assessment Process*). Compared analytical laboratory data collected during the Subsurface Study to New York State Department of Environmental Conservation (NYSDEC) TAGM 4046 (*Determination of Soil Cleanup Objectives and Cleanup Levels*) and TOGS 1.1.1 (*Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations*) soil and groundwater standards respectively. Conducted drain dye testing to determine discharge location of various drains within the on-site building. Estimated vertical and horizontal extent of MGP-type waste in the subsurface. Developed an opinion of probable cost to remediate the delineated volume of MGP-type waste. Performed an indoor air and sub-slab air evaluation in accordance with New York State Department of Health (NYSDOH) document titled: “*Final Guidance for Evaluating Soil Vapor Intrusion in the State of New York*”. Oversaw the completion of an air communication test to aid in the design of a sub-slab depressurization (SSD) vapor mitigation system. Oversaw the installation of a SSD vapor mitigation system to verify installation was completed in accordance with design specifications. Conducted post SSD confirmatory indoor air testing to evaluate the effectiveness of the SSD system. Submitted a Final Engineering Report documenting the SSD system installation and confirmatory testing results to the NYSDEC and NYSDOH.

NATHAN E. SIMON, P.E.
(continued)

Metro North Railroads. Responsible for data management of daily, monthly and quarterly non-aqueous phase liquid (NAPL) measurements. These measurements are used to calculate NAPL recovery quantities that are reported on a quarterly or annually basis.

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EDUCATION:

B.S. Chemistry, William Smith College, Geneva, NY

Graduated June 1990

Chemistry GPA 3.41, Overall GPA 2.94

Research Topic: 'Kinetics and Mechanism of Electrophilic Substitution Reactions Involving Fe, Co, Ni, Cu and Zn Ions in Meso-tetraphenylporphyrins.'

PhD Candidate in Chemistry, Pennsylvania State University,

University Park, PA

June 1990 – August 1991

Bioinorganic Chemistry

Research Topic: Energy Transfer of Europium Chelates Using Lanthanide Luminescence

PROFESSIONAL EXPERIENCE:

Owner/Data Validator – Vali-Data of WNY, LLC, West Falls, NY (February 2008 to present)

Formed a Limited Liability Corporation and became a Woman-Owned Business in September 2009.

Responsibilities include the assessment of project data, determination of its usability and documentation of the findings in accordance with project requirements. Have completed several projects for consulting firms and/or laboratories requiring the preparation of Data Usability Summary Reports (DUSRs) for NYSDEC projects. Analytical suites validated have included, but are not limited to, TCL Volatile Organics, TCL Semi-Volatile Organics, Pesticides/PCBs, TAL Metals, Wet Chemistry for soil and water samples, and TO-15 and TO-17 Volatile Organics analysis for soil gas/vapor intrusion samples.

Analytical Chemist – Elf Atochem North America, Inc., King of Prussia, PA (1992 to 1994).

Responsibilities included chemical analysis of process samples via NMR Spectroscopy and the formulation of analytical methodologies. Performed analyses, and provided QA/QC of process intermediates and products to manufacturing and research facilities.

GC Analyst/Laboratory Technician – Centre Analytical Laboratories, Start College, PA (1991 to 1992)

Analytical chemist performing analyses of environmental samples.

HONORS:

Honors in Chemistry

Bioinorganic chemistry research conducted from June 1988 – June 1990. Requirements included: one year of research, written and oral examinations and a written thesis.

ATTACHMENT 2

ASTM Standard Practices for Drilling



Standard Guide for Direct Push Soil Sampling for Environmental Site Characterizations¹

This standard is issued under the fixed designation D 6282; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide addresses direct push soil samplers, which also may be driven into the ground from the surface or through prebored holes. The samplers can be continuous or discrete interval units. Samplers are advanced by a combination of static push, or impacts from hammers, or vibratory methods, or a combination thereof, to the depth of interest. The guide does not cover open chambered samplers operated by hand such as augers, agricultural samplers operated at shallow depths, or side wall samplers. This guide does not address single sampling events in the immediate base of the drill hole using rotary drilling equipment with incremental drill hole excavation. Other sampling standards, such as Test Methods [D 1586](#) and [D 1587](#) and Practice [D 3550](#) apply to rotary drilling activities. This guide does not address advancement of sampler barrel systems with methods that employ cuttings removal as the sampler is advanced. Other drilling and sampling methods may apply for samples needed for engineering and construction applications.

1.2 Guidance on preservation and transport of samples, as given in Guide [D 4220](#), may or may not apply. Samples for chemical analysis often must be subsampled and preserved for chemical analysis using special techniques. Practice [D 3694](#) provides information on some of the special techniques required. Additional information on environmental sample preservation and transportation is available in other references ([1](#), [2](#)).² Samples for classification may be preserved using procedures similar to Class A. In most cases, a direct push sample is considered as Class B in Practice [D 4220](#) but is protected, representative, and suitable for chemical analysis. The samples taken with this practice do not usually produce Class C and D (with exception of thin wall samples of standard size) samples for testing for engineering properties, such as shear strength and compressibility. Guide [D 4700](#) has some information on mechanical soil sampling devices similar to direct push tech-

niques, however, it does not address most direct push sampling methods. If sampling is for chemical evaluation in the Vadose Zone, consult Guide [D 4700](#) for any special considerations.

1.3 Field methods described in this guide, include the use of discreet and continuous sampling tools, split and solid barrel samplers and thin walled tubes with or without fixed piston style apparatus.

1.4 Insertion methods described include static push, impact, percussion, other vibratory/sonic driving, and combinations of these methods using direct push equipment adapted to drilling rigs, cone penetrometer units, and specially designed percussion/direct push combination machines. Hammers providing the force for insertion include drop style, hydraulically activated, air activated and mechanical lift devices.

1.5 Direct push soil sampling is limited to soils and unconsolidated materials that can be penetrated with the available equipment. The ability to penetrate strata is based on hammer energy, carrying vehicle weight, compactness of soil, and consistency of soil. Penetration may be limited or damage to samplers and conveying devices can occur in certain subsurface conditions, some of which are discussed in [5.5](#). Successful sample recovery also may be limited by the ability to retrieve tools from the borehole. Sufficient retract force must be available when attempting difficult or deep investigations.

1.6 This guide does not address the installation of any temporary or permanent soil, ground water, vapor monitoring, or remediation devices.

1.7 The practicing of direct push techniques may be controlled by local regulations governing subsurface penetration. Certification, or licensing requirements, or both, may need to be considered in establishing criteria for field activities.

1.8 The values stated in SI units are to be regarded as standard; however, dimensions used in the drilling industry are given in inch-pound units by convention. Inch-pound units are used where necessary in this guide.

1.9 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

¹ This guide is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.21 on Ground Water and Vadose Zone Investigation.

Current edition approved Jan. 1, 2005. Published February 2005. Originally approved in 1998. Last previous edition approved in 1998 as D 6282–98.

² The boldface numbers in parentheses refer to the list of references at the end of this standard.

1.10 *This guide offers an organized collection of information or a series of options and does not recommend a specific course of action. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this guide may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.*

2. Referenced Documents

2.1 ASTM Standards:³

- D 653 Terminology Relating to Soil, Rock and Contained Fluids
- D 1586 Test Method for Penetration Test and Split-Barrel Sampling of Soils
- D 1587 Practice for Thin-Wall Tube Sampling of Soils
- D 2488 Practice for Description and Identification of Soils (Visual-Manual Method)
- D 3550 Practice for Ring-Lined Barrel Sampling of Soils
- D 3694 Practices for Preparation of Sample Containers and for Preservation of Organic Constituents
- D 4220 Practices for Preserving and Transporting Soil Samples
- D 4700 Guide for Soil Sampling from the Vadose Zone
- D 5088 Practice for Decontamination of Field Equipment Used at Nonradioactive Waste Sites
- D 5092 Practice for Design and Installation of Ground Water Monitoring Wells in Aquifers
- D 5299 Guide for Decommissioning of Ground Water Wells, Vadose Zone Monitoring Devices, Boreholes, and Other Devices for Environmental Activities
- D 5434 Guide for Field Logging of Subsurface Explorations of Soil and Rock
- D 6001 Guide for Direct-Push Water Sampling for Geoenvironmental Investigations

3. Terminology

3.1 *Definitions*—General definitions for terminology used in this guide are in accordance with Terminology D 653. Definitions for terms related to direct push water sampling for geoenvironmental investigations are in accordance with Guide D 6001.

3.1.1 *assembly length, n*—length of sampler body and riser pipes.

3.1.2 *borehole, n*—a hole of circular cross-section made in soil or rock.

3.1.3 *casing, n*—pipe furnished in sections with either threaded connections or bevelled edges to be field-welded, which is installed temporarily or permanently to counteract

caving, to advance the borehole, or to isolate the interval being monitored, or combination thereof.

3.1.4 *caving/sloughing, n*—the inflow of unconsolidated material into an unsupported borehole that occurs when the borehole walls lose their cohesive strength.

3.1.5 *decontamination, n*—the process of removing undesirable physical or chemical constituents, or both, from equipment to reduce the potential for cross-contamination.

3.1.6 *direct push sampling, n*—sampling devices that are advanced into the soil to be sampled without drilling or borehole excavation.

3.1.7 *extension rod, n*—hollow steel rod, threaded, in various lengths, used to advance and remove samplers and other devices during direct pushing boring. Also known as *drive rod*. In some applications, small diameter solid extension rods are used through hollow drive rods to activate closed samples at depth.

3.1.8 *incremental drilling and sampling, n*—insertion method where rotary drilling and sampling events are alternated for incremental sampling. Incremental drilling often is needed to penetrate harder or deeper formations.

3.1.9 *percussion driving, n*—insertion method where rapid hammer impacts are performed to advance the sampling device. The percussion normally is accompanied with the application of a static down-force.

3.1.10 *push depth, n*—the depth below a ground surface datum to which the lower end, or tip, of the direct-push sampling device is inserted.

3.1.11 *sample interval, n*—defined zone within a subsurface strata from which a sample is gathered.

3.1.12 *sample recovery, n*—the length of material recovered divided by the length of sampler advancement and stated as a percentage.

3.1.13 *soil core, n*—cylindrical shaped specimen of sediments or other unconsolidated accumulations of solid particles produced by the physical and chemical disintegration of rocks and which may or may not contain organic matter recovered from a soil sampler.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *closed barrel sampler, n*—a sampling device with a piston or other secured device that is held to block the movement of material into the barrel until the blocking device is removed or released. Liners are required in closed barrel samplers. Also may be referred to as a *protected type sampler*.

3.2.2 *impact heads/drive heads, n*—pieces or assemblies that fit to top of the above ground portion of the direct push tool assembly to receive the impact of the hammering device and transfer the impact energy to sampler extensions.

3.2.3 *open barrel sampler, n*—sampling barrel with open end allowing material to enter at any time or depth. Also may be referred to as an *unprotected type sampler*.

3.2.4 *piston lock, n*—device to lock the sampler piston in place to prevent any entry of a foreign substance into the sampler chamber prior to sampling.

3.2.5 *single tube system, n*—a system whereby single extension/drive rods with samplers attached are advanced into the subsurface strata to collect a soil sample.

³ For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

3.2.6 *solid barrel sampler, n*—a soil sampling device consisting of a continuous or segmented tube with a wall thickness sufficient to withstand the forces necessary to penetrate the strata desired and gather a sample. A cutting shoe and a connecting head are attached to the barrel.

3.2.7 *split barrel sampler, n*—a soil sampling device consisting of the two half circle tubes manufactured to matching alignment, held together on one end by a shoe and on the other by a connecting head.

3.2.8 *two tube systems, n*—a system whereby inner and outer tubes are advanced simultaneously into the subsurface strata to collect a soil sample. The outer tube is used for borehole stabilization. The inner tube for sampler recovery and insertion.

4. Summary of Guide

4.1 Direct push soil sampling consists of advancing a sampling device into subsurface soils by applying static pressure, by applying impacts, or by applying vibration, or any combination thereof, to the above ground portion of the sampler extensions until the sampler has been advanced to the desired sampling depth. The sampler is recovered from the borehole and the sample removed from the sampler. The sampler is cleaned and the procedure repeated for the next desired sampling interval. Sampling can be continuous for full depth borehole logging or incremental for specific interval sampling. Samplers used can be protected type for controlled specimen gathering or unprotected for general soil specimen collection.

5. Significance and Use

5.1 Direct push methods of soil sampling are used for geologic investigations, soil chemical composition studies, and water quality investigations. Examples of a few types of investigations in which direct push sampling may be used include site assessments, underground storage tank investigations, and hazardous waste site investigations. Continuous sampling is used to provide a lithological detail of the subsurface strata and to gather samples for classification and index or for chemical testing. These investigations frequently are required in the characterization of hazardous waste sites. Samples, gathered by direct push methods, provide specimens necessary to determine the chemical composition of soils, and in most circumstances, contained pore fluids (3).

5.2 Direct push methods can provide accurate information on the characteristics of the soils encountered and of the chemical composition if provisions are made to ensure that discrete samples are collected, that sample recovery is maximized, and that clean decontaminated tools are used in the sample gathering procedure. For purposes of this guide, “soil” shall be defined in accordance with Terminology D 653. Using sealed or protected sampling tools, cased boreholes, and proper advancement techniques can assure good representative samples. Direct push boreholes may be considered as a supplementary part of the overall site investigation or may be used for the full site investigation if site conditions permit. As such, they should be directed by the same procedural review and quality assurance standards that apply to other types of

subsurface borings. A general knowledge of subsurface conditions at the site is beneficial.

5.3 Soil strata profiling to shallow depths may be accomplished over large areas in less time than with conventional drilling methods because of the rapid sample gathering potential of the direct push method. More site time is available for actual productive investigation as the time required for ancillary activities, such as decontamination, rig setup, tool handling, borehole backfill, and site clean-up is reduced over conventional drilling techniques. Direct push soil sampling has benefits of smaller size tooling, smaller diameter boreholes, and minimal investigative derived waste.

5.4 The direct push soil sampling method may be used as a site characterization tool for subsurface investigation and for remedial investigation and corrective action. The initial direct push investigation program can provide good soil stratigraphic information depending on the soil density and particle size, determine ground water depth, and provide samples for field screening and for formal laboratory analysis to determine the chemical composition of soil and contained pore fluids. Use of this method, results in minimum site disturbance and no cuttings are generated.

5.5 This guide may not be the correct method for investigations in all cases. As with all drilling methods, subsurface conditions affect the performance of the sample gathering equipment and methods used. Direct push methods are not effective for solid rock and are marginally effective in partially weathered rock or very dense soils. These methods can be utilized to determine the rock surface depth. The presence or absence of ground water can affect the performance of the sampling tools. Compact gravelly tills containing boulders and cobbles, stiff clay, compacted gravel, and cemented soil may cause refusal to penetration. Certain cohesive soils, depending on their water content, can create friction on the sampling tools which can exceed the static delivery force, or the impact energy applied, or both, resulting in penetration refusal. Some or all of these conditions may complicate removal of the sampling tools from the borehole as well. Sufficient retract force should be available to ensure tool recovery. As with all borehole advancement methods, precautions must be taken to prevent cross contamination of aquifers through migration of contaminants up or down the borehole. Regardless of the tool size, the moving of drilling and sampling tools through contaminated strata carries risks. Minimization of this risk should be a controlling factor in selecting sampling methods and drilling procedures. The user should take into account the possible chemical reaction between the sample and the sampling tool itself, sample liners, or other items that may come into contact with the sample (3, 4).

5.6 In some cases this guide may combine water sampling, or vapor sampling, or both, with soil sampling in the same investigation. Guides D 6001 and D 4700 can provide additional information on procedures to be used in such combined efforts.

6. Criteria for Selection

6.1 Important criteria to consider when selecting sampling tools include the following:

6.1.1 Size of sample.

6.1.2 Sample quality (Class A,B,C,D) for physical testing. Refer to Practice D 4220.

6.1.3 Sample handling requirements, such as containers, preservation requirements.

6.1.4 Soil conditions anticipated.

6.1.5 Ground water depth anticipated.

6.1.6 Boring depth required.

6.1.7 Chemical composition of soil and contained pore fluids.

6.1.8 Probability of cross contamination.

6.1.9 Available funds.

6.1.10 Estimated cost.

6.1.11 Time constraints.

6.1.12 History of tool performance under anticipated conditions (consult experienced users and manufacturers).

6.2 Important criteria to consider when selecting direct push equipment include the following:

6.2.1 Site accessibility.

6.2.2 Site visibility.

6.2.3 Soil conditions anticipated.

6.2.4 Boring depth required.

6.2.5 Borehole sealing requirements.

6.2.6 Equipment performance history.

6.2.7 Personnel requirements.

6.2.8 Decontamination requirements.

6.2.9 Equipment grouting capability.

6.2.10 Local regulatory requirements.

7. Apparatus

7.1 *General*—A direct push soil sampling system consists of a sample collection tool, hollow extension rods for advancement, retrieval, and transmission of energy to the sampler, and an energy source to force sampler penetration. Auxiliary tools are required to handle, assemble and disassemble, clean, and repair the sample collection tools and impact surfaces. Necessary expendable supplies are sample containers, sample container caps, sample liners, sample retainers, appropriate lubricants, and personal safety gear.

7.2 Direct Push Tool Systems:

7.2.1 *Two Tube System*—An outer casing and an inner extension rod with a sampler attached (see Fig. 1) are advanced simultaneously into the soil for the length capacity of the sampler. The sampler is removed from the borehole and a new sampler barrel or plug bit is inserted for each increment of depth. Two-tube sampling systems also may incorporate sample gathering chambers that are fitted into the outer casing shoe. These sample barrels are designed to create a minimum of sample disturbance while gathering high quality specimens (see Fig. 2). Samplers are held in the proper position by different methods, such as extension rods, pneumatic or mechanical packers, spring activated latches, or other devices (see Figs. 1 and 2). Locking devices must be strong enough to hold the sampler while penetrating the sample strata. The outer casing supports the borehole wall. Sample retrieval is expedited by the cased hole and continuous sampling is simplified. Continuous sampling may be a benefit to lithological logging. A cased borehole can be sealed from the bottom up as the casing is extracted (see Section 10). A cased hole may reduce the risk of contamination migration down the borehole and

sample cross contamination. The two-tube system is more susceptible to soil friction because of its larger diameter and may require larger direct push energy than single-tube systems. An oversized drive shoe is sometimes used to reduce friction and buckling but may increase the risk of contamination migration down the borehole.

7.2.2 *Single Tube System*—The single tube system (see Fig. 3), uses a hollow extension/drive rod to advance and retrieve the sampler. The sampler is attached to the bottom of the extension/drive rod. A drive cap is added to the top of the extension/drive rod and the sampler is pushed into the soil. Extension/drive rods generally are smaller in diameter than the sampler. The single tube system minimizes effort for discrete interval sampling under many subsurface conditions. Tool connection time per interval is reduced. Time of removal and reinsertion of samplers into the borehole is affected by soil conditions. Repeated movement of the sampler through contaminated subsurface strata may increase the risk of contamination migration down the borehole. Bottom up borehole sealing may require re-entry in soil formations that collapse (see Section 10).

7.3 Samplers:

7.3.1 *Split Barrel Samplers*—Split barrel samplers (see Fig. 4) are available for use with direct push drilling methods and are available in various sizes up to 3.0 in. (76.2-mm) inside diameter. The inside tolerance should allow for use of liners. Split barrel sampler shoes used in two tube systems must be of sufficient diameter to prevent the intrusion of soil between the outer diameter of the shoe and the inside wall of the outer tube. Split barrel shoes should be replaced when the leading edge is damaged. Damaged shoes can negatively affect sample recovery. Samplers can be used with or without ball check value fitted split barrel heads. The ball check prevents uphole fluids from flowing down through the sample. Where soil sampling will be performed below the water table, the split barrel head, equipped with a ball check, should be used. The open split barrel is best used with the two tube system because the outer casing protects the borehole against cave-in or sloughing, or in soils in which the borehole wall will not collapse. Split barrel sealing systems are available. Split barrel sections can be joined to create a sampler with a nominal sample length capacity of 48 in. (1.22 m). It is understood that samplers with usable lengths beyond 24 in. (0.61 m) are used to advantage in certain soil types; however, the added weight of the soil sample in the chamber and the added friction within the sampler may prevent loose soils from entering the sampler, affecting sample recovery and representativeness. Split barrel samplers can be fitted with a basket to improve recovery in cohesionless soils. Retainers are available in many styles and materials. Retainers should allow the passage of softer soils. Stiff retainers can reduce specimen recovery in soft soils.

7.3.2 Solid Barrel Samplers:

7.3.2.1 *Open Solid Barrel Samplers*—Open solid barrel (see Fig. 5) samplers are used with all types of direct push sampling systems. Solid barrels can have inside diameters ranging up to 3 in. (76.2 mm). Barrel lengths range from 6 in. (152.4 mm) to 5 ft (1.53 m). Solid barrel samplers may be one piece or segmented. Sample liners should be used to facilitate removal

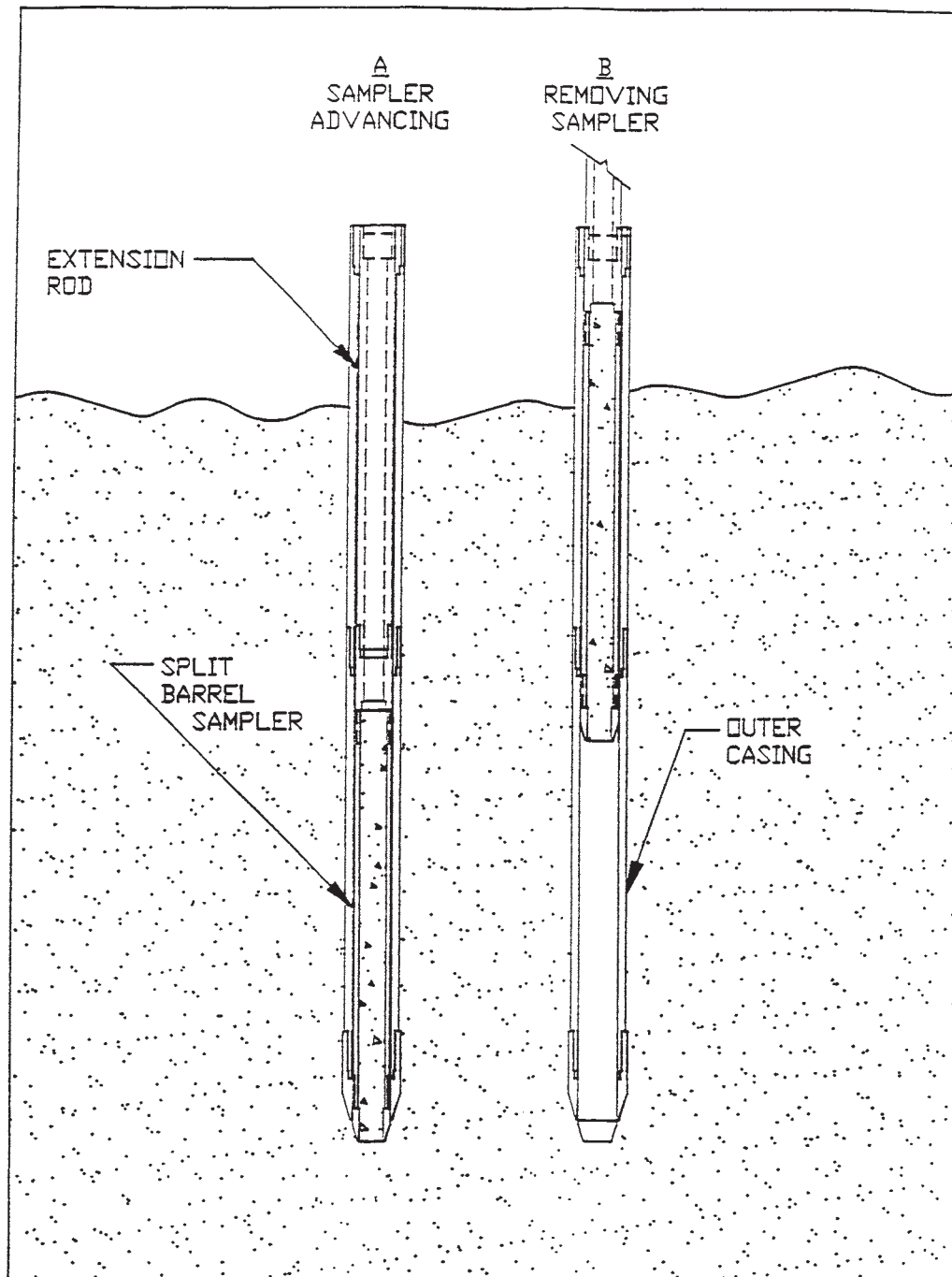


FIG. 1 Split Spoon Sampling, Two Tube System

of the sample from the solid barrel. Without the use of liners, samples are extruded mechanically. Liner lengths should fit sampler barrel lengths. Solid barrel samplers are generally assembled with a removable cutting shoe and a drive head (see Fig. 6). The head provides a backing to hold the liner stationary while the sampler is advanced and serves as a connector to the extension/drive rods. The shoe is manufactured to hold the liner stationary during the soil collection procedure. The liner should be slightly larger than the inner diameter of the cutting shoe. It may be slipped over the cutting shoe (see Fig. 6) or nested inside of the cutting shoe (see Fig. 7). The shoe is

manufactured to cut the sample to a slightly undersized diameter allowing it to pass into the sample liner with a minimum of side friction to reduce sample disturbance. The amount of specimen contact with the inside of the shoe should be held to the minimum distance possible to aid in achieving the maximum amount of recovery.

7.3.3 Closed Barrel Sampler—Closed barrel samplers (see Figs. 2 and 3, Figs. 5-8) are devices, which remain sealed shut until an action is taken to open the sample receiving chamber. These samplers are used most often for single events (discrete point sampling) where a sealed sampler is required to avoid

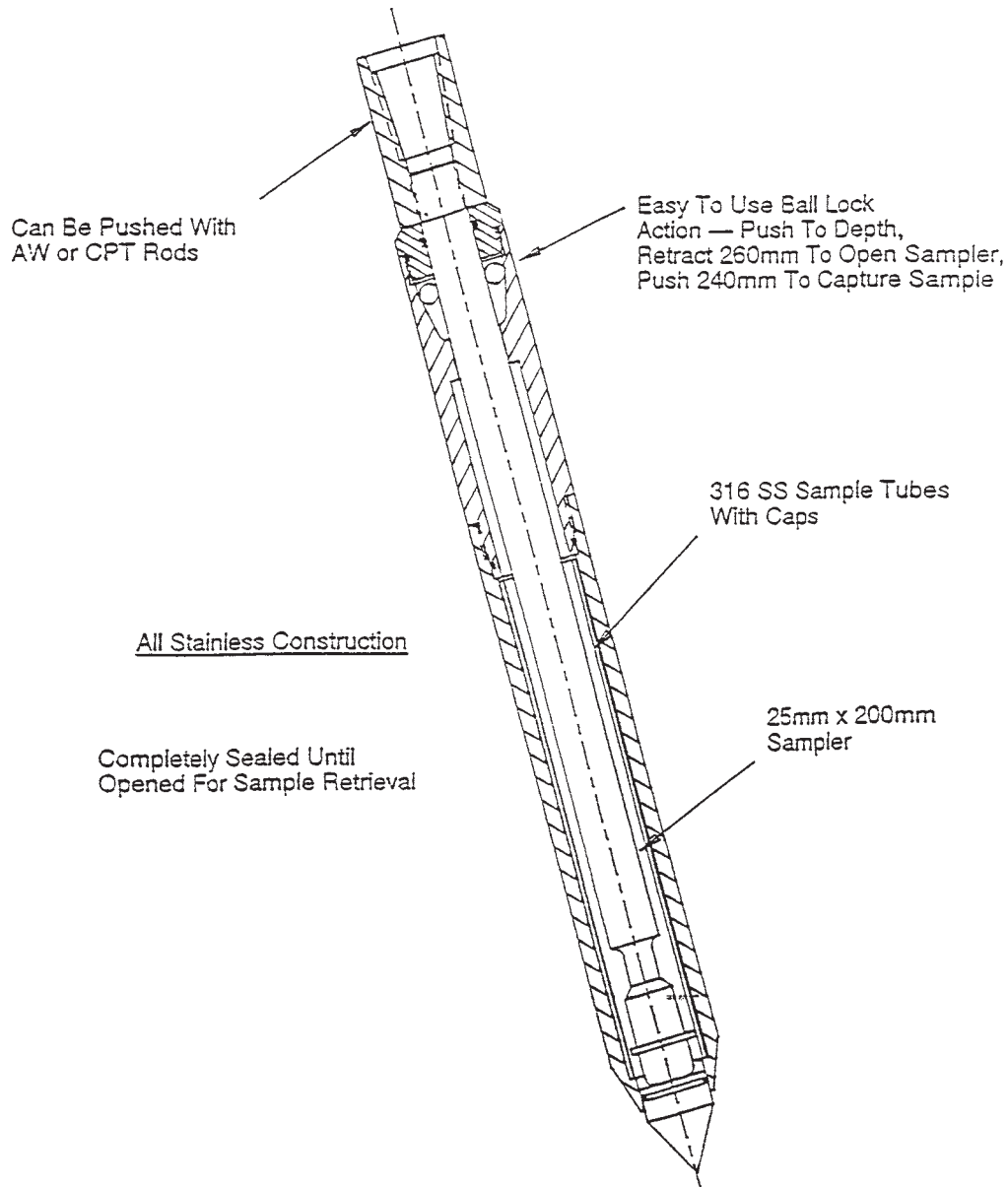


FIG. 2 Sealed Sample Barrel, Single Tube System

cross contamination or in circumstances where borehole wall stability cannot be assured. The shoe sealing device generally is a point designed to allow the continuous flow of soil around and past the sampler until such time as it is removed or released. The piston point can be fitted with seals, such as “O” rings at top and bottom to hold fluid out until sampling the desired interval. The piston rod extends through the sample retaining liner and must be released or removed for the soil to enter (see Fig. 3, Fig. 5, Fig. 7). The piston can be removed manually before sampling or be displaced by the soil entering the sampler chamber. Using the displacement method can result in reduced recovery if sampled soils do not have sufficient strength to displace the piston. Pistons are locked in place by several methods, such as a spring loaded latch. The latch holds several balls (see Fig. 2, Fig. 7, Fig. 8) into a groove in the latch coupling. When the latch is released by lifting up on the latch stem, the balls slip back into the latch chamber

allowing the piston to be removed. Another method uses a locking screw. A reverse thread pin (Fig. 3, Fig. 6) is positioned in the sampler head to prevent the piston from being displaced by the soil when advancing the sampler. At the sampling interval, small diameter extension rods are inserted through the sampler extension/drive rods and rotated clockwise to unscrew the locking pin. A third method uses an inflated packer. An inflated packer (see Fig. 9) is attached to the top of the sampler barrel. The sample barrel is lowered into position in the drive casing and the packer inflated. The packer is deflated to release and the sample barrel is recovered after being advanced the sampling interval.

7.3.4 Thin Wall Tube—A 1.0-in. (25.4-mm) diameter thin wall tube (see Fig. 10) is available for use with direct push equipment and is manufactured according to Practice D 1587. Thin wall tubes can be effective when used with dual tube direct push systems as the borehole must be kept clear of

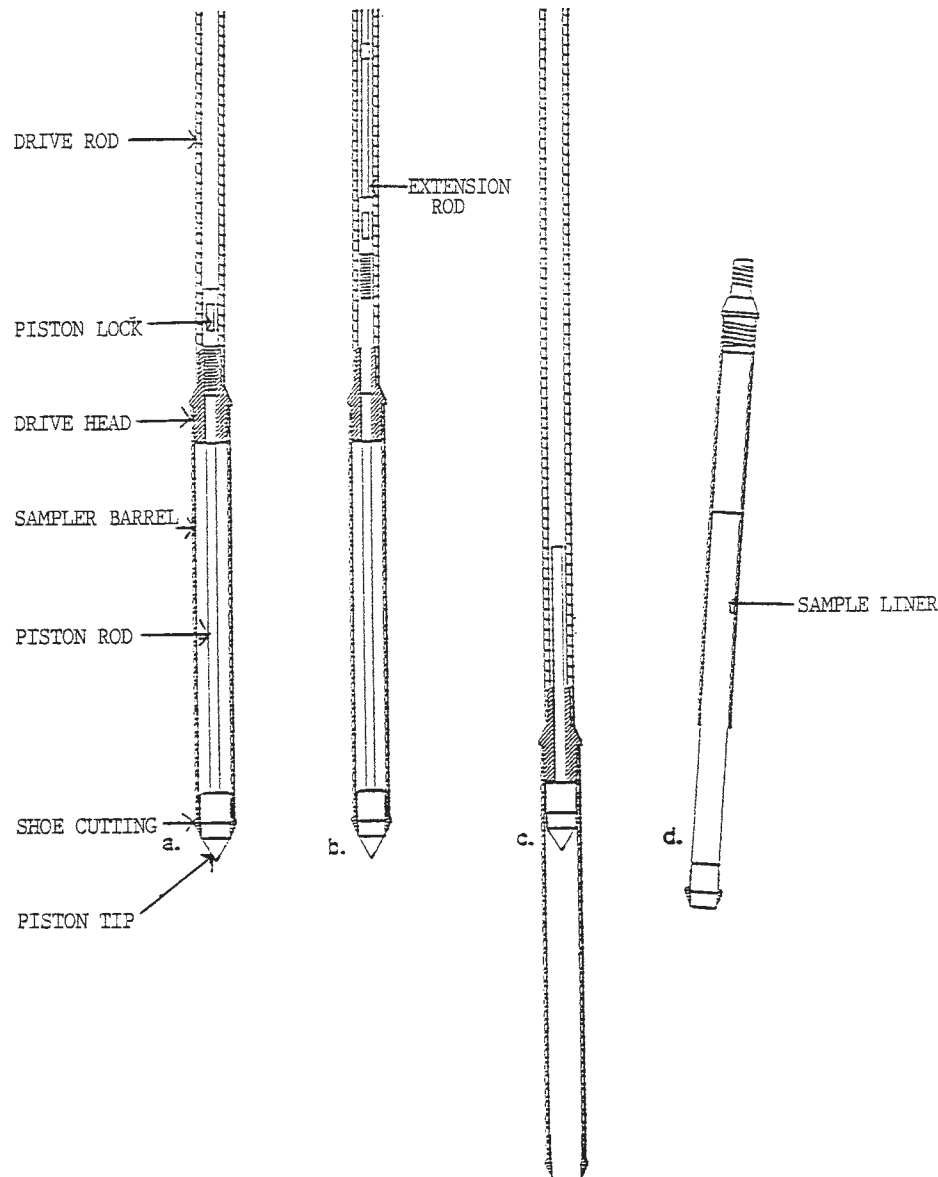


FIG. 3 Driving and Sampling, Single Tube System

- (a) Driving the sealed sampler. (b) Removing the stop-pin.
(c) Collecting a sample (d) Recovering sample in liner.

disturbed soil prior to gathering a sample. Thin wall tubes may be effective in cohesive soils with single tube systems when the borehole can be kept clear of disturbed soil. Thin wall tubes must have an outside diameter that will allow passage through the outer casing. The thin wall tube can be operated in accordance with Practice D 1587, or it can be advanced using the percussion hammer of the direct push equipment. The primary use of the thin wall tube is to gather relatively undisturbed samples in cohesive soils. Sealing of thin wall tube ends should be completed in accordance with Practice D 4220. Fixed piston apparatus (see Fig. 10) also is available for use with thin walled tubes. The fixed piston action allows the sampling of very soft formations, which may not be retained in conventional samplers. In certain soil formations, the thin wall tube provides the best method to collect an undisturbed sample.

7.3.5 Sampler Extension/Drive Rods—Sampler extension/drive rods are lengths of rod or tube generally constructed of steel to withstand the pushing or percussion forces applied. Extension drive rods are available in various lengths. Rod lengths should be mated with casing and sampling equipment used. Thread types and classes vary between equipment manufacturers. Rod joints can be sealed to prevent fluid intrusion with “O” rings. Teflon™ washers or Teflon™ tape. Because of the percussive effort, joint seals should be checked for each sampling effort. Extension/drive rods should have sufficient inside diameter to accommodate the equipment necessary to perform the desired action.

7.3.6 Sampler Liners—Sampler liners are used to collect and store samples for shipment to laboratories, for field index testing of samples and for removing samples from solid barrel

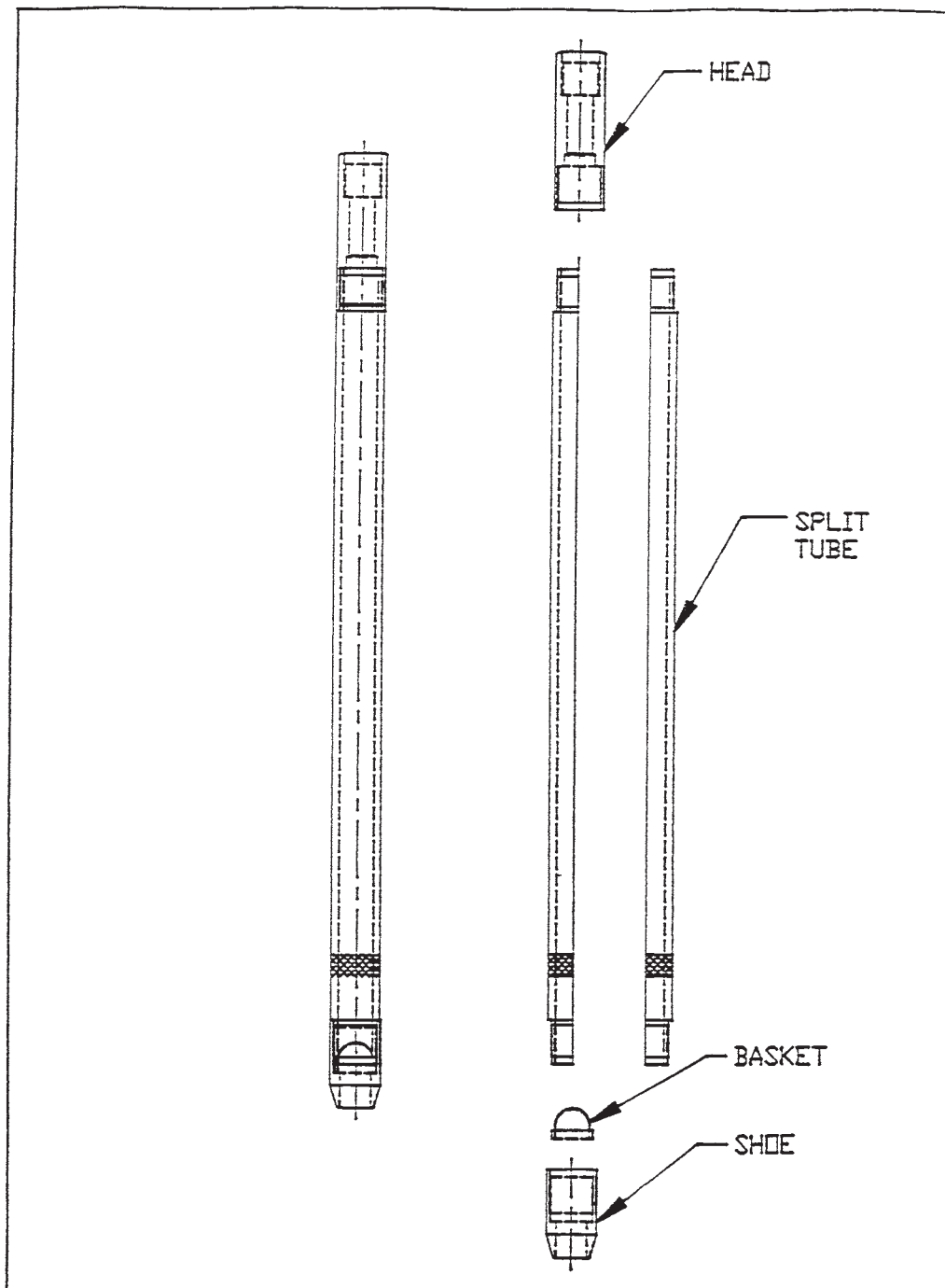


FIG. 4 Split Barrel Sampler, Two Tube System

type samplers. Liners are available in plastics, Teflon[®], brass, and stainless steel. Other materials can be used as testing needs dictate. Liners are available in lengths from 6 in. (152.4 mm) to 5.0 ft (1.53 m). Liner material selection often is based on the chemical composition of liner/soil to minimize sample reaction with liner. Most liner use is short term as samples are subsampled and preserved immediately on site. A general rule for liner selection is stainless steel for organic compounds and plastic for metals. Teflon[®] may be required for mixed wastes and for long time storage. Liners should be sealed in accordance with Practice D 4220 when samples are collected for

physical testing. Other appropriate procedures must be used when samples are collected for environmental analysis (see Practices D 3694) (1, 2). Liners generally are split in the field for subsampling. Individually split liners are available in some sizes for field use. The liner should have a slightly larger inside diameter than the soil specimen to reduce soil friction and enhance recovery. When a slightly oversized liner is used, the potential for air space exists around the sample. Certain chemical samples may be affected by the enclosed air. Liners having less tolerance may be required and a shortened sampled interval used to reduce friction in the liner. Metal liners can be

A. OPEN

B. CLOSED

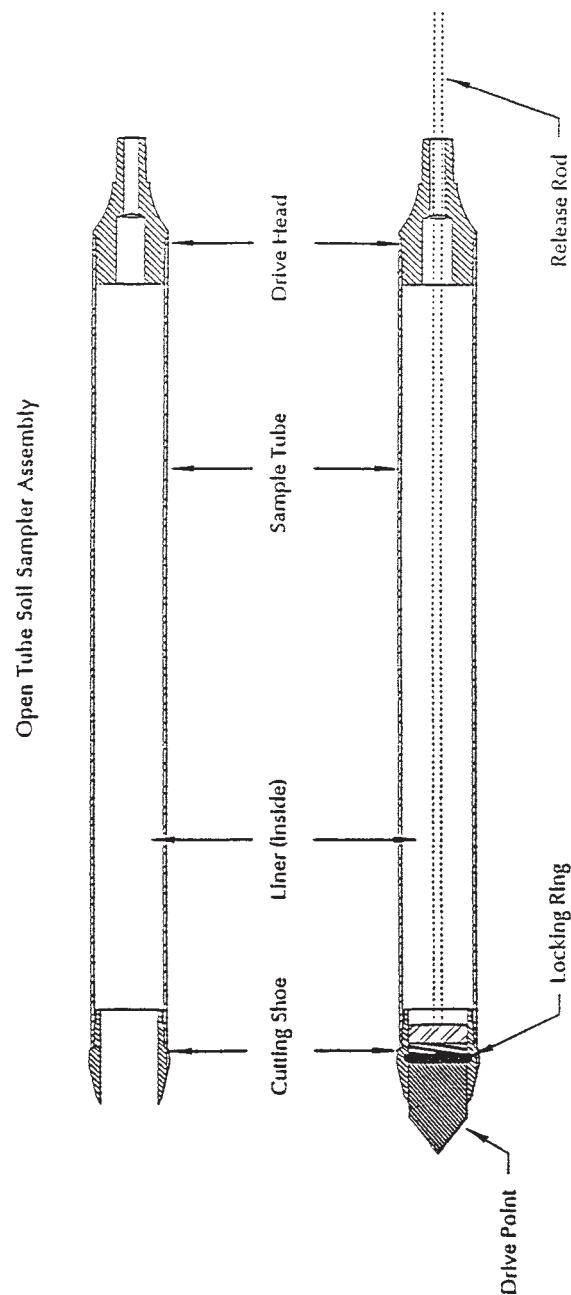


FIG. 5 (A) Open and (B) Closed Piston Sampler Assembly, Single Tube System

reused after proper cleaning and decontamination. Plastic liners should be disposed of properly after use.

7.3.7 Sample Containers—Sample containers should be prescribed according to the anticipated use of the sample specimen. Samples taken for chemical testing may require decontaminated containers with specific preservatives. Practice D 3694 provides information on some of the special containers and preservation techniques required (1, 2). These containers generally will be decontaminated to specific criteria. Samples for geotechnical testing require certain minimum volumes and specific handling techniques. Practice D 4220 offers guidance for sample handling of samples submitted for physical testing.

7.4 Direct Push Power Sources—Soil probing percussion driving systems, penetrometer drive systems, and rotary drilling equipment may be used to drive casings and direct push soil sampling devices. The equipment should be capable of applying sufficient static force, or dynamic force, or both, to advance the sampler to the required depth to gather the desired sample. The system must have adequate retraction force to remove the sampler and extension/drive rods once the selected strata has been penetrated. Rotation of the drill string can be added during insertion, as well as during retraction if the drive system can impart rotation.

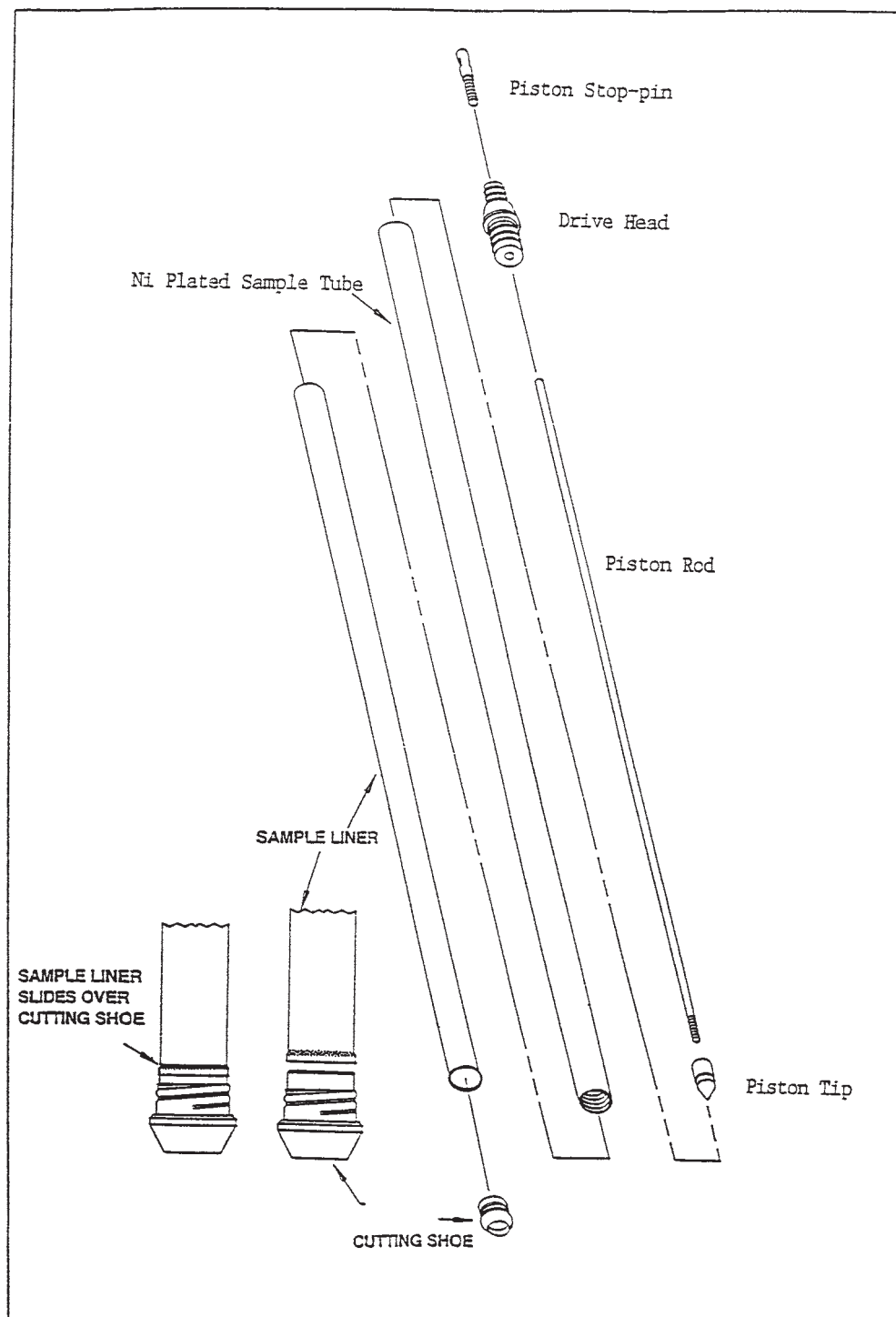


FIG. 6 Sampler Parts, Single Tube System

7.4.1 Retraction Force—The retraction force can be applied by direct mechanical pull back using the hydraulic system of the power source; line pull methods using mechanical or hydraulic powered winches, or cathead and rope windlass type devices. Winches used with direct push technology should have a minimum of 2000 lb (907 kg) top layer rating capacity and a line speed of 400 ft (121.96 m)/min to provide effective tool handling. Direct push sampling tools can be retracted by back pounding using weights similar to those of standard

penetration testing practices. Backpounding to recover samples can affect recovery and cause disturbances to the sample. Other forms of extraction, such as jacking, that do not cause undue disturbance to the sample, are preferable.

7.4.2 Percussion Devices—Percussion devices for use with direct push methods are hydraulically-operated hammers, air-operated hammers, and mechanically-operated hammers. Hydraulically-operated hammers should have sufficient energy to be effective in moving the samplers through the subsurface

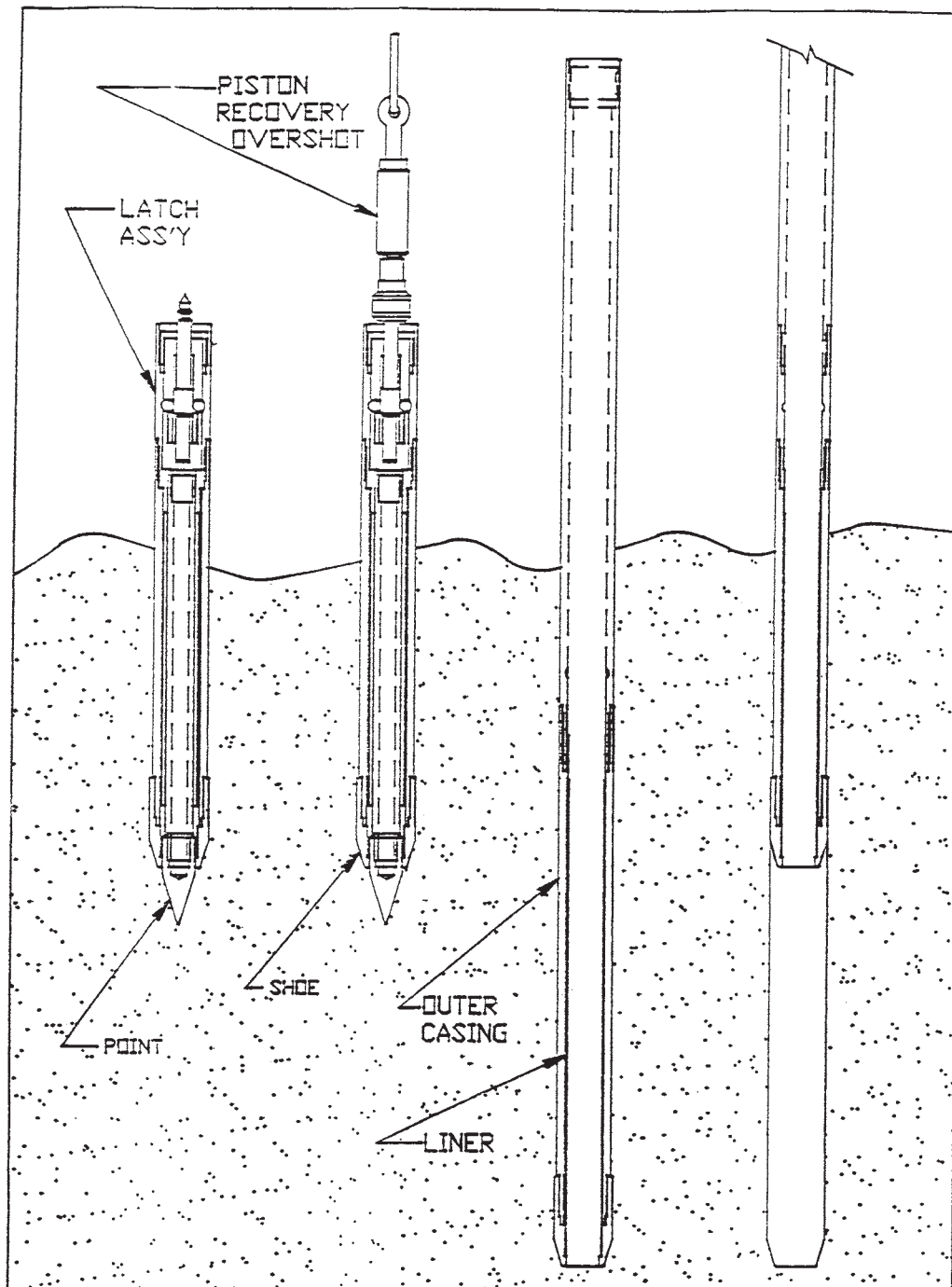


FIG. 7 Closed Solid Barrel Sampler, Single Tube System

strata. The maximum energy application is dependent on the tools used. Hammer energy that exceeds tool tolerance will result in tool damage or loss and will not achieve the goal of collecting high quality samples. Air-operated hammers should be capable of delivering sufficient energy, as well. Hammer systems utilizing hydraulic oil or air should be operated in the range specified by the manufacturer. Manually-operated hammers can be used to advance direct push tools. These hammers can be operated mechanically or manually using cathead and rope. These systems generally involve using 140 lb, standard penetration (see Test Method [D 1586](#)) hammers, which can

work well for direct push sampling. In operation, these hammers tend to be slower than hydraulic hammers and can cause tool damage if direct push tools are not designed to take the heavy blows associated with these hammers. The hydraulic- and air-operated hammers strike up to 2000 blows/min. In addition to the energy transferred, the rapid hammer action sets up a vibratory effect, which also aids in penetration. This vibratory effect, along with the percussive effort, may disturb some soil samples.

7.4.3 Static Push Systems—Cone penetrometer systems are an example of static push systems. They impart energy to the

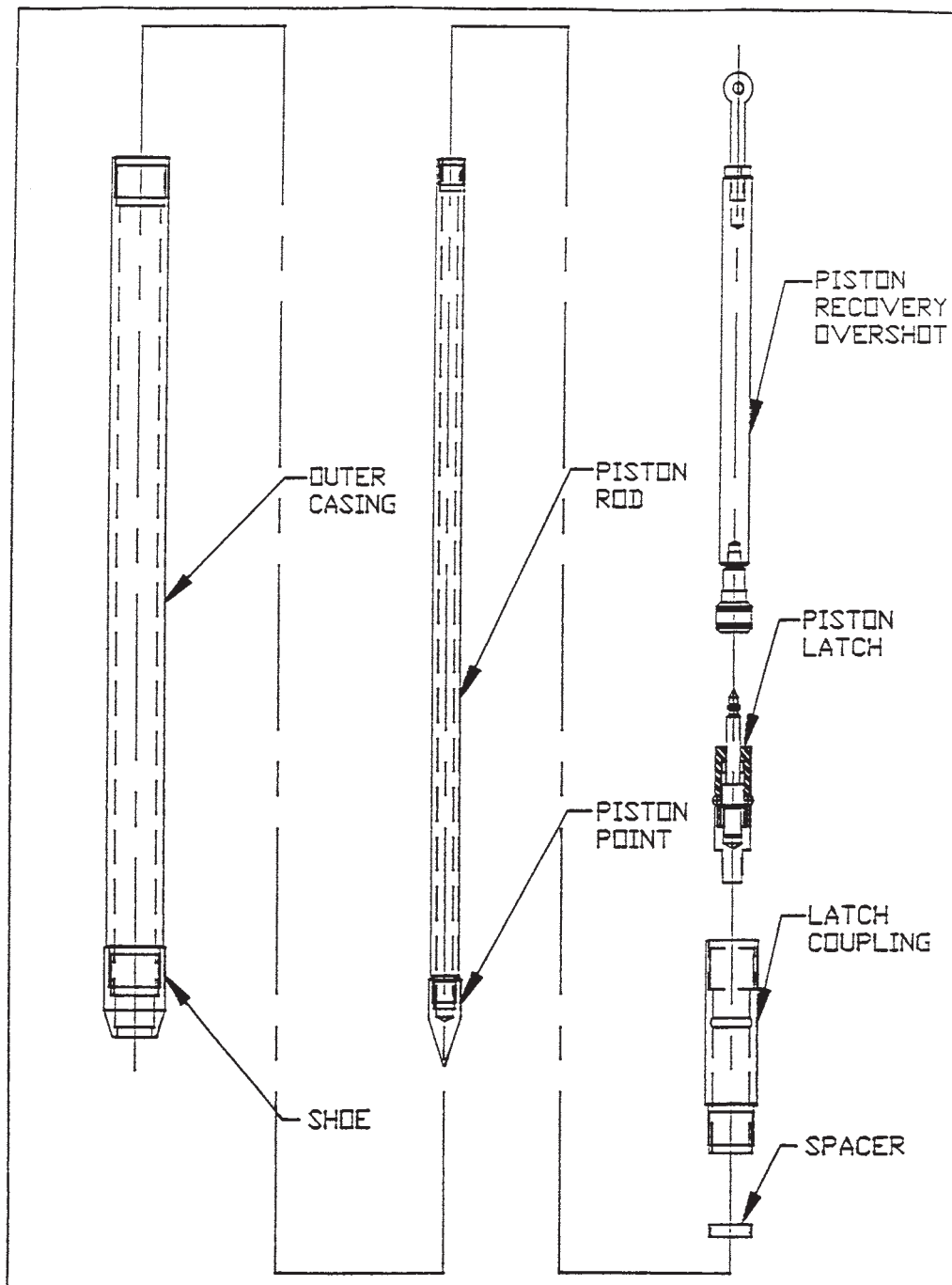


FIG. 8 Closed Solid Barrel Sampler, Single Tube System

sampler and extension rods by using hydraulic rams to apply pressure. The pressure applied is limited to the reactive weight of the drive vehicle. Retraction of the sampler and extension rods is by static pull from the hydraulic rams.

7.4.4 Vibratory/Sonic Systems—These systems utilize a vibratory device, which is attached to the top of the sampler extension rods. Reactive pressure and vibratory action are applied to the sampler extensions moving the sampler into the formation. In certain formations, sample recovery and formation penetration is expedited; however, all formations do not react the same to vibratory penetration methods.

7.4.4.1 Sonic or Resonance Drilling Systems—These are high powered vibratory systems that can be effective in advancing large diameter single or dual tube systems. They generally have depth capabilities beyond the smaller direct push systems.

7.4.5 Rotary Drilling Equipment—Direct push systems are readily adaptable to rotary drill units. The drill units offer a ready hydraulic system to operate percussion hammers, as well as reactive weight for static push. Because most drills are equipped with leveling jacks, better weight application is achieved. Vertical pushing is improved because of the ability to

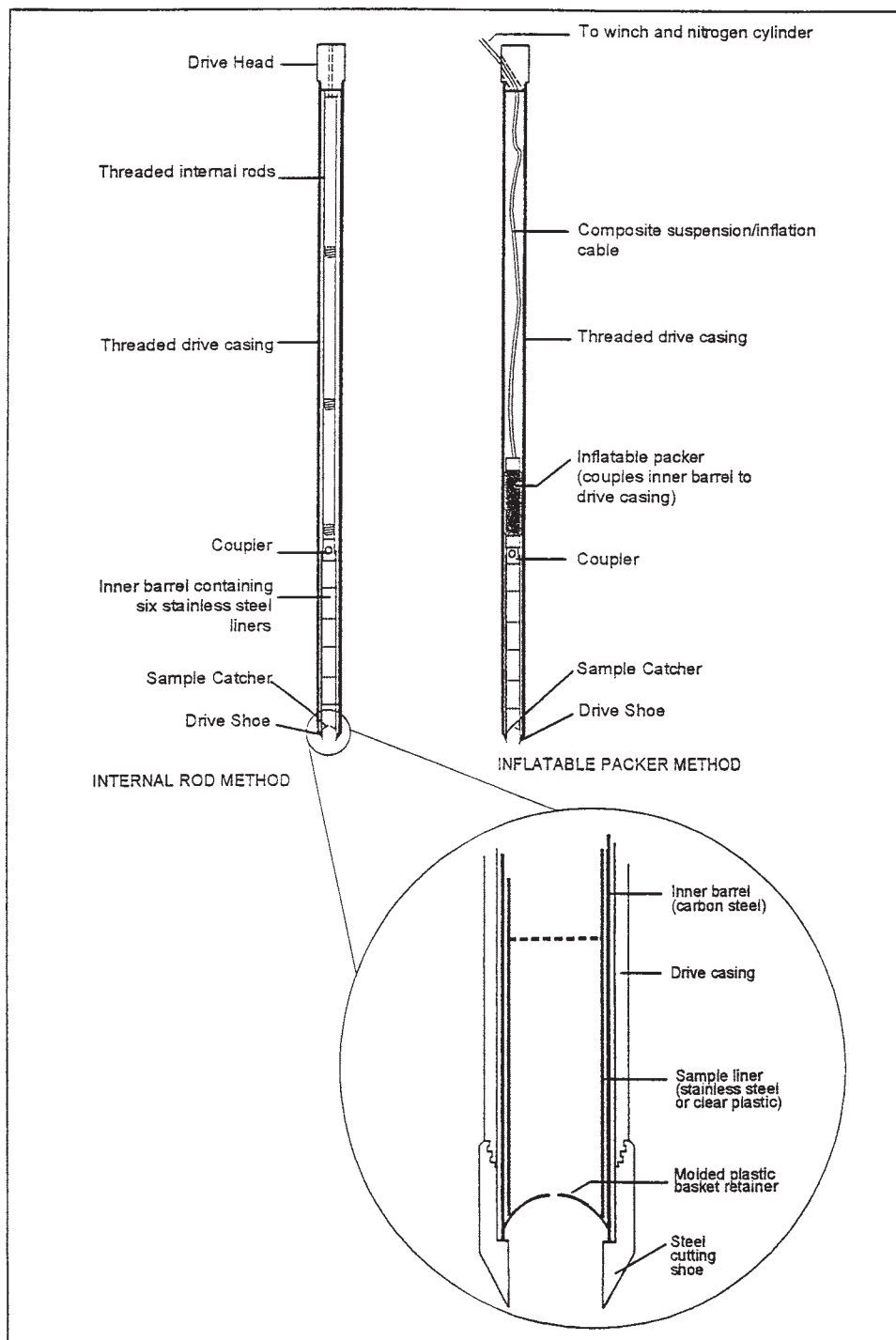


FIG. 9 Sampler Holding Methods, Two Tube System

level the machine. Tool handling is facilitated by high speed winches common to drilling rigs, extended masts for long tool pulls, and longer feed stroke length. Drill units with direct push adaptations also offer drilling techniques should obstacles be encountered while using direct push technology. Large drill units may have reactive weights that can exceed the tool capacity, thereby resulting in damaged tools.

8. Conditioning

8.1 Decontamination—Sampling equipment that will contact the soil to be sampled should be cleaned and decontaminated before and after the sampling event. Extension rods should be cleaned prior to each boring to avoid the transfer of contaminants and to ease the connecting of joints. Thread

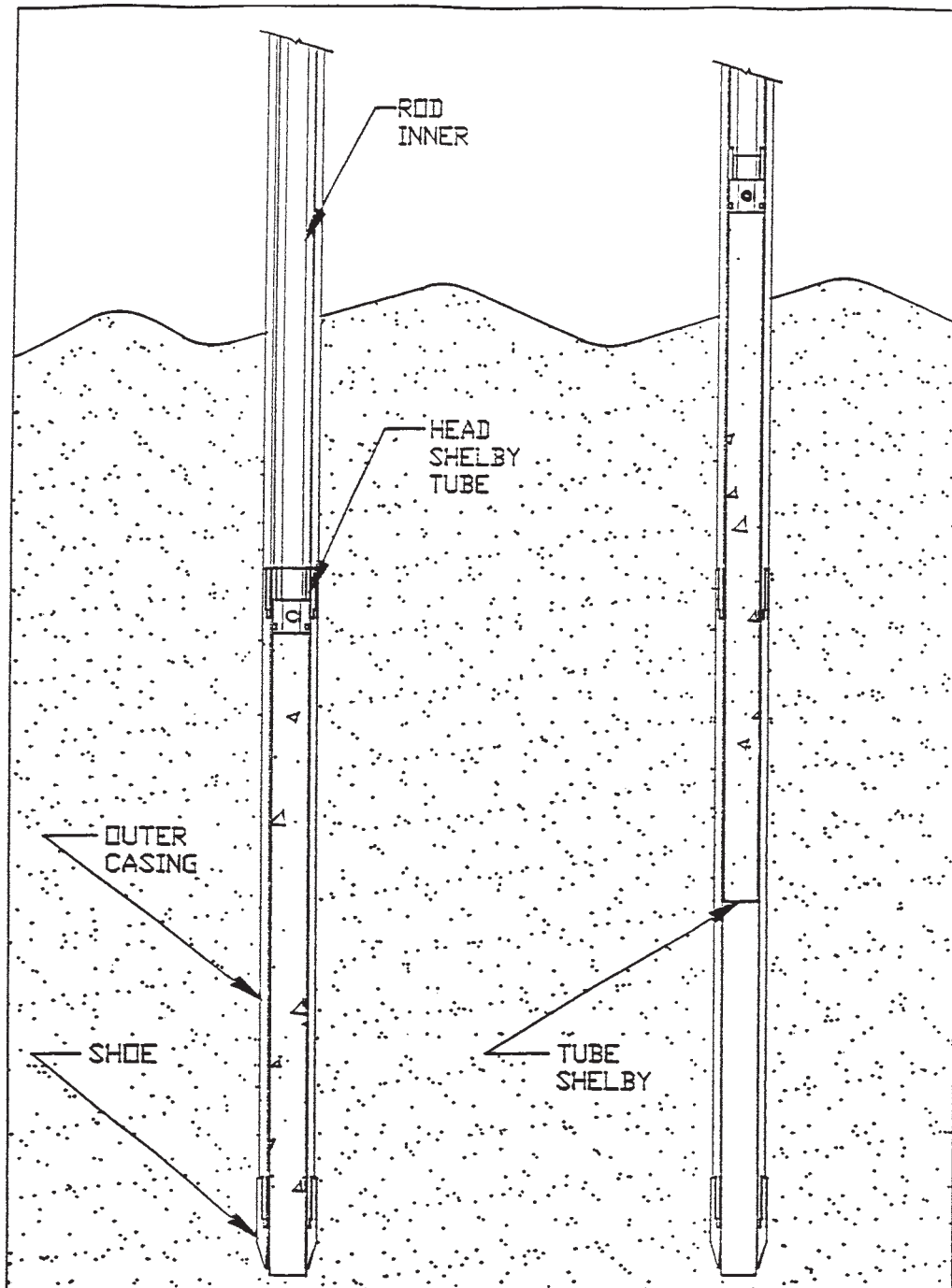


FIG. 10 Thin Wall Tube Sampler, Two Tube System

maintenance is necessary to ensure long service life of the tools. Sample liners should be kept in a sealed or clean environment prior to use. Reusable liners should be decontaminated between each use. All ancillary tools used in the sampling process should be cleaned thoroughly, and if contaminants are encountered, decontaminated before leaving the site. It should not be assumed that new tools are clean. They should be cleaned and decontaminated before use. Decontamination should be performed following procedures outlined in

Practice **D 5088** along with any site safety plans, sampling protocols, or regulatory requirements.

8.2 *Tool Selection*—Prior to dispatch to the project site an inventory of the necessary sampling tools should be made. Sample liners, containers, sampling tools, and ancillary equipment should be checked to ensure its proper operation for the work program prescribed. Sampling is expedited by having two or more samplers on site. Since samples can be recovered quite fast, a supply of samplers will allow a boring to be

completed so other functions can be performed while samples are being processed. A backup tool system adaptable to and within the capabilities of the power source should be available should the original planned method prove unworkable. Materials for proper sealing of boreholes should always be available at the site (5-7).

9. Procedure

9.1 While procedures for direct push soil sampling with two common direct push methods are outlined here, other systems may be available. As long as the basic principles of practice relating to sampler construction and use are followed, other systems may be acceptable.

9.2 *General Set-Up*—Select the boring location and check for underground and overhead utilities and other site obstructions. Establish a reference point on the site for datum measurements, and set the direct push unit over the boring location. Stabilize and level the unit, raise the drill mast or frame into the drilling position, and attach the hammer assembly to the drill head if not permanently attached. Attach the anvil assembly in the prescribed manner, slide the direct push unit into position over the borehole, save a portion of the sliding distance for alignment during tool advancement, and ready the tools for insertion.

9.2.1 *Tool Preparation*—Inspect the direct push tools before using, and clean and decontaminate as necessary. Inspect drive shoes for damaged cutting edges, dents, or thread failures as these conditions can cause loss of sample recovery and slow the advancement rate. Where permissible, lubricate rod joints with appropriate safe products, and check impact surfaces for cracks or other damage that could result in failure during operations. Assemble samples and install where required, install sample retainers where needed, and install and secure sampler pistons to ensure proper operation where needed.

9.2.2 *Sample Processing*—Sample processing should follow a standard procedure to ensure quality control procedures are completed. View sample in the original sampling device, if possible. Open the sampling device with care to keep disturbance to a minimum. When using liners or thin wall tubes, protect ends to prevent samples from falling out or being disturbed by movement within the liner. Measure recovery accurately, containerize as specified in the work plan or applicable ASTM procedures, and label recovered samples with sufficient information for proper identification. When collecting samples for volatile chemical analysis, sample specimens must be contained and preserved as soon as possible to prevent loss of these components. Follow work plan instructions or other appropriate documents (see Practice D 3694) when processing samples collected for chemical analysis.

9.3 Two Tube System:

9.3.1 *Split Barrel Sampling* (see Fig. 1)—Assemble the outer casing with the drive shoe on the bottom, attach the drive head to the top of the outer casing, and attach the sampler to the extension rods. Connect the drive head to the top of the sampler extension rods, and insert the sampler assembly into the outer casing. The sampler cutting shoe should contact the soil ahead of the outer casing to prevent unnecessary sample disturbance. The split spoon cutting shoe should extend a

minimum of 0.25 in. (6.25 mm) ahead of the outer casing. Greater extensions may improve recovery in soft formations. Mark the outer casing to designate the required drive length, position the outer casing and sampler assembly under the drill head, and move the drill head downward to bring pressure on the tool string. If soil conditions allow, advance the sampler/casing assembly into the soil at a steady rate slow enough to allow the soil to be cut by the shoe and move up inside the sample barrel. If advancement is too rapid, it can result in loss of recovery because of soil friction in the shoe. Occasional hammer action during the push may help recovery by agitating the sample surface. If soil conditions prevent smooth static push advancement, activate the hammer to advance the sampler. Apply a continuous pressure while hammering to expedite soil penetration. The pressure required is controlled by subsurface conditions. Applications of excessive down pressure may result in the direct push unit being shifted off the borehole causing misalignment with possible tool damage. Stop the hammer at completion of advancement of the measured sampling barrel length. Release the pressure and move the drill head off the drive head. Attach a pulling device to the extension rods or position the hammer bail and retrieve the sampler from the borehole. At the surface remove the sampler from the extension rods and process. Soil classification is accomplished easily using split barrel samplers as the specimen is available readily for viewing, physical inspection and subsampling when the barrel is opened. Clean, decontaminate, and reassemble the sampler. Reattach the sampler to the extension rod, add the necessary extension rod and outer casing to reach the next sampling interval, and sound the borehole for free water before each sample interval. If water is present, it may be necessary to change sampling tools. Unequal pressure inside the casing may result in blow-in of material disturbing the soil immediately below the casing. Lower the sampler to its proper position, add the drive heads, and repeat the procedure. If it is desired that the pass through certain strata without sampling, install an extension rod point in lieu of the sampler. When the sampling interval is reached, remove the point and install the sampler. Advance the sampler as described. Upon completion of the borehole, remove the outer casing after instrumentation has been set or as the borehole is sealed as described in Section 10 (6).

9.3.2 Two Tube System—Other Samplers:

9.3.2.1 *Thin Wall Tubes*—Thin wall tubes (see Fig. 10) can be used with the dual tube system. Attach the tube to the tube head using removable screws. Attach the tube assembly to the extension rods and position at the base of the outer casing shoe protruding a minimum of 0.25 in. (6.25 mm) to contact the soil ahead of the outer casing. Advance the tube, with or without the outer casing, at a steady rate similar to the requirements of Practice D 1587. At completion of the advancement interval, let the tube remain stationary for 1 min. Rotate the tube slowly two revolutions to shear off the sample. Remove the tube from the borehole, measure recovery, and classify soil. The thin wall tube can be field extruded for on-site analysis or sealed in accordance with Practice D 4220 and sent to the laboratory for

processing. Samples for environmental testing generally require the subsampling and preservation of samples in controlled containers. Soil samples generally are removed from the sampling device for storage and shipping. Thin wall tubes should be cleaned and decontaminated before and after use.

9.3.2.2 *Thin Wall Tube Piston Sampler* (see Fig. 11)—Check the fixed piston sampling equipment for proper operation of the cone clamping assembly and the condition of the sealing “O” rings. Slide the thin wall tube over the piston, and attach it to the tube head. Position the piston at the sharpened

end of the thin wall tube just above the sample relief bend. Attach the sampler assembly to the extension rods, and lower the sampler into position through the outer casing. Install the actuator rods through the extension rod, and attach to the actuator rod in the sampler assembly. Attach a holding ring to the top of the actuator rod string, and hook the winch cable or other hook to the holding ring to hold the actuator rods in a fixed position. Attach the pushing fork to the drill head/probe hammer, and slowly apply downward pressure to the extension rods advancing the thin wall tube over the fixed piston into the

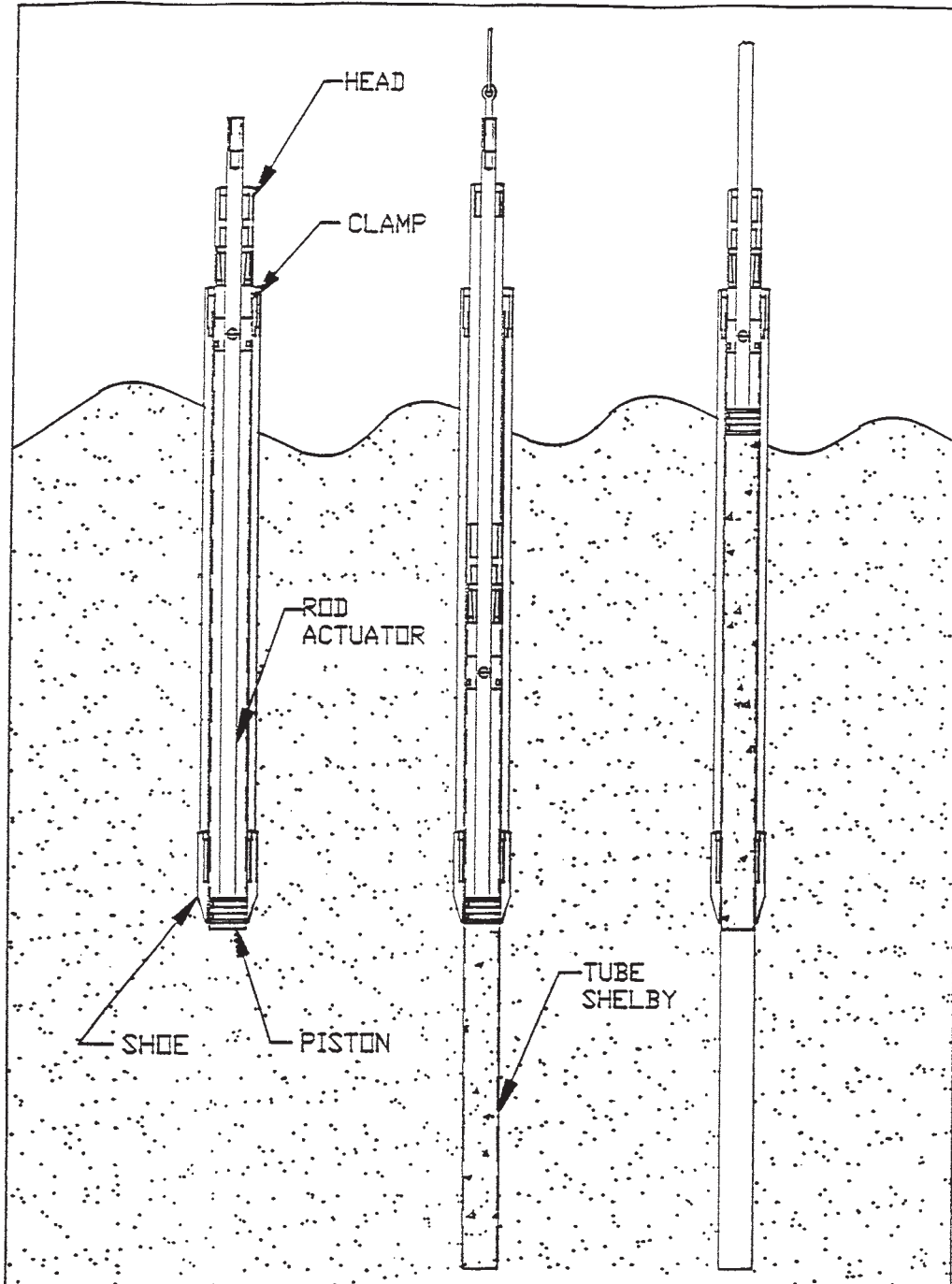


FIG. 11 Fixed Piston Sampler, Two Tube System

soil for the sample increment. Rest sampler 1 min to allow sample to conform to tube. Rotate tube one revolution to shear off sample. Remove sampler assembly from borehole and process sample (6).

9.3.2.3 Open Solid Barrel Samplers—Use solid barrel samplers in advance of the outer casing where the soil conditions could cause swelling of split barrel samplers, or where friction against the outer casing precludes its advancement and sampling must still be accomplished. The solid, single, or segmented barrel sampler requires the use of liners for removal of the sample. The sampler must be cleaned and decontaminated before use. Use of the sampler follows the procedure described in 9.3.1.

9.4 Single Tube System:

9.4.1 Open Solid Barrel Sampler (see Figs. 5 and 6)—Attached the required liner to the cutting shoe by insertion into the machined receptacle area or by sliding over the machined tube. Insert the liner and shoe into the solid barrel, and attach the shoe (6, 8-11). Attach the sampler head to the sampler barrel providing a backing plate for the liner. Attach the sampler assembly to the drive rod and the drive head to the drive rod. Position the assembly under the hammer anvil and advanced as described in 9.3.1. At completion of the sampling increment, remove the sampler from the borehole. Remove the filled sample liner from the barrel by unscrewing the shoe, cap the liner for laboratory testing or spit open for field processing, and advance the borehole by repeating the procedure. Because the solid barrel cannot be opened for cleaning, it may require more effort for cleaning and decontamination. The open solid barrel sampler is used in soil formations that have sufficient wall strength to maintain a borehole wall without sloughing or cave-in. In soil formations not affording such structure, other sampling methods may be required or the opening sealed. To enhance recovery in some soil strata, it may be necessary to vary the length of the sampling increment. Shorter increments generally improve recovery because of lower sample friction and compression inside the sampler chamber. Sample recovery can be enhanced in some formations by intermittent use of the percussion hammer (6, 8, 10, 11).

9.4.2 Closed Solid Barrel Sampler (see Figs. 5-7, Fig. 11)—Insert or attach the sample liner to the shoe, and insert the assembly into the solid barrel sampler. Install sample retaining basket if desired. Attach the latch coupling or sampler head to the sampler barrel, and attach the piston assembly with point and “O” rings if free water is present, to the latching mechanism or holder. Insert the piston or packer into the liner to its proper position so the point leads the sampler shoe. Set latch, charge packer, or install locking pin, and attach assembled sampler to drive rod. Add drive head and position under the hammer anvil. Apply down pressure, hammer if needed, to penetrate soil strata above the sampling zone. When the sampling zone is reached, insert the piston latch release and recovery tool, removing the piston, or insert the locking pin removal/extension rods through the drive rods, turn counter-clockwise, and remove the piston locking pin so the piston can float on top of the sample, or release any other piston holding device. Direct push or activate the hammer to advance the sampler the desired increment. Retrieve the sampler from the

borehole by withdrawing the extension/drive rods. Remove the shoe, and withdraw the sample liner with sample for processing. Clean and decontaminate the sampler, reload as described, and repeat the procedure. Extreme stress is applied to the piston when driving through dense soils. If the piston releases prematurely, the sample will not be recovered from the correct interval, and a resample attempt must be made. The piston sampler can be used as a re-entry grouting tool for sealing boreholes on completion if it is equipped with a removable piston (5, 6, 7, 10, 11).

9.4.3 Standard Split Barrel Sampler—Attach the split spoon to an extension rod or drill rod. Using a mechanical or hydraulic hammer drive the sampler into the soil the desired increment, as long as that increment does not exceed the sampler chamber length. Remove the sampler from the borehole, disassemble, and process sample. Standard split barrel samplers can be used, as long as borehole wall integrity can be maintained and the additional friction can be overcome. If caving or sloughing occurs, the sampler tip should be sealed or other sampling tools used (9).

9.5 Quality Control:

9.5.1 Quality Control—Quality control measures are necessary to ensure that sample integrity is maintained and that project data quality objectives are accomplished. By following good engineering principles and applying common sense, reliable site characterizations can be accomplished.

9.5.2 Water Checks—Water seeping into the direct push casing or connecting rods from contaminated zones may influence testing results. Periodically check for ground water before inserting samplers into borehole or into outer casings in the two tube system. If water is encountered, it may be necessary to switch to the sealed piston type samplers to protect sample integrity. Sealed piston type samples may not always be water tight. Sealing of rod or casing joints can prevent ground water from entering through the joints.

9.5.3 Datum Points—Establishment of a good datum reference is essential to providing reliable sample interval depths and elevators. Select datum reference points that are sufficiently protected from the work effort, and that can be located for future reference. Field measurements should be to 0.1 ft (3.05 mm). Measure extension rods as the bore advances to locate sample depth. Mark rods before driving each sample interval to determine accurate measurement of sample recovery and to accurately log borehole depth.

9.5.4 Sample Recovery—Sample recovery should be monitored closely and results documented. Poor recovery could indicate a change in sampling method is needed, that improper sampling practices are being conducted, or that sampling tools are incorrect. Sample recovery involves both volume and condition. Poor sample recovery should cause an immediate review of the sampling program.

9.5.5 Decontamination—Follow established decontamination procedures. Taking shortcuts may result in erroneous or suspect data.

10. Completion and Sealing

10.1 Completion—For boreholes receiving permanent monitoring devices, completion should be in accordance with Practice D 5092, site work plan, or regulatory requirements.

10.2 Borehole Sealing—Seal direct push boreholes to minimize preferential pathways for containment migration. Additional information and guidance on borehole sealing can be found in Guide **D 6001** and in Guide **D 5299**. State or local regulations may control both the method and the materials for borehole sealing. Regulations generally direct bottom up borehole sealing as it is the surest and most permanent method for complete sealing. High pressure grouting is available for use with direct push technology for bottom up borehole sealing.

10.2.1 Sealing by Slurry, Two Tube System—Sound the borehole for free water. If water exists in the casing, place the extension rods, open-ended, to the bottom of the outer casing, as a tremie. Mix the slurry to standard specifications prescribed by regulation or work plan. Pump slurry through the extension/drive rod until it appears at the surface of the outer casing. Remove the extension rods. If no free water exists in the borehole, the slurry can be placed by gravity. Top off the outer casing as it is removed from the borehole.

10.2.1.1 Slurry Mixes—Slurry mixes used for slurry grouting of direct push boreholes generally are of lower viscosity because of the small diameter tremie pipes required. Usable mixes are 6 to 8 gal (22.7 to 30.28 L) of water/94-lb (42.64-kg) bag of cement with 5 lb (2.27 kg) of bentonite or 24 to 36 gal (90.84 to 136.28 L) of water to 50 lb (22.68 kg) of bentonite.

10.2.2 Sealing by Gravity—Two Tube System—Measure the cased hole to ensure it is open to depth. Slowly add bentonite chips or granular bentonite to fill the casing approximately 2 ft. Withdraw the casing 2 ft and recheck depth. Hydrate the bentonite by adding water. Repeat this procedure as the outer casing is withdrawn. The bentonite must be below the bottom of the casing during hydration. Wetness inside the rods may affect the flow of granular bentonite to the bottom of the casing. Fill the top foot of the borehole with material that is the same as exists in that zone.

10.2.3 Borehole Sealing Single Tube System:

10.2.3.1 Gravity Sealing from Surface—If the soil strata penetrated has sufficient wall strength to maintain an open hole, then it may be possible to add sealing materials from the surface. Dry bentonite chips or granular bentonite can be placed by gravity. The borehole volume should be determined and the borehole sounded every 10 ft (3 m) to ensure bridging has not occurred. The bentonite should be hydrated by adding approximately 1 pt (0.57 L) of water for each 5 ft of filled borehole. Seal the surface with native material.

10.2.3.2 Wet Grout Mix Tremie Sealing—Tremie sealing methods can be used with single tube systems when borehole wall strength is sufficient to maintain an open hole or when extension rods with an expendable point are used to reenter the borehole. The grout pipe should be inserted immediately after the direct push tools are withdrawn or through the annulus of the extension rods that have been reinserted down the borehole for grouting. Care must be taken to not plug the end of the grout pipe. Side discharge grout pipes also can be used to prevent plugging.

10.2.4 Re-Entry Grouting—If the borehole walls are not stable, the borehole can be re-entered by static pushing grouting tools, such as an expendable point attached to the extension/drive rods to the bottom of the original borehole. Pump a slurry through the rods as they are withdrawn. High pressure grouting equipment may be beneficial in pumping standard slurry mixes through small diameter gravity pipes. Care must be taken to ensure the original borehole is being sealed.

11. Record Keeping

11.1 Field Report—The field report may consist of boring log or a report of the sampling event and a description of the sample. Soil samples can be classified in accordance with Practice **D 2488** or other methods as required for the investigation (**12**). Prepare the log in accordance with standards set in Guide **D 5434** listing the parameters required for the field investigation program. List all contaminants identified, instrument readings taken, and comments on sampler advancement. Record any special field tests performed and sample processing procedures beyond those normally used in the defined investigation. Record borehole sealing procedures, materials used, and mix formulas on the boring log. Survey or otherwise locate the boring site to provide a permanent record of its replacement.

11.2 Backfilling Record—Record the method of sealing, materials used, and volume of materials placed in each borehole. This information can be added to the field boring log or recorded on a separate abandonment form.

12. Keywords

12.1 decontamination; direct push; ground water; sealing; soil sampling



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Standard Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling¹

This standard is issued under the fixed designation D 6151; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice covers how to obtain soil samples using hollow-stem sampling systems and use of hollow-stem auger drilling methods for geotechnical exploration. This practice addresses how to obtain soil samples suitable for engineering properties testing.

1.2 In most geotechnical explorations, hollow-stem auger drilling is combined with other sampling methods. Split barrel penetration tests (Test Method D 1586) are often performed to provide estimates of engineering properties of soils. Thin-wall tube (Practice D 1587) and ring-lined barrel samples (Practice D 3550) are also frequently taken. This practice discusses hole preparation for these sampling events. For information on the sampling process, consult the related standards. Other in situ tests, such as the vane shear Test Method D 2573, can be performed below the base of the boring by access through the drill string.

1.3 This practice does not include considerations for geoenvironmental site characterizations and installation of monitoring wells which are addressed in Guide D 5784.

1.4 This practice may not reflect all aspects of operations. It offers guidance on current practice but does not recommend a specific course of action. It should not be used as the sole criterion or basis of comparison, and does not replace or relieve professional judgment.

1.5 *Hollow-stem auger drilling for geotechnical exploration often involves safety planning, administration, and documentation. This standard does not purport to specifically address exploration and site safety. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to its use.* Performance of the test usually involves use of a drill rig, therefore, safety requirements as outlined in applicable safety standards, for example OSHA (Occupational Health and Safety Administration) regulations, DCDMA safety manual (1),² drilling safety manuals, and other applicable state and local regulations must be observed.

¹ This practice is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Investigations.

Current edition approved August 10, 1997, Published December 1997.

² The boldface numbers in parentheses refer to the references at the end of this practice.

2. Referenced Documents

2.1 ASTM Standards:

D 420 Guide to Site Characterization for Engineering, Design, and Construction Purposes³

D 653 Terminology Relating to Soil, Rock, and Contained Fluids³

D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)³

D 5434 Guide for Field Logging of Subsurface Explorations of Soil and Rock³

2.2 Standards for Sampling of Soil and Rock:

D 1452 Practice for Soil Investigation and Sampling by Auger Borings³

D 1586 Test Method for Penetration Test and Split-Barrel Sampling of Soils³

D 1587 Practice for Thin-Walled Tube Geotechnical Sampling of Soils³

D 2113 Practice for Diamond Core Drilling for Site Investigation³

D 3550 Practice for Ring-Lined Barrel Sampling of Soils³

D 4220 Practice for Preserving and Transporting Soil Samples³

D 4700 Guide for Soil Sampling from the Vadose Zone³

D 5079 Practices for Preserving and Transporting Rock Core Samples³

2.3 In situ Testing:

D 2573 Test Method for Field Vane Shear Test in Cohesive Soils³

D 3441 Test Method for Deep, Quasi Static, Cone and Friction-Cone Penetration Tests of Soil³

D 4719 Test Method for Pressuremeter Testing in Soils³

2.4 Instrument Installation and Monitoring:

D 4428 Test Methods for Crosshole Seismic Testing³

D 4750 Test Method for Determining Subsurface Liquid Levels in a Borehole or Monitoring Well (Observation Well)³

D 5092 Practice for Design and Installation of Ground Water Monitoring Wells in Aquifers³

2.5 Drilling Methods:

D 5784 Guide for the Use of Hollow-Stem Augers for

³ Annual Book of ASTM Standards, Vol 04.08.

Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices⁴
D 5876 Guide for the Use of Direct Rotary Wireline Casing Advancement Drilling Methods for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices⁴

3. Terminology

3.1 *Definitions*: Terminology used within this practice is in accordance with Terminology D 653 with the addition of the following (see Figs. 1-5 for typical system components):

3.1.1 *auger cutter head*—the terminal section of the lead auger equipped with a hollow cutting head for cutting soil. The cutter head is connected to the lead auger. The cutter head is equipped with abrasion-resistant cutting devices, normally with carbide surfaces. The cutter can be teeth (usually square or conical), or blades (rectangular or spade design). Cutter head designs may utilize one style cutter or a combination of cutters.

3.1.2 *bit clearance ratio*—a ratio, expressed as a percentage of the difference between the inside diameter of the sampling

⁴ Annual Book of ASTM Standards, Vol 04.09.

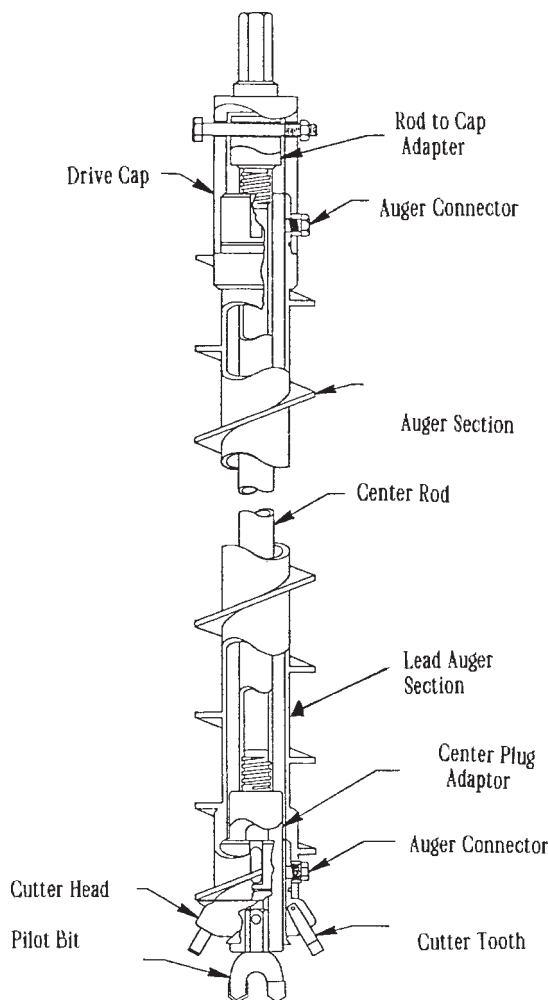


FIG. 1 Rod-Type Auger System With Pilot Bit⁶

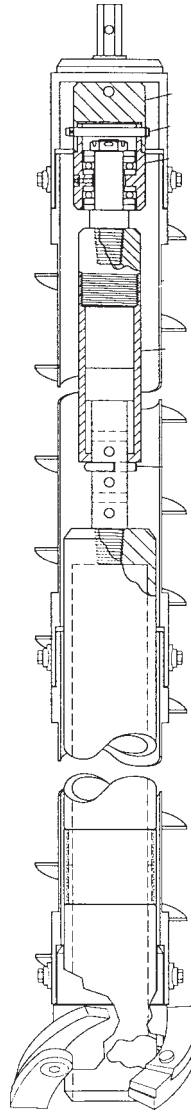


FIG. 2 Example of Rod-Type Sampling System⁵

tube and the inside diameter of the cutting bit divided by the inside diameter of the sampling tube.

3.1.3 *blow-in*—(Practice D 5092)—the inflow of groundwater and unconsolidated material into the borehole or casing caused by differential hydraulic heads; that is, caused by the presence of a greater hydraulic head outside the borehole/casing than inside. Also known as *sanding in* or *soil heave*.

3.1.4 *clean out depth*—the depth to which the end of the drill string (bit or core barrel cutting end) has reached after an interval of drilling. The clean out depth (or drilled depth as it is referred to after cleaning out of any sloughed material or cuttings in the bottom of the drill hole) is normally recorded to the nearest 0.1 ft. (0.03 m).

3.1.5 *continuous sampling devices*—sampling systems which continuously sample as the drilling progresses. Hollow-stem sampling systems are often referred to as continuous samplers because they can be operated in that mode. Hollow-stem sampling systems are double-tube augers where barrel-type samplers fit within the lead auger of the hollow auger column. The double-tube auger operates as a soil coring system

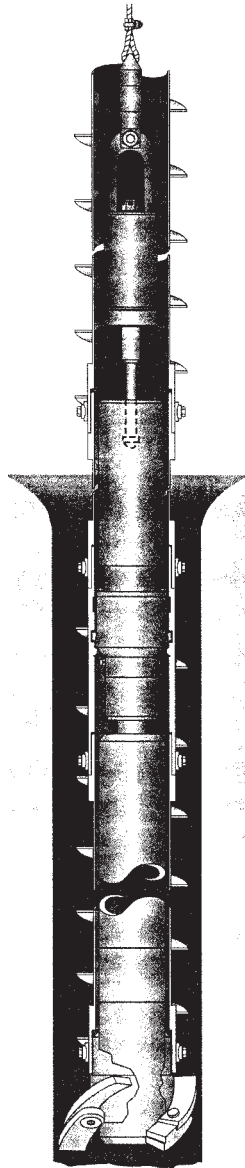


FIG. 3 Example of Wireline Sampling System⁵

in certain subsurface conditions where the sampler barrel fills with material as the augers advance. The barrel can be removed and replaced during pauses in drilling for continuous coring.

3.1.6 *double-tube auger*—an auger equipped with an inner barrel for soil sampling (soil coring). If equipped with an inner barrel and liner, the auger system can be described as a triple-tube auger.

3.1.7 *drill hole*—a cylindrical hole advanced into the subsurface by mechanical means. Also known as borehole or boring.

3.1.8 *drill string*—the complete drilling assembly under rotation including augers, core barrel or pilot bit, drill rods, and connector subassemblies. Drilling depth is determined by

knowledge of the total length of the drill string, and by subtracting the string length above a ground surface datum.

3.1.9 *fluid injection devices*—pumps, fittings, hose and pipe components, or drill rig attachments that may be used to inject a fluid within a hollow auger column during drilling.

3.1.10 *HSA*—Hollow stem auger(s). See 3.1.11.

3.1.11 *hollow stem auger*—a cylindrical hollow tube with a continuous helical fluting/fighting on the outside, which acts as a screw conveyor to lift cuttings produced by an auger drill head or cutter head bit to the surface.

3.1.12 *in-hole-hammer*—a drop hammer for driving a soil sampling device. The in-hole hammer is designed to run down-hole within the HSA column. It is usually operated with

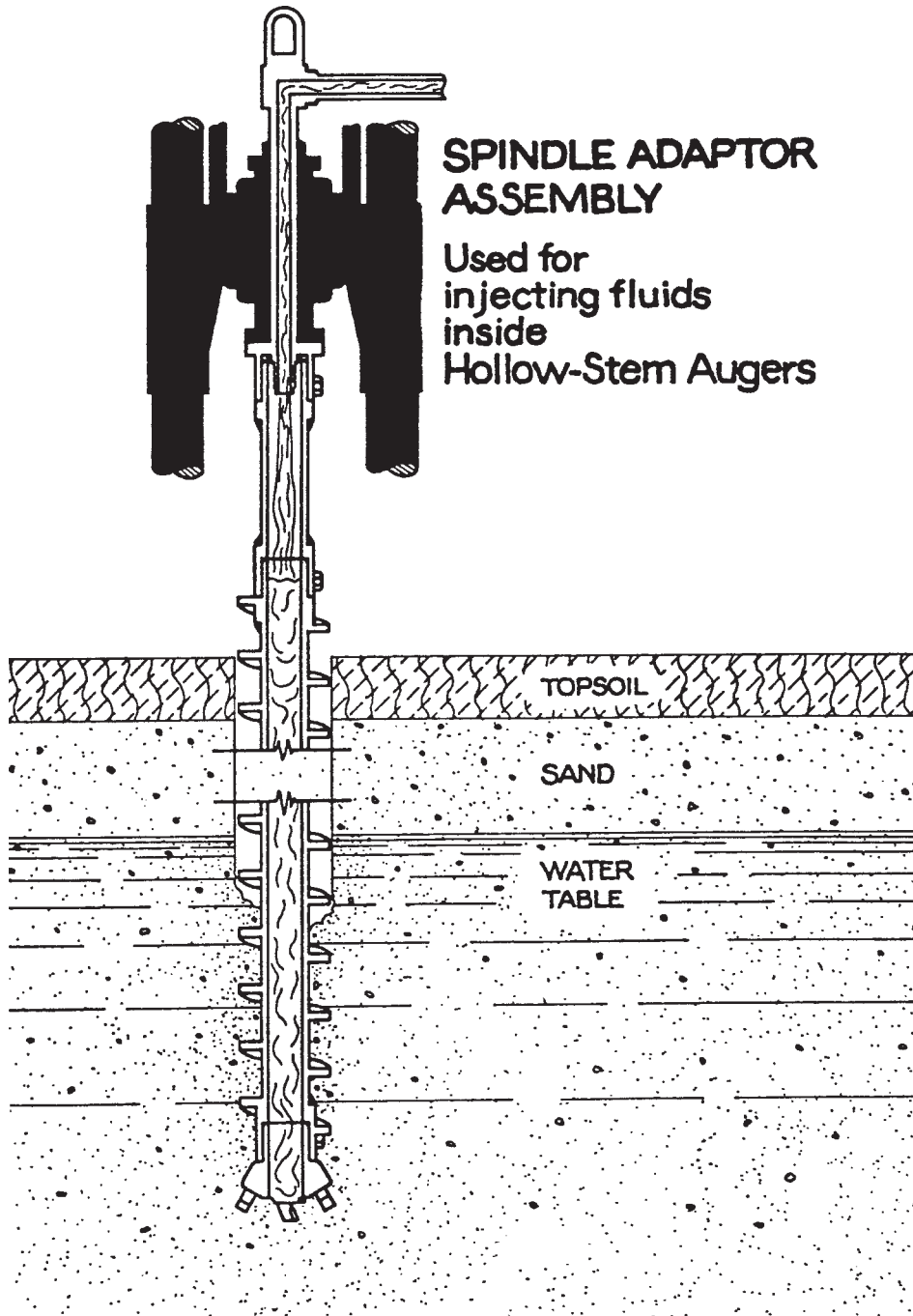


FIG. 4 Spindle Adaptor Assembly

a free-fall wireline hoist capable of lifting and dropping the hammer weight to drive the sampler below the HSA column and retrieve the hammer and sampler to the surface. See Fig. 6⁵

3.1.13 *in situ testing devices*—sensors or probes, used for obtaining test data for estimation of engineering properties, that are typically pushed, rotated, or driven in advance of the hollow auger column assembly at a designated depth or advanced simultaneously with advancement of the auger column (see 2.3).

3.1.14 *intermittent sampling devices*—barrel-type samplers that may be rotated, driven, or pushed below the auger head at a designated depth prior to advancement of the auger column (see 2.2).

3.1.15 *lead auger assembly*—the first hollow stem auger to be advanced into the subsurface. The end of the lead auger assembly is equipped with a cutter head for cutting. The lead auger may also contain a pilot bit assembly or sample barrel assembly housed within the hollow portion of the auger. If a wireline system is used, the lead auger assembly will have an adapter housing on top of the first auger containing a latching

⁵ Foremost Mobile, Mobile Drilling Company Inc., 3807 Madison Avenue, Indianapolis, IN.

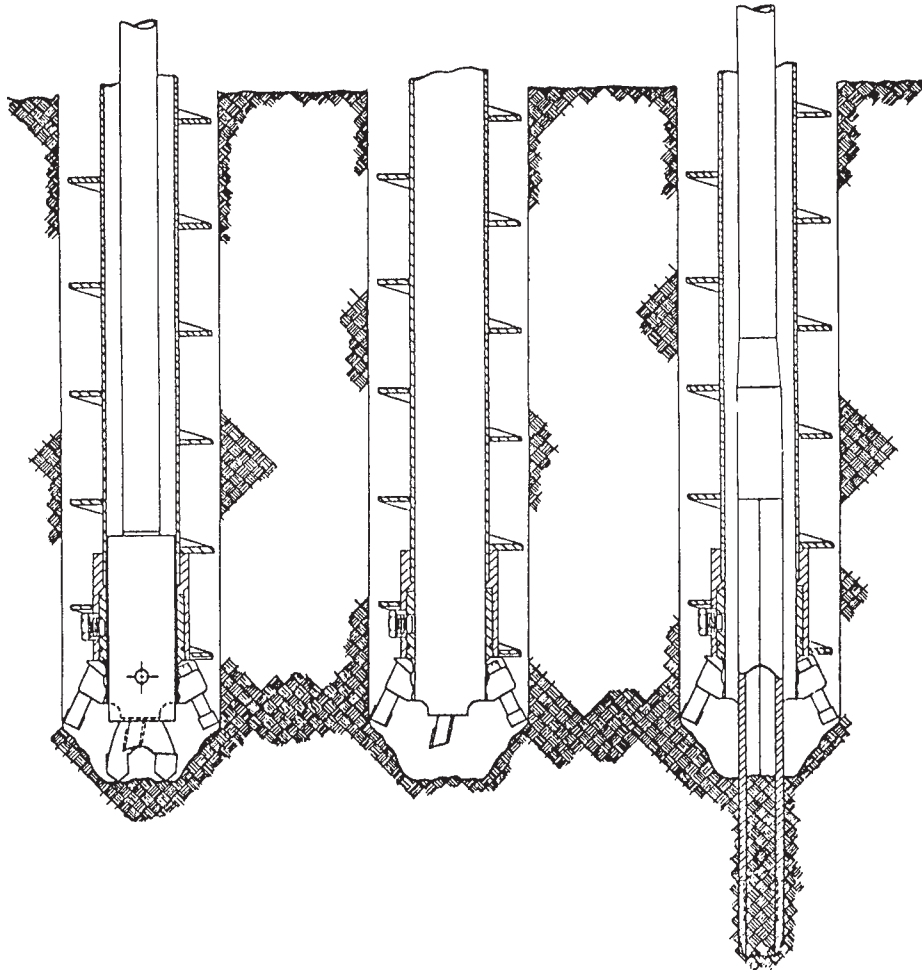


FIG. 5 Example of Drive Case Sampling Through HSA

device for locking the pilot bit assembly or sampling core barrel into the lead auger assembly.

3.1.16 *lead distance*—the mechanically adjusted length or distance that the inner core barrel cutting shoe is set to extend beyond the lead auger assembly cutting head.

3.1.17 *overshot*—a latching mechanism located at the end of the hoisting line (wireline). It is specially designed to latch onto or release the pilot bit or core barrel assemblies. It serves as a lifting device for removing the pilot bit or sampler assembly.

3.1.18 *O-ring*—a rubber ring for preventing leakage between joining metal connections, such as hollow-stem auger sections.

3.1.19 *percent recovery*—percentage which indicates the success of sample retrieval, calculated by dividing the length of sample recovered by the length of sampler advancement.

3.1.20 *pilot bit assembly*—an assembly designed to attach to a drill rod or lock into the lead auger assembly for drilling without sampling. The pilot bit can have various configurations (drag bit, roller cone, tooth bit, or combination of designs) to aid in more efficient or rapid hole advancement.

3.1.21 *recovery length*—the length of sample actually retrieved during the sampling operation.

3.1.22 *sanding in*—a condition that occurs when sand or silt enters the auger after removal of the pilot bit or sampling

barrel. See *blow-in*. Sanding in can occur from hydrostatic imbalance or by suction forces caused by removal of the pilot bit or sampling barrel.

3.1.23 *slough*—the disturbed material left in the bottom of the borehole, usually from falling off the side of the borehole, or falling out of the sampler, or off of the auger.

3.1.24 *soil coring, hollow-stem*—The drilling process of using a double-tube HSA system to intermittently or continuously sample the subsurface material (soil).

3.1.25 *wireline drilling, hollow-stem*—a rotary drilling process using a lead auger which holds a pilot bit or sampling barrel delivered and removed by wireline hoisting. Latching assemblies are used to lock or unlock the pilot bit or sampler barrel. The pilot bit or core barrel is raised or lowered on a wireline cable with an overshot latching device.

4. Significance and Use

4.1 Hollow-stem augers are frequently used for geotechnical exploration. Often, hollow-stem augers are used with other sampling systems, such as split barrel penetration resistance testing, Test Method D 1586, or thin-wall tube sampling, Practice D 1587 (see 2.5). Hollow-stem augers may be used to advance a drill hole without sampling using a pilot bit assembly, or they may be equipped with a sampling system for obtaining soil cores. In some subsurface conditions that contain

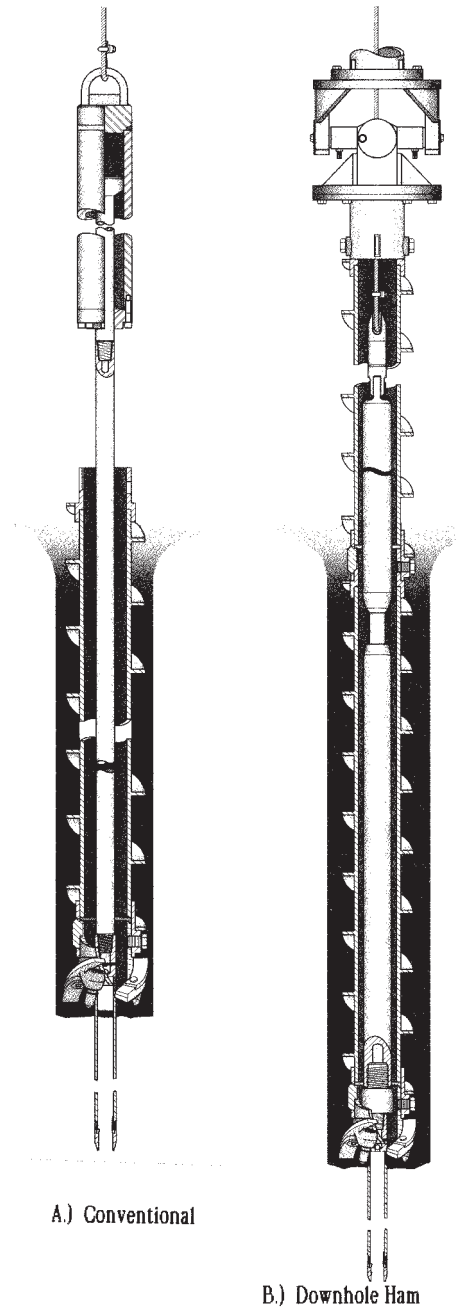


FIG. 6 In-Hole-Hammer and Conventional Drive Hammer⁵

cohesive soils, the drillhole can be successfully advanced without the use of a pilot bit assembly. Intermittent drilling (advancing of the HSA column with or without a pilot bit) and sampling can be performed depending on the intervals to be sampled, or continuous sampling can be performed. During pauses in the drilling and sampling process, in situ testing or other soil sampling methods can be performed through the hollow auger column below the lead auger assembly. At completion of the boring to the depth of interest, the hole may be abandoned or testing or monitoring devices can be installed. Hollow-stem auger drilling allows for drilling and casing the hole simultaneously, thereby eliminating hole caving problems and contamination of soil samples (2). The hollow-stem auger

drilling and sampling method can be a satisfactory means for collecting samples of shallow unconsolidated subsurface materials (2). Additional guidance on use can be found in Refs. 2, 3, 4, 5, 6.

4.2 Soil sampling with a double-tube hollow-stem sampling system provides a method for obtaining continuous or intermittent samples of soils for accurate logging of subsurface materials to support geotechnical testing and exploration. A wide variety of soils from clays to sands can be sampled. The sampling systems can be particularly effective in dry soft to stiff clayey or silty deposits but also can work well under saturated conditions. Saturated cohesionless soils such as clean sands may flow and cave during drilling (see Note 1). In many



cases, the HSA soil core sampling system can produce very little disturbance to the sample and can provide samples for laboratory tests for measurement of selected engineering properties. Large-diameter soil cores, if taken carefully, can provide Class C and D samples as described in Practice D 4220. The HSA systems can also provide disturbed samples of unsaturated sands and gravels with some structure preserved. Full 5-ft (1.5-m) long cores usually cannot be obtained in unsaturated sands due to increasing side wall friction between the dry sands and inside surface of the sample core barrel. Sample length of 2 to 2.5 ft. (0.60 to 0.75 m) is generally the limit of amount of sample that can be recovered in unsaturated sands before the friction between the sampler and the sand becomes too high and causes blocking or plugging of the sampler. Shorter large diameter core runs of 2.5 ft with the 5-ft sample barrel system, or with a 2.5-ft sample barrel system, have generally proven to result in the best samples.

NOTE 1—Research on thin-wall piston sampling in clean sands indicates that in general it is impossible to obtain truly undisturbed samples of saturated clean sands. These soils can dilate or collapse upon insertion of a sampling tube. The hollow-stem auger double-tube system can only obtain partially disturbed samples of sands below the water table.

4.3 Hollow-stem auger drilling is considered a shallow drilling method with maximum depth of drilling of 200 to 300 ft (60 to 90 m) depending on torque and pull down/retract capacity of the drilling equipment and subsurface conditions of the formation(s) encountered. Saturated loose unconsolidated deposits further limit maximum depth that can be attained. Hollow-stem augers can act as casings set through unconsolidated surficial soils and drilling can be converted to other methods (see 2.5) for deeper drilling.

4.4 Drilling and soil sampling can be accomplished with a variety of hollow-stem auger systems. Types of systems can be chosen depending on the advantages of handling, sampling requirements, and subsurface conditions. There are two basic types of systems. One type of system uses inner drill rods or hex rods connecting the sampler or pilot bit assembly to the surface for advancing and retrieving the sampler barrel or pilot bit assembly (Fig. 1⁶ and Fig. 2⁵). Another system uses a wireline latching system in the HSA column to lower, latch, and retrieve a core barrel or pilot bit assembly (Fig. 3⁵).

4.5 Double tube hollow-stem auger sampling systems can be particularly advantageous for sampling water-sensitive soils, such as collapsible soils, since fluid is not used in the drilling process. Since no pressurized circulation medium is used during the drilling process, the possibility for hydraulic fracturing of formation materials and core contamination from drill fluids is reduced.

4.6 Difficulties in drilling may occur if cohesionless soils are drilled below the water table. Possibilities for sand lock or wedging of cuttings may occur (2). In cases where sands enter the HSA, water or drilling fluid may be added to the HSA column to provide hydrostatic balance or special pilot bit assemblies can be used (see 5.6). Problems may occur in getting the soil core barrel or pilot bit assembly back to the

bottom of the HSA column. Highly saturated sands or liquefiable material may be drawn into the HSA by vacuum created when the sampler barrel or pilot bit assembly is initially pulled back through the cutter head of the lead auger assembly from the bottom of the borehole.

4.7 Consideration should be given to proper decontamination and cleaning of drilling equipment, hollow-stem augers, samplers, and soil coring components.

5. Apparatus

5.1 Fig. 1 illustrates the components of a hollow-stem auger used with a pilot bit for hole advancement using a center-inner rod system. Figs. 2 and 3 illustrate hollow-stem augers equipped for soil sampling in either a rod-type or wireline system. Hollow-stem auger systems consist of rotating outer hollow-stem augers and a cutter head assembly, with either a center pilot bit or a nonrotating inner sample barrel with a smooth cutting shoe.

5.2 *Hollow-stem Augers*—Each auger section of the hollow-stem auger assembly consists of a cylindrical steel tube with continuous helical steel flights rigidly attached to the outer surface of the tube (see Fig. 1). Each hollow auger section has a coupling at each end for attaching additional auger sections at the top end to make up the articulated hollow-stem auger column. The bottom of the lead auger has a coupling attachment for the cutter head. Typical hollow-stem auger inside diameters are $2\frac{1}{4}$, $3\frac{1}{4}$, $3\frac{3}{8}$, $4\frac{1}{4}$, $4\frac{5}{8}$, $6\frac{1}{4}$, $6\frac{5}{8}$, and range up to $12\frac{1}{4}$ in. (57, 83, 86, 108, 117, 159, 168, and 311 mm). Outside diameters of the auger flights range from 5 to 18 in. (127 to 457 mm). Typical HSA double-tube sample inside diameters range from 2.25 to 6.85 (57 to 174 mm). Hollow-stem augers are normally supplied in 5-ft (1.5-m) lengths. The helical auger flights are often hard surfaced for better wearing characteristics.

5.2.1 *Diameter Requirements*—The inside diameter of the hollow-stem auger system is selected by considering sample size requirements, intermittent sampling and in situ testing tool size, and completion requirements. For undisturbed sampling, larger-diameter systems generally produce less disturbance (6). For logging purposes, where a disturbed sample is sufficient, smaller diameters are selected. The inside diameter of the hollow stem must be large enough to insert intermittent sampling or in situ testing devices if used (sec 2.2 and 2.3). When using sampling methods such as split barrel, Method D 1586, or thin-wall tube Test Method D 1587, the inside diameter of the hollow-stem should be at least 0.25 in. (6 mm) larger than the sampler outside diameter or rod diameter, which ever is largest. If other drilling methods (see 2.5) are to be used, the inside diameter of the HSA drill string should be selected to accommodate those tools. If special completion is required, such as piezometer or well casing installation, the diameter should be large enough for placing completion materials. For example, if a 2-in. (50 mm) riser pipe is to be completed for shear wave velocity testing in accordance with Test Methods D 4428, consideration of clearance for tremie pipes may also increase diameter requirements. If the lead auger section contains a stabilizer ring, this clearance may govern available diameter for sampling, testing, or completion (see 5.4.1).

⁶ Modified from Central Mine Equipment Company, 4215 Rider Trail North, Earth City, MO.

5.2.2 Auger Connections—Augers are connected using either locking bolts, drive pins, locking collars, or threaded connections. In some cases when drilling saturated soils, water entering the augers may cause difficulty with drilling or sampling. Hollow-stem augers may be used with O-ring seals or other sealing designs at the HSA connections to prevent leakage. Some HSA connection designs have compression seals and bolt caps to facilitate sealing between auger connections. This can prevent soil or water ingress through the auger connecting joints (in certain drilling conditions) and the accumulation of a high solids slurry in the bottom of the HSA column that may interfere with the latching system for retrieval and placement of sample barrel assembly by means of the wireline/overshot system

5.3 Drive Cap—The drive cap assembly (see Fig. 1) attaches to the uppermost hollow-stem auger section and transfers rotary power and axial force from the drill rig to the auger drill string assembly.

5.4 Lead Auger Section—The lead auger has a hollow cutter head. The cutter head is attached to the lead auger of the hollow auger column and usually contains replaceable, abrasion-resistant cutters or teeth (see Fig. 1). As the hollow auger head is rotated, it cuts and directs the cuttings to the auger flights which convey the cuttings to the surface. The cutters can be made of hardened steel or carbide and in several designs. Cutter head types should be selected to effectively remove cuttings and minimize soil disturbance when sampling. The cutter head or cutter teeth, or both, should be replaced if worn or damaged.

5.4.1 If a wireline system is used, there can be an adapter coupling on top of the lead auger and may contain inside barrel grooves or recesses for latching systems for wireline tooling.

5.4.2 A stabilizer ring may be used (usually made of brass) in the end of the HSA cutter head opening. The stabilizer ring is machined to a close tolerance to be slightly larger than the outside diameter of the sample barrel or pilot bit. The actual opening of the end of the HSA column at the cutter head is smaller with this stabilizer ring than the normal designated inside diameter of the HSA being used. The stabilizer ring keeps the sample barrel centered in the middle of the HSA cutter head and prevents material that may interfere with the sample barrel remaining stationary from lodging around the barrel and shoe and between the full opening of the HSA cutter head. In some cases, in unstable soils the vacuum created during removal of the pilot bit through a stabilizer ring may produce sanding in. In these cases, provisions for venting may be required.

5.5 Sampler or bit retrieval system:

5.5.1 Rod-type System (Fig. 1 and Fig. 2)—The sampler or pilot bit can be inserted into the lead auger using a system of inner rods. The inner rods are typically AW, or NW size (7) or hex rods. Rods are supplied in the same lengths as the hollow-stem augers.

5.5.2 Wireline system, In-hole-hammer—The sampler or pilot bit can be inserted into the lead auger by using a free-fall wireline cable hoist capable of lifting and dropping the hammer weight down the hole within the HSA column to drive the sampler below the HSA column. This wireline method can also

be used in conjunction with a drilling rig with an open spindle rotary head to allow the wireline and in-hole-hammer with the proper bit to act as a pilot bit assembly while advancing the HSA column. The weight of the hammer and pilot bit is allowed to float within the HSA column and advance with the cutter head and lead auger section to deter material from entering the HSA column.

5.5.3 Wireline System, Double-tube HSA (Fig. 3)—The sampler or pilot bit is raised and lowered using a wireline and latching mechanism. A wireline system may consist of a latching lead auger section, a locking or latching head assembly above the sample barrel or pilot bit, and an overshot (retrieving tool) that locks into the locking head assembly to hoist and lower the sample barrel or pilot bit assembly through the HSA column.

5.6 Pilot Bit Assembly—The pilot bit assembly can be a machined plug with a bit attached to the bottom to enhance cutting when used with the cutter head of the HSA and to keep material from entering the hollow-stem auger. Another version is a center auger with left-handed flighting to provide a downward spiral rotation in the middle of the HSA drill string. This left hand flighting keeps material from entering the HSA drill string forcing the parent material down and to the outside of the main auger. While the HSA drill string is rotating and drilling, the material displaced by the left hand flighting is conveying up along the outer flighting away from the cutter head to the surface.

5.7 Hollow-stem Double-tube Auger Sample Barrel Systems—The sampler is suspended in the HSA column and is retained in a stationary position. The head may be made with connections to a latching assembly including a bearing assembly. A bearing assembly helps prevent rotation of the sampler barrel and is especially important for undisturbed sampling. In the wireline system the barrel is connected to a latching and hanger bearing assembly that locks into the HSA column (Fig. 3). In the rod-type system (Fig. 2) the bearing is located either down hole or at the top of the auger column and is connected to drill rods or hex rods extending to the top of the HSA column. The drill rod or hex rod string is connected through the auger drive adapter to the drill rig to provide a means of controlling rotation of the sampler.

5.7.1 The sample barrel may be of various sizes and lengths. The barrel may be used with or without liners. A split barrel without a liner is most often used for easy examination of disturbed soil cores while a barrel with a liner is most often used for preserving specimens for laboratory testing. The liners fit in the inside of the barrel to facilitate sample collection. The sample barrel and HSA are matched with respect to size. The actual sample diameter varies with different manufacturers. The sample diameter is controlled by the inside diameter of the cutting shoe. With some manufacturer's designs, the inside diameter of the cutting shoe varies depending upon the liners used in the sample barrel. To obtain samples with minimal disturbance, care must be taken to ensure a smooth transition from the insides diameter of the cutting shoe to the barrel or liners. There should be no gaps or upset surfaces in the inside clearance. A smaller inside diameter shoe can be used when coring swelling materials, such as stiff clays, to allow for the



sample to swell inside the barrel without blocking. Core swelling may affect engineering properties determinations.

5.7.2 Sample barrels may be 5-ft (1.5-m) long, solid or split, 5-ft long one piece, or two 30-in. (0.75-m) barrels (solid or split), with a coupling to make a 5-ft barrel. The 5-ft barrel length matches the length of the lead HSA section. The shorter 2.5-ft (0.75-m) barrel may be used in place of the 5-ft barrel for shorter sampling runs to reduce disturbance and to facilitate handling.

5.7.3 *Retainers*—Basket retainers are used, if necessary, to prevent the sample from falling out of the barrel during retrieval. They are generally used when sampling some wet clays and wet or dry sands and gravels. The retainers may affect the sample quality.

5.7.4 *Cutting Shoe and Lead Distance*—The sample barrel with cutting shoe is extended beyond the cutter head in varying increments. The shoe is set at or beyond the bottom of the cutter bits, or teeth. The extent of the distance the shoe is set beyond the cutter head is dictated by the stiffness of the material to be sampled (cored). When the sampler cutting shoe is extended beyond the cutter head, the cutting edge of the shoe is being forced down in front of the cutter head before the HSA cutter head cuts the soil away. The HSA column and cutter head is rotating around the double-tube HSA soil coring barrel as the drill rig applies down force and rotation to the HSA soil coring column. The softer the material, the greater the lead distance. The harder the soil, the shorter the lead distance. Adjusting the lead distance for the sample barrel shoe may be done by various methods. Some systems require adjusting the lead distance directly above the sample barrel assembly, some can be adjusted at the top of the HSA column. Examples of adjusting methods include the following: rod subs, adjustable hex extension with U-pins, threaded adjustment with locking nut, special HSA drive adapter with adjusting slots, or different shoe lengths. The length of extension may vary from the shoe being flush (even) with the cutter bits to as much as 6 in. (150 mm) or more.

5.7.5 *Liners*—The sample barrel may be fitted with liners. Liners are nominally one 5-ft (1.5-m) length or two 2½-ft (0.75-m) sections. The liners can be metal, stainless steel, or acrylic. Acrylic tubing provides for visual inspection of the material sampled. Clear liners can sometimes show detailed soil layering, but, in many cases, the core could be smeared or masked by the disturbance. If the purpose of the exploration program is detailed, logging the complete core should be inspected. Liners should be checked for roundness and wall thickness. Acrylic tubing is reusable but should be checked for cracks before reuse.

5.8 Auxiliary components of a HSA system are various devices such as auger connector wrenches, auger forks, hoisting hooks, hoisting assemblies, pipe vices, strap wrenches or chain wrenches, and fluid injection swivels or adapters (Fig. 4).

5.9 A drill rig is used to rotate and advance the auger column. The drill rig must be capable of producing controlled rotation, feed pressure, and feed rate. The drill rig should be capable of applying sufficient power and torque at a rotary velocity of 50 to 100 r/min. The drill rig should have a feed stroke of at least the effective length of the auger sections plus

the effective length of the auger couplings plus about 4 in. (100 mm). As the HSA soil coring systems diameters increase, more torque and pulldown/retract capacities of the drill rig will be required. The subsurface conditions to be explored will also affect the torque and pulldown/retract capabilities required of the drill rig. Conditions such as depth to ground water, cemented or very dense formations, loose sands and gravels, cobbles, cohesiveness of soil, and potential for saturated flowing conditions and heaving sands will affect the depth that can be explored with a drill of any given torque and pulldown/retract capability.

6. Drilling and Sampling Procedures

6.1 *General*—Several drilling approaches are discussed in the following sections. Hollow-stem auger drilling can be performed with a pilot bit to advance a boring. During pauses in drilling, sampling and field testing can be performed at the base of the augers. A section is also devoted to taking continuous or intermittent cores with the double tube auger soil coring method. Any combination of these drilling and sampling methods may be performed in a single boring.

6.2 General Drilling and Sampling Considerations:

6.2.1 *Site Setup*—Stabilize the drill rig, erect the drill rig mast, and attach an initial assembly of hollow-stem auger components (Fig. 1) to the rotary drive of the drill rig. When erecting the mast, check above the drilling rig for overhead obstructions or hazards, such as power lines, prior to lifting the mast. Perform a survey of underground and all other utilities prior to drilling to evaluate possible hazards. Establish and document a datum for measuring hole depth. This datum normally consists of the ground surface, or a stake driven into stable ground surface, or a drilling deck if used. If the hole is to be surveyed later for elevation, record and report the height of the datum to the ground surface.

6.2.2 *Hole Starting*—Push the auger column assembly below the ground surface and initiate rotation at a low velocity. Good practice for starting a straight hole normally requires minimum rotation speed while maintaining firm downward pressure to avoid whipping and widening of the top of the hole (1). An auger guide may be used (if available) to aid in starting the first auger to maintain a straight hole.

6.2.3 *Hole Advancement and Cuttings Return*—As the augers are rotating, apply down feed pressure to the HSA column to clean the hole and bring cuttings to the surface. Use rotation and penetration rates compatible with efficient cuttings returns. The use of excessive penetration rates faster than cuttings can be returned to the surface may result in the following: (1) cuttings which are packed into the auger flights, prohibiting newly penetrated materials from moving up the auger or, (2) forcing materials into the hole wall and increasing the chances of locking or binding of the HSA drill string. After advance of the auger string to the desired incremental depth in a hole advancement mode with pilot bits, rotation is normally continued without penetration for a time period long enough to ensure circulation of the cuttings up the flights.

6.2.4 *Pauses in Drilling*—Sampling or in situ testing can be performed at any depth by interrupting the advance of the augers and stopping rotation. During pauses in drilling the

HSA drill string can be held in place with an auger fork inserted at the surface. The fork will suspend the augers and prevent settling.

6.2.5 Drill Hole Advancement—Drilling at greater depths is accomplished by attaching additional hollow-stem auger sections to the top of the previously advanced HSA column assembly. If drilling with the pilot bit assembly in the HSA column using a wireline/overshot system; HSA sections can be added to the top of the HSA column without pulling the pilot bit assembly or adding any drill rods to advance the hole to a predetermined depth. When using the rod-type system, add a new inner rod along with an additional hollow-stem section.

6.2.6 Cuttings Removal and Classification—Periodically remove cuttings from around the top of the auger column, typically with a shovel. Soil cuttings above the ground water may be representative of deposits being penetrated if proper conveyance up the auger flight is maintained. Cuttings from below the ground water surface are likely to be mixed from varying formations in the hole and are usually not representative of deposits at the end of the auger. If cuttings are sampled for classification (Practice D 2488) and relation to lithology, report and document the intervals sampled.

6.2.7 Recording of Drilling Information—Record depths, progress, and location of samples or testing as drilling progresses. Monitor down feed pressures, rotation rates, and cuttings return during drilling. Note any indications of binding or locking of the augers during drilling. Observe the ease or difficulty of advancing the HSA drill string during drilling as it relates to the geologic strata being penetrated. Document occurrences of any significant abrupt changes and anomalies which occur during drilling. As drilling progresses, note and document drilling procedures such as water or drilling fluid added and losses, and intervals where equipment is changed or drilling method is changed.

6.3 Hole Advancement with Pilot Bit:

6.3.1 General Considerations—Following an increment of drilling, removal of the pilot bit assembly should be performed slowly so that the entrance of material into the bottom of the HSA column is minimized prior to sampling or installation of testing devices. The success of pilot assembly removal without disturbance will depend upon the following several principal factors: (1) the character of the soil at the auger head, (2) the water levels inside and outside the HSA column prior to removal of the pilot assembly, (3) the type of pilot assembly used, and (4) the speed of removal. As drilling progresses in saturated, granular materials, it usually becomes progressively more difficult to maintain the stability of the material below the auger column because of unbalanced hydraulic heads between outside ground water and inside the hollow stem. The stability of the material below the auger head may be enhanced by using special pilot assemblies, or maintaining fluid level in the HSA column during auger advancement and during retrieval of the pilot bit assembly (Fig. 4). Under some circumstances it may be effective to drill without using a pilot assembly. If a pilot assembly is not used, however, and water or drilling fluid is not injected into the auger column simultaneously with advancement, material often will enter the hollow stem of the auger column. In some cases when drilling in saturated granular

materials, a screened lead auger section may be used to help deter blow-in. The screened auger allows formation water to flow into the HSA column to help prevent water level differences and maintain a hydrostatic balance.

6.3.2 Knock Out Plugs—If sampling or in situ testing is not required during drilling for installation of an instrumentation device, the boring can be advanced (for some geologic conditions) using an expendable, knock-out plate or plug, or flexible center plug instead of a pilot assembly. Knock-out plates or plugs usually remain in the ground close to the instrumentation device. It may be necessary to fill or partially fill the auger stem with water or drilling fluid to prevent blow-in, or sanding in at the time of plate or plug removal. An auger head with an integral, hinged aperture cover or flexible center plug can be used to deter entrance of materials into the auger stem.

6.3.2.1 Flexible Plug—The flexible center plug system uses a plastic basket with flexible finger, inverted in the HSA column at the cutter head. The flexible center plug allows split spoon sampling through the flexible fingers and helps prevent water-bearing sands from entering the HSA column while advancing the augers.

6.3.3 Locking Problems, Blow-in—There may be instances, during insertion of the pilot bit, when difficulties are encountered in locking of the bit and getting it back to the bottom of the HSA column. If material is present in the hollow-stem auger, it may be necessary to lift the HSA column to engage the locking mechanism. The action of lifting the hollow-stem augers can cause subsurface disturbance. Blow-in can be minimized by venting or the use of fluids in the hollow-stem auger.

6.4 Intermittent Sampling or Field Testing—Sampling or field testing can be performed at any depth by interrupting the advance of the augers and stopping rotation. Solid sampling is usually accomplished by either of the following two methods: (1) drive, push, or core sampling or (2) soil coring using hollow-stem augers (see 6.5)

6.4.1 Soil sampling and in situ testing methods, some of which are listed in 2.2 and 2.3, are often used to obtain samples or perform tests at the base of the boring. Slowly remove the pilot assembly, if being used, and insert a sampler or testing device through the hollow stem of the auger column. The sampled or tested depth should be compared to the clean-out depth if the sampler is attached to the rods. This comparison is accomplished by resting the sampler or testing device at the bottom of the hole and comparing the apparent depth with the clean-out depth. If cuttings, cave in material, or sanding in is apparent, these conditions should be noted. Sampler barrels which drop past the cutting teeth of the augers may indicate excessive disturbance at the base of the drill hole. If there is material in the HSA column that does not allow for the sampler to rest at the augured depth below the end of the HSA bit, it may be necessary to allow the material to fall out of the HSA column. Actual depth of the sampler in relation to the bottom of the hole should be considered, not where the bottom of HSA string is setting. If in situ testing is performed below the base of the borehole, check for disturbance below the base of the borehole, and advance the testing instrument well in advance of any disturbance at the base of the boring.



6.5 Continuous or Intermittent Soil Sampling with the Double-Tube HSA Soil Coring System:

6.5.1 Intermittent Sampling—The pilot bit can be replaced at any time with the double-tube HSA core barrel assembly and samples taken at desired depths. Samples can be taken at selected intervals of concern and based on change of soils encountered.

6.5.2 Continuous Sampling—In the continuous soil sampling process a sampler barrel is used during hole advancement. Remove and replace barrels as drilling progresses. Detailed stratigraphic logging and sampling for geotechnical exploration may be obtained.

6.5.3 Hole Advancement and Cuttings Return—When using the double-tube HSA soil coring system, typically perform drilling at a rotary velocity of about 50 to 100 r/min. Advance the system to a depth equal to the length of the sample barrel, or where intermittent sampling or in situ testing is required, or until the cutter head assembly is advanced to the desired depth. When using the HSA double-tube soil sampling system, rotational speeds and rate of down feed may vary with the degree of resistance of the material being sampled. As the augers are rotating, apply down feed pressure to the HSA column. Cut away the material from around the inner barrel by the cutter head. The rotating action of the cutter head around the sampler barrel cutting shoe allows the inner sample barrel to push/core down over the column of material filling the inner barrel. Cuttings are directed to the HSA flights and conveyed to the surface by the rotating HSA column. Rotation to clean cuttings from the hole should be limited in the HSA double-tube soil sampling mode to prevent sample from being vibrated (loosen) out of the sample barrel. Rotation for borehole cleaning can be accomplished after removal of the HSA sample barrel prior to the beginning of the next sampling increment.

6.5.4 Selection of HSA Sampling Barrel—Depending on the exploration needs, different types of sample barrels may be used. Split barrels are often used for lithologic logging and soil classification. Split barrel samples are often taken in 5-ft (1.5-m) lengths. Sample length can be reduced to reduce disturbance. Undisturbed samples consistent with Practice D 4220, Class c and d are often taken in liners. For undisturbed sampling, it is important to adjust the clearance ratio and the lead distance to reduce disturbance. In general, satisfactory undisturbed samples are usually at least 3 in. (75 mm) in diameter and larger and sampling length is reduced to 2.5 ft (0.75 m).

6.5.4.1 Considerations for Undisturbed Sampling:

6.5.4.1.1 Undisturbed Sampling—If the goal of the investigation program is to obtain samples with minimal disturbance, lead distance and cutting shoe clearance ratio must be adjusted for optimum sample recovery. This will be a trial-and-error process. The ultimate goal in undisturbed sampling is to achieve core recovery as close to 100 % as possible with a sample that just fills the liner.

6.5.4.1.2 Lead Distance Optimization—The lead distance of the core barrel cutting shoe should be adjusted to obtain optimum sample recovery (see 5.7.4). With wireline systems, the lead distance can be checked by vertically suspending the

entire lead auger so that the inner barrel assembly can hang freely and then latch inside the lead auger.

6.5.4.1.3 Clearance Ratio Optimization—The clearance ratio of the cutting shoe should be optimized for the soil formations to be sampled (see 5.7.4). For undisturbed sampling, hold the liners in place in the sample barrel assembly by the cutting shoe which threads onto the end of the barrel. Cutting shoes are machined with different bit clearance ratios (see 3.1.2). Cutting shoe bit clearance ratios should be checked prior to use. Guidelines for bit clearance ratios for different soil types are as follows:

Bit clearance ratio %	Material
0 to ½	sands with little or no fines
½ to 1	silty sand, clay, silt
1 to 1½	expansive clay, shales, claystones

6.5.5 General HSA Sampling Considerations—When the bit or sample barrel assembly is removed and replaced, check the depth to the base of the boring where the end of the string rests and compare to the clean-out depth to evaluate hole quality. Hole depth is recorded by knowing the length of the auger assemblies and the actual amount of extension of the end of the sample barrel beyond the end of the HSA cutter head. This will facilitate accurate depth calculation of the sample taken and comparison of its position relative to the established surface datum. Excessive slough or cuttings within the hollow stem are undesirable and should be corrected by changes in technique, changes in equipment, or repair of equipment. Carefully record the start and stop depths of the sampling interval. Calculate the recovery. Sample recovery is the most important indicator of sample quality. To enhance sample recovery, the rate of penetration should be no greater than the speed at which the HSA cutter head is able to cut; that is, the downward force on the sampler barrel assembly should be a minimum. The speed of rotation should be limited to that which will not tear or break the soil during sampling (generally this varies from 40 to 125 r/min.) Important considerations for optimum sampling are lead distance and clearance ratio or head space of the cutting shoe and prevention of inner barrel rotation (5). Extension of the sample barrel shoe beyond the HSA cutter head depends on the soil type and should be the least amount which will result in a fully filled sample barrel (see 5.7.4).

6.5.6 Sample Barrel Recovery and Reinsertion

6.5.6.1 Rod Systems—After drilling the length of the sample barrel, stop, secure, and disconnect the HSA column from the drill rig drive connector. Disconnect the connecting rods inside the HSA column that may be attached to or extend through the rotary spindle of the drill rig. Remove the drill rotary head off the hole and hoist the rods connecting the sample barrel out of the HSA column. Replace the barrel by attachment of a new barrel to inner rods which are lowered back into the hollow-stem column and secured through the drive cap or rotary spindle attachment.

6.5.6.2 Wireline Systems—If a wireline/overshot system is used, after disconnecting the drill rig rotary drive connector from the top of the HSA column and removing the rotary head, lower the overshot retrieval tool down the HSA column to latch into the latching head on top of the sample barrel assembly. After the overshot is locked into the latching head assembly, hoist the sample barrel out of the HSA drill string on a wire

cable attached to a hydraulic winch on the drill rig. Remove the sample barrel and connect another sample barrel assembly to the latching head and hoist and lower down the HSA column by means of the overshot and wireline assembly until the latching head locks into the latching connector box (part of the HSA column above the lead HSA and cutter head). Release the overshot from the locking head above the sample barrel and hoist to the surface.

6.5.6.3 Reinsertion—Add the next HSA section to the top of the HSA column and connect to the drill rig rotary spindle. Connect inner connecting rods (if not the wireline system) to or through the rotary spindle before the auger drive adapter is connected to the top of the HSA column. In special cases, such as in loose sand, lift the HSA drill string by the drill rig to remove the auger holding fork, and then lower to the bottom of the hole where the previous sample stopped. Rotate and push the HSA column to begin the soil coring procedure again.

6.5.6.4 There may be instances, during insertion of the sample barrel, when difficulties are encountered in locking of the barrel and returning it back to the bottom of the HSA column. If material is present in the hollow-stem auger it may be necessary to lift the HSA column to engage the locking mechanism. This will allow the sample barrel assembly to fall to the bottom of the HSA column, forcing out the slough and reach the locking position. When the sample barrel assembly is connected to drill rods or hex rods to the top of the HSA column, the rods may have to be pushed with the hydraulics of the drill rig to the bottom of the HSA column to reach the proper depth to begin the next soil coring interval. When drilling in 5-ft (1.5-m) intervals, a shorter HSA coring interval may have to be run to allow for slough material. If 2.5-ft (0.75-m) sample intervals are being used, use of a 5-ft barrel will allow for accommodation of slough. Note and record sample intervals, recovery, and any slough, cuttings, fluid exposure, or evidence of rotation contained in the samples recovered.

6.5.7 Sample Testing and Handling—First measure samples for recovery upon retrieval. Handle and transport samples in accordance with Practice D 4220. Classify soil samples in accordance with Practice D 2488. Samples from split liners can be classified and stored in jars or bags. Report the locations of specimens removed for testing. Collect material for classification of samples in liners to be stored for laboratory testing from the ends of the sample. Trim and seal the sample ends for preservation. The average soil in-place unit weight can be determined (6). Moisture specimens can be obtained from the cutting shoe or liner trimmings. Report results and locations of any tests performed on cores such as Torvane or pocket penetrometer.

7. Drill Hole Monitoring and Completion

7.1 Monitoring—It is advisable to monitor ground water levels, if present, in the drill hole during and after drilling. Ground water elevations should be measured and documented during drilling. If ground water is not encountered or if the level is of doubtful reliability, such information should also be documented.

7.2 Installation of Instrumentation Devices:

7.2.1 Instrumentation devices, such as piezometers or inclinometers (see 2.4) are installed using hollow-stem augers following a three-step procedure: (1) drilling, with or without sampling, (2) removal of the pilot assembly, if being used, and insertion of the instrumentation device, and (3) incremental removal of the hollow auger column as completion materials such as backfill or grout is installed as required.

7.2.1.1 If materials enter the bottom of the auger hollow stem during removal of the pilot assembly, they can be removed with a bailer, other device, or fluid rotary drilling (see 2.4) .

7.2.1.2 Completion materials such as bentonite pellets, granules and chips, and grouts should be selected and installed to specific subsurface instrumentation requirements.

7.3 Other Completion Methods—Depending on requirements of the investigation it may be necessary to perform special installations with protective casings or to the backfilling. An example of special completion is for the seismic crosshole test (Test Methods D 4428) which requires grouted PVC casings. These installations are also performed using the three-step method in 7.2.1. Several methods are available for grouting of casings. It is desirable to use injection grouting where injection is performed at the base of the boring, and grouts are pumped up the annulus until they reach the surface indicating a continuous seal.

7.4 Drill hole Abandonment—If there are no needs for special completion or instrument installations for the drill hole, it should be backfilled for completion. The method of backfilling for abandonment depends on the requirements of the exploration program and should be specified as part of the program. Certain state and local regulations may apply. At a minimum, the surface of the hole should be backfilled to reduce potential hazard to those at the surface. In cases where the hole is to be backfilled completely, the condition of the hole should be evaluated and documented. Any zones of caving or blocking which preclude complete backfilling should be documented. Backfilling can be performed by addition of backfill materials from the surface or through injection by tremie pipes. When backfilling from the surface, either cuttings spoil, (only if suitable for replacement) bentonite pellets or granules, or select materials may be added. If complete backfilling is desired using surface methods, use of uniform backfill materials such as bentonite pellets or granules will reduce the possibility of bridging. The hole can be probed to test for bridging. The tremie methods ensure the best backfilling and should be performed when exploration plans require assurance of complete backfilling. Tremie methods consist of placing a small-diameter grout pipe near the base of the drill hole and pumping either cement or bentonite grouts to the surface while displacing any drill hole fluid. The tremie pipe is withdrawn in increments, but the tip is maintained below the grout surface. Typical grout consistencies depend on equipment and the needs of the exploration program. Typical grout mixtures are given in Practice D 5092 and Test Methods D 4428.

8. Report

8.1 Report information in accordance with Guide D 5434 of “Subsurface Explorations of Soil” and identified as necessary



and pertinent to the needs of the exploration program. Information is normally required for the project, exploration type and execution, drilling equipment and methods, subsurface conditions encountered, ground water conditions, sampling events, and installations.

8.2 Other information in addition to that mentioned in Guide D 5434 should be considered if deemed appropriate and necessary to the requirements of the exploration program. Additional information should be considered as follows:

8.2.1 Drilling Methods:

8.2.1.1 Report description of the hollow-stem auger system including the head, drive, and pilot assemblies. Provide information on drill hole and sample sizes. Note intervals of equipment change or drilling method changes and reasons for change.

8.2.1.2 Report type, quantities, and locations of use of additives such as water added to the hole. If changes to the circulating medium are made, such as addition of water, the depth(s) or interval(s) of these changes should be documented.

8.2.1.3 Report descriptions of down-feed pressures, rotation rates, and cuttings returns over intervals drilled. Note locations of loss of cuttings return and probable cause. Note any indications of binding or locking of the augers during drilling. Observe the ease of drilling during advancement as it relates to the geologic strata being penetrated. Document occurrences of any significant abrupt changes and anomalies in drilling conditions which occur during drilling.

8.2.1.4 If blow-in or sanding-in is evident in the HSA column, note occurrences and the amount. As the drilling progresses, note and document drilling procedures such as

cuttings return, water added and losses, and intervals where equipment is changed or drilling method is changed.

8.2.2 Sampling:

8.2.2.1 Report depth interval sampled, recovery, classification, and any other tests performed, such as moisture or soil in-place unit weight determinations.

8.2.2.2 When core sampling or undisturbed sampling at the base of the boring, report condition of the base of the boring prior to sampling and report any slough or cuttings present in the recovered sample.

8.2.2.3 If cuttings are sampled for classification and relation to lithology, report and document the intervals sampled.

8.2.2.4 During insertion of the continuous sample barrel note any difficulties in locking of the barrel. Note any disturbances or evidence of rotation observed in the samples recovered.

8.2.3 In situ Testing:

8.2.3.1 For devices which were inserted below the base of the drill hole, report the depths below the base of the hole and any unusual conditions during testing.

8.2.3.2 For devices testing or seating at the drill hole wall, report any unusual conditions of the drill hole wall such as inability to seat pressure packers.

8.2.4 *Completion and Installations*—A description of completion materials and methods of placement, approximate volumes placed, intervals of placement, methods of confirming placement, and areas of difficulty or unusual occurrences.

9. Keywords

9.1 continuous sampling; double-tube auger; drilling; hollow-stem augers; soil coring; soil sampling; subsurface exploration

REFERENCES

- (1) *DCDMA Drilling Safety Manual*, Drilling Equipment Manufacturers Assn., 3008 Millwood Ave., Columbia SC 29205, 1991.
- (2) Shuter, E., and Teasdale, W.E., "Application of Drilling, Coring, and Sampling Techniques to Test holes and Wells - Chapter F1 - Techniques of Water-Resource Investigations of the United States Geological Survey," U.S. Government Printing Office, Washington, DC, 1989.
- (3) *Groundwater and Wells*, F.G. Driscoll, 2nd ed, Johnson Filtration Systems, St. Paul, MN, 1989.
- (4) O'Rourke, J.E., Gibbs, H.J., and O'Connor, K.O., "Core Recovery Techniques for Soft or Poorly Consolidated Materials," *Final Report*, Contract No. J0275003, U.S. Bureau of Mines, Department of Interior, Washington, DC, April 28, 1978.
- (5) *Drillers Handbook*, T.C. Ruda and P.J. Bosscher, eds, National Drilling Contractors Assn., 3008 Millwood Ave., Columbia, SC 29205, June 1990.
- (6) USBR D-7115, "Undisturbed Sampling Using Mechanical Drilling Methods," Part II, *Earth Manual*, 3rd ed, U.S. Department of Interior, Bureau of Reclamation, U.S. Government Printing Office, Washington, DC, 1990.
- (7) *DCDMA Technical Manual*, Drilling Equipment Manufacturers Assn., 3008 Millwood Ave., Columbia, SC 29205, 1991.

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Standard Practice for Rock Core Drilling and Sampling of Rock for Site Investigation¹

This standard is issued under the fixed designation D 2113; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice covers the guidelines, requirements, and procedures for core drilling, coring, and sampling of rock for the purposes of site investigation. The borehole could be vertical, horizontal, or angled.

1.2 This practice is described in the context of obtaining data for the design, construction, or maintenance of structures, and applies to surface drilling and drilling from adits and exploratory tunnels.

1.3 This practice applies to core drilling in hard and soft rock.

1.4 This practice does not address considerations for core drilling for geo-environmental site characterization and installation of water quality monitoring devices (see Section 2).

1.5 The values stated in inch-pound units are to be regarded as standard. The SI values given in parentheses are provided for information purposes only.

1.6 This practice does not purport to comprehensively address all of the methods and the issues associated with coring and sampling of rock. Users should seek qualified professionals for decisions as to the proper equipment and methods that would be most successful for their site investigation. Other methods may be available for drilling and sampling of rock, and qualified professionals should have flexibility to exercise judgment as to possible alternatives not covered in this practice. This practice is current at the time of issue, but new alternative methods may become available prior to revisions; therefore, users should consult with manufacturers or producers prior to specifying program requirements.

1.7 *This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this practice may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the*

title of this document means only that the document has been approved through the ASTM consensus process.

1.8 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* Also, the user must comply with prevalent regulatory codes, such as OSHA (Occupational Health and Safety Administration) guidelines, while using this practice. For good safety practice, consult applicable OSHA regulations and other safety guides on drilling (1).

2. Referenced Documents

2.1 ASTM Standards:

D 420 Guide to Site Characterization for Engineering Design, and Construction Purposes²

D 653 Terminology Relating to Soil, Rock, and Contained Fluids²

D 4630 Test Method for Determining Transmissivity and Storage Coefficient of Low Permeability Rocks by In Situ Measurements Using the Constant Head Injection Test²

D 5079 Practices for Preserving and Transporting Rock Core Samples²

D 5434 Guide for Field Logging of Subsurface Explorations of Soil and Rock³

D 5782 Guide for the Use of Direct Air-Rotary Drilling for Geoenvironmental Exploration and Installation of Subsurface Water Quality Monitoring Devices³

D 5783 Guide for Use of Direct Rotary Drilling With Water-Based Drilling Fluid for Geoenvironmental Exploration and Installation of Subsurface Water Quality Monitoring Devices³

D 5876 Guide for Use of Direct Rotary Wireline Casing Advancement Drilling Methods for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices³

D 6032 Test Method for Determining Rock Quality Designation (RQD) of Rock Core³

D 6151 Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling³

2.2 American Petroleum Institute Standard:

¹ This Practice is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Investigations.

Current edition approved May 10, 1998 and January 10, 1999. Published October 1999. Originally published as D 2113 – 62T. Last previous edition D 2113 – 83 (1993)^{ε1}.

² *Annual Book of ASTM Standards*, Vol 04.08.

³ *Annual Book of ASTM Standards*, Vol 04.09.

API RP 13B Recommended Practice Standard Procedure for Testing Drilling Fluids⁴

2.3 NSF Standard:

NSF 60-1988⁵

3. Terminology

3.1 Definitions:

3.1.1 *blind hole, n*—borehole that yields no fluid recovery of the drilling fluids.

3.1.2 *casing, n*—hollow tubes of steel used to support bore hole walls or where fluid losses must be stopped.

3.1.3 *caving hole, n*—borehole whose walls or bottom are unstable and cave or collapse into the drilled borehole.

3.1.4 *core barrels, n*—hollow tubes of steel used to collect cores of drilled rock.

3.1.5 *core bits, n*—coring bits with surface set or impregnated diamonds in tungsten carbide mix of hardened steel, polycrystalline bits, or tungsten carbide (TC) inserts, mounted on a cylindrical coring bit that does the actual core cutting.

3.1.6 *drill rig, n*—includes drilling machine, mast or derrick, circulating pumps, and mounting platform.

3.1.7 *drill rod, n*—hollow steel tubes that are connected to the drill bit or core barrel and to the rotary head of the drilling machine.

3.1.8 *drill platform, n*—a platform for drilling rig.

3.1.8.1 *Discussion*—The platform may need to be constructed at the drilling site to provide a firm base upon which the drill rig is then placed. Platforms are also constructed in the vicinity of the drill hole for workers to hold equipment, serve as a datum, and to allow safe operations.

3.1.9 *drilling machine, n*—includes power unit, hoisting unit, controlled-feed rotary drill head, and water or mud pump.

3.1.10 *overshot, n*—a latching mechanism at the end of the hoisting line, specially designed to latch onto or release pilot bit or core barrel assemblies when using *wireline drilling*.

(D 5786)

3.1.11 *pilot bit assembly, n*—designed to lock into the end section of drill rod for *wireline drilling* without sampling. The pilot bit can be either drag, roller cone, or diamond plug types. The bit can be set to protrude from the rod coring bit depending on the formation being drilled.

(D 5786)

3.1.12 *squeezing hole, n*—borehole whose walls move into the drilled opening and squeeze on the drill rods.

3.1.13 *wireline drilling, n*—a rotary drilling process using special enlarged inside diameter drilling rods with special latching pilot bits or core barrels raised or lowered inside the rods with a wireline and overshot latching mechanism.

(D 5786)

3.2 Additional terms are defined in Terminology D 653.

4. Summary of Practice

4.1 Drilling:

4.1.1 Drilling is accomplished by circulating a drilling medium through the drill bit while rotating and lowering or

advancing the string of drill rods as downward force is applied to a cutting bit. The bit cuts and breaks up the material as it penetrates the formation, and the drilling medium picks up the cuttings generated by the cutting action of the bit. The drilling medium, with cuttings, then flows outward through the annular space between the drill rods and drill hole, and carries the cuttings to the ground surface, thus cleaning the hole. The string of drill rods and bit is advanced downward, deepening the hole as the operation proceeds.

4.1.1.1 Fluid drilling is accomplished by circulating water or a water-based fluid with additives. Additives such as bentonite or polymers are frequently added to water to lubricate and cool the bit and to circulate (transport) cuttings to the surface. Drill fluid can also act to prevent cave or collapse of the drill hole. After the drilling fluid reaches the surface, it flows to a ditch or effluent pipe and into a settling pit where the cuttings settle to the bottom. Cuttings are sometimes run through a shaker to remove the larger particles. From the settling pit, the drilling fluid overflows into the main pit, from which it is picked up by the suction line of the mud pump and recirculated through the drill string.

NOTE 1—The decrease of mud velocity upon entering the mud pit may cause gelling of the mud and prevent cuttings from settling. Agitation of the mud in the pit can remedy the problem.

4.1.1.2 Air drilling is performed where introduction of fluids is undesirable. Air rotary drilling requires use of an air compressor with volume displacement large enough to develop sufficient air velocity to remove cuttings. Cuttings can be collected at the surface in cyclone separators. Sometimes a small amount of water or foam may be added to the air to enhance return of cuttings. Air drilling may not be satisfactory in unconsolidated and cohesionless soils under the ground water table.

4.2 Coring:

4.2.1 Coring is the process of recovering cylindrical cores of rock by means of rotating a hollow steel tube (core barrel) equipped with a coring bit. The drilled core is carefully collected in the core barrel as the drilling progresses.

4.3 Sampling:

4.3.1 Once the core has been cut and the core barrel is full, the drill rods or overshot assembly are pulled and the core retrieved. Samples are packaged and shipped for testing (see Practices D 5079).

5. Significance and Use

5.1 Rock cores are samples of record of the existing subsurface conditions at given borehole locations. The samples are expected to yield significant indications about the geological, physical, and engineering nature of the subsurface for use in the design and construction of an engineered structure. The core samples need to be preserved using specific procedures for a stipulated time (Practices D 5079). The period of storage depends upon the nature and significance of the engineered structure.

5.2 Rock cores always need to be handled such that their properties are not altered in any way due to mechanical damage or changes in ambient conditions of moisture and temperature or other environmental factors.

⁴ Available from American Petroleum Institute, 2101 L St. NW, Washington, DC

⁵ Available from NSF International, P.O. Box 130140, Ann Arbor, MI 48113-0140.

6. Apparatus

6.1 *General*—Fig. 1 shows the schematic of a typical rock core drill setup (2). Essential components of the drilling equipment include the drilling rig with rotary power, hoisting systems, casing, rods, core barrels, including bits and liners, and pumps with circulating system. In addition, equipment should include necessary tools for hoisting and coupling and uncoupling the drill string and other miscellaneous items such as prefabricated mud pits and racks for rod stacking and layout. Normally, a drilling platform of planking is built up around the drilling site.

6.1.1 Rock coring operations can proceed at high rotation rates. It is imperative the drill rig, rods, and core barrels are straight and have a balanced center of gravity to avoid whipping and resulting damage to cores and expensive bits.

6.2 *Drilling Rig*— The drill rig provides the rotary power and downward (or advance) force or hold-back force on the core barrel to core the rock. The preferred diamond drill coring equipments are designs with hydraulic or gear-driven variable speed hollow spindle rotary drill heads, although some core rigs are manufactured with gear or chain pulldown/retract systems. Precise control over bit pressure can best be accomplished by a variable setting hydraulic pulldown/retract system. Hydraulic systems are often equipped with a detent valve, which allows downfeed (or advance) rate to be set at a certain speed regardless of tool weight or down pressure exerted on the

coring bit. Hydraulic feed drill rigs should be supplied with a hydraulic pressure gage that can be related to bit pressures. Deep hole drill rigs should be equipped with hydraulic hold-back control so, if required, the full weight of the drill rods is not exerted on the bit when drilling downward. Diamond drill rigs can apply high rotation rates as high as 1000 rpm as opposed to normal rotary drills operating at 60 to 120 rpm (3). Most diamond core drills are equipped with a mast and powered hoist for hoisting heavy drill strings. A second wireline hoist is helpful for wireline drilling.

6.2.1 The drill machine frame is either skid or truck mounted and should be equipped with a slide base for ease in working around the drill hole. In special cases, the drilling machine may be mounted on a trailer, barge (for overwater drilling), or columns (for underground work). Some drill rigs are designed to be broken down into several pieces for transport into remote areas. The drilling machine may be powered by hydraulics, air, electricity, gas, or diesel. Most surface skid or truck mounted rigs are diesel or gas powered.

6.2.2 Drilling directions are rarely vertical in underground applications, and smaller rigs are frequently equipped with swivel heads to accommodate drilling at angles. Special accommodations must be made for holding and breaking rods when drilling at high angles into crowns of adits. Either top drive drill or column mount machines with hydraulic or pneumatic rod jacks are equipped to handle up holes. For

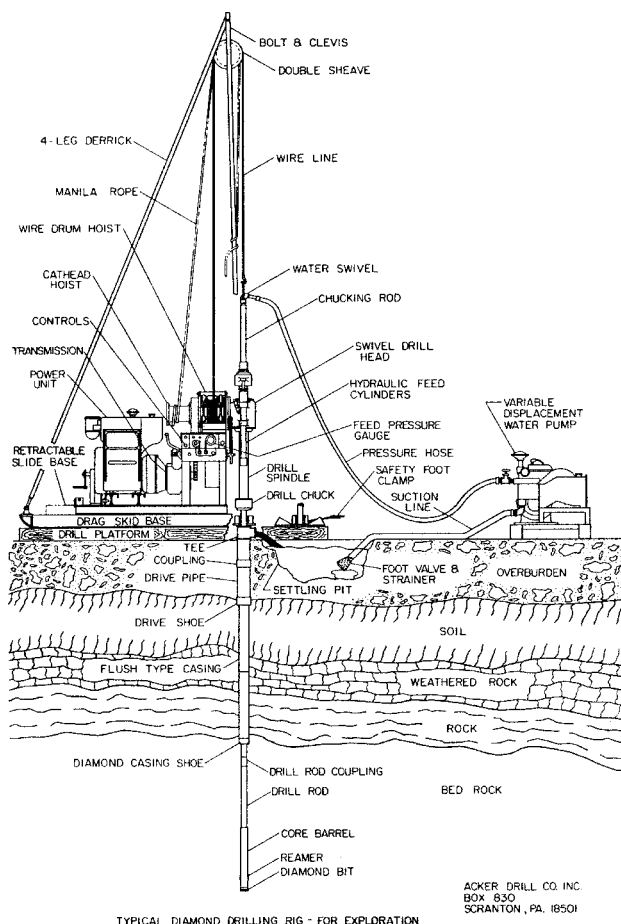


FIG. 1 Schematic of Typical Diamond Core Drill Set-up (2)

confined space drilling operations, drills are column mounted or mounted on small skids. Special power sources may be required for underground work due to air quality considerations. Remote power pack stations usually electric, hydraulic, compressed air, or a combination of the three. Electrically powered hydraulic systems are most common in underground use today.

6.3 *Fluid or Air Circulation Systems:*

6.3.1 *Selection of Drill Media*—The two primary methods for circulating drill cuttings are water or water-based fluids or air with or without additives. The predominant method of drilling is water-based fluids. Water-based drilling is effective in a wide range of conditions both above and below the water table. Air drilling is selected when water-sensitive soils such as swelling clays or low density collapsible soils are encountered. Air drilling may also be required above the water table if special testing is required in the unsaturated zone. Air drilling is also convenient in highly fractured igneous rocks and porous formations where water-based fluid losses are unacceptable. The primary functions of the drill fluid are:

- 6.3.1.1 Remove drill cuttings,
- 6.3.1.2 Stabilize the borehole,
- 6.3.1.3 Cool and lubricate the bit,
- 6.3.1.4 Control fluid loss,
- 6.3.1.5 Drop cuttings into a settling pit,
- 6.3.1.6 Facilitate logging of the borehole, and
- 6.3.1.7 Suspend cuttings in the drill hole during coring.

6.3.1.8 No single drill fluid mixture can satisfy all of the above requirements perfectly. In the sections below, considerations for materials that could be used in drilling medium are given.

6.3.2 The pressure hose conducts the drilling fluid or air from the circulation pump or compressor to the swivel.

6.3.3 The swivel directs the drilling fluid or air to a rotating kelly or drill-rod column.

6.3.4 *Rotary Drilling with Water-based Drilling Fluids:*

6.3.4.1 The mud pit is a reservoir for the drilling fluid, and, if properly designed and used, provides sufficient flow velocity reduction to allow separation of drill cuttings from the fluid before recirculation. The mud pit can be a shallow, open metal tank with baffles or an excavated pit with some type of liner, and designed to prevent loss of drilling fluid. The mud pit can be used as a mixing reservoir for the initial quantity of drilling fluid, and, in some circumstances, for adding water and additives to the drilling fluid as drilling progresses. It may be necessary to have additional storage tanks for preparing fluids while drilling progresses.

6.3.4.2 The suction line, sometimes equipped with a foot valve or strainer, or both, conducts the drilling fluid from the mud pit to the fluid circulation pump.

6.3.4.3 The fluid circulation pump must be able to lift the drilling fluid from the mud pit and move it through the system against variable pumping heads at a flow rate to provide an annular velocity that is adequate to transport drill cuttings out of the drill hole.

6.3.4.4 *Water-based Drilling Fluids*—The four main classes of water-based drilling fluids are: (1) clean, fresh water, (2) water with clay (bentonite) additives, (3) water with polymeric

additives, and (4) water with both clay and polymer additives. For commonly used materials added to water-based fluid, see Section 7 on Materials.

(1) Clean fresh water alone is often not acceptable for core drilling due to poor bit lubrication, erosion due to high velocities required for lifting cuttings, and excessive water loss. In water-sensitive soils, it is desirable to use drill additives to form drill hole wall cakes and prevent moisture penetration. In some cases, water may be required for piezometer installations where other fluid additives are not acceptable, but often newer synthetic polymer materials are acceptable for piezometer and well installations.

(2) Bentonitic drill muds are often used in rotary drilling applications. The bentonite should be added to water with vigorous mixing and recirculation to ensure uniform properties and to reach a dispersed deflocculated state. For diamond core drilling, low viscosity is usually required due to small clearances. The viscosity of a fluid-mud mixture is related to the solids content and particle shapes and alignments of the additives. During the high speed rotary drilling process, solids have a tendency to spin out and collect inside drill rods. For diamond drilling, low solids content is desirable. If mass is required to balance high hydrostatic pressures, additives such as barite or ilmenite (see 7.1.8) can be added to keep solids contents low.

(3) The need for low solids contents and good lubrication properties point to the use of polymer drill fluids. Natural or synthetic polymer fluids are the best additives for diamond core drilling. Polymer chains such as those from guar gum exhibit flow thinning characteristics in high velocity and shear conditions. Polymer fluids can be weighted with salts to balance hydrostatic pressures. Detergents or deflocculating agents can be added to discharge lines to assist in dropping cuttings to maintain fluid properties.

(4) Fluid management requires considerable experience for successful drilling and sampling. Important fluid parameters include viscosity and density, and these parameters can be tested to improve fluid properties. Test Method D 4380 and American Petroleum Institute (API) test procedures are available for testing drill fluids. Fluid design can be improved by consultation with manufacturers, suppliers, and by review of literature (2-8). Because of a large number of suppliers, varying grades of drill fluid products, and varying requirements of each project, providing an exact procedure for design and mixing of drill fluids, is impossible.

6.3.5 *Rotary Drilling Using Air As the Circulation Medium:*

6.3.5.1 The air compressor should provide an adequate volume of air, without significant contamination, for removal of cuttings. Air requirements depend upon the drill rod and bit type, character of the material penetrated, depth of drilling below ground water level, and total depth of drilling. Airflow rate requirements are usually based on an annulus upflow (or outflow) air velocity of about 3000 to 4000 ft/min (1000 to 1300 m/min) although air upflow (or outflow) rates of less than 3000 ft/min (1000 m/min) are often adequate for cuttings transport. Special reaming shells may be required to maintain air circulation between the annulus of the hole wall and large diameter drill rods (9). For some geologic conditions, air-blast

erosion may increase the borehole diameter in easily eroded materials such that the 1000 m/min (3000 ft/min) circulation rate may not be appropriate for cuttings transport.

6.3.5.2 Compressed air alone often can transport cuttings from the borehole and cool the bit. Pure air alone does not work well in very moist soils. In moist, clayey matrices, mud rings and bit balling may occur. For some geologic conditions, water injected into the air stream will help control dust or break down “mud rings” that can form on the drill rods. If water is injected, the depth(s) of water injection should be documented. In these cases, adding water and a foaming agent to make a misting mixture is desirable (3). Under other circumstances, for example if the borehole starts to produce water, injection of a foaming agent may be required. The depth at which a foaming agent is added should also be recorded. If water infiltration into the borehole impedes circulation, the use of stiffer foams or slurries may be needed (3). Air drilling may not be satisfactory in unconsolidated or cohesionless soils under the ground water table, and fluid drilling systems may be required.

6.3.5.3 The dust collector conducts air and cuttings from the borehole annulus past the drill rod column to an air cleaning device (cyclone separator).

6.3.5.4 The air cleaning device (cyclone separator) separates cuttings from the air returning from the borehole via the dust collector. A properly sized cyclone separator can remove practically all of the cuttings from the return air. A small quantity of fine particles is usually discharged to the atmosphere with the “cleaned” air. Some air cleaning devices consist of a cyclone separator alone and others use a cyclone separator combined with a power blower and sample collection filters. When foaming agents are used, a cyclone-type cuttings separator is not used and foam discharge is accumulated near the top of the borehole.

6.4 *Hole Diameters*—Selection of hole diameter and core size is the most important consideration when planning a coring program. Most rock coring operations are performed with casings and core barrels whose sizes have been standardized by the Diamond Core Drill Manufacturers Association (DCDMA) (5,10). Table 1 provides a summary of nomenclature used for drill hole sizing. For each size of hole, there is a family of casings, core barrels, bits, casing bits, and drill rods with the same primary letter symbol (A through Z) whose design is compatible. Furthermore, the size steps are such that the next smaller size letter equipment can be used inside the next larger group. This nesting of casings, barrels, and rods allows for tapering or telescoping of a drill hole through difficult formations. Since the core barrel must pass through the casings selected, anticipating the necessity for telescoping the hole is important so a large enough diameter is selected at the start.

NOTE 2—Inclusion of the following tables and use of letter symbols in the foregoing text is not intended to limit the practice to use of DCDMA tools. The table and the text references are included as a convenience to the user since the majority of tools in use do meet the DCDMA dimensional standards. Similar equipment of approximately equal size on the metric standard system is acceptable unless otherwise stipulated by the engineer or geologist.

6.4.1 Core diameter, barrel design, bit design, and drilling method have a direct influence on sample quality. Usually

when drilling in delicate formations, larger diameter samples provide higher quality samples. Often, obtaining samples of the weaker seams or joints in the rock is critical to design. A larger diameter core barrel can often reduce shearing stresses imparted to a seam or joint in the core and thus reduce mechanical breakage. For core operations related to most surface drilling project investigations, the minimum core size would correspond to “N” sized borings.

6.4.2 In concrete coring operations, the primary consideration for selecting a core diameter is the maximum size aggregate. For interface shear strength determinations on lift lines, the core diameter should be 2½ to 3 times the maximum size aggregate (11).

6.4.3 In underground hard rock drilling, smaller cores may be used for ease of operation.

6.5 *Casing*—For most coring operations, setting casings in overburden materials will be necessary, especially near the surface to control drill fluid circulation. Typically, water-sensitive soils and loose overburden soils are protected by casings that are set in competent bedrock or to firm seating at an elevation below the water-sensitive formation. The casing used should allow for unobstructed passage of the largest core barrel to be used, and should be free of upsets in inside diameter. A listing of DCDMA casing sizes is shown in Table 1. For rock coring operations, the flush inside diameter “W” series casing is used to allow for use of the matching core barrel. In some cases, flush coupled drive pipe can be used to support the hole. Drive pipe is available in thickness schedules 40, 80, and 160.

6.5.1 Casing and drill rod selection should be based on uphole (or outflow) velocity of the circulation system selected. Uphole (or outflow) velocity should be sufficient to bring up all drill cuttings.

6.5.2 Casing or temporary drill hole support can be accomplished through several methods. One casing advancement technique is to drill incrementally ahead of the casing and then drive the casing to the previous depth. Driven casings should be equipped with a hardened shoe to protect end threads. The inside diameter of the shoe should be flush with the casing inside diameter to avoid hang-ups of the core barrel. In some cases, water-sensitive zones may require cementing for stabilization. Casing can be equipped with diamond casing shoes that allow the casing to be advanced with rotary drilling. The casing shoe should have the same inside diameter as the casing. Casing “shoes” should not be confused with casing “bits” (10). Casing bits are only acceptable for temporary, rotary installation of casing where coring operations are not required, such as temporary installation of a large diameter telescoped casing. Casing “bits” have an inside diameter that is not large enough to pass a core barrel of the same nominal hole size. Hollow-stem augers may be used as casing through overburden soils. Liners may be used inside large diameter casings or augers to increase fluid circulation velocity and optimize cuttings return. If liners are used, they should not be driven and care should be taken to maintain true hole alignment.

6.6 *Drill Rods*—Drill rod selection should be based on consideration of the uphole (or outflow) velocity of the circulating fluids for the circulation system selected. Uphole

TABLE 1 Diamond Core Drill Manufacturers Association Casing Specifications (10)

NOTE 1—W series casing is known as “flush-coupled casing”. W series casing has flush inside diameter throughout, while X series casing has upset diameter with coupling inside diameter equal to flush wall inside diameter.

DCDMA Casing Design										
Size	Outside Diameter		Inside Diameter W Series		Inside Diameter X Series		Gallons Per 100 ft	Mass Per ft	Threads Per Inch	
	in.	mm	in.	mm	in.	mm			W series	X series
RW, RX	1.44	36.5	1.20	30.5	1.20	302.0	5.7	1.8	5	8
EW, EX	1.81	46.0	1.50	38.1	1.63	41.3	9.2	2.8	4	8
AW, AX	2.25	57.2	1.91	48.1	2.00	50.8	14.8	3.8	4	8
BW, BX	2.88	73.0	2.38	60.3	2.56	65.1	23.9	7.0	4	8
NW, NX	3.50	88.9	3.00	76.2	3.19	81.0	36.7	8.6	4	8
HW, HX	4.50	114.3	4.00	100.0	4.13	104.8	65.3	11.3	4	5
PW, PX	5.50	139.7	5.00	127.0	5.13	130.2		14.0	3	5
SW, SX	6.63	168.3	6.00	152.4	6.25	158.8		16.0	3	5
UW, UX	7.63	193.7	7.00	177.8	7.19	182.6			2	4
ZW, ZX	8.63	219.1	8.00	203.2	8.19	208.0			2	4

velocity should be sufficient to bring up all drill cuttings. Most drilling operations are done with DCDMA drilling rods conforming to the dimensions given in Table 2. Drill rods are normally constructed of tubular steel and have a flush outside wall diameter. Drill rod sections usually have threaded female connections machined in each end. The rods are connected by either removable or welded pins (in one end) strengthened by addition of material at the inside walls. Some drill rod pins are constructed of high strength steel because the joints are a weak link and are subject to failure. Some larger rods are composed of composite materials to reduce weight. Nonmagnetic rods are available for drill holes requiring use of magnetic surveying equipment.

6.6.1 Tables 3 and 4 lists dimensions of wireline and API drill rods that also can be used. Wireline drill rod dimensions are not standardized and are specific to individual manufacturers. The API internal flush joint rods have upset walls on the outside joint and should not be used in air drilling, as air erosion of the formation could occur at the joints.

6.7 *Conventional Core Barrels*—Many types of core barrels are available. A conventional core barrel is attached to the

drilling rods (see 6.6) and the complete set of connected rods and barrel must be removed from the hole at the end of each core run. Torque is applied to the drill rods while the circulating fluid is pumped through the center of the drill rods to the bit. Fluid returns along the annulus between the borehole wall and barrel and drill rods. Conventional barrels are used in smaller drilling operations, such as short underground holes, or when intermittent sampling is to be performed. Most continuous high production coring today is performed with wireline equipment.

6.7.1 Several series of conventional core barrels have standardized dimensions set by the DCDMA (10) in North America. Other organizations such as the British Standards Institute have adopted DCDMA size conventions, while others have different standard dimensions such as metric or Swedish (Craelius) (4). The DCDMA WG, WM, WT series of barrels have standard dimensions as shown in Table 5. Most manufacturers make core barrels fitting the dimensional requirements of one of these series, but there may be variation of other design features such as inner liners, bearings, fluid routing, or

TABLE 2 Diamond Core Drill Manufacturers Association Drill Rod Specifications (10)

Drill Rods, W Series Drill Rod									
Rod Type	Outside Diameter		Inside Diameter		Coupling Identification		Mass Per Foot, lbm	Threads Per Inch	Thread Type
	in.	mm	in.	mm	in.	mm			
RW	1.094	27.8	0.719	18.3	0.406	10.3	1.4	4	Regular
EW	1.375	34.9	0.938	22.2	0.437	12.7	2.7	3	Regular
AW	1.750	44.4	1.250	31.0	0.625	15.9	4.2	3	Regular
BW	2.125	54.0	1.500	44.5	0.750	19.0	6.1	3	Regular
NW	2.625	66.7	2.000	57.4	1.38	34.9	7.8	3	Regular
HW	3.500	88.9	3.062	77.8	2.375	60.3	9.5	3	Regular
WJ Series Drill Rod									
AWJ	1.75	44.5	1.43	36.4	0.63	16.1	3.6	5	Taper
BWJ	2.13	54.0	1.81	46.0	0.75	19.3	5.0	5	Taper
NWJ	2.63	66.7	2.25	57.0	1.13	28.8	6.0	4	Taper
KWJ	2.88	73.0	2.44	61.9	1.38	34.9	...	4	Taper
HWJ	3.50	88.9	2.88	73.1	1.75	44.5	...	4	Taper
Old Standard									
E	1.313	33.3	0.844	21.4	0.438	11.1	...	3	Regular
A	1.625	41.3	1.266	28.6	0.563	14.3	...	3	Regular
B	1.906	48.4	1.406	35.7	0.625	15.9	...	5	Regular
N	2.375	60.3	2.000	50.8	1.000	25.4	...	4	Regular

TABLE 3 Wireline Drill Rod Dimensions

Wireline Drill Rods								
Rod Type	Outside Diameter		Inside Diameter		Gallons Per 100 ft	Weight Per lbm	Threads Per Inch	Thread Type
	in.	mm	in.	mm				
AQWL ^A	1.750	44.5	1.375	34.9	7.7	3.3	4	Taper
AXWL ^B	1.813	46.0	1.500	38.1	9.18	2.8	4	Regular
BQWL ^A	2.188	55.6	1.812	46.0	13.4	4.0	3	Taper
BXWL ^B	2.250	57.2	1.906	48.4	14.82	3.8	4	Regular
NQWL ^A	2.750	69.9	2.375	60.3	23.0	5.2	3	Taper
NXWL ^B	2.875	73.0	2.391	60.7	23.30	6.8	3	Regular
HQWL ^A	3.500	88.9	3.062	77.8	38.2	7.7	3	Taper
HXWL ^B	3.500	88.9	3.000	76.2	36.72	8.7	3	Regular
PQWL ^A	4.625	117.5	4.062	103.2	...	...	...	...
CPWL ^B	4.625	117.5	4.000	101.6	...	...	...	...

^AQ Series rods are specific manufacturer's design.

^BX Series rods are specific manufacturer's design.

TABLE 4 American Petroleum Institute Drill Rod Dimensions (12)

API Tool Joints—Regular External Flush (in.-lb System)				
Type/size	Rod o.d. (in.)	Rod o.d. (mm)	Rod i.d. (in.)	Rod i.d. (mm)
API 2-3/8	3.125	79.4	1	25.4
API 2-7/8	3.75	95.3	1.25	31.8
API 3-1/2	4.25	108.0	1.5	38.1
API 4	5.25	133.4	1.75	44.5
API 4-1/2	5.75	146.1	2.25	57.2
API 5 1/2	6.75	171.5	2.75	69.9
API 6 5/8	7.75	196.9	3.5	88.9
API 7 5/8	8.88	225.6	4.0	101.6
API 8 5/8	10.0	254	4.75	120.7
API Tool Joints—Regular Internal Flush				
Type/size	Rod o.d. (in.)	Rod o.d. (mm)	Rod i.d. (in.)	Rod i.d. (mm)
API 2-3/8	3.375	85.7	1.75	44.5
API 2-7/8	4.125	104.8	2.125	54.0
API 3-1/2	4.75	120.7	2.687	68.3
API 4	5.75	146.1	3.25	82.6
API 4-1/2	6.125	155.6	3.75	95.3

core extrusion methods. Some manufacturers make core barrels that do not fit dimensional DCDMA standards for core diameters. An example is the “D₃ and D₄” series core barrels shown in Table 5. Use of other nonstandardized core barrels is acceptable if the type of barrel is appropriate for the drilling conditions and the type of barrel used is reported.

6.7.2 For most investigations and when rock types are unknown, it is desirable to specify a swivel type, double tube core barrel with a split inner barrel, or solid inner barrel with split liners (also know as “triple tube”). The barrel should be equivalent to, or better than, “M” series design to reduce fluid exposure. If the formation is poorly lithified, and contains soil-like layers such as shales with interbedded clay seams, a large diameter core barrel may be specified to aid in recovery. These desired components are discussed below.

6.7.3 Core barrels generally come in 5- or 10-ft core run lengths. Ten-foot core runs can be performed with good rock conditions. If soft, friable, or highly fractured formations are encountered, it may be necessary to select barrels with 5-ft core runs to reduce the possibility of blockages and improve core recovery.

6.7.4 Important design components of a conventional core barrel are tube type (triple, double, or single), inner tube rotation (rigid or swivel), core bit type, including fluid discharge locations (internal discharge - contacting core, or face

TABLE 5 Approximated Core and Hole Diameters for Core Barrels

^A Core barrel type/group	Set bit dimension inside diameter = core diameter		Set reaming shell = hole diameter	
	in.	mm	in.	mm
Conventional Core Barrels ^B				
RWT (d)	0.735	18.7	1.175	29.8
EWD ₃	0.835	21.2	1.485	37.7
EWG (s.d.), EWM (d)	0.845	21.5	1.485	37.7
EWT (d)	0.905	23.0	1.485	37.7
AWD ₃ , AWD ₄	1.136	28.9	1.890	48.0
AWG (s.d.), AWM (d)	1.185	30.1	1.890	48.0
AWT (d)	1.281	32.5	1.890	48.0
BWD ₃ , BWD ₄	1.615	41.0	2.360	59.9
BWG (s.d.), BWM (d)	1.655	42.0	2.360	59.9
BWT (s.d.)	1.750	44.4	2.360	59.9
NWD ₃ , NWD ₄	2.060	52.3	2.980	75.7
NWG (s.d.), NWM (d)	2.155	54.7	2.980	75.7
NWT (s.d.)	2.313	58.8	2.980	75.7
HWD ₃ , HWD ₄	2.400	61.1	3.650	92.7
HWG (s.d.)	3.000	76.2	3.907	99.2
HWT (s.d.)	3.187	80.9	3.907	99.2
DCDMA Large Diameter—Double-Tube Swivel—Core Barrels				
2 3/4 × 3 3/8	2.690	68.3	3.875	98.4
4 × 5 1/2	3.970	100.8	5.495	139.3
6 × 7 3/4	5.970	151.6	7.750	196.8
Wireline Core Barrel Systems ^C				
AXWL (joy)	1.016	25.8	1.859	47.2
AQWL	1.065	27.1	1.890	48.0
BXWL	1.437	36.5	2.375	60.3
BQWL	1.432	36.4	2.360	60.0
BQ ₃ WL	1.313	33.4	2.360	60.0
NXWL	2.000	50.8	2.984	75.8
NQWL	1.875	47.6	2.980	75.7
NQ ₃ WL	1.75	44.4	2.980	75.7
HXWL	2.400	61.0	3.650	92.7
HQWL	2.500	63.5	3.790	96.3
HQ ₃ WL	2.375	60.3	3.790	96.3
CPWL	3.345	85.0	4.827	122.6
PQWL	3.345	85.0	4.827	122.6
PQ ₃ WL	3.25	82.6	4.827	122.6

^As = single tube; d = double tube.

^BConventional double-tube core barrels are available in either rigid or swivel designs. The swivel design inner barrel is preferred for sampling because it aids in preventing core rotation. In general, smallest hole for given hole size results in best recovery in difficult conditions, that is, triple-tube core barrels. Use of double-tube-swivel type barrels with split liners is recommended in geotechnical investigations for best recovery and least sample damage.

^CWireline dimensions and designations may vary according to manufacturer.

discharge and waterway design), core lifter, and reaming shell.

6.7.5 *Single Tube Core Barrel*—The single tube core barrel

is the simplest in design (see Fig. 2). The core is subjected to drill fluid circulation over its entire length. Once the core in the barrel is broken from parent material, it will rotate with the assembly. These effects break up all but the most competent core (4, 12). Because of fluid exposure and rotational effects, this barrel should not be used to sample weak, friable, and water-sensitive materials. Additional disadvantages of this core barrel include: poor diamond performance of the cutting bit in fractured or friable formations, frequent core blocking, and severe diamond erosion due to re-drilling of broken fragments. This system is only suitable for sampling massive, hard,

competent, homogeneous rock or concrete. Due to these disadvantages, this core barrel type is not recommended for routine investigations.

6.7.5.1 In shallow applications, generally less than 5 ft (2 m) competent concrete or soil cement is cored with single tube masonry core barrels with portable drill rigs (11). If there is evidence of excessive core erosion, breakage, or blocking, use of double tube swivel type barrels should be considered.

6.7.6 *Double Tube Core Barrel*—Double tube core barrels contain an inner barrel that protects the core from contact with drill fluid and from erosion or washing from the circulating

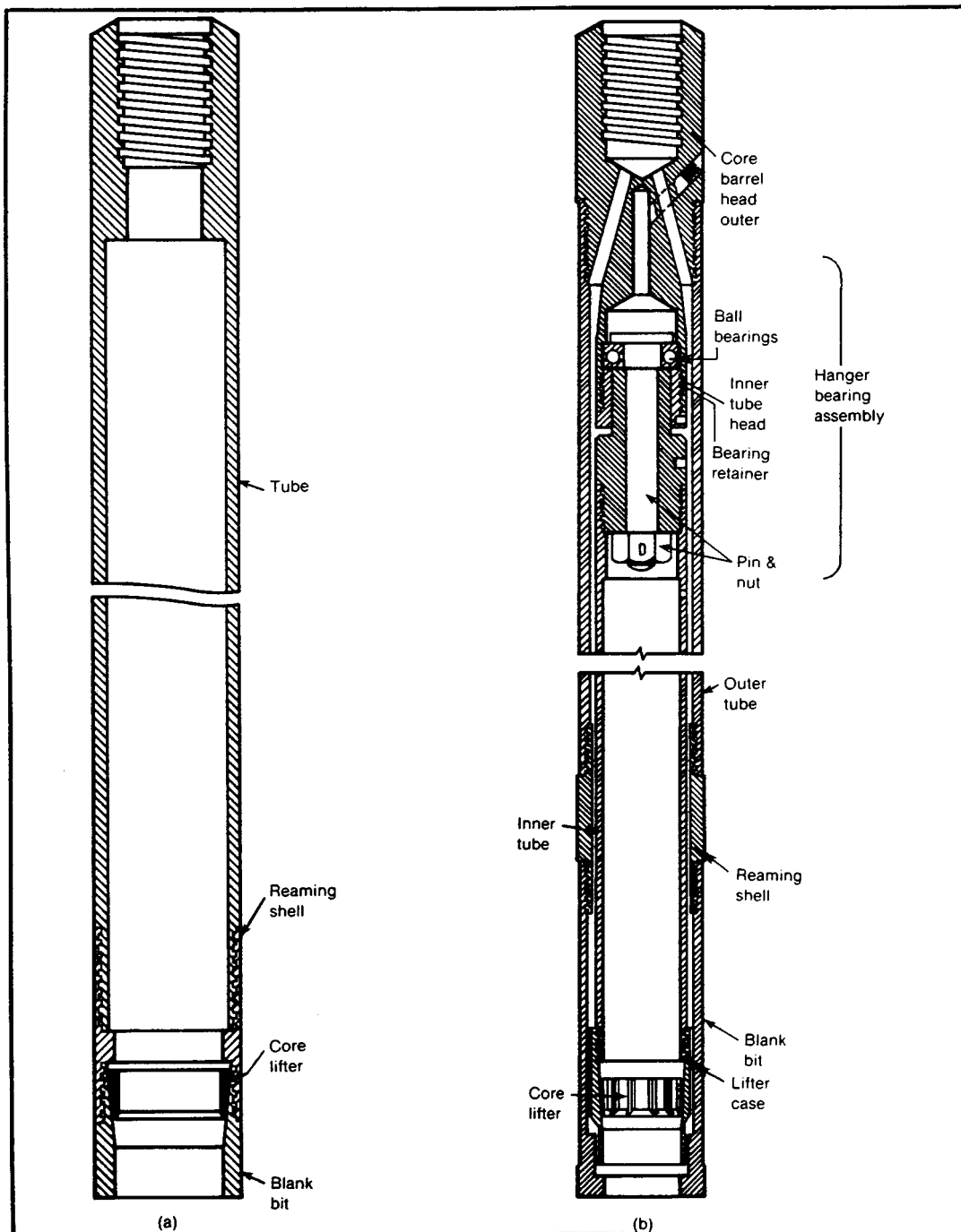


FIG. 2 Diagram of Two Types of Core Barrels: (a) Single Tube and (b) Double Tube

fluid. The bottom of the core may be subjected to fluid exposure depending on the locations of fluid discharge. Some barrel designs have fluid discharge near the lifter, near the bit, or on the bit face (see 6.7.7). The advantage of double tube design is greater protection of the core. Washing erosion is reduced and weaker zones can be recovered.

6.7.6.1 The inner barrel of double tube core barrels may be either solid or split. The barrel may be designed to accept split liners. Barrels accepting liners require a special inside diameter bit gage. Use of a split barrel or inner liners is preferred for easier handling of cores. Sections of the cores containing weak seams are more likely to remain intact. The cores may be rolled onto PVC half rounds. The use of split liners or PVC half rounds aids in placement of core in core boxes and handling of cores that require sealing for moisture preservation. In certain materials, such as expansive shales or blocked high fractured materials, the split liner may spring apart even though it is taped before sampling. In these cases, removing the inner barrel may be difficult. Remedies include use of a shorter core barrel, triple tube design with extruder (see 6.7.7.1), or the solid liner.

6.7.6.2 Double tube core barrels come in two designs, either rigid or swivel type.

(1) *Rigid Double Tube Barrel*—This barrel is rarely used in practice today due to limitations listed below. In the rigid barrel design, the inner barrel is fixed and it spins at the same rate as the outer barrel. Rigid tube barrels have fewer working parts, but suffer from similar disadvantages as single tube barrels. Core recovery is poor and diamond wear in friable and fractured formations is excessive. In softer deposits, there will be rotation of broken core, core blockage, and resulting crushing and grinding, which causes excessive bit wear. This type of design is not preferred for routine investigations where rock conditions are not known, as the equipment is only acceptable in hard competent formations.

(2) *Swivel Type Double Tube Barrels*—In the swivel type barrel (Fig. 3 and Fig. 4 show typical barrels) the inner barrel is connected to the drill string through a bearing that allows the inner barrel to remain stationary during coring. The core is completely protected once it enters the liner. This design reduces rock crushing and grinding and resulting blockages. Depending on the fluid discharge point, the core may be exposed to fluids near the bottom of the barrel and there could be erosion of soft or fractured formations.

(3) Double tube swivel type core barrels are the best selection for drilling rock of varying hardness and fracture. This type of barrel is typically the minimum requirement when drilling investigations are for engineering structures where varying conditions would be encountered.

6.7.7 *Triple Tube Core Barrels*—The triple tube barrel is essentially a double tube barrel with a liner inside the inner tube. The inner liner is made from either split metal half rounds or tubular acrylic. The use of split liners increases efficiency in handling and logging. If the purpose of the investigation is solely for logging of cores, the use of solid acrylic liners may be acceptable.

6.7.7.1 Many manufacturers offer the triple tube option and barrels are available that also have hydraulic core extrusion

systems. These systems help with removing the inner liners by use of a piston in the top of the inner barrel. This feature is especially helpful if split liners are bowed apart by lateral expansion of the core. The extrusion systems allow for simple loading and unloading of liners.

6.7.8 *Conventional Barrel Standardized Designs*—DCDMA standardized barrels come in three designs, WG, WM, and WT series.

6.7.8.1 The “G” series barrels are the most simple in design and have a simple pin threaded bit into which the core lifter is inserted. Due to the simplicity of design, these barrels are the most rugged, with fewer parts and less maintenance. The only disadvantage is that the fluid exits above the lifter and the bottom of the core is exposed to fluids during drilling.

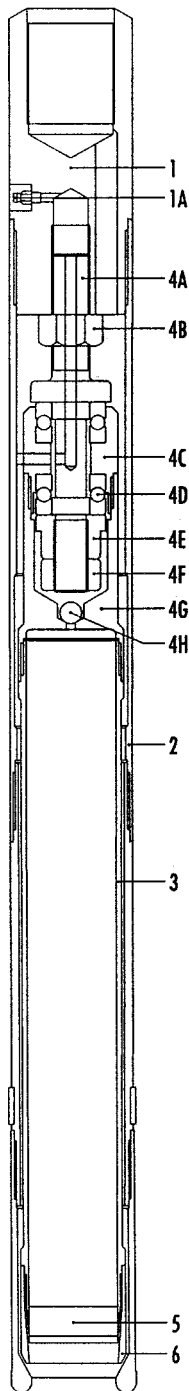
6.7.8.2 The “M” design core barrel is the best available tool for recovering of rock cores even in the most friable and caving strata. The inner barrel is equipped with a lifter case that extends into the bit shank and therefore reduces exposure of the core to fluid during drilling. The fluid only contacts the core near the crown of the bit, and washing or eroding of the core is minimized. Face discharge bits are also available for almost no core exposure to fluids. The DCDMA “M” designs have been modified by individual manufacturers. Barrels such as the D₄ type barrels are equivalent to “M” design barrels.

6.7.8.3 The “T” series design stands for thin walled or thin kerf. This design provides larger core-to-hole size ratio. This barrel style has a thin kerf and requires fewer diamonds and less torque for drilling. It gives good performance in hard, dense, and friable shattered rock formations (4). This type of core barrel is thin and lightweight and must be handled with care.

6.7.9 *Large Diameter, Double Tube, Swivel Design*—The large diameter conventional core barrel is similar in design to the double tube, swivel type, “WM” design, but with the addition of a ball valve in all the three sizes to control fluid flow. A sludge barrel to catch heavy cuttings is also incorporated on the two larger sizes (Fig. 5). The three sizes standardized by DCDMA are 2¾-in. (69.8 mm) by 3⅞-in. (98.4 mm), 4-in. (101.6 mm) by 5½-in. (139.7 mm), and 6-in. (152.4 mm) by 7¾-in. (196.8 mm). Other sizes such as 4⅝-in. (117.5 mm) by 3-in. (76.2 mm), 5¼-in. (146 mm) by 4-in. (101.6 mm), and 8-in. (203.2 mm) by 5⅞-in. (149.2 mm) have been designed by individual manufacturers. The larger barrels with increased annulus are suitable for larger rotary rig mud pumps and air compressors. Options include either conventional or face discharge bits with either conventional core lifter or spring finger basket retainers. Some core barrel systems can be converted to soil coring operations, but require carbide bit and a projecting cutting shoe. Some large diameter barrels are convertible from conventional to wireline coring operation.

6.8 *Wireline Core Barrels*—Wireline drilling for investigation in rock is a principal drilling system used for deep rock coring applications using surface mounted drill rigs (Fig. 6 and Fig. 7). In the wireline system, the drill rods are only removed from the hole to replace the coring bit, to free a stuck inner barrel, or to adjust the headspace of the inner barrel. The inner core barrel can be removed and replaced without removing the drill rods, allowing for continuous coring. The drill rods

NWD4-SERIES D4 CORE BARREL



NWD4 SERIES D4 CORE BARREL					
HOLE SIZE	CORE SIZE	OUTER TUBE O.D.	OUTER TUBE I.D.	INNER TUBE O.D.	INNER TUBE I.D.
2.980 in	2.060 in	2.906 in	2.562 in	2.375 in	2.135 in
75.7 mm	51.3 mm	73.8 mm	65.1 mm	60.3 mm	54.2 mm
NWD4 SERIES D4 CORE BARREL ASSEMBLIES					
PART DESCRIPTION					
Core Barrel Assembly - 5 ft (1.5 m)					
Core Barrel Assembly - 10 ft (3.0 m)					
Core Barrel Assembly - 5 ft (1.5 m) Split					
Core Barrel Assembly - 10 ft (3.0 m) Split					
SPARE PARTS FOR NWD4 SERIES D4 CORE BARREL					
1. Core Barrel Head, NW Rod					
A. Grease Fitting					
2. Outer Tube, 5 ft (1.5 m), C.P. Ends					
Outer Tube, 10 ft (3.0 m), C.P. Ends					
3. Inner Tube, 5 ft (1.5 m), C.P. ID					
Inner Tube, 10 ft (3.0 m), C.P. ID					
Inner Tube, Split, 5 ft (1.5 m) C.P. ID					
Inner Tube, Split, 10 ft (3.0 m) C.P. ID					
4. Bearing Assembly					
A. Bearing Shaft					
B. Lock Nut					
C. Bearing Retainer					
D. Bearing, Thrust Ball (2 Required)					
E. Hex Nut, Flanged					
F. Hex Nut, Regular					
G. Inner Tube Connector					
H. Ball					
5. Core Lifter, Skirtless					
6. Inner Tube Shoe/Case, C.P. ID					
7. Thread Protector Sub					

FIG. 3 Typical Double Tube Swivel Type-Conventional Core Barrel

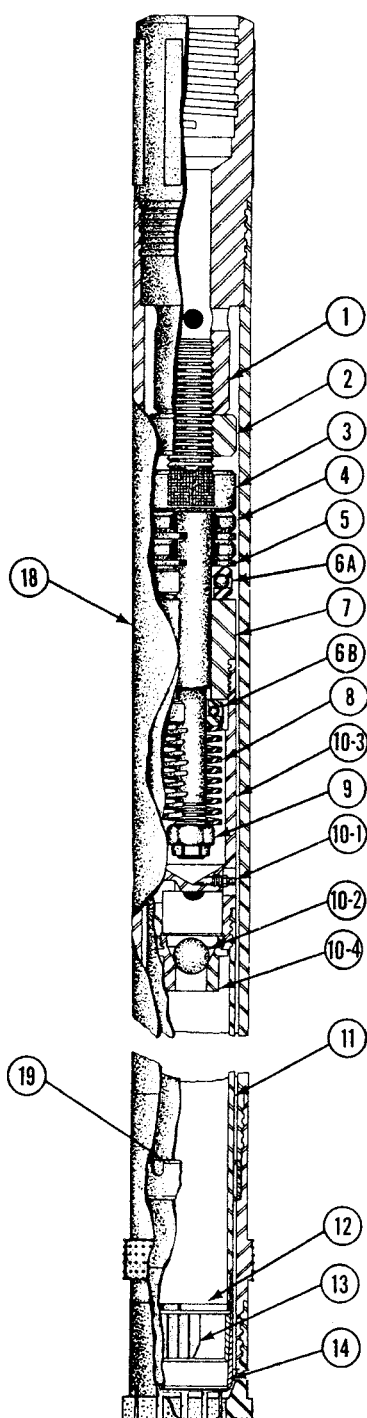
also act as a casing, and fluid is circulated from the bit through the annulus between the drill hole wall and drill rod. Wireline drill rod dimensions are not standardized. Table 3 lists the typical wireline rod sizes and Table 5 lists core barrel sizes of predominant types of wireline equipment available. Other systems such as heavy duty systems with differing dimensions may be available and are acceptable for use if dimensions are reported.

6.8.1 The inner barrel assembly is locked into the lead section of wireline drill rod by means of a retrievable overshot latching mechanism. A latching device locks into a complementary recess in the wall of the leading outer tube such that the outer tube could be rotated without causing the rotation of the inner tube. After the core run, the overshot mechanism is lowered through the rods and latches onto a spearhead on the top of the core barrel assembly and is hoisted to the surface

Double-Tube Swivel Type STANDARD CONVENTIONAL SYSTEM

Parts List

NV2" Core Barrel



Item No.	Description	No. Req'd	Unit Weight	
			lbs	kg
1-20	Core Barrel Assy 5 ft	—	76.0	34,5
1-20	Core Barrel Assy10 ft	—	126.0	57,2
-	Core Barrel Assy15 ft **	—	178.0	80,8
1-10	Head Assy	—	19.0	8,6
1	Outer Tube Head	1	8.7	3,9
2	Lock Nut	1	*	*
3	Spindle	1	3.1	1,4
4	Shut Off Valve	2	*	*
5	Valve Adjusting Washer	2	*	*
6A	Ball Thrust Bearing	1	*	*
6B	Hanger Bearing	1	*	*
7	Spindle Bearing	1	1.6	0,7
8	Compression Spring	1	*	*
9	Self Locking Nut	1	*	*
10	Inner Tube Cap Assy	—	3.6	1,6
10-1	Hydraulic Grease Fitting	1	*	*
10-2	Stainless Steel Ball	1	*	*
10-3	Inner Tube Cap	1	3.2	1,5
10-4	Check Valve Body	1	*	*
11	Inner Tube, 5 ft	1	12.3	5,6
11	Inner Tube, 10 ft	1	24.5	11,1
11	Inner Tube, 15 ft	1	38.0	17,2
12	Stop Ring	1	*	*
13	Fluted Core Lifter	1	*	*
14	Core Lifter Case	1	*	*
18	Outer Tube, 5 ft	1	44.0	20,0
18	Outer Tube, 10 ft	1	77.6	35,2
19	Inner Tube Stabilizer	1	*	*
20	Thread Protector (not shown)	1	2.5	1,1

Weights less than one pound (0.45 kg)

The Core Barrel Assembly 15 foot, consists of one Head Assembly, one each inner Tube 15 foot, Stop Ring, Core Lifter, Core Lifter Case, Outer Tube 5 foot, Outer Tube 10 foot, Thread Protector and two Inner Tube Stabilizers.

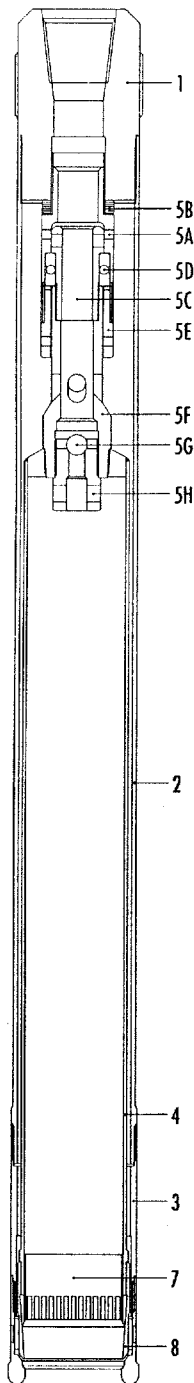
FIG. 4 Typical Double Tube Swivel Type-Core Barrel

with cable and wireline winch. The inner tube assembly consists of an inner tube with removable core lifter case and core lifter at one end, and a removable inner tube head swivel bearing, suspension adjustment, and a latching device with a release mechanism at the opposite end. If continuous coring is

not required, the retrievable inner core barrel assembly can be replaced with a pilot bit for hole advancement.

6.8.2 Wireline coring systems are designed for long life bits with wide kerf and impregnated or surface set diamonds. Both internal discharge and face discharge bits are available. The

7-3/4 in X 5-7/8 in CORE BARREL



7-3/4 in X 5-7/8 in CORE BARREL					
HOLE SIZE	CORE SIZE	OUTER TUBE O.D.	OUTER TUBE I.D.	INNER TUBE O.D.	INNER TUBE I.D.
8.000 in	5.875 in	7.500 in	7.000 in	6.500 in	6.125 in
203.2 mm	149.2 mm	190.5 mm	177.8 mm	165.1 mm	155.6 mm
7-3/4 in X 5-7/8 in CORE BARREL ASSEMBLIES					
PART DESCRIPTION					
Core Barrel Assembly - 5 ft (1.5 m)					
Core Barrel Assembly - 10 ft (3.0 m)					
Core Barrel Assembly - 5 ft (1.5 m) Split					
Core Barrel Assembly - 10 ft (3.0 m) Split					
SPARE PARTS FOR 7-3/4 in X 5-7/8 in CORE					
1. Core Barrel Head (4-1/2" A.P.I. Reg.)					
2. Outer Tube, 5 ft (1.5 m)					
Outer Tube 10 ft (3.0 m)					
3. Outer Tube Sub					
4. Inner Tube 5 ft (1.5 m), CP, ID					
Inner Tube 10 ft (3.0 m), CP, ID					
Inner Tube 5 ft (1.5 m) Split					
Inner Tube 10 ft (3.0 m) Split					
5. Bearing Assembly					
A. Cartridge Cap					
B. Shim, Set					
C. Bearing Retainer					
D. Bearing, Thrust, Ball					
E. Cartridge Plug					
F. Inner Tube Plug					
G. Ball					
H. Pressure Relief Plug					
6. Inner Tube Connector, Split					
7. Core Lifter, HF					
8. Inner Tube Shoe, BW					
9. Thread Protector Sub					
10. Tube Clamp, 7-1/2 in (190.5 mm) (outer)					
OPTIONAL EQUIPMENT					
11. Core Lifter, Skirtless, HF					

Note: If you do not see the item or size you are looking for, please contact you for additional product information.

FIG. 5 Typical Large Diameter Series —Conventional Core Barrel

inner core barrel has a dual shut-off valve that stops fluid circulation to alert the driller of a core blockage.

6.8.3 The advantages of wireline drilling are:

6.8.3.1 Significant reduction in rod handling time compared with conventional core barrels.

6.8.3.2 Increased coring bit life with decreased diamond loss.

6.8.3.3 High core recovery.

6.8.3.4 Caving is reduced and rods aid to stabilize the drill hole walls.

6.8.3.5 Rods are flush or near flush both inside and outside and can be used as a temporary casing.

6.8.3.6 Various in-hole instrumentation packages can be sent through the end of the drill string to test the bottom of the hole. Wireline packer systems can be used for pressure water test (Test Method D 4630).

NQ Core Barrel

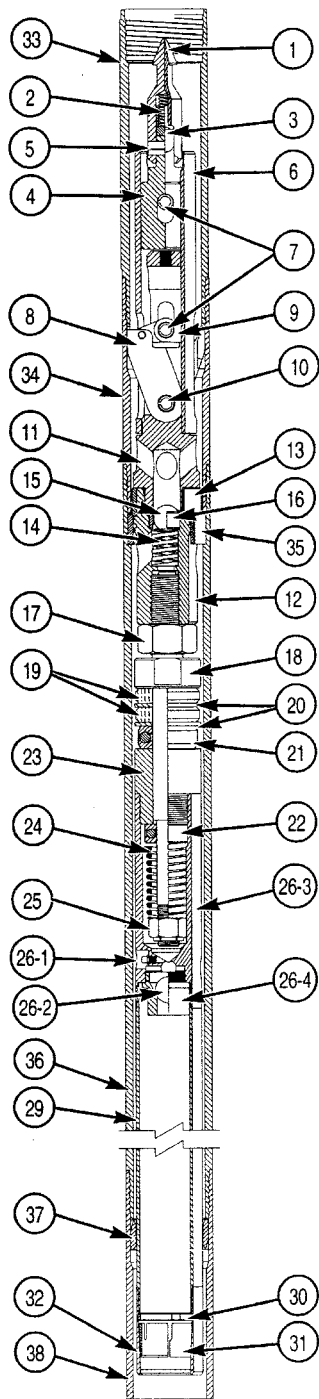


FIG. 6 Typical Wireline Rock Coring System

Item No.	Description	No. Req'd	Unit Weight lbs	kg
1-38	Core Barrel Assy 5 ft	—	-	-
1-38	Core Barrel Assy 10 ft	—	-	-
1-32	Inner Tube Assy 5 ft	—	-	-
1-32	Inner Tube Assy 10 ft	—	-	-
1-28	Head Assy	—	-	-
1	Spearhead Point	1	*	*
2	Compression Spring	1	*	*
3	Detent Plunger	1	*	*
4	Spearhead Base	1	1.3	0.6
5	Spiral Pin, 7/16" x 1"	1	*	*
6	Retracting Case	1	-	-
7	Spring Pin, 1/2" x 2"	2	*	*
8	Latch	2	*	*
9	Link	2	*	*
10	Spring Pin, 1/2" x 1-1/2"	1	*	*
11	Upper Latch Body	1	2.9	1.3
12	Lower Latch Body	1	3.1	1.4
13	Landing Shoulder	1	-	-
14	Dry Hole Spring, Light (not installed)			
15	Stainless Steel Ball, 22 mm (not installed)			
16	Bushing (not installed)			
17	Hex Nut	1	*	*
18	Spindle	1	3.1	1.4
19	Shut Off Valve, Hard	2	*	*
20	Valve Adjusting Washer	2	*	*
21	Thrust Bearing	1	*	*
22	Hanger Bearing	1	*	*
23	Spindle Bearing	1	1.6	0.7
24	Compression Spring	1	*	*
25	Self Locking Nut	1	*	*
26	Inner Tube Cap Assy	—	3.3	1.5
	(consists of 26-1, -2, -3, -4)			
26-1	Hydraulic Grease Fitting	1	*	*
26-2	Stainless Steel Ball, 22 mm	1	*	*
26-3	Inner Tube Cap	1	2.9	1.3
26-4	Check Valve Body	1	*	*
27	Landing Indicator Bushing (not installed)			
28	Dry Hole Spring, Medium (not installed)			
29	Inner Tube, 5 ft	1	12.3	5.6
29	Inner Tube, 10 ft	1	24.5	11.1
30	Stop Ring	1	*	*
31	Core Lifter	1	*	*
32	Core Lifter Case	1	1.6	0.7
33	Full-Hole H/T Tanged Locking Coupling**	1	5.9	2.7
34	Adapter Coupling	1	3.2	1.5
35	Landing Ring	1	*	*
36	Outer Tube, 5 ft	1	44.0	20.0
36	Outer Tube, 10 ft	1	77.6	35.2
37	Inner Tube Stabilizer	1	*	*
38	Thread Protector	1	2.5	1.1

Weights less than 1.0 lb (0.45 kg)

*H/T" means "Heat-Treated"

6.8.3.7 Two inner barrel assemblies can be used for maximum productivity in continuous coring operations.

6.8.4 The disadvantages of wireline drilling are:

6.8.4.1 Equipment is more expensive than conventional equipment, and

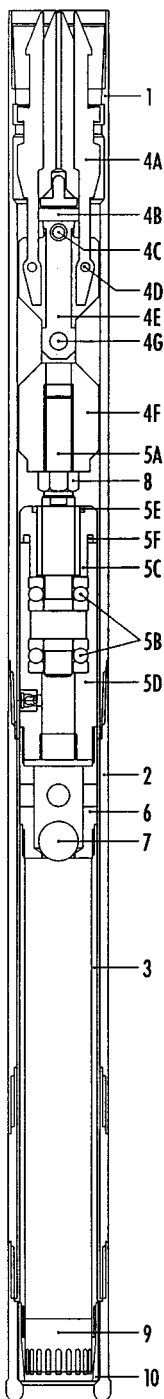
6.8.4.2 Wireline systems are complicated and operations require additional training.

6.8.5 Table 5 lists common wireline core barrel sizes. They are available in "A" through "P" size. When rock samples are

to be obtained for testing of engineering properties, "H" size is recommended, "N" is minimum, and "P" size will result in better recovery of difficult formations.

6.8.6 The wireline core barrel is essentially a double tube swivel type core barrel. Since the core lifter is part of the inner barrel assembly, exposure of the core to drill fluid is minimized similar to "M" style conventional core barrels. Most systems can be adjusted for front discharge (inside above bit gage) or face discharge.

NXB WIRELINE CORE BARREL



NXB WIRELINE CORE BARREL					
HOLE SIZE	CORE SIZE	OUTER TUBE O.D.	OUTER TUBE I.D.	INNER TUBE O.D.	INNER TUBE I.D.
2.980 in	1.875 in	2.875 in	2.391 in	2.200 in	1.969 in
75.7 mm	47.6 mm	73.0 mm	60.7 mm	55.9 mm	50.0 mm
NXB WIRELINE CORE BARREL ASSEMBLIES					
PART DESCRIPTION					
Core Barrel Assembly - 5 ft Complete (1.5 m)					
Core Barrel Assembly - 10 ft Complete (3.0 m)					
Core Barrel Assembly 5 ft (1.5 m) Split					
Core Barrel Assembly 10 ft (3.0 m) Split					
SPARE PARTS FOR NXB WIRELINE CORE BARREL					
1. Locking Coupling					
Locking Coupling, NQ Box Thread					
2. Outer Tube 5 ft (1.5 m)					
Outer Tube 10 ft (3.0 m)					
3. Inner Tube 5 ft (1.5 m)					
Inner Tube 10 ft (3.0 m)					
Inner Tube, Split, 5 ft (1.5 m)					
Inner Tube, Split, 10 ft (3.0 m)					
4. Quad-Latch Pivot Head Assembly					
A. Quad latch (4 required)					
B. Spring - Blue (Top)					
C. Spring - Red (Bottom)					
D. Pin (4 required)					
E. Head Base (Top)					
F. Head Base (Bottom)					
G. Pin					
5. Bearing Assembly					
A. Bearing Shaft					
B. Bearing (2 required)					
C. Bearing Retainer					
D. Housing w/Zerk & cap					
E. O-Ring					
F. O-Ring					
6. Inner Tube Connector					
InnerTube Connection, Split					
7. Ball					
8. Nut					
9. Core Lifter, Skirtless, Buttress					
10. Inner Tube Shoe/Case. CP					

FIG. 7 Typical Wireline Rock Coring System

6.8.7 Most manufacturers offer a triple tube barrel, which is preferred for most operations. The third tube is a split inner liner that facilitates sample handling.

6.8.8 Some wireline barrels systems are convertible from soil sampling to rock sampling operation. These barrels are equipped with soil barrels that can lead in front of the core bit. Some systems are equipped with spring loaded soil core barrels. These systems are advantageous when soils or soft rock are encountered.

6.9 Core Barrel Bits— One of the most important equipment decisions in rock core drilling is the bit selection. Both the bit and reaming shell act together to cut the hole. There are many bit design factors involved when selecting the proper bit for good core recovery. Factors included in selection are:

- 6.9.1 Diamond type—source,
- 6.9.2 Diamond matrix (surface set or impregnated),
- 6.9.3 Rock hardness, grain size, and formation,
- 6.9.4 Drill power, and

6.9.5 Barrel type.

6.9.6 Bit selection is a trial and error process that may require several iterations. After a bit is selected, it is tried with the drill to be used. Penetration rate and bit life should be evaluated and a different design selected if necessary.

6.9.7 Important features of diamond drilling bits include crown shape, diamonds, and waterways. The crown is the end of the bit that contains a kerf equipped with cutting media. A round or semi-round kerf is frequently used with conventional core barrels. Flat, stepped, or v-ring designs are often used with wireline drilling with impregnated bits.

6.9.8 Important features of the diamonds themselves are the size, quality, quantity, setting, and matrix quality (4). Surface set bits are used in most conventional coring operations. The size of diamonds is expressed in equivalent stones per carat (SPC). The typical SPC range is from 20 to 100 for surface set bits, with the finer stones being used for harder rock matrixes. Larger diamonds are used for softer, more friable formations. Impregnated bits are fragments mixed with metal and pressed and sintered into the bit. The diamond fragments are throughout the crown and the bit is, in a sense, self-sharpening. Impregnated bits are used in more severe drilling conditions and in wireline drilling where long life is essential.

6.9.9 Waterway design is also an important aspect of bit selection. Surface channel routing of the fluids from inside gage to outside is typical in conventional and wireline drilling for most crystalline rocks that are not sensitive to fluid erosion. Face discharge bits should be used for soft friable formations where fluid erosion is detrimental. Step-face discharge configurations further inhibit core erosion. Special flush discharge air ports are used with air and air-foam drilling operations. The softer the matrix, the larger the waterways must be to avoid blocking and plugging.

6.9.10 For very soft materials, it is not necessary to use diamonds as the cutting media. Diamonds can often be replaced with tungsten carbide or polycrystalline inserts for coring soft materials. Carbide and polycrystalline bits often have cutting teeth arranged in a sawtooth fashion. Polycrystalline bits (diamond grown to tungsten carbide substrates that are soldered or furnace onto the crown) have replaced natural diamonds for coring in some softer sedimentary formations. Some core barrels, such as the large diameter series, can readily be changed from diamond rock coring to carbide soil sampling modes.

6.9.11 Manufacturers are an excellent resource to assist in selecting the matrix and style of bit, depending on rock conditions, drill power, and barrel type. Most manufacturers have a method for rating diamond matrices and bits into different series and groups (3). DCDMA has selection codes for impregnated bits (10). Manufacturers should be consulted for initial recommendations for your specific drilling conditions, and as the project progresses, they can work with the driller to refine designs and drilling technique. Based on wear patterns, it may be possible to switch series or design to optimize results. In hard competent formations, bit selection may be drill rig-dependent (rotation rate and advance forces). It is beyond the scope of this practice to address drill bit selection. In addition to manufacturers' advice, there are

several useful references to provide information in evaluating causes for wear (3, 4, 10).

6.9.12 Most diamond bits have salvage value and should be returned to manufacturers for credit toward future purchases.

6.10 *Reaming Shells*—The reaming shell is a subassembly of a row or strip of material placed on the outside of the core barrel for some distance behind the core bit. It is designed to ream and enlarge the hole to a final diameter and must allow for adequate fluid circulation to the surface. The shell also acts as a collar or centralizer for the barrel. Manufacturers should be consulted for appropriate reaming shell designs for the formations to be drilled. They may be surface set with diamond bits, impregnated with diamond particles, inserted with tungsten carbide strips or slugs, hard faced with various types of hard surfacing materials, or furnished blank, as appropriate to the formation being cored.

6.11 *Core Lifters*—Core lifters are used to break the core from parent material at the end of a core run. As coring progresses, the lifter floats up in its beveled recessed slot in the shoe. After an increment of core has been drilled that corresponds to core barrel length, the rotation is stopped. Fluid is circulated until cuttings are cleared, and then the drill pipe is steadily retracted. The lifter will slide down the beveled shoe and impart an increasing grip on the core. The core frequently breaks near the base of the hole, and often a snap can be felt in the drill pipe as the core breaks from parent material.

6.11.1 Core lifters of the split ring type, either plain or hard surfaced, are recommended and must be maintained in good condition, along with core lifter cases or inner tubes extensions or inner tube shoes. Basket or finger type lifters with any necessary adapters may be used with core barrels if directed by the engineer or the geologist.

6.12 *Core Boxes*—These are durable waxed cardboard or wooden boxes with partitioned compartments for storing the core samples (see Practice D 5079).

6.13 *Auxiliary Equipment*—The following auxiliary equipment is typically used for the rock core drilling project:

6.13.1 *Drilling bits*—roller rock bits, drag bits, chopping bits, boulder busters, and fishtail bits;

6.13.2 *Tools*—pipe wrenches, core barrel wrenches, chain tong, strap wrench, watch, RPM counter, lubrication equipment, core splitters, rod wicking, extruders, hand sieves or strainers, and marking and packaging tools;

6.13.3 *Rod holding equipment*—closed pulling ring, open iron ring, knife edge holding dog, holding iron, chucking rods, safety foot clamp, manila rope, bolt, and clevis pins;

6.13.4 *Fluid circulation equipment*—hoses, positive displacement pump along with packing and seals, water swivel, pressure gages, flow meters, water-level meters, and mud pit; and

6.13.5 *Drill area, platform, and leveling*—cribbing, planking, lumber, saw horses, metal saw horses with chain vise.

7. Reagents and Materials

7.1 *Water-Based Drill Fluid Additives*—Listed below are commonly used additives for water-based drilling fluids. Drilling additives in contact with drinking water aquifers should meet the requirements of NSF 60-1988.

NOTE 3—In some areas, certain types of drill fluid products are not allowed by state and local environmental authorities. Before using any drill fluid product, check with the authorities to determine its acceptability.

7.1.1 Beneficiated bentonite, a primary viscosifier and drill hole sealer, consists of montmorillonite with other naturally occurring minerals and various additives such as guar gum, sodium carbonate, or polyacrylates, or a combination thereof.

7.1.2 Unbeneficiated bentonite, a primary viscosifier and drill hole sealer, consists of montmorillonite with other naturally occurring minerals, but without additives such as guar gum, sodium carbonate, or polyacrylates.

7.1.3 Sodium carbonate powder (soda ash) is used to precipitate calcium carbonate from the drilling fluid water-base before adding other components. An increase in pH will occur with the addition of sodium carbonates. Sodium hydroxides (caustic soda) generally should not be used for this application.

7.1.4 Carboxymethylcellulose powder (CMC) is sometimes used in a water-based fluid as a viscosifier and as an inhibitor to clay hydration. Some additives to water-based drilling-fluid systems retard clay hydration, thus inhibiting swelling of clays on the drill hole wall and “balling” or “smearing” of the bit.

7.1.5 Potassium chloride (muriated potash) or diammonium phosphate can be used as an inhibitor to clay hydration.

7.1.6 Polyacrylamide, a primary viscosifier and clay hydration inhibitor, is a polymer mixed with water to create a drilling fluid.

7.1.7 Guar gum, a primary viscosifier, drill-hole sealer, and hydration inhibitor, is a starch mixed with a water base. The water must be neutral to slightly acidic and hydrochloric acid is sometimes used to pre-treat the water base. Guar gum will degrade with time, but various chemicals can be used to accelerate decomposition.

7.1.8 Barium sulfate increases the density of water-based drilling fluids to help support the borehole wall. It is a naturally occurring high-specific gravity mineral processed to a powder for rotary drilling fluid applications.

7.1.9 Lost-circulation materials are added to the drilling fluid to seal the drill-hole wall when fluids are being lost through large pores, cracks, or joints. These additives usually consist of various coarse textured materials such as shredded paper or plastic, bentonite chips, wood fibers, or mica.

7.1.10 Attapulgate, a primary viscosifier for rotary drilling in high-salinity environments, is a clay mineral drilling-fluid additive.

8. Precautions

8.1 The drilling and sampling equipment shall be complete and in good order. A sufficient amount of drill rods, casings, drill bits, core barrels, core barrel liners, water meters, pumps, and pressure gages shall be in hand before the start of drilling. Measurement devices such as pressure gages and RPM counters shall be functioning in conformance with the manufacturer’s specifications.

8.2 The use of fluid or air under high pressure may cause damage to formation materials by fracturing or excessive erosion if drilling conditions are not carefully maintained and monitored. If formation damage is evident and undesirable,

other drilling method(s) should be considered.

8.2.1 Fluid pressure should be monitored during drilling. Fluid pressure at the bit should be as low as possible to maintain circulation and to reduce possibility of hydraulic fracturing or excessive erosion of surrounding materials. Normally, injection fluid pressures are fully monitored. Changes in fluid return and circulation pressure may indicate occurrence of excessive erosion, formation fluid loss, core blockage, or formation fracturing. Any abrupt changes or anomalies in the fluid pressure should be noted and documented, including the depth(s) of occurrence(s).

9. Procedure

9.1 Perform site inspections to determine locations of boreholes, and to select disposal sites for waste products during drilling.

9.1.1 Evaluate applicable methods for environmental protection and traffic regulation during core drilling.

9.1.2 Determine site accessibility and availability of water for core drilling operation. Check around the drill site for overhead obstructions or hazards, such as power lines, before raising the mast. A survey of underground and all other utilities is required before drilling to evaluate hazards.

9.2 Fabricate and assemble the drill mounting platform. The platform can take a variety of forms. The type of platform will depend on the terrain encountered, the stipulated depth of the borehole, and the accessibility of the drill site. Specialized mountings such as a barge or stilts or specially constructed towers are necessary to mount platforms for drilling over water.

9.3 For water-based fluid drilling operation, a mud pit is positioned to collect and filter fluid return flow. An initial quantity of drilling fluid is mixed, usually using the mud pit as the primary mixing reservoir.

9.3.1 For air-based circulation systems, the dust collector or cyclone separator is positioned and “sealed” to the ground surface.

9.4 Case any interval of the borehole that penetrates the overburden. This will prevent collapsing of loose materials into the borehole or loss of drill fluid. The casing should extend through the overburden and extend at least 5 ft (1.5 m) into the rock. Casing may be omitted if the borehole will stand open without caving. Deeper casing(s) or nested casing(s) may be required to facilitate adequate drill hole fluid circulation and hole control. Records of casing(s) lengths and depth intervals installed should be maintained and documented.

9.4.1 Surface casings can be installed using a variety of drilling methods. Hollow-stem auger drilling (D 6151) has been used successfully for surface casing and has an added benefit of obtaining samples of the overburden soils. The surface casing is normally backfilled, pressed, or sealed in place with bentonite or cement, or both.

9.4.2 A datum for measuring drill hole depth should be established and documented. This datum normally consists of a stake driven into stable ground surface, the top of the surface casing, or the drilling deck. If there is possibility for movement of the surface casing, it should not be used as a datum. If the hole is to be later surveyed for elevation, record and report the height of the datum to the ground surface.

9.5 The core barrel is assembled following manufacturers' instructions. Keep core barrels cleaned and lubricated and free from damage, dents, or other defects that might affect core quality. Inspect barrels for wear, clearances, dents, or galls. Check condition of core lifters, fluid passages, relief holes, ball checks, valve rubbers, and inner barrel stabilizers, if present. Assemble and disassemble core barrels with the correct tools for the job.

9.5.1 The inner tube of double tube core barrels must be positioned correctly for proper operation. For both conventional and wireline systems where fluid circulates between the bit and lifter case, check that the proper clearance is maintained for circulation. For wireline systems, this will require engaging the inner barrel while the outer barrel is held vertically. If clearances are not correct, they should be adjusted using the adjustment screw on top of the barrel assembly.

9.5.2 For swivel type inner barrels, inspect the bearing assemblies and confirm the inner barrel is free to rotate smoothly when assembled.

9.6 An initial assembly of lead drill rod and core barrel is attached to the drill mechanism through a spindle or below the drill head, and placed within the top of the surface casing. Hole depth is determined by keeping track of the length of the rod-bit assemblies and comparing its position relative to the established surface datum. Hole depth for increments of drilling, coring, and sampling is recorded on the drill log.

9.7 The drilling-fluid circulation pump or air compressor is activated, causing drilling fluid or air to circulate through the system.

9.8 Drilling fluid or air circulation is initiated and rotation and axial force are applied to the drill rod and bit until drilling progresses to a depth where: (1) when the core sample has fully entered the core barrel or blockage is apparent, (2) sampling or in-situ testing will be performed, or (3) the length of the drill-rod column limits further penetration.

9.8.1 Maintain fluid circulation at a rate suitable for the formation to be drilled. Fluid should be circulated at a rate sufficient to circulate cuttings and cool the bit. Fluid pressures should be monitored during drilling. Avoid drilling at excessive advance rate, which could cause plugging of the bit and core blockage and damage. Changes in fluid return and circulation pressures may indicate occurrence of excessive erosion, formation fluid loss, or formation fracturing. Any abrupt changes or anomalies in fluid pressure should be noted and documented, including depth(s) of occurrence(s).

9.8.2 Maintain air circulation at a rate suitable for the formation, and avoid circulation losses. Add water or foam as necessary to maintain circulation. Zones of low air return or no air return should be documented. Should air-blast erosion occur, depth(s) of the occurrence(s) should be noted and documented. Air is particularly susceptible to blocking off circulation and causing uplift to occur very quickly.

9.8.3 Samples of drill cuttings can be collected for analysis of materials penetrated. If cuttings samples are obtained, the depth(s) and interval(s) should be documented.

9.8.4 The selection of proper rotation rate and down feed (advance) or hold-back pressure depends on many factors. The drilling process is iterative in nature. Diamond drilling in a

harder matrix usually requires higher rotation rates and down force pressures. With the correct material and equipment configurations, diamond bit performance is generally optimum at rotation rates of at least 400 rpm or greater. Rates of up to 1000 rpm can be used, depending on the material. However, too high a rate can cause tearing of the formation and core recovery problems. Softer materials with other bits such as polycrystalline, require slower rotation rates. Vibration is extremely important to the drill hole and core quality and must be minimized. Sufficient thrust needs to be transmitted to the bit so that bit elements can cut the rock. The goal is to find the rotation rate and thrust that will result in high quality core and acceptable bit life.

9.8.4.1 Monitor advance or down force pressure, or hold-back pressures, and rotation rates of drill rods during drilling. Observe the penetration rate and drill cuttings as they relate to the geologic strata being penetrated. Document occurrences of any significant abrupt changes and anomalies during drilling.

9.9 Rotation is stopped, the advance or down force pressure is released, and circulation is continued for a short time until the drill cuttings are removed from the borehole annulus. Circulation is stopped and the barrel is rested on the hole bottom to determine hole depth.

9.10 Remove the core barrel and the core from the borehole. Disassemble the core barrel and remove the core.

9.10.1 With double tube barrels, when the barrel is retracted, the core lifter grips the core and the core is normally broken from the base material at the base of the hole. The core lifter is located inside the barrel above the bit typically about 0.1ft. When the core is broken there will be a small pedestal of core left in the hole. As long as the lifter is not slipping, and core is of good quality, successive recoveries will be close to 100%. If for some reason, the lifter case slips, there will be low recovery recorded and there will be a longer pedestal on the subsequent sampling event. If there appears to be excessive core on the subsequent run, or there is visible evidence of the lifter slipping, these occurrences should be noted. If it is obvious the pedestal was present, the length can be accounted for in determination of recovery (see 10.1) of the previous run. These occurrences and corrections should be appropriately noted in the drill report.

9.10.2 With single tube core barrels in shallow drilling operations, the core can be broken with a wedge and lifted by wire hoop to the surface.

9.11 Reassemble the core barrel and return it to the borehole. Check for proper barrel conditions as noted in 9.7. The use of two barrels can greatly speed coring operations; as one barrel is cleaned and reassembled the other is in use in coring.

9.12 Drilling depth is increased by attaching an additional drill-rod section(s) to the top of the previously advanced drill-rod column and resuming drilling operations in accordance with 9.8-9.12.

9.13 *Rock Core Handling*—Use of split inner barrel liners greatly increases the efficiency of handling of cores, especially in broken formations. Cores can be transferred into plastic half rounds for logging and sealing. Log, preserve, and place core samples in core boxes in accordance with Practice D 5079.

9.14 *Rock Core Recovery*—Rock core shall be recovered

continuously in the borehole. If recovery drops below 100 % (see Section 10), modify the drilling procedure, that is, adjust the drilling RPM, down feed pressure, the drilling fluid type and flow, or change the type and the size of core barrel or bit used, until core recovery is improved to a level acceptable to the project geologist or project engineer. Minimize mechanical breaks in the core during core drilling as much as possible.

9.14.1 *Poor Recovery*— Stop core drilling when recovery equals or falls below 50 %. If recovering samples is important, select a better core barrel or bit design. In some cases, it may be necessary to attempt soil sampling techniques (11).

9.15 If conditions prevent advance of the drill hole to the stipulated depth, the borehole shall be cemented and redrilled, or reamed and cased, cased and advanced with a smaller size drill bit and core barrel, or abandoned, as directed by the engineer or geologist.

9.16 Prepare boring logs and place the rock sample in core boxes, and mark and pack them in accordance with Practice D 5079.

10. Calculation

10.1 *Calculate Percent Core Recovery*—Determine the rock core recovery as the ratio of length of core recovered to the length drilled, and express as a percent.

$$\text{Percent core recovery} = \frac{\text{Length of the recovered core}}{\text{Total length of the core run}} \times 100 \quad (1)$$

10.2 Calculate Rock Quality Designation (RQD) in accordance with D 6032.

11. Report

11.1 Report the following information:

11.1.1 *Site Conditions*— Site description: description of the site and any unusual circumstances.

11.1.2 *Personnel*—document all personnel at the site during the drilling process, including the driller, helpers, geologist or logger, engineer, and other monitors or visitors.

11.1.3 *Weather conditions during drilling.*

11.1.4 Working hours, operating times, break-down times, and sampling times. Report any long-term delays in the drilling and installation process.

11.1.5 Report any unusual occurrences that may have happened during the investigation.

11.1.6 *Drilling Methods:*

11.1.6.1 Description of the coring system including type, sizes, core barrels, fluid pump, fluid circulation, and discharge systems. Note intervals of equipment change or drilling method changes and reasons for change.

11.1.6.2 Type, quantities, and drill hole locations of use of additives added to the circulation media. If changes to the circulating medium are made, such as addition of water or conversion to foam, the depth(s) or interval(s) of these changes should be documented.

11.1.6.3 Descriptions of circulation rates, cuttings returns, including quantities, over intervals used. Note the quantity and locations of loss of circulation and probable cause.

11.1.6.4 Descriptions of drilling conditions related to drilling pressures, rotation rates, and general ease of drilling related to subsurface materials encountered. These descriptions can be

very general, and should report how the sampling of different materials progressed.

11.1.6.5 *Records of casing installed*—Report type, amount and times of installation. Record water levels (dates and elevation) observed during drilling.

11.1.7 *Sampling*—When core sampling or undisturbed sampling at the base of the boring separate from coring operations, report condition of the base of the boring before sampling and any slough or cuttings present in the recovered sample. Samples of fluid circulation cuttings can be collected for analysis of materials being penetrated. If cuttings samples are taken, the depth(s) and interval(s) should be documented.

11.1.8 *In-situ Testing:*

11.1.8.1 For devices inserted below the base of the drill hole, report the depths below the base of the hole and any unusual conditions during testing.

11.1.8.2 For devices testing or seating at the drill hole wall, report any unusual conditions of the drill hole wall such as inability to seat pressure packers.

11.1.9 *Installations*— A description of completion materials and methods of placement, approximate volumes placed, intervals of placement, methods of confirming placement, and areas of difficulty or unusual occurrences.

11.2 *Boring Logs*— Boring logs should be completed in accordance with Guide D 5434. Some information that the boring log should include is:

11.2.1 Project identification, boring number, location, orientation, date boring began, date boring completed, and drillers' name(s).

11.2.2 Elevation coordinates of the top of the borehole.

11.2.3 Elevation of, or depth to, ground water surface, and any changes in water level, including the dates and times measured.

11.2.4 Elevations or depths at which the drilling fluid returns were lost and amount of return with depth. Report advance or down feed and hold-back pressures, rotation rates of drill rods, fluid/gas pressure, and circulations return during drilling. Report the penetration rate and drill cuttings as they relate to the geologic strata being penetrated. Document any significant abrupt changes and anomalies that occur during drilling.

11.2.5 Size, type, and design of core barrels used. Size, type, and set of core bits and reaming shells used. Size, type, and design and lengths of all casing used, and locations or elevations of casings used. Records of casing(s) lengths and depth intervals installed should be maintained and documented.

11.2.6 Length of each core run and the percentage of core recovery.

11.2.7 Driller's description of the core in each run, if no engineer or geologist was present.

11.2.8 Geologist's or engineer's description of the core recovered in each run. Subsurface description, including dip of strata, jointing, cavities, fissures, core loss, and any other observations made by the geologist, engineer, or the driller that could yield information about the formation encountered during drilling. Depth, thickness, and apparent nature of the filling of each soft seam or cavity encountered. Report the

calculated RQD and D 6032.

11.2.9 Any change in the character of the drilling fluid or drilling fluid return.

11.2.10 Reservoir, tidal, or current information, if the drilling is near or over a body of water.

11.2.11 Drilling time in minutes per foot and down feed gage pressure, when applicable, and the RPM of the drill rods.

11.2.12 Notations of character of drilling, that is, soft, slow, easy, smooth, and others.

12. Precision and Bias

12.1 This practice does not produce numerical data; therefore, a precision and bias statement is not applicable.

12.2 The boring log reflects the subjective opinions of the engineer, the geologist, or the driller. Therefore, the designer must exercise proper prudence when interpreting the boring logs.

12.3 This procedure produces data on rock type and rock quality and recovery factors such as RQD (D 6032) that may reflect the biases of the persons collecting the data. Precision for determination of RQD will be addressed in D 6032.

13. Keywords

13.1 diamond drilling; exploration; rock; rock coring; rock investigations; site characterization

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SUMMARY OF CHANGES

This section identifies the principal changes to this practice that have been incorporated since the last issue. There have been significant changes to the standard. The previous standard was developed in the 1970's. Since that time wireline systems have gained preference in industry.

- (1) Expanded Section 1 to add reference to other drilling standards and safety standards.
- (2) Added logging and transport and storage standards to Section 2.
- (3) Added a Terminology section and defined drilling-related terms.
- (4) Added Section 4, Summary of Practice, to describe drilling, coring, and sampling processes.
- (5) Expanded Apparatus section to discuss the advantages and disadvantages of selecting specific designs. Added sections on fluid and air drilling. Changed and expanded section on wireline drilling methods.
- (6) Added section on materials and presented major drill fluid materials and additives.
- (7) Removed section on transportation and storage of rock core and referred to Practice D 5079.
- (8) Added new Section 8, Precautions, to warn against fracturing and drill hole disturbance.
- (9) Added section on Calculations and added recovery and RQD. Referred to RQD as a separate D 6032.
- (10) Changed section Boring Log to Report and referred to Guide D 5434.

 D 2113

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ATTACHMENT 3

Field Logs and Construction Diagrams



DAY ENVIRONMENTAL, INC.

ENVIRONMENTAL CONSULTANTS

AN AFFILIATE OF DAY ENGINEERING, P.C.

Project #:
Project Address: 1560 Lake Avenue
Rochester, New York
DAY Representative:
Drilling Contractor:
Sampling Method:

Ground Elevation: Datum:
Date Started: Date Ended:
Borehole Depth: Borehole Diameter:
Completion Method: ☐ Well Installed ☐ Backfilled with Grout ☐ Backfilled with Cuttings
Water Level (Date):

Test Boring TB-

Page 1 of 2

Depth (ft)	Blows per 0.5 ft.	Sample Number	Sample Depth (ft)	% Recovery	N-Value or RQD%	Headspace PID (ppm)	PID Reading (ppm)	Sample Description	Notes
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									

Notes: 1) Water levels were made at the times and under conditions stated. Fluctuations of groundwater levels may occur due to seasonal factors and other conditions.

2) Stratification lines represent approximate boundaries. Transitions may be gradual.

3) PID readings are referenced to an isobutylene standard. A MiniRae 3000 equipped with a 10.6 eV lamp was used to obtain the PID readings.

4) NA = Not Available or Not Applicable

5) Headspace PID readings may be influenced by moisture

Test Boring TB-

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ENVIRONMENTAL CONSULTANTS

AN AFFILIATE OF DAY ENGINEERING, P.C.

Project #:
Project Address: 1560 Lake Avenue
Rochester, New York
DAY Representative:
Drilling Contractor:
Sampling Method:

Ground Elevation: Datum: Page 2 of 2
Date Started: Date Ended:
Borehole Depth: Borehole Diameter:
Completion Method: ☐ Well Installed ☐ Backfilled with Grout ☐ Backfilled with Cuttings
Water Level (Date):

Test Boring TB-

Depth (ft)	Blows per 0.5 ft.	Sample Number	Sample Depth (ft)	% Recovery	N-Value or RQD%	Headspace PID (ppm)	PID Reading (ppm)	Sample Description	Notes
17									
18									
19									
20									
21									
22									
23									
24									
25									
26									
27									
28									
29									
30									
31									
32									

Notes: 1) Water levels were made at the times and under conditions stated. Fluctuations of groundwater levels may occur due to seasonal factors and other conditions.
2) Stratification lines represent approximate boundaries. Transitions may be gradual.
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Project #:
Project Address: 1560 Lake Avenue
Rochester, New York
DAY Representative:
Drilling Contractor:
Sampling Method:

Test Boring TB-

Page 2 of 2

Ground Elevation: Datum:
Date Started: Date Ended:
Borehole Depth: Borehole Diameter:
Completion Method: ☐ Well Installed ☐ Backfilled with Grout ☐ Backfilled with Cuttings
Water Level (Date):

Depth (ft)	Blows per 0.5 ft.	Sample Number	Sample Depth (ft)	% Recovery	N-Value or RQD%	Headspace PID (ppm)	PID Reading (ppm)	Sample Description	Notes
33									
34									
P									
36									
37									
38									
39									
40									
41									
42									
43									
44									
45									
46									
47									
48									

Notes: 1) Water levels were made at the times and under conditions stated. Fluctuations of groundwater levels may occur due to seasonal factors and other conditions.
2) Stratification lines represent approximate boundaries. Transitions may be gradual.
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5) Headspace PID readings may be influenced by moisture

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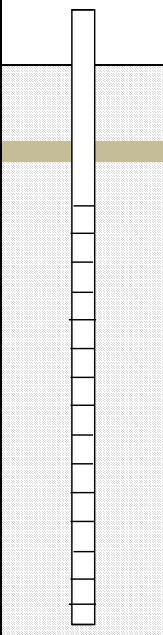


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AN AFFILIATE OF DAY ENGINEERING, P.C.

OVERBURDEN MONITORING WELL CONSTRUCTION DIAGRAM

Project #:				MONITORING WELL MW-	
Project Address:		1560 Lake Avenue			
		Rochester, New York			
DAY Representative:					
Drilling Contractor:					
		Ground Elevation:		Datum:	
		Date Started:		Date Ended:	
		Water Level (Date):			
Refer to Test Boring Log TB- ~ for Soil Description		_____ Height of Stickup (ft)			
		← Ground Surface			
		_____ Depth to Bottom of Cement Surface Patch (ft)			
		Backfill Type _____			
		_____ Depth to Top of Bentonite Seal (ft)			
		_____ Depth to Bottom of Bentonite Seal (ft)			
		_____ Depth to Top of Well Screen (ft)			
		_____ Diameter of Borehole (in)			
		Backfill Type _____			
		_____ Inside Diameter of Well (in)			
		Type of Pipe _____			
		Screen slot size _____			
		_____ Depth to Bottom of Well Screen (ft)			
		_____ Depth to Bottom of Borehole (ft)			
		Notes: 1) Water levels were made at the times and under conditions stated. Fluctuations of groundwater levels may occur due to seasonal factors and other conditions. 2) NA = Not Available or Not Applicable			
				MONITORING WELL MW-	

S:\Fieldforms\Monitoring Well Installation Log (revised November 2013)

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BEDROCK MONITORING WELL CONSTRUCTION DIAGRAM

Project #:

Project Address: 1560 Lake Avenue

Rochester, New York

DAY Representative:

Drilling Contractor:

MONITORING WELL MW-

Ground Elevation:

Datum:

Date Started:

Date Ended:

Water Level (Date):

Refer to Test Boring Log TB- ~ for Soil Description

____ Height of Stickup (ft)

← Ground Surface

____ Depth to Top of Cement/Bentonite Seal (ft)

Backfill Type _____

____ Diameter of Borehole to Top of Bedrock (in)

____ Diameter of Steel Casing (in)

____ Depth to top of Bedrock(ft)

____ Diameter of Rock Socket (in)

____ Depth to Bottom of Rock Socket/Top of Open Core (ft)

____ Diameter of Rock Core (in)

____ Depth to Bottom of Open Core (ft)

Notes: 1) Water levels were made at the times and under conditions stated. Fluctuations of groundwater levels may occur due to seasonal factors and other conditions.

2) NA = Not Available or Not Applicable

MONITORING WELL MW-

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WELL DEVELOPMENT DATA **MW-**

SITE LOCATION: 1560 Lake Avenue, Rochester, New York

JOB#: _

DATE/ TIME								
EVACUATION METHOD								
PID/FID (PPM)								
DEPTH OF WELL (FT)								
STATIC WATER LEVEL (SWL) FT								
VOLUME EVACUATED (GAL)								
TOTAL VOLUME EVACUATED (GAL)								
TEMPERATURE (°C)								
pH								
ORP (mV)								
CONDUCTIVITY (µs/cm)								
TURBIDITY (NTU)								
VISUAL OBSERVATION								

LEGEND: NC = Not Collected
ND = Not Detected
*= Not Measurable

Day Environmental, Inc.
1563 Lyell Avenue
Rochester, New York 14606

SECTION 1 - SITE AND WELL INFORMATION		
SITE LOCATION	1560 lake Avenue, Rochester, New York	JOB # _____
PROJECT NAME:	BCP RI	DATE: _____
SAMPLE COLLECTOR(S):	_____	WEATHER: _____
PID READING IN WELL HEADSPACE (PPM): _____ CASING TYPE: PVC SCREENED INTERVAL [FT BGS]: _____ WELL DEPTH [FT BGS]: _____ (Do <u>NOT</u> Measure Well depth Prior To Purging And Sampling) MEASURING POINT (for water levels): Top of Casing WELL DIAMETER (INCHES): _____ INITIAL WATER LEVEL SWL / Date Measured (SWL) [FT]: _____ / _____ DEPTH OF PUMP INTAKE [FT BGS]: _____ OTHER OBSERVATIONS: _____ LNAPL: _____ DNAPL: _____		

SECTION 2 – SAMPLING EQUIPMENT	
PUMP TYPE: <u>Geotech Geopump™ - Peristaltic pump</u>	WATER LEVEL METER: _____
WATER QUALITY METER(s): _____	
STABILIZED PUMP RATE (ml/min): _____	STABILIZED DRAWDOWN WATER LEVEL [FT]: _____

SECTION 3 – WATER QUALITY DATA MONITORING									
Time	Pumping Rate (ml/min)	Water Level (ft) (<0.33 ft)	DO (mg/L) ($\pm 10\%$)	ORP (mv) (± 10 mV)	Turbidity (NTU) (± 10 NTUs, if >10 NTU)	Conductivity (mS/cm) ($\pm 3\%$)	pH (± 0.1)	Temp. (C°) ($\pm 10\%$)	Total Vol. Pumped (ml)
	SAMPLE OBSERVATIONS: ~								

SECTION 4 - SAMPLE IDENTIFICATION AND ANALYTICAL LABORATORY PARAMETERS			
SAMPLE ID #	DATE / TIME	SAMPLING METHOD	ANALYTICAL SCAN(S)
		Peristaltic Pump	



DAY ENVIRONMENTAL, INC.

ENVIRONMENTAL CONSULTANTS

AN AFFILIATE OF DAY ENGINEERING, P.C.

SOIL VAPOR PROBE CONSTRUCTION DIAGRAM

Project #:		Soil Vapor Probe SV-
Project Address:	1560 Lake Avenue Rochester, New York	
DAY Representative:		Ground Elevation: _____ Datum: _____
Drilling Contractor:		Date Started: _____ Date Ended: _____
		Water Level (Date): _____

Refer to Test Boring Log TB- ~ for Soil Description		_____ Depth to Top of Bentonite Seal (ft)
		_____ Depth to Bottom of Bentonite Seal (ft)
		_____ Depth to Top of Screen (ft)
		_____ Diameter of Borehole (in)
		Backfill Type _____
		_____ Inside Diameter of probe (in)
		Type of screen _____
		Screen mesh size _____
		_____ Depth to Bottom of Probe Screen (ft)
		_____ Depth to Bottom of Borehole (ft)

Notes: 1) Water levels were made at the times and under conditions stated. Fluctuations of groundwater levels may occur due to seasonal factors and other conditions.
2) NA = Not Available or Not Applicable

Soil Vapor Probe-

S:\Fieldforms\Soil vapor probe Installation Log (revised June 2014)

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ATTACHMENT 4

**Guidance Documents for
Method 5035 VOC Soil Sampling and Analysis,
and Emerging Contaminants Sampling and Analysis**

CLOSED-SYSTEM PURGE-AND-TRAP AND EXTRACTION FOR
VOLATILE ORGANICS IN SOIL AND WASTE SAMPLES

1.0 SCOPE AND APPLICATION

1.1 This method describes a closed-system purge-and-trap process for the analysis of volatile organic compounds (VOCs) in solid materials (e.g., soils, sediments, and solid waste). While the method is designed for use on samples containing low levels of VOCs, procedures are also provided for collecting and preparing solid samples containing high concentrations of VOCs and for oily wastes. For these high concentration and oily materials, sample collection and preparation are performed using the procedures described here, and sample introduction is performed using the aqueous purge-and-trap procedure in Method 5030. These procedures may be used in conjunction with any appropriate determinative gas chromatographic procedure, including, but not limited to, Methods 8015, 8021, and 8260.

1.2 The low soil method utilizes a hermetically-sealed sample vial, the seal of which is never broken from the time of sampling to the time of analysis. Since the sample is never exposed to the atmosphere after sampling, the losses of VOCs during sample transport, handling, and analysis are negligible. The applicable concentration range of the low soil method is dependent on the determinative method, matrix, and compound. However, it will generally fall in the 0.5 to 200 µg/kg range.

1.3 Procedures are included for preparing high concentration samples for purging by Method 5030. High concentration samples are those containing VOC levels of >200 µg/kg.

1.4 Procedures are also included for addressing oily wastes that are soluble in a water-miscible solvent. These samples are also purged using Method 5030..

1.5 Method 5035 can be used for most volatile organic compounds that have boiling points below 200°C and that are insoluble or slightly soluble in water. Volatile, water-soluble compounds can be included in this analytical technique. However, quantitation limits (by GC or GC/MS) are approximately ten times higher because of poor purging efficiency.

1.6 Method 5035, in conjunction with Method 8015 (GC/FID), may be used for the analysis of the aliphatic hydrocarbon fraction in the light ends of total petroleum hydrocarbons, e.g., gasoline. For the aromatic fraction (BTEX), use Method 5035 and Method 8021 (GC/PID). A total determinative analysis of gasoline fractions may be obtained using Method 8021 in series with Method 8015.

1.7 As with any preparative method for volatiles, samples should be screened to avoid contamination of the purge-and-trap system by samples that contain very high concentrations of purgeable material above the calibration range of the low concentration method. In addition, because the sealed sample container cannot be opened to remove a sample aliquot without compromising the integrity of the sample, multiple sample aliquots should be collected to allow for screening and reanalysis.

1.8 The closed-system purge-and-trap equipment employed for low concentration samples is not appropriate for soil samples preserved in the field with methanol. Such samples should be analyzed using Method 5030 (see the note in Sec. 6.2.2).

1.9 This method is restricted to use by or under the supervision of trained analysts. Each analyst must demonstrate the ability to generate acceptable results with this method.

2.0 SUMMARY OF METHOD

- 2.1 Low concentration soil method - generally applicable to soils and other solid samples with VOC concentrations in the range of 0.5 to 200 µg/kg.

Volatile organic compounds (VOCs) are determined by collecting an approximately 5-g sample, weighed in the field at the time of collection, and placing it in a pre-weighed vial with a septum-sealed screw-cap (see Sec. 4) that already contains a stirring bar and a sodium bisulfate preservative solution. The vial is sealed and shipped to a laboratory or appropriate analysis site. The entire vial is then placed, unopened, into the instrument carousel. Immediately before analysis, organic-free reagent water, surrogates, and internal standards (if applicable) are automatically added without opening the sample vial. The vial containing the sample is heated to 40°C and the volatiles purged into an appropriate trap using an inert gas combined with agitation of the sample. Purged components travel via a transfer line to a trap. When purging is complete, the trap is heated and backflushed with helium to desorb the trapped sample components into a gas chromatograph for analysis by an appropriate determinative method.

- 2.2 High concentration soil method - generally applicable to soils and other solid samples with VOC concentrations greater than 200 µg/kg.

The sample introduction technique in Sec. 2.1 is not applicable to all samples, particularly those containing high concentrations (generally greater than 200 µg/kg) of VOCs which may overload either the volatile trapping material or exceed the working range of the determinative instrument system (e.g., GC/MS, GC/FID, GC/EC, etc.). In such instances, this method describes two sample collection options and the corresponding sample purging procedures.

2.2.1 The first option is to collect a bulk sample in a vial or other suitable container without the use of the preservative solution described in Sec. 2.1. A portion of that sample is removed from the container in the laboratory and is dispersed in a water-miscible solvent to dissolve the volatile organic constituents. An aliquot of the solution is added to 5 mL of reagent water in a purge tube. Surrogates and internal standards (if applicable) are added to the solution, then purged using Method 5030, and analyzed by an appropriate determinative method. Because the procedure involves opening the vial and removing a portion of the soil, some volatile constituents may be lost during handling.

2.2.2 The second option is to collect an approximately 5-g sample in a pre-weighed vial with a septum-sealed screw-cap (see Sec 4) that contains 5 mL of a water-miscible organic solvent (e.g., methanol). At the time of analysis, surrogates are added to the vial, then an aliquot of the solvent is removed from the vial, purged using Method 5030 and analyzed by an appropriate determinative method.

- 2.3 High concentration oily waste method - generally applicable to oily samples with VOC concentrations greater than 200 µg/kg that can be diluted in a water-miscible solvent.

Samples that are comprised of oils or samples that contain significant amounts of oil present additional analytical challenges. This procedure is generally appropriate for such samples when they are soluble in a water-miscible solvent.

2.3.1 After demonstrating that a test aliquot of the sample is soluble in methanol or polyethylene glycol (PEG), a separate aliquot of the sample is spiked with surrogates and diluted in the appropriate solvent. An aliquot of the solution is added to 5 mL of reagent water in a purge tube, taking care to ensure that a floating layer of oil is not present in the purge tube. Internal standards (if applicable) are added to the solution which is then purged using Method 5030 and analyzed by an appropriate determinative method.

2.3.2 Samples that contain oily materials that are not soluble in water-miscible solvents must be prepared according to Method 3585.

3.0 INTERFERENCES

3.1 Impurities in the purge gas and from organic compounds out-gassing from the plumbing ahead of the trap account for the majority of contamination problems. The analytical system must be demonstrated to be free from contamination under the conditions of the analysis by running method blanks. The use of non-polytetrafluoroethylene (non-PTFE) plastic coating, non-PTFE thread sealants, or flow controllers with rubber components in the purging device must be avoided, since such materials out-gas organic compounds which will be concentrated in the trap during the purge operation. These compounds will result in interferences or false positives in the determinative step.

3.2 Samples can be contaminated by diffusion of volatile organics (particularly methylene chloride and fluorocarbons) through the septum seal of the sample vial during shipment and storage. A trip blank prepared from organic-free reagent water and carried through sampling and handling protocols serves as a check on such contamination.

3.3 Contamination by carryover can occur whenever high-concentration and low-concentration samples are analyzed in sequence. Where practical, samples with unusually high concentrations of analytes should be followed by an analysis of organic-free reagent water to check for cross-contamination. If the target compounds present in an unusually concentrated sample are also found to be present in the subsequent samples, the analyst must demonstrate that the compounds are not due to carryover. Conversely, if those target compounds are not present in the subsequent sample, then the analysis of organic-free reagent water is not necessary.

3.4 The laboratory where volatile analysis is performed should be completely free of solvents. Special precautions must be taken to determine methylene chloride. The analytical and sample storage area should be isolated from all atmospheric sources of methylene chloride, otherwise random background levels will result. Since methylene chloride will permeate through PTFE tubing, all GC carrier gas lines and purge gas plumbing should be constructed of stainless steel or copper tubing. Laboratory workers' clothing previously exposed to methylene chloride fumes during common liquid/liquid extraction procedures can contribute to sample contamination. The presence of other organic solvents in the laboratory where volatile organics are analyzed will also lead to random background levels and the same precautions must be taken.

4.0 APPARATUS AND MATERIALS

4.1 Sample Containers

The specific sample containers required will depend on the purge-and-trap system to be employed (see Sec. 4.2). Several systems are commercially available. Some systems employ 40-mL clear vials with a special frit and equipped with two PTFE-faced silicone septa. Other

systems permit the use of any good quality glass vial that is large enough to contain at least 5 g of soil or solid material and at least 10 mL of water and that can be sealed with a screw-cap containing a PTFE-faced silicone septum. Consult the purge-and-trap system manufacturer's instructions regarding the suitable specific vials, septa, caps, and mechanical agitation devices.

4.2 Purge-and-Trap System

The purge-and-trap system consists of a unit that automatically adds water, surrogates, and internal standards (if applicable) to a vial containing the sample, purges the VOCs using an inert gas stream while agitating the contents of the vial, and also traps the released VOCs for subsequent desorption into the gas chromatograph. Such systems are commercially available from several sources and shall meet the following specifications.

4.2.1 The purging device should be capable of accepting a vial sufficiently large to contain a 5-g soil sample plus a magnetic stirring bar and 10 mL of water. The device must be capable of heating a soil vial to 40°C and holding it at that temperature while the inert purge gas is allowed to pass through the sample. The device should also be capable of introducing at least 5 mL of organic-free reagent water into the sample vial while trapping the displaced headspace vapors. It must also be capable of agitating the sealed sample during purging, (e.g., using a magnetic stirring bar added to the vial prior to sample collection, sonication, or other means). The analytes being purged must be quantitatively transferred to an absorber trap. The trap must be capable of transferring the absorbed VOCs to the gas chromatograph (see 4.2.2).

NOTE: The equipment used to develop this method was a Dynatech PTA-30 W/S Autosampler. This device was subsequently sold to Varian, and is now available as the Archon Purge and Trap Autosampler. See the Disclaimer at the front of this manual for guidance on the use of alternative equipment.

4.2.2 A variety of traps and trapping materials may be employed with this method. The choice of trapping material may depend on the analytes of interest. Whichever trap is employed, it must demonstrate sufficient adsorption and desorption characteristics to meet the quantitation limits of all the target analytes for a given project and the QC requirements in Method 8000 and the determinative method. The most difficult analytes are generally the gases, especially dichlorodifluoromethane. The trap must be capable of desorbing the late eluting target analytes.

NOTE: Check the responses of the brominated compounds when using alternative charcoal traps (especially Vocarb 4000), as some degradation has been noted when higher desorption temperatures (especially above 240 - 250°C) are employed. 2-Chloroethyl vinyl ether is degraded on Vocarb 4000 but performs adequately when Vocarb 3000 is used. The primary criterion, as stated above, is that all target analytes meet the sensitivity requirements for a given project.

4.2.2.1 The trap used to develop this method was 25 cm long, with an inside diameter of 0.105 inches, and was packed with Carbopack/Carbosieve (Supelco, Inc.).

4.2.2.2 The standard trap used in other EPA purge-and-trap methods is also acceptable. That trap is 25 cm long and has an inside diameter of at least 0.105 in. Starting from the inlet, the trap contains the equal amounts of the adsorbents listed below. It is recommended that 1.0 cm of methyl silicone-coated packing (35/60 mesh, Davison, grade 15 or equivalent) be inserted at the inlet to extend the life of the trap. If

the analysis of dichlorodifluoromethane or other fluorocarbons of similar volatility is not required, then the charcoal can be eliminated and the polymer increased to fill 2/3 of the trap. If only compounds boiling above 35°C are to be analyzed, both the silica gel and charcoal can be eliminated and the polymer increased to fill the entire trap.

4.2.2.2.1 2,6-Diphenylene oxide polymer - 60/80 mesh, chromatographic grade (Tenax GC or equivalent).

4.2.2.2.2 Methyl silicone packing - OV-1 (3%) on Chromosorb-W, 60/80 mesh or equivalent.

4.2.2.2.3 Coconut charcoal - Prepare from Barnebey Cheney, CA-580-26, or equivalent, by crushing through 26 mesh screen.

4.2.2.3 Trapping materials other than those listed above also may be employed, provided that they meet the specifications in Sec. 4.2.3, below.

4.2.3 The desorber for the trap must be capable of rapidly heating the trap to the temperature recommended by the trap material manufacturer, prior to the beginning of the flow of desorption gas. Several commercial desorbers (purge-and-trap units) are available.

4.3 Syringe and Syringe Valves

4.3.1 25-mL glass hypodermic syringes with Luer-Lok (or equivalent) tip (other sizes are acceptable depending on sample volume used).

4.3.2 2-way syringe valves with Luer ends.

4.3.3 25-μL micro syringe with a 2 inch x 0.006 inch ID, 22° bevel needle (Hamilton #702N or equivalent).

4.3.4 Micro syringes - 10-, 100-μL.

4.3.5 Syringes - 0.5-, 1.0-, and 5-mL, gas-tight with shut-off valve.

4.4 Miscellaneous

4.4.1 Glass vials

4.4.1.1 60-mL, septum-sealed, to collect samples for screening, dry weight determination.

4.4.1.2 40-mL, screw-cap, PTFE lined, septum-sealed. Examine each vial prior to use to ensure that the vial has a flat, uniform sealing surface.

4.4.2 Top-loading balance - Capable of accurately weighing to 0.01 g.

4.4.3 Glass scintillation vials - 20-mL, with screw-caps and PTFE liners, or glass culture tubes with screw-caps and PTFE liners, for dilution of oily waste samples.

4.4.4 Volumetric flasks - Class A, 10-mL and 100-mL, with ground-glass stoppers.

4.4.5 2-mL glass vials, for GC autosampler - Used for oily waste samples extracted with methanol or PEG.

4.4.6 Spatula, stainless steel - narrow enough to fit into a sample vial.

4.4.7 Disposable Pasteur pipettes.

4.4.8 Magnetic stirring bars - PTFE- or glass-coated, of the appropriate size to fit the sample vials. Consult manufacturer's recommendation for specific stirring bars. Stirring bars may be reused, provided that they are thoroughly cleaned between uses. Consult the manufacturers of the purging device and the stirring bars for suggested cleaning procedures.

4.5 Field Sampling Equipment

4.5.1 Purge-and-Trap Soil Sampler - Model 3780PT (Associated Design and Manufacturing Company, 814 North Henry Street, Alexandria, VA 22314), or equivalent.

4.5.2 EnCore™ sampler - (En Chem, Inc., 1795 Industrial Drive, Green Bay, WI 54302), or equivalent.

4.5.3 Alternatively, disposable plastic syringes with a barrel smaller than the neck of the soil vial may be used to collect the sample. The syringe end of the barrel is cut off prior to sampling. One syringe is needed for each sample aliquot to be collected.

4.5.4 Portable balance - For field use, capable of weighing to 0.01 g.

4.5.5 Balance weights - Balances employed in the field should be checked against an appropriate reference weight at least once daily, prior to weighing any samples, or as described in the sampling plan. The specific weights used will depend on the total weight of the sample container, sample, stirring bar, reagent water added, cap, and septum.

5.0 REAGENTS

5.1 Organic-free reagent water - All references to water in this method refer to organic-free reagent water, as defined in Chapter One.

5.2 Methanol, CH₃OH - purge-and-trap quality or equivalent. Store away from other solvents.

5.3 Polyethylene glycol (PEG), H(OCH₂CH₂)_nOH - free of interferences at the detection limit of the target analytes.

5.4 Low concentration sample preservative

5.4.1 Sodium bisulfate, NaHSO₄ - ACS reagent grade or equivalent.

5.4.2 The preservative should be added to the vial prior to shipment to the field, and must be present in the vial prior to adding the sample.

5.5 See the determinative method and Method 5000 for guidance on internal standards and surrogates to be employed in this procedure.

6.0 SAMPLE COLLECTION, PRESERVATION, AND HANDLING

Refer to the introductory material in this chapter, Organic Analytes, Sec. 4.1, for general sample collection information. The low concentration portion of this method employs sample vials that are filled and weighed in the field and never opened during the analytical process. As a result, sampling personnel should be equipped with a portable balance capable of weighing to 0.01 g.

6.1 Preparation of sample vials

The specific preparation procedures for sample vials depend on the expected concentration range of the sample, with separate preparation procedures for low concentration soil samples and high concentration soil and solid waste samples. Sample vials should be prepared in a fixed laboratory or other controlled environment, sealed, and shipped to the field location. Gloves should be worn during the preparation steps.

6.1.1 Low concentration soil samples

The following steps apply to the preparation of vials used in the collection of low concentration soil samples to be analyzed by the closed-system purge-and-trap equipment described in Method 5035.

6.1.1.1 Add a clean magnetic stirring bar to each clean vial. If the purge-and-trap device (Sec. 4.2) employs a means of stirring the sample other than a magnetic stirrer (e.g., sonication or other mechanical means), then the stir bar is omitted.

6.1.1.2 Add preservative to each vial. The preservative is added to each vial prior to shipping the vial to the field. Add approximately 1 g of sodium bisulfate to each vial. If samples markedly smaller or larger than 5 g are to be collected, adjust the amount of preservative added to correspond to approximately 0.2 g of preservative for each 1 g of sample. Enough sodium bisulfate should be present to ensure a sample pH of ≤ 2 .

6.1.1.3 Add 5 mL of organic-free reagent water to each vial. The water and the preservative will form an acid solution that will reduce or eliminate the majority of the biological activity in the sample, thereby preventing biodegradation of the volatile target analytes.

6.1.1.4 Seal the vial with the screw-cap and septum seal. If the double-ended, fritted, vials are used, seal both ends as recommended by the manufacturer.

6.1.1.5 Affix a label to each vial. This eliminates the need to label the vials in the field and assures that the tare weight of the vial includes the label. (The weight of any markings added to the label in the field is negligible).

6.1.1.6 Weigh the prepared vial to the nearest 0.01 g, record the tare weight, and write it on the label.

6.1.1.7 Because volatile organics will partition into the headspace of the vial from the aqueous solution and will be lost when the vial is opened, surrogates, matrix spikes, and internal standards (if applicable) should only be added to the vials after the sample has been added to the vial. These standards should be introduced back in the

laboratory, either manually by puncturing the septum with a small-gauge needle or automatically by the sample introduction system, just prior to analysis.

6.1.2 High concentration soil samples collected without a preservative

When high concentration samples are collected without a preservative, a variety of sample containers may be employed, including 60-mL glass vials with septum seals (see Sec. 4.4).

6.1.3 High concentration soil samples collected and preserved in the field

The following steps apply to the preparation of vials used in the collection of high concentration soil samples to be preserved in the field with methanol and analyzed by the aqueous purge-and-trap equipment described in Method 5030.

6.1.3.1 Add 10 mL of methanol to each vial.

6.1.3.2 Seal the vial with the screw-cap and septum seal.

6.1.3.3 Affix a label to each vial. This eliminates the need to label the vials in the field and assures that the tare weight of the vial includes the label. (The weight of any markings added to the label in the field is negligible).

6.1.3.4 Weigh the prepared vial to the nearest 0.01 g, record the tare weight, and write it on the label.

NOTE: Vials containing methanol should be weighed a second time on the day that they are to be used. Vials found to have lost methanol (reduction in weight of >0.01 g) should not be used for sample collection.

6.1.3.5 Surrogates, internal standards and matrix spikes (if applicable) should be added to the sample after it is returned to the laboratory and prior to analysis.

6.1.4 Oily waste samples

When oily waste samples are known to be soluble in methanol or PEG, sample vials may be prepared as described in Sec. 6.1.3, using the appropriate solvent. However, when the solubility of the waste is unknown, the sample should be collected without the use of a preservative, in a vial such as that described in Sec. 6.1.2.

6.2 Sample collection

Collect the sample according to the procedures outlined in the sampling plan. As with any sampling procedure for volatiles, care must be taken to minimize the disturbance of the sample in order to minimize the loss of the volatile components. Several techniques may be used to transfer a sample to the relatively narrow opening of the low concentration soil vial. These include devices such as the EnCore™ sampler, the Purge-and-Trap Soil Sampler™, and a cut plastic syringe. Always wear gloves whenever handling the tared sample vials.

6.2.1 Low concentration soil samples

6.2.1.1 Using an appropriate sample collection device, collect approximately 5 g of sample as soon as possible after the surface of the soil or other solid material has been exposed to the atmosphere: generally within a few minutes at most. Carefully wipe the exterior of the sample collection device with a clean cloth or towel.

6.2.1.2 Using the sample collection device, add about 5 g (2 - 3 cm) of soil to the sample vial containing the preservative solution. Quickly brush any soil off the vial threads and immediately seal the vial with the septum and screw-cap. Store samples on ice at 4°C.

NOTE: Soil samples that contain carbonate minerals (either from natural sources or applied as an amendment) may effervesce upon contact with the acidic preservative solution in the low concentration sample vial. If the amount of gas generated is very small (i.e., several mL), any loss of volatiles as a result of such effervescence may be minimal if the vial is sealed quickly. However, if larger amounts of gas are generated, not only may the sample lose a significant amount of analyte, but the gas pressure may shatter the vial if the sample vial is sealed. Therefore, when samples are known or suspected to contain high levels of carbonates, a test sample should be collected, added to a vial, and checked for effervescence. If a rapid or vigorous reaction occurs, discard the sample and collect low concentration samples in vials that do not contain the preservative solution.

6.2.1.3 When practical, use a portable balance to weigh the sealed vial containing the sample to ensure that 5.0 ± 0.5 g of sample were added. The balance should be calibrated in the field using an appropriate weight for the sample containers employed (Sec. 4.5.5). Record the weight of the sealed vial containing the sample to the nearest 0.01 g.

6.2.1.4 Alternatively, collect several trial samples with plastic syringes. Weigh each trial sample and note the length of the soil column in the syringe. Use these data to determine the length of soil in the syringe that corresponds to 5.0 ± 0.5 g. Discard each trial sample.

6.2.1.5 As with the collection of aqueous samples for volatiles, collect at least two replicate samples. This will allow the laboratory an additional sample for reanalysis. The second sample should be taken from the same soil stratum or the same section of the solid waste being sampled, and within close proximity to the location from which the original sample was collected.

6.2.1.6 In addition, since the soil vial cannot be opened without compromising the integrity of the sample, at least one additional aliquot of sample must be collected for screening, dry weight determination, and high concentration analysis (if necessary). This third aliquot may be collected in a 60-mL glass vial or a third 40-mL soil sample vial. However, this third vial must *not* contain the sample preservative solution, as an aliquot will be used to determine dry weight. If high concentration samples are collected in vials containing methanol, then two additional aliquots should be collected, one for high concentration analysis collected in a vial containing methanol, and another for the dry weight determination in a vial without either methanol or the low concentration aqueous preservative solution.

6.2.1.7 If samples are known or expected to contain target analytes over a wide range of concentrations, thereby requiring the analyses of multiple sample aliquots, it may be advisable and practical to take an additional sample aliquot in a low concentration soil vial containing the preservative, but collecting only 1-2 g instead of the 5 g collected in Sec. 6.2.1.1. This aliquot may be used for those analytes that exceed the instrument calibration range in the 5-g analysis.

6.2.1.8 The EnCore™ sampler has not been thoroughly evaluated by EPA as a sample storage device. While preliminary results indicate that storage in the EnCore™ device may be appropriate for up to 48 hours, samples collected in this device should be transferred to the soil sample vials as soon as possible, or analyzed within 48 hours.

6.2.1.9 The collection of low concentration soil samples in vials that contain methanol is not appropriate for samples analyzed with the closed-system purge-and-trap equipment described in this method (see Sec. 6.2.2).

6.2.2 High concentration soil samples preserved in the field

The collection of soil samples in vials that contain methanol has been suggested by some as a combined preservation and extraction procedure. However, this procedure is not appropriate for use with the low concentration soil procedure described in this method.

NOTE: The use of methanol preservation has not been formally evaluated by EPA and analysts must be aware of two potential problems. First, the use of methanol as a preservative and extraction solvent introduces a significant dilution factor that will raise the method quantitation limit beyond the operating range of the low concentration direct purge-and-trap procedure (0.5-200 µg/kg). The exact dilution factor will depend on the masses of solvent and sample, but generally exceeds 1000, and may make it difficult to demonstrate compliance with regulatory limits or action levels for some analytes. Because the analytes of interest are volatile, the methanol extract cannot be concentrated to overcome the dilution problem. Thus, for samples of unknown composition, it may still be necessary to collect an aliquot for analysis by this closed-system procedure and another aliquot preserved in methanol and analyzed by other procedures. The second problem is that the addition of methanol to the sample is likely to cause the sample to fail the ignitability characteristic, thereby making the unused sample volume a hazardous waste.

6.2.2.1 When samples are known to contain volatiles at concentrations high enough that the dilution factor will not preclude obtaining results within the calibration range of the appropriate determinative method, a sample may be collected and immediately placed in a sample vial containing purge-and-trap grade methanol.

6.2.2.2 Using an appropriate sample collection device, collect approximately 5 g of sample as soon as possible after the surface of the soil or other solid material has been exposed to the atmosphere: generally within a few minutes at most. Carefully wipe the exterior of the sample collection device with a clean cloth or towel.

6.2.2.3 Using the sample collection device, add about 5 g (2 - 3 cm) of soil to the vial containing 10 mL of methanol. Quickly brush any soil off the vial threads and immediately seal the vial with the septum and screw-cap. Store samples on ice at 4°C.

6.2.2.4 When practical, use a portable balance to weigh the sealed vial containing the sample to ensure that 5.0 ± 0.5 g of sample were added. The balance should be calibrated in the field using an appropriate weight for the sample containers employed (Sec. 4.5.5). Record the weight of the sealed vial containing the sample to the nearest 0.01 g.

6.2.2.5 Alternatively, collect several trial samples with plastic syringes. Weigh each trial sample and note the length of the soil column in the syringe. Use these data to determine the length of soil in the syringe that corresponds to 5.0 ± 0.5 g. Discard each trial sample.

6.2.2.6 Other sample weights and volumes of methanol may be employed, provided that the analyst can demonstrate that the sensitivity of the overall analytical procedure is appropriate for the intended application.

6.2.2.7 The collection of at least one additional sample aliquot is required for the determination of the dry weight, as described in Sec. 6.2.1.6. Samples collected in methanol should be shipped as described in Sec. 6.3, and must be clearly labeled as containing methanol, so that the samples are not analyzed using the closed-system purge-and-trap equipment described in this procedure.

6.2.3 High concentration soil sample not preserved in the field

The collection of high concentration soil samples that are not preserved in the field generally follows similar procedures as for the other types of samples described in Secs. 6.2.1 and 6.2.2, with the obvious exception that the sample vials contain neither the aqueous preservative solution nor methanol. However, when field preservation is not employed, it is better to collect a larger volume sample, filling the sample container as full as practical in order to minimize the headspace. Such collection procedures generally do not require the collection of a separate aliquot for dry weight determination, but it may be advisable to collect a second sample aliquot for screening purposes, in order to minimize the loss of volatiles in either aliquot.

6.2.4 Oily waste samples

The collection procedures for oily samples depend on knowledge of the waste and its solubility in methanol or other solvents.

6.2.4.1 When an oily waste is known to be soluble in methanol or PEG, the sample may be collected in a vial containing such a solvent (see Sec. 6.1.4), using procedures similar to those described in Sec. 6.2.2.

6.2.4.2 When the solubility of the oily waste is not known, the sample should either be collected in a vial without a preservative, as described in Sec. 6.2.3, or the solubility of a trial sample should be tested in the field, using a vial containing solvent. If the trial sample is soluble in the solvent, then collect the oily waste sample as described in Sec. 6.2.2. Otherwise, collect an unpreserved sample as described in Sec. 6.2.3.

6.3 Sample handling and shipment

All samples for volatiles analysis should be cooled to approximately 4°C, packed in appropriate containers, and shipped to the laboratory on ice, as described in the sampling plan.

6.4 Sample storage

6.4.1 Once in the laboratory, store samples at 4°C until analysis. The sample storage area should be free of organic solvent vapors.

6.4.2 All samples should be analyzed as soon as practical, and within the designated holding time from collection. Samples not analyzed within the designated holding time must be noted and the data are considered minimum values.

6.4.3 When the low concentration samples are strongly alkaline or highly calcareous in nature, the sodium bisulfate preservative solution may not be strong enough to reduce the pH of the soil/water solution to below 2. Therefore, when low concentration soils to be sampled are known or suspected to be strongly alkaline or highly calcareous, additional steps may be required to preserve the samples. Such steps include: addition of larger amounts of the sodium bisulfate preservative to non-calcareous samples, storage of low concentration samples at -10°C (taking care not to fill the vials so full that the expansion of the water in the vial breaks the vial), or significantly reducing the maximum holding time for low concentration soil samples. Whichever steps are employed, they should be clearly described in the sampling and QA project plans and distributed to both the field and laboratory personnel. See Sec. 6.2.1.2 for additional information.

7.0 PROCEDURE

This section describes procedures for sample screening, the low concentration soil method, the high concentration soil method, and the procedure for oily waste samples. High concentration samples are to be introduced into the GC system using Method 5030. Oily waste samples are to be introduced into the GC system using Method 5030 if they are soluble in a water-miscible solvent, or using Method 3585 if they are not.

7.1 Sample screening

7.1.1 It is highly recommended that all samples be screened prior to the purge-and-trap GC or GC/MS analysis. Samples may contain higher than expected quantities of purgeable organics that will contaminate the purge-and-trap system, thereby requiring extensive cleanup and instrument maintenance. The screening data are used to determine which is the appropriate sample preparation procedure for the particular sample, the low concentration closed-system direct purge-and-trap method (Sec. 7.2), the high concentration (methanol extraction) method (Sec. 7.3), or the nonaqueous liquid (oily waste) methanol or PEG dilution procedure (Sec. 7.4).

7.1.2 The analyst may employ any appropriate screening technique. Two suggested screening techniques employing SW-846 methods are:

7.1.2.1 Automated headspace (Method 5021) using a gas chromatograph (GC) equipped with a photoionization detector (PID) and an electrolytic conductivity detector (HECD) in series, or,

7.1.2.2 Extraction of the sample with hexadecane (Method 3820) and analysis of the extract on a GC equipped with a FID and/or an ECD.

7.1.3 The analyst may inject a calibration standard containing the analytes of interest at a concentration equivalent to the upper limit of the calibration range of the low concentration soil method. The results from this standard may be used to determine when the screening results approach the upper limit of the low concentration soil method. There are no linearity or other performance criteria associated with the injection of such a standard, and other approaches may be employed to estimate sample concentrations.

7.1.4 Use the low concentration closed-system purge-and-trap method (Sec. 7.2) if the estimated concentration from the screening procedure falls within the calibration range of the selected determinative method. If the concentration exceeds the calibration range of the low concentration soil method, then use either the high concentration soil method (Sec. 7.3), or the oily waste method (Sec. 7.4).

7.2 Low concentration soil method (Approximate concentration range of 0.5 to 200 µg/kg - the concentration range is dependent upon the determinative method and the sensitivity of each analyte.)

7.2.1 Initial calibration

Prior to using this introduction technique for any GC or GC/MS method, the system must be calibrated. General calibration procedures are discussed in Method 8000, while the determinative methods and Method 5000 provide specific information on calibration and preparation of standards. Normally, external standard calibration is preferred for the GC methods (non-MS detection) because of possible interference problems with internal standards. If interferences are not a problem, or when a GC/MS method is used, internal standard calibration may be employed.

7.2.1.1 Assemble a purge-and-trap device that meets the specification in Sec. 4.2 and that is connected to a gas chromatograph or a gas chromatograph/mass spectrometer system.

7.2.1.2 Before initial use, a Carbowack/Carbosieve trap should be conditioned overnight at 245°C by backflushing with an inert gas flow of at least 20 mL/minute. If other trapping materials are substituted for the Carbowack/Carbosieve, follow the manufacturers recommendations for conditioning. Vent the trap effluent to the hood, not to the analytical column. Prior to daily use, the trap should be conditioned for 10 minutes at 245°C with backflushing. The trap may be vented to the analytical column during daily conditioning; however, the column must be run through the temperature program prior to analysis of samples.

7.2.1.3 If the standard trap in Sec. 4.2.2.2 is employed, prior to initial use, the trap should be conditioned overnight at 180°C by backflushing with an inert gas flow of at least 20 mL/min, or according to the manufacturer's recommendations. Vent the trap effluent to the hood, not to the analytical column. Prior to daily use, the trap should be conditioned for 10 min at 180°C with backflushing. The trap may be vented to the analytical column during daily conditioning; however, the column must be run through the temperature program prior to analysis of samples.

7.2.1.4 Establish the purge-and-trap instrument operating conditions. Adjust the instrument to inject 5 mL of water, to heat the sample to 40°C, and to hold the sample at 40°C for 1.5 minutes before commencing the purge process, or as recommended by the instrument manufacturer.

7.2.1.5 Prepare a minimum of five initial calibration standards containing all the analytes of interest and surrogates, as described in Method 8000, and following the instrument manufacturer's instructions. The calibration standards are prepared in organic-free reagent water. The volume of organic-free reagent water used for calibration must be the same volume used for sample analysis (normally 5 mL added to the vial before shipping it to the field plus the organic-free reagent water added by the instrument). The calibration standards should also contain approximately the same amount of the sodium bisulfate preservative as the sample (e.g., ~1 g), as the presence of the preservative will affect the purging efficiencies of the analytes. The internal standard solution must be added automatically, by the instrument, in the same fashion as used for the samples. Place the soil vial containing the solution in the instrument carousel. In order to calibrate the surrogates using standards at five concentrations, it may be necessary to disable the automatic addition of surrogates to each vial containing a calibration standard (consult the manufacturer's instructions). Prior to purging, heat the sample vial to 40°C for 1.5 minutes, or as recommended by the manufacturer.

7.2.1.6 Carry out the purge-and-trap procedure as outlined in Secs. 7.2.3. to 7.2.5.

7.2.1.7 Calculate calibration factors (CF) or response factors (RF) for each analyte of interest using the procedures described in Method 8000. Calculate the average CF (external standards) or RF (internal standards) for each compound, as described in Method 8000. Evaluate the linearity of the calibration data, or choose another calibration model, as described in Method 8000 and the specific determinative method.

7.2.1.8 For GC/MS analysis, a system performance check must be made before this calibration curve is used (see Method 8260). If the purge-and-trap procedure is used with Method 8021, evaluate the response for the following four compounds: chloromethane; 1,1-dichloroethane; bromoform; and 1,1,2,2-tetrachloroethane. They are used to check for proper purge flow and to check for degradation caused by contaminated lines or active sites in the system.

7.2.1.8.1 Chloromethane is the most likely compound to be lost if the purge flow is too fast.

7.2.1.8.2 Bromoform is one of the compounds most likely to be purged very poorly if the purge flow is too slow. Cold spots and/or active sites in the transfer lines may adversely affect response.

7.2.1.8.3 Tetrachloroethane and 1,1-dichloroethane are degraded by contaminated transfer lines in purge-and-trap systems and/or active sites in trapping materials.

7.2.1.9 When analyzing for very late eluting compounds with Method 8021 (i.e., hexachlorobutadiene, 1,2,3-trichlorobenzene, etc.), cross-contamination and memory effects from a high concentration sample or even the standard are a common problem.

Extra rinsing of the purge chamber after analysis normally corrects this. The newer purge-and-trap systems often overcome this problem with better bakeout of the system following the purge-and-trap process. Also, the charcoal traps retain less moisture and decrease the problem.

7.2.2 Calibration verification

Refer to Method 8000 for details on calibration verification. A single standard near the mid-point of calibration range is used for verification. This standard should also contain approximately 1 g of sodium bisulfate.

7.2.3 Sample purge-and-trap

This method is designed for a 5-g sample size, but smaller sample sizes may be used. Consult the instrument manufacturer's instructions regarding larger sample sizes, in order to avoid clogging of the purging apparatus. The soil vial is hermetically sealed at the sampling site, and MUST remain so in order to guarantee the integrity of the sample. Gloves must be worn when handling the sample vial since the vial has been tared. If any soil is noted on the exterior of the vial or cap, it must be carefully removed prior to weighing. Weigh the vial and contents to the nearest 0.01 g, even if the sample weight was determined in the field, and record this weight. This second weighing provides a check on the field sampling procedures and provides additional assurance that the reported sample weight is accurate. Data users should be advised on significant discrepancies between the field and laboratory weights.

7.2.3.1 Remove the sample vial from storage and allow it to warm to room temperature. Shake the vial gently, to ensure that the contents move freely and that stirring will be effective. Place the sample vial in the instrument carousel according to the manufacturer's instructions.

7.2.3.2 Without disturbing the hermetic seal on the sample vial, add 5 mL of organic-free reagent water, the internal standards, and the surrogate compounds. This is carried out using the automated sampler. Other volumes of organic-free reagent water may be used, however, it is imperative that all samples, blanks, and calibration standards have exactly the same final volume of organic-free reagent water. Prior to purging, heat the sample vial to 40°C for 1.5 minutes, or as described by the manufacturer.

7.2.3.3 For the sample selected for matrix spiking, add the matrix spiking solution described in Sec. 5.0 of Method 5000, either manually, or automatically, following the manufacturer's instructions. The concentration of the spiking solution and the amount added should be established as described in Sec. 8.0 of Method 8000.

7.2.3.4 Purge the sample with helium or another inert gas at a flow rate of up to 40 mL/minute (the flow rate may vary from 20 to 40 mL/min, depending on the target analyte group) for 11 minutes while the sample is being agitated with the magnetic stirring bar or other mechanical means. The purged analytes are allowed to flow out of the vial through a glass-lined transfer line to a trap packed with suitable sorbent materials.

7.2.4 Sample Desorption

7.2.4.1 Non-cryogenic interface - After the 11 minute purge, place the purge-and-trap system in the desorb mode and preheat the trap to 245°C without a flow

of desorption gas. Start the flow of desorption gas at 10 mL/minute for about four minutes (1.5 min is normally adequate for analytes in Method 8015). Begin the temperature program of the gas chromatograph and start data acquisition.

7.2.4.2 Cryogenic interface - After the 11 minute purge, place the purge-and-trap system in the desorb mode, make sure that the cryogenic interface is at -150°C or lower, and rapidly heat the trap to 245°C while backflushing with an inert gas at 4 mL/minute for about 5 minutes (1.5 min is normally adequate for analytes in Methods 8015). At the end of the 5-minute desorption cycle, rapidly heat the cryogenic trap to 250°C. Begin the temperature program of the gas chromatograph and start the data acquisition.

7.2.5 Trap Reconditioning

After desorbing the sample for 4 minutes, recondition the trap by returning the purge-and-trap system to the purge mode. Maintain the trap temperature at 245°C (or other temperature recommended by the manufacturer of the trap packing materials). After approximately 10 minutes, turn off the trap heater and halt the purge flow through the trap. When the trap is cool, the next sample can be analyzed.

7.2.6 Data Interpretation

Perform qualitative and quantitative analysis following the guidance given in the determinative method and Method 8000. If the concentration of any target analyte exceeds the calibration range of the instrument, it will be necessary to reanalyze the sample by the high concentration method. Such reanalyses need only address those analytes for which the concentration exceeded the calibration range of the low concentration method. Alternatively, if a sample aliquot of 1-2 g was also collected (see Sec. 6.2.1.7), it may be practical to analyze that aliquot for the analytes that exceeded the instrument calibration range in the 5-g analysis. If results are to be reported on a dry weight basis, proceed to Sec. 7.5

7.3 High concentration method for soil samples with concentrations generally greater than 200 µg/kg.

The high concentration method for soil is based on a solvent extraction. A solid sample is either extracted or diluted, depending on sample solubility in a water-miscible solvent. An aliquot of the extract is added to organic-free reagent water containing surrogates and, if applicable, internal and matrix spiking standards, purged according to Method 5030, and analyzed by an appropriate determinative method. Wastes that are insoluble in methanol (i.e., petroleum and coke wastes) are diluted with hexadecane (see Sec. 7.3.8).

The specific sample preparation steps depend on whether or not the sample was preserved in the field. Samples that were not preserved in the field are prepared using the steps below, beginning at Sec. 7.3.1. If solvent preservation was employed in the field, then the preparation begins with Sec. 7.3.4.

7.3.1 When the high concentration sample is not preserved in the field, the sample consists of the entire contents of the sample container. Do not discard any supernatant liquids. Whenever practical, mix the contents of the sample container by shaking or other mechanical means without opening the vial. When shaking is not practical, quickly mix the contents of the vial with a narrow metal spatula and immediately reseal the vial.

7.3.2 If the sample is from an unknown source, perform a solubility test before proceeding. Remove several grams of material from the sample container. Quickly reseal the container to minimize the loss of volatiles. Weigh 1-g aliquots of the sample into several test tubes or other suitable containers. Add 10 mL of methanol to the first tube, 10 mL of PEG to the second, and 10 mL of hexadecane to the third. Swirl the sample and determine if it is soluble in the solvent. Once the solubility has been evaluated, discard these test solutions. If the sample is soluble in either methanol or PEG, proceed with Sec. 7.3.3. If the sample is only soluble in hexadecane, proceed with Sec. 7.3.8.

7.3.3 For soil and solid waste samples that are soluble in methanol, add 9.0 mL of methanol and 1.0 mL of the surrogate spiking solution to a tared 20-mL vial. Using a top-loading balance, weigh 5 g (wet weight) of sample into the vial. Quickly cap the vial and reweigh the vial. Record the weight to 0.1 g. Shake the vial for 2 min. If the sample was not soluble in methanol, but was soluble in PEG, employ the same procedure described above, but use 9.0 mL of PEG in place of the methanol. Proceed with Sec. 7.3.5.

NOTE: The steps in Secs. 7.3.1, 7.3.2, and 7.3.3 must be performed rapidly and without interruption to avoid loss of volatile organics. These steps must be performed in a laboratory free from solvent fumes.

7.3.4 For soil and solid waste samples that were collected in methanol or PEG (see Sec. 6.2.2), weigh the vial to 0.1 g as a check on the weight recorded in the field, add the surrogate spiking solution to the vial by injecting it through the septum, shake for 2 min, as described above, and proceed with Sec. 7.3.5.

7.3.5 Pipet approximately 1 mL of the extract from either Sec. 7.3.3 or 7.3.4 into a GC vial for storage, using a disposable pipet, and seal the vial. The remainder of the extract may be discarded. Add approximately 1 mL of methanol or PEG to a separate GC vial for use as the method blank for each set of samples extracted with the same solvent.

7.3.6 The extracts must be stored at 4°C in the dark, prior to analysis. Add an appropriate aliquot of the extract (see Table 2) to 5.0 mL of organic-free reagent water and analyze by Method 5030 in conjunction with the appropriate determinative method. Proceed to Sec. 7.0 in Method 5030 and follow the procedure for purging high concentration samples.

7.3.7 If results are to be reported on a dry weight basis, determine the dry weight of a separate aliquot of the sample, using the procedure in Sec. 7.5, after the sample extract has been transferred to a GC vial and the vial sealed.

7.3.8 For solids that are not soluble in methanol or PEG (including those samples consisting primarily of petroleum or coking waste) dilute or extract the sample with hexadecane using the procedures in Sec. 7.0 of Method 3585.

7.4 High concentration method for oily waste samples

This procedure for the analysis of oily waste samples involves the dilution of the sample in methanol or PEG. However, care must be taken to avoid introducing any of the floating oil layer into the instrument. A portion of the diluted sample is then added to 5.0 mL of organic-free reagent water, purged according to Method 5030, and analyzed using an appropriate determinative method.

For oily samples that are not soluble in methanol or PEG (including those samples consisting primarily of petroleum or coking waste), dilute or extract with hexadecane using the procedures in Sec. 7.0 of Method 3585.

The specific sample preparation steps depend on whether or not the sample was preserved in the field. Samples that were not preserved in the field are prepared using the steps below, beginning at Sec. 7.4.1. If methanol preservation was employed in the field, then the preparation begins with Sec. 7.4.3.

7.4.1 If the waste was not preserved in the field and it is soluble in methanol or PEG, weigh 1 g (wet weight) of the sample into a tared 10-mL volumetric flask, a tared scintillation vial, or a tared culture tube. If a vial or tube is used instead of a volumetric flask, it must be calibrated prior to use. This operation must be performed prior to opening the sample vial and weighing out the aliquot for analysis.

7.4.1.1 To calibrate the vessel, pipet 10.0 mL of methanol or PEG into the vial or tube and mark the bottom of the meniscus.

7.4.1.2 Discard this solvent, and proceed with weighing out the 1-g sample aliquot.

7.4.2 Quickly add 1.0 mL of surrogate spiking solution to the flask, vial, or tube, and dilute to 10.0 mL with the appropriate solvent (methanol or PEG). Swirl the vial to mix the contents and then shake vigorously for 2 minutes.

7.4.3 If the sample was collected in the field in a vial containing methanol or PEG, weigh the vial to 0.1 g as a check on the weight recorded in the field, add the surrogate spiking solution to the vial by injecting it through the septum. Swirl the vial to mix the contents and then shake vigorously for 2 minutes and proceed with Sec. 7.4.4.

7.4.4 Regardless of how the sample was collected, the target analytes are extracted into the solvent along with the majority of the oily waste (i.e., some of the oil may still be floating on the surface). If oil is floating on the surface, transfer 1 to 2 mL of the extract to a clean GC vial using a Pasteur pipet. Ensure that no oil is transferred to the vial.

7.4.5 Add 10 - 50 μ L of the methanol extract to 5 mL of organic-free reagent water for purge-and-trap analysis, using Method 5030.

7.4.6 Prepare a matrix spike sample by adding 10 - 50 μ L of the matrix spike standard dissolved in methanol to a 1-g aliquot of the oily waste. Shake the vial to disperse the matrix spike solution throughout the oil. Then add 10 mL of extraction solvent and proceed with the extraction and analysis, as described in Secs. 7.4.2 - 7.4.5. Calculate the recovery of the spiked analytes as described in Method 8000. If the recovery is not within the acceptance limits for the application, use the hexadecane dilution technique in Sec. 7.0 of Method 3585.

7.5 Determination of % Dry Weight

If results are to be reported on a dry weight basis, it is necessary to determine the dry weight of the sample.

NOTE: It is highly recommended that the dry weight determination only be made after the analyst has determined that no sample aliquots will be taken from the 60-mL vial for high

concentration analysis. This is to minimize loss of volatiles and to avoid sample contamination from the laboratory atmosphere. There is no holding time associated with the dry weight determination. Thus, this determination can be made any time prior to reporting the sample results, as long as the vial containing the additional sample has remained sealed and properly stored.

7.5.1 Weigh 5-10 g of the sample from the 60-mL VOA vial into a tared crucible.

7.5.2 Dry this aliquot overnight at 105°C. Allow to cool in a desiccator before weighing. Calculate the % dry weight as follows:

$$\% \text{ dry weight} = \frac{\text{g of dry sample}}{\text{g of sample}} \times 100$$

WARNING: The drying oven should be contained in a hood or vented. Significant laboratory contamination may result from a heavily contaminated hazardous waste sample.

8.0 QUALITY CONTROL

8.1 Refer to Chapter One for specific quality control procedures and Method 5000 for sample preparation QC procedures.

8.2 Before processing any samples, the analyst should demonstrate through the analysis of an organic-free reagent water method blank that all glassware and reagents are interference free. Each time a set of samples is extracted, or there is a change in reagents, a method blank should be processed as a safeguard against chronic laboratory contamination. The blank samples should be carried through all stages of the sample preparation and measurement.

8.3 Initial Demonstration of Proficiency - Each laboratory must demonstrate initial proficiency with each sample preparation and determinative method combination it utilizes, by generating data of acceptable accuracy and precision for target analytes in a clean matrix. The laboratory must also repeat this demonstration whenever new staff are trained or significant changes in instrumentation are made. See Sec. 8.0 of Methods 5000 and 8000 for information on how to accomplish this demonstration.

8.4 Sample Quality Control for Preparation and Analysis - See Sec. 8.0 in Method 5000 and Method 8000 for procedures to follow to demonstrate acceptable continuing performance on each set of samples to be analyzed. These include the method blank, either a matrix spike/matrix spike duplicate or a matrix spike and duplicate sample analysis, a laboratory control sample (LCS), and the addition of surrogates to each sample and QC sample.

8.5 It is recommended that the laboratory adopt additional quality assurance practices for use with this method. The specific practices that are most productive depend upon the needs of the laboratory and the nature of the samples. Whenever possible, the laboratory should analyze standard reference materials and participate in relevant performance evaluation studies.

9.0 METHOD PERFORMANCE

9.1 Single laboratory accuracy and precision data were obtained for the method analytes in three soil matrices, sand, a soil collected 10 feet below the surface of a hazardous landfill, called the

C-Horizon, and a surface garden soil. Each sample was fortified with the analytes at a concentration of 20 ng/5 g, which is equivalent to 4 µg/kg. These data are listed in tables found in Method 8260.

9.2 Single laboratory accuracy and precision data were obtained for certain method analytes when extracting oily liquid using methanol as the extraction solvent. The data are presented in a table in Method 8260. The compounds were spiked into three portions of an oily liquid (taken from a waste site) following the procedure for matrix spiking described in Sec. 7.4. This represents a worst case set of data based on recovery data from many sources of oily liquid.

10.0 REFERENCES

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TABLE 1

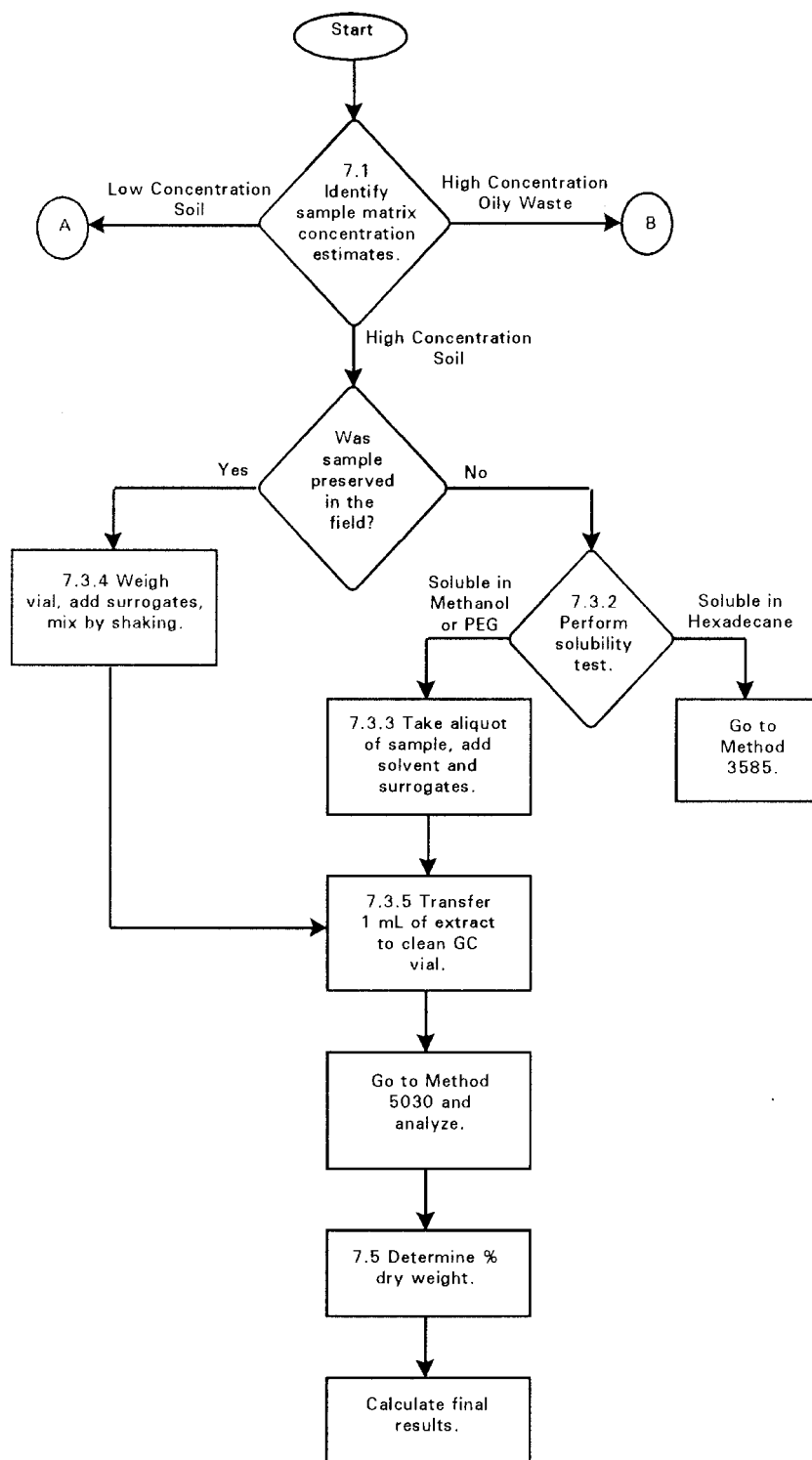
QUANTITY OF METHANOL EXTRACT REQUIRED FOR ANALYSIS OF
HIGH CONCENTRATION SOILS/SEDIMENTS

Approximate Concentration Range			Volume of Methanol Extract ^a
500	-	10,000 µg/kg	100 µL
1,000	-	20,000 µg/kg	50 µL
5,000	-	100,000 µg/kg	10 µL
25,000	-	500,000 µg/kg	100 µL of 1/50 dilution ^b

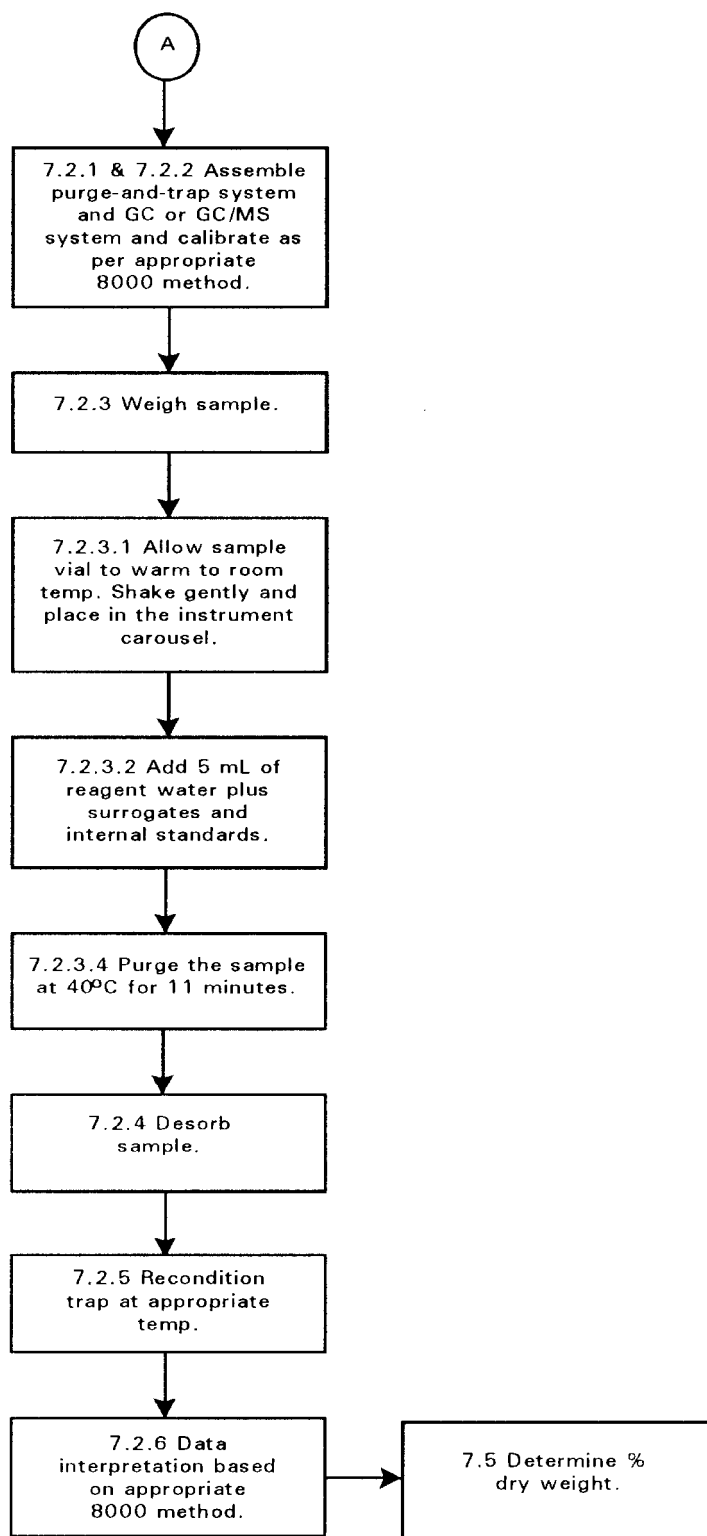
Calculate appropriate dilution factor for concentrations exceeding those in this table.

- ^a The volume of methanol added to 5 mL of water being purged should be kept constant. Therefore, add to the 5-mL syringe whatever volume of methanol is necessary to maintain a total volume of 100 µL of methanol.
- ^b Dilute an aliquot of the methanol extract and then take 100 µL for analysis.

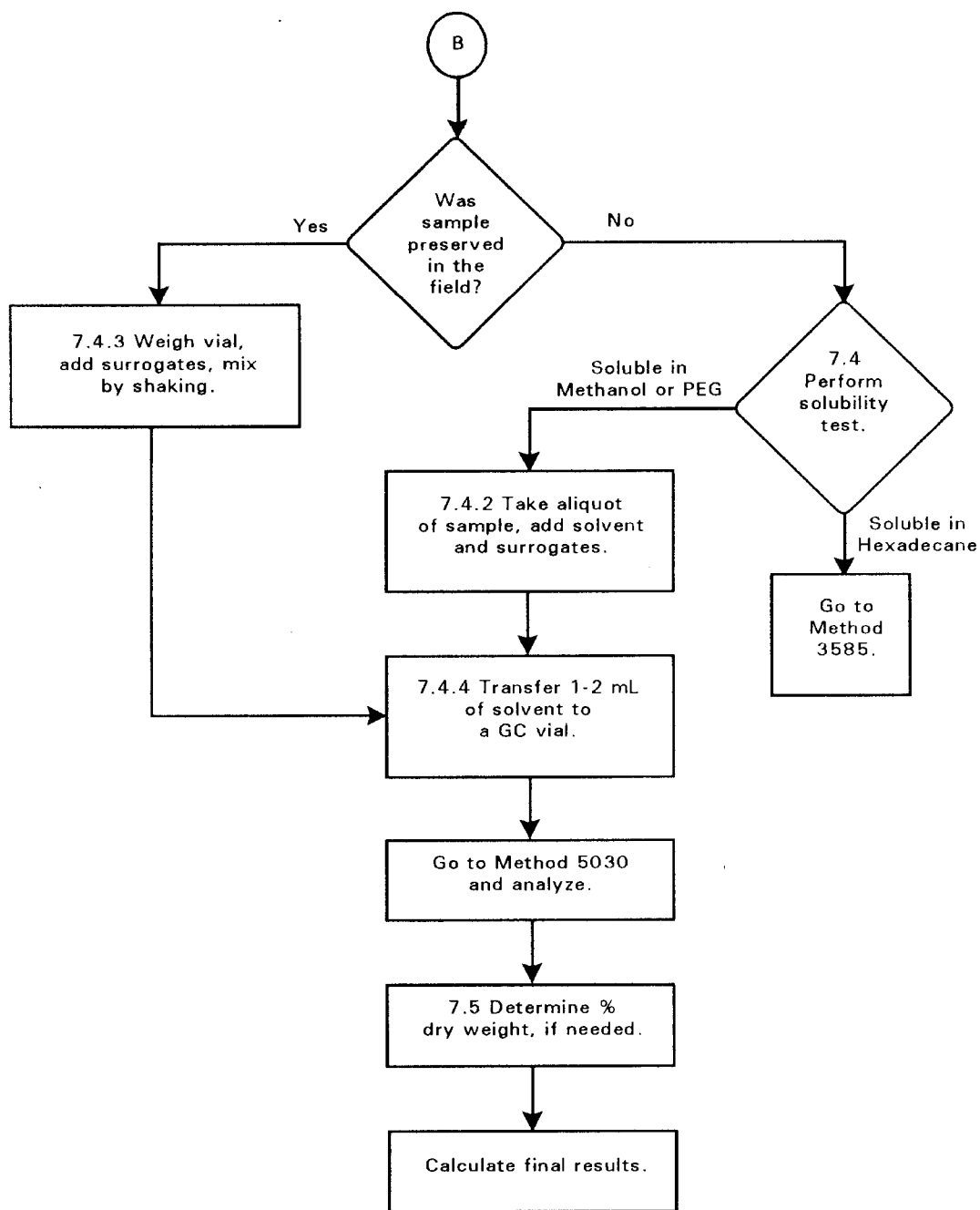
METHOD 5035
CLOSED-SYSTEM PURGE-AND-TRAP AND EXTRACTION
FOR VOLATILE ORGANICS IN SOIL AND WASTE SAMPLES



METHOD 5035 (CONTINUED)



METHOD 5035 (CONTINUED)



Groundwater Sampling for Emerging Contaminants

April 2018

Issue: NYSDEC has committed to analyzing representative groundwater samples at remediation sites for emerging contaminants (1,4-dioxane and PFAS) as described in the below guidance.

Implementation

NYSDEC project managers will be contacting site owners to schedule sampling for these chemicals. Only groundwater sampling is required. The number of samples required will be similar to the number of samples where “full TAL/TCL sampling” would typically be required in a remedial investigation. If sampling is not feasible (e.g., the site no longer has any monitoring wells in place), sampling may be waived on a site-specific basis after first considering potential sources of these chemicals and whether there are water supplies nearby.

Upon a new site being brought into any program (i.e., SSF, BCP), PFAS and 1,4-dioxane will be incorporated into the investigation of groundwater as part of the standard “full TAL/TCL” sampling. Until an SCO is established for PFAS, soil samples do not need to be analyzed for PFAS unless groundwater contamination is detected. Separate guidance will be developed to address sites where emerging contaminants are found in the groundwater. The analysis currently performed for SVOCs in soil is adequate for evaluation of 1,4-dioxane, which already has an established SCO.

Analysis and Reporting

Labs should provide a full category B deliverable, and a DUSR should be prepared by a data validator, and the electronic data submission should meet the requirements provided at: <https://www.dec.ny.gov/chemical/62440.html> ,

The work plan should explicitly describe analysis and reporting requirements.

PFAS sample analysis: Currently, ELAP does not offer certification for PFAS compounds in matrices other than finished drinking water. However, laboratories analyzing environmental samples (ex. soil, sediments, and groundwater) are required, by DER, to hold ELAP certification for PFOA and PFOS in drinking water by EPA Method 537 or ISO 25101.

Modified EPA Method 537 is the preferred method to use for groundwater samples due to the ability to achieve 2 ng/L (ppt) detection limits. If contract labs or work plans submitted by responsible parties indicate that they are not able to achieve similar reporting limits, the project manager should discuss this with a DER chemist. Note: Reporting limits for PFOA and PFOS should not exceed 2 ng/L.

PFAS sample reporting: DER has developed a PFAS target analyte list (below) with the intent of achieving reporting consistency between labs for commonly reportable analytes. It is expected that reported results for PFAS will include, at a minimum, all the compounds listed. This list may be updated in the future as new information is learned and as labs develop new capabilities. If lab and/or matrix specific issues are encountered for any particular compounds, the NYSDEC project manager will make case-by-case decisions as to whether particular analytes may be temporarily or permanently discontinued from analysis for each site. Any technical lab issues should be brought to the attention of a NYSDEC chemist.

Some sampling using this full PFAS target analyte list is needed to understand the nature of contamination. It may also be critical to differentiate PFAS compounds associated with a site from other

sources of these chemicals. Like routine refinements to parameter lists based on investigative findings, the full PFAS target analyte list may not be needed for all sampling intended to define the extent of contamination. Project managers may approve a shorter analyte list (e.g., just the UCMR3 list) for some reporting on a case by case basis.

1,4-Dioxane Analysis and Reporting: The method detection limit (MDL) for 1,4-dioxane should be no higher than 0.28 µg/l (ppb). ELAP offers certification for both EPA Methods 8260 and 8270. In order to get the appropriate detection limits, the lab would need to run either of these methods in “selective ion monitoring” (SIM) mode. DER is advising the use of method 8270, since this method provides a more robust extraction procedure, uses a larger sample volume, and is less vulnerable to interference from chlorinated solvents (we acknowledge that 8260 has been shown to have a higher recovery in some studies).

Full PFAS Target Analyte List

Group	Chemical Name	Abbreviation	CAS Number
Perfluoroalkyl sulfonates	Perfluorobutanesulfonic acid	PFBS	375-73-5
	Perfluorohexanesulfonic acid	PFHxS	355-46-4
	Perfluoroheptanesulfonic acid	PFHpS	375-92-8
	Perfluorooctanesulfonic acid	PFOS	1763-23-1
	Perfluorodecanesulfonic acid	PFDS	335-77-3
Perfluoroalkyl carboxylates	Perfluorobutanoic acid	PFBA	375-22-4
	Perfluoropentanoic acid	PFPeA	2706-90-3
	Perfluorohexanoic acid	PFHxA	307-24-4
	Perfluoroheptanoic acid	PFHpA	375-85-9
	Perfluorooctanoic acid	PFOA	335-67-1
	Perfluorononanoic acid	PFNA	375-95-1
	Perfluorodecanoic acid	PFDA	335-76-2
	Perfluoroundecanoic acid	PFUA/PFUdA	2058-94-8
	Perfluorododecanoic acid	PFDoA	307-55-1
	Perfluorotridecanoic acid	PFTriA/PFTrDA	72629-94-8
	Perfluorotetradecanoic acid	PFTA/PFTeDA	376-06-7
Fluorinated Telomer Sulfonates	6:2 Fluorotelomer sulfonate	6:2 FTS	27619-97-2
	8:2 Fluorotelomer sulfonate	8:2 FTS	39108-34-4
Perfluorooctane-sulfonamides	Perfluorooctanesulfonamide	FOSA	754-91-6
Perfluorooctane-sulfonamidoacetic acids	N-methyl perfluorooctanesulfonamidoacetic acid	N-MeFOSAA	2355-31-9
	N-ethyl perfluorooctanesulfonamidoacetic acid	N-EtFOSAA	2991-50-6

Bold entries depict the 6 original UCMR3 chemicals

Collection of Groundwater Samples for Perfluorooctanoic Acid (PFOA) and Perfluorinated Compounds (PFCs) from Monitoring Wells Sample Protocol

Samples collected using this protocol are intended to be analyzed for perfluorooctanoic acid (PFOA) and other perfluorinated compounds by Modified (Low Level) Test Method 537.

The procedure used must be consistent with the NYSDEC March 1991 Sampling Guidelines and Protocols http://www.dec.ny.gov/docs/remediation_hudson_pdf/sgpsect5.pdf with the following materials limitations.

At this time acceptable materials for sampling include: stainless steel, high density polyethylene (HDPE), PVC, silicone, acetate and polypropylene. Equipment blanks should be generated at least daily. Additional materials may be acceptable if pre-approved by NYSDEC. Requests to use alternate equipment should include clean equipment blanks. **NOTE: Grunfos pumps and bladder pumps are known to contain PFC materials (e.g. Teflon™ washers for Grunfos pumps and LDPE bladders for bladder pumps).** All sampling equipment components and sample containers should not come in contact with aluminum foil, low density polyethylene (LDPE), glass or polytetrafluoroethylene (PTFE, Teflon™) materials including sample bottle cap liners with a PTFE layer. Standard two step decontamination using detergent and clean water rinse will be performed for equipment that does come in contact with PFC materials. Clothing that contains PTFE material (including GORE-TEX®) or that have been waterproofed with PFC materials must be avoided. Many food and drink packaging materials and “plumbers thread seal tape” contain PFCs.

All clothing worn by sampling personnel must have been laundered multiple times. The sampler must wear nitrile gloves while filling and sealing the sample bottles.

Pre-cleaned sample bottles with closures, coolers, ice, sample labels and a chain of custody form will be provided by the laboratory.

1. Fill two pre-cleaned 500 mL HDPE or polypropylene bottle with the sample.
2. Cap the bottles with an acceptable cap and liner closure system.
3. Label the sample bottles.
4. Fill out the chain of custody.
5. Place in a cooler maintained at $4 \pm 2^{\circ}$ Celsius.

Collect one equipment blank for every sample batch, not to exceed 20 samples.

Collect one field duplicate for every sample batch, not to exceed 20 samples.

Collect one matrix spike / matrix spike duplicate (MS/MSD) for every sample batch, not to exceed 20 samples.

Request appropriate data deliverable (Category A or B) and an electronic data deliverable.

Sampling for 1,4-Dioxane and Per- and Polyfluoroalkyl Substances (PFAS) Under DEC's Part 375 Remedial Programs

Objective

The Department of Environmental Conservation (DEC) is requiring sampling of all environmental media and subsequent analysis for the emerging contaminants 1,4-Dioxane and PFAS as part of all remedial programs implemented under 6 NYCRR Part 375, as further described in the guidance below.

Sample Planning

The number of samples required for emerging contaminant analyses is to be the same number of samples where "full TAL/TCL sampling" would typically be required in an investigation or remedial action compliance program.

Upon a new site being brought into any program (e.g., SSF, BCP), PFAS and 1,4-dioxane will be incorporated into the investigation of potentially affected media, including soil, groundwater, surface water, and sediment as an addition to the standard "full TAL/TCL sampling." Biota sampling may be necessary based upon the potential for biota to be affected as determined pursuant to a Fish and Wildlife Impact analysis. Soil vapor sampling for PFAS and 1,4-dioxane is not required.

Upon an emerging contaminant being identified as a contaminant of concern (COC) for a site, those compounds must be assessed as part of the remedy selection process in accordance with Part 375 and DER-10 and included as part of the monitoring program upon entering the site management phase.

Soil imported to a site for use in a soil cap, soil cover, or as backfill must be sampled for 1,4-dioxane and PFAS contamination in general conformance with DER-10, section 5.4(e). Assessment of the soil data will be made on a site-specific basis to determine appropriateness for use.

The work plan should explicitly describe analysis and reporting requirements, including laboratory analytical procedures for modified methods discussed below.

Analysis and Reporting

Labs should provide a full category B deliverable, and a DUSR should be prepared by an independent 3rd party data validator. QA/QC samples should be collected as required in DER-10, Section 2.3(c). The electronic data submission should meet the requirements provided at:

<https://www.dec.ny.gov/chemical/62440.html>.

PFAS analysis and reporting: DEC has developed a *PFAS Analyte List* (below) for remedial programs. It is expected that reported results for PFAS will include, at a minimum, all the compounds listed. If lab and/or matrix specific issues are encountered for any compounds, the DEC project manager, in consultation with the DEC remedial program chemist, will make case-by-case decisions as to whether certain analytes may be temporarily or permanently discontinued from analysis at each site.

Currently, ELAP does not offer certification for PFAS compounds in matrices other than finished drinking water. However, laboratories analyzing environmental samples (e.g., soil, sediments, and groundwater) are required by DER to hold ELAP certification for PFOA and PFOS in drinking water by EPA Method 537 or ISO 25101.

Modified EPA Method 537 is the preferred method to use for environmental samples due to its ability to achieve very low detection limits. Reporting limits for PFAS in groundwater and soil are to be 2 ng/L (ppt) and 1 ug/kg (ppb), respectively. If contract labs or work plans submitted by responsible parties indicate that they are not able to achieve these reporting limits for the entire list of 21 PFAS, site-specific decisions will need to be made by the DEC project manager in consultation with the DEC remedial program chemist. Note: Reporting limits for PFOA and PFOS in groundwater should not exceed 2 ng/L.

Additional laboratory methods for analysis of PFAS may be warranted at a site. These methods include Synthetic Precipitation Leaching Procedure (SPLP) by EPA Method 1312 and Total Oxidizable Precursor Assay (TOP Assay).

SPLP is a technique for determining the potential for chemicals in soil to leach to groundwater and may be helpful in determining the need for addressing PFAS-containing soils or other solid material as part of the remedy. SPLP sampling need not be considered if there are no elevated PFAS levels in groundwater. If elevated levels of PFAS are detected in water, and PFAS are also seen in soil, then an SPLP test should be considered to better understand the relationship between the PFAS in the two media.

The TOP Assay can assist in determining the potential PFAS risk at a site. For example, some polyfluoroalkyl substances may transform to form perfluoroalkyl substances, resulting in an increase in perfluoroalkyl substance concentrations as contaminated groundwater moves away from the site. To conceptualize the amount and type of oxidizable perfluoroalkyl substances which could be liberated in the environment, a "TOP Assay" analysis can be performed, which approximates the maximum concentration of perfluoroalkyl substances that could be generated if all polyfluoroalkyl substances were oxidized.

PFAS-containing materials can be made up of per- and polyfluoroalkyl substances that are not analyzable by routine analytical methodology (LC-MS/MS). The TOP assay converts, through oxidation, polyfluoroalkyl substances (precursors) into perfluoroalkyl substances that can be detected by current analytical methodology. Please note that analysis of highly contaminated samples, such as those from an AFFF site, can result in incomplete oxidation of the samples and an underestimation of the total perfluoroalkyl substances. Please consult with a DEC remedial program chemist for assistance interpreting the results.

1,4-Dioxane analysis and reporting: The reporting limit for 1,4-dioxane in groundwater should be no higher than 0.35 µg/L (ppb) and no higher than 0.1 mg/kg (ppm) in soil. Although ELAP offers certification for both EPA Method 8260 SIM and EPA Method 8270 SIM in waters, DER is advising the use of Method 8270 SIM because it provides a more robust extraction procedure, uses a larger sample volume, and is less vulnerable to interference from chlorinated solvents. The analysis currently performed for SVOCs in soil is adequate for evaluation of 1,4-dioxane in soil, which already has an established SCO.

Refinement of sample analyses

As with other contaminants that are analyzed for at a site, the emerging contaminant analyte list may be refined for future sampling events based on investigative findings. Initially, however, sampling using this PFAS Analyte List and 1,4-dioxane is needed to understand the nature of contamination.

PFAS Analyte List

Group	Chemical Name	Abbreviation	CAS Number
Perfluoroalkyl sulfonates	Perfluorobutanesulfonic acid	PFBS	375-73-5
	Perfluorohexanesulfonic acid	PFHxS	355-46-4
	Perfluoroheptanesulfonic acid	PFHpS	375-92-8
	Perfluorooctanesulfonic acid	PFOS	1763-23-1
	Perfluorodecanesulfonic acid	PFDS	335-77-3
Perfluoroalkyl carboxylates	Perfluorobutanoic acid	PFBA	375-22-4
	Perfluoropentanoic acid	PFPeA	2706-90-3
	Perfluorohexanoic acid	PFHxA	307-24-4
	Perfluoroheptanoic acid	PFHpA	375-85-9
	Perfluorooctanoic acid	PFOA	335-67-1
	Perfluorononanoic acid	PFNA	375-95-1
	Perfluorodecanoic acid	PFDA	335-76-2
	Perfluoroundecanoic acid	PFUA/PFUdA	2058-94-8
	Perfluorododecanoic acid	PFDoA	307-55-1
	Perfluorotridecanoic acid	PFTriA/PFTrDA	72629-94-8
	Perfluorotetradecanoic acid	PFTA/PFTeDA	376-06-7
Fluorinated Telomer Sulfonates	6:2 Fluorotelomer sulfonate	6:2 FTS	27619-97-2
	8:2 Fluorotelomer sulfonate	8:2 FTS	39108-34-4
Perfluorooctane-sulfonamides	Perfluorooctanesulfonamide	FOSA	754-91-6
Perfluorooctane-sulfonamidoacetic acids	N-methyl perfluorooctanesulfonamidoacetic acid	N-MeFOSAA	2355-31-9
	N-ethyl perfluorooctanesulfonamidoacetic acid	N-EtFOSAA	2991-50-6

Laboratory Guidance for Analysis of Per- and Polyfluoroalkyl Substances (PFAS) in Non-Potable Water and Solids

The Division of Environmental Remediation (DER) developed the following guidance for laboratories submitting PFAS data to DER. If laboratories cannot comply with any of the following requirements, they must contact Dana Maikels at dana.maikels@dec.ny.gov prior to analysis of samples.

1. Standards containing both branched and linear isomers must be used when standards are commercially available. Currently, quantitative standards are available for PFHxS, PFOS, NMeFOSAA, and NEtFOSAA. All isomer peaks present in the standard must be integrated and the areas summed. Samples must be integrated in the same manner as the standards.

Since a quantitative standard does not exist for branched isomers of PFOA, the instrument must be calibrated using just the linear isomer and a technical (qualitative) PFOA standard must be used to identify the retention time of the branched PFOA isomers in the sample. The total response of PFOA branched and linear isomers must be integrated in the samples and quantitated using the calibration curve of the linear standard.

2. Quantifier and qualifier ions must be monitored for all target analytes (PFPeA and PFBA are an exception). The ratio of quantifier ion response to qualifier ion response must be calculated for each target analyte and the ratio compared to standards. Lab derived criteria can be used to determine if the ratios are acceptable.
3. The ion transitions below must be used for the following PFASs:

PFOA	413 > 369
PFOS	499 > 80
PFHxS	399 > 80
PFBS	299 > 80
6:2 FTS	427 > 407
8:2 FTS	527 > 507
NEtFOSAA	584 > 419
NMeFOSAA	570 > 419

4. For all target analyte ions used for quantification, signal to noise ratio must be 3:1 or greater.
5. For water samples, the entire sample bottle must be extracted, and the sample bottle rinsed with appropriate solvent to remove any residual PFAS.
6. Detections below the reporting limit should be reported and qualified with a J qualifier.

ATTACHMENT 5

Table 1 (Sampling and Analysis Plan)

Table 1
Sampling and Analysis Plan
RI/RAA
1560 Lake Avenue, Rochester, New York

Task	Sample Matrix	Sample Location	Depth	Rationale for Sampling Location	Sampling Reference	Analytical Parameters	Analytical Methods	Anticipated # of Field Samples	Trip Blanks	MS/MSD or MS/MD	Field Blanks
Test Borings (Twelve 0-2' bgs Samples)	Soil/Fill	TB-200 to TB-211	0-2 ft.	Delineate nature and extent in soil and HFM	DAY QAPP and NYSDEC DER 10 3.5.2 and 3.11	Full Suite	8260, 8270, 6010/7471, 9012, 8082, 8081, 8150, 7270 SIM, 537	3	0	0	0
						TCL VOCs+TICs	8260	9	0	0	0
						TCL SVOCs+TICs	8270	9	0	0	0
						TAL Metals	6010/7471	9	0	0	0
Test Borings (Twelve >2' bgs Samples)	Soil/Fill	TB-200 to TB-209, TB-212R and TB-213R	Variable between 2-20 ft.	Delineate nature and extent in soil and HFM	DAY QAPP and NYSDEC DER 10 3.5.2 and 3.11	Full Suite	8260, 8270, 6010/7471, 9012, 8082, 8081, 8150, 7270 SIM, 537	2	0	1	1
						TCL VOCs+TICs	8260	10	0	1	1
						TCL SVOCs+TICs	8270	10	0	1	1
						TAL Metals	6010/7471	10	0	1	1
Groundwater Evaluation (First Round, 20 Overburden Wells)	Groundwater	MW-1 to MW-6, MW-102, MW-104, MW-105, MW-107, MW-108, and MW-126, MW-LE-01 to MW-LE-05, MW-200, MW-206 and MW-206	Variable between 5-15 ft.	Delineate nature and extent in groundwater	DAY QAPP and NYSDEC DER 10 3.7.2 and 3.7.3	Full Suite	8260, 8270, 6010/7471, 9012, 8082, 8081, 8150, 7270 SIM, 537	4	1	1	1
						TCL VOCs+TICs	8260	16	0	0	0
Groundwater Evaluation (First Round, 7 Bedrock Wells)	Groundwater	MW-103R, MW-121R, MW-127R, MW-128R, MW-129R, MW-209R and MW-210R	Variable between 20-40 ft.	Delineate nature and extent in groundwater	DAY QAPP and NYSDEC DER 10 3.7.2 and 3.7.3	Full Suite	8260, 8270, 6010/7471, 9012, 8082, 8081, 8150, 7270 SIM, 537	2	1	1	1
						TCL VOCs+TICs	8260	5	0	0	0
Groundwater Evaluation Second Round, 20 Overburden Wells)*	Groundwater	MW-1 to MW-6, MW-102, MW-104, MW-105, MW-107, MW-108, and MW-126, MW-LE-01 to MW-LE-05, MW-200, MW-206 and MW-206	Variable between 5-15 ft.	Delineate nature and extent in groundwater	DAY QAPP and NYSDEC DER 10 3.7.2 and 3.7.3	Full Suite	8260, 8270, 6010/7471, 9012, 8082, 8081, 8150, 7270 SIM, 537	4	1	1	1
						TCL VOCs+TICs	8260	16	0	0	0
Groundwater Evaluation Second Round, 7 Bedrock Wells)*	Groundwater	MW-103R, MW-121R, MW-127R, MW-128R, MW-129R, MW-209R and MW-210R	Variable between 20-40 ft.	Delineate nature and extent in groundwater	DAY QAPP and NYSDEC DER 10 3.7.2 and 3.7.3	Full Suite	8260, 8270, 6010/7471, 9012, 8082, 8081, 8150, 7270 SIM, 537	2	1	1	1
						TCL VOCs+TICs	8260	5	0	0	0
Soil Vapor Evaluation (Five Soil Vapor and 1 Outdoor Air)	Air	SV-1 to SV-5, OA-1	Up to 8 ft.	Investigate soil vapor at or near perimeter of Site	DAY QAPP, NYSDEC DER-10 Section 3.6, and NYSDOH Guidance Document	VOCs	TO-15	6	0	0	0
Waste Characterization (IDW)	Solid	Investigation-Derived Waste	NA	Waste characterization	DAY QAPP	Full TCLP	1311,8260, 8270, 6010/7470, 8081, 8151	1	0	0	0
						TCL VOCs	8260	1	0	0	0
						Ignitability	1010 or 1030	1	0	0	0
						Reactivity	7.3, 9012, 9034	1	0	0	0
						Corrosivity (pH)	9045	1	0	0	0
	Liquid	Investigation-Derived Waste	NA	Waste characterization	DAY QAPP	TCL VOCs	624	1	0	0	0
						TCL SVOCs	625	1	0	0	0
						TCL PCBs	608	1	0	0	0
						RCRA Metals	200.7/245.2	1	0	0	0

Full Suite = TCL VOCs + TICs, TCL SVOCs and TICs, TAL Metals, CN, PCBs, Pesticides, Herbicides, 1,4-Dioxane, and TAL PFAS

TCL = Target Compound List

TAL = Target Analyte List

VOCs = Volatile Organic Compounds

SVOCs =- Semi-Volatile Organic Compounds

CN = Cyanide

PCBs = Polychlorinated Biphenyls

PFAS = Perfluoroakyl and Polyfluoroakyl Substances

TICs = Tentatively Identified Compounds

* = Same as Round 1, or as determined with input and approval from the NYSDEC

HFM = Historic Fill Material

NA - Not Applicable, Not Available

QAPP = Quality Assurance Project Plan